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Evaluation of Rheumatoid Information Providing Web Site on the Internet

Jae Hyun Lee[a], Myonghwa Park[b]

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Abstract and objective

The purpose of this study was to analyze and evaluate internet web sites about rheumatic arthritis in Korea. The results indicated the need of regular and reliable monitoring of the health information websites.

Keywords:

rheumatoid arthritis, information, internet

Introduction

The increasing health information on the web indicates the need of monitoring and evaluation of the quality of web based health information.

Methods

One hundred forty eight sites of general/university hospitals were searched through domestic search engines and included in the 1st analysis. Eleven websites which are entirely developed for RA information, were selected and secondly analyzed using web evaluation tools developed by Kim(2003)[1)].

Results

In the 148 web sites of general/university hospitals, there were 60 sites(40.5%) with bulletin board, 107 sites(73.6%) with web master contact information, 115 sites(79.1%) with the site maps for the convenient search, 136 sites(92.6%) with search function, and 106 sites(71.6%) with customer service functions. Second analysis of selected 11 web sites which are developed entirely for health information about rheumatoid arthritis, showed high scores in the website purpose items(purpose and target users are indicated clearly), and reliability items(developer information and contact information are clearly provided) but resulted in relatively low scores in source of references(36.4%), site maps/outlines(45.5%), how-to-use/help function(18.2%).

Conclusion

The results from this study indicated that internet information about rheumatoid arthritis were not enough quantitatively and qualitatively[2)]. It is necessary to improve the understandability of information for consumers, and provide the reference sources to improve the reliability of health information.

Table 1 - Analysis of the quality of the RA websites

Criteria	Description	Yes N(%)	No N(%)
Purpose	Purpose of web site is stated clearly.	11(100)	0(0.0)
	Subject is stated clearly.	11(100)	0(0.0)
Contents	Contents serve the purpose of the web site.	11(100)	0(0.0)
	Contents are appropriate for the subject.	11(100)	0(0.0)
	Contents are suitable for targeted theme.	11(100)	0(0.0)
	Design is appropriate for intended subject.	7(63.6)	4(36.4)
	Contents covered the related topics enough.	8(72.7)	3(27.3)
	Information for the theme is consistent.	11(100)	0(0.0)
	Information is correct and accurate.	11(100)	0(0.0)
	Information has clear sources.	4(36.4)	7(63.0)
Authority	Author or information provider is indicated.	9(81.8)	2(18.2)
	Contact information (e-mail, tel) is indicated.	9(81.8)	2(18.2)
	Author has an authority in the related field.	8(72.7)	3(27.3)
Reliability	Developer and supporter of site is indicated.	10(90.9)	1(9.1)
	Contact information is indicated.	11(100)	0(0.0)
Interface	Contact e-mail is provided.	10(90.9)	1(9.1)
	Users' opinion page is provided	9(81.8)	2(18.2)
	Users' opinions are considered	8(72.7)	3(27.3)
Search	Site map indicates overall site structure.	5(45.5)	6(54.5)
	Instruction to use is available.	2(18.2)	9(81.8)
	Search function serves the site.	10(90.9)	1(9.1)
	Site title is suitable for purpose and content	11(100)	0(0.0)
	URL/Domain name of web site is appropriate.	10(90.9)	1(9.1)
Updates	The opening date of web site is indicated.	8(72.7)	3(27.3)
	Latest update date is indicated.	1(9.1)	10(90.9)
	Recent comments in bulletin board have dates.All links are available.	9(81.8) 7(63.6)	2(18.2) 4(36.4)

References

[1] Kim JO, Kim US, Go IS, Gang SM. An evaluation study of hypertension information providing web sites on the internet. Journal of Korean Society of Medical Informatics, 2003; 9(1): 45-52.

[2] Kim HA, Bae YC, Seo YI. Arthritis information on the web and its influence on patients and physicians: a Korean study. Clinical & Experimental Rheumatology, 2004; 22(1): 49-54.

Acknowledgement

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Results

	RA Information N(%)	Bulletin Board N(%)	Webmaster e-mail N(%)	Site map N(%)	Search N(%)	Medical Consult N(%)
Yes	64(43.9)	60(40.5)	107(73.6)	115(79.1)	136(92.6)	106(71.6)
No	82(56.1)	86(59.5)	39(26.4)	31(20.9)	10(7.4)	40(28.4)
Total	148(100)	148(100)	148(100)	148(100)	148(100)	148(100)

Results

Second analysis of selected 11 web sites which are developed entirely for health information about rheumatoid arthritis, showed high scores in the website purpose items(purpose and target users are indicated clearly), and reliability items(developer information and contact information are clearly provided) but resulted in relatively low scores in source of references(36.4%), site maps/outlines(45.5%), how-to-use/help function(18.2%).

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	Subject is stated clearly.	11(100)	0(0.0)
Contents	Contents serve the purpose of the web site.	11(100)	0(0.0)
	Contents are appropriate for the subject.	11(100)	0(0.0)
	Contents are suitable for targeted theme.	11(100)	0(0.0)
	Design is appropriate for intended subject.	7(63.6)	4(36.4)
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	Author has an authority in the related field.	8(72.7)	3(27.3)

Results

Criteria	Description	Yes N(%)	No N(%)
Reliability	Developer and supporter of site is indicated.	10(90.9)	1(9.1)
	Contact information is indicated.	11(100)	0(0.0)
Interface	Contact e-mail is provided.	10(90.9)	1(9.1)
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Conclusion

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Experiences and Insights from the Development of a Mobile Self Management System for Cystic Fibrosis Sufferers in Tasmania.

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Abstract

Among approaches aimed at addressing chronic illness are a number advocating the improvement of patient self-management and self-efficacy skills as a means of improving health outcomes. While comparison between these approaches is difficult, most report benefits. It is clear however that considerable uncertainty remains over the best methods for supporting patient self-management.

For sufferers of Cystic Fibrosis (CF) a major challenge in this regard is how to effectively support a transition from a model of care that is heavily reliant on specialists and parental control to one supporting self-guided management, particularly amongst adolescents and young adults.

This paper explores these issues in the context of experiences and insights emerging from the development of a mobile self-management system for cystic fibrosis patients' across Tasmania. Based on case study research within the CF community, initial insights highlight how patients involved with the mobile self-management system have readily accepted it and actively incorporated it into their daily routine.

Keywords:

self management, self efficacy, computer communication networks, mobile phone

Introduction

This paper presents experiences and insights from a project exploring how mobile technologies can be used to support the development of self-management and self-efficacy amongst cystic fibrosis (CF) sufferers across Tasmania. While supporting self-management and self-efficacy amongst the chronically ill has been shown to have benefit, the role that information and communication technologies (ICTs) can play remains under-researched. There are currently few systems that allow patients to remotely monitor and self-manage their health conditions in a non-obtrusive and cost effective manner. More significantly, many of the systems that do exist, fail to acknowledge the conceptual and practical difficulties of avoiding simply replacing dependency on health professionals for dependency on technology.

Information systems (IS) clearly have a role to play in enabling home based medical systems. Indeed, some research points to positive outcomes for patients with chronic illness in self–managing their conditions with ICTs. It is acknowledged that computer based support systems can be valuable tools to assist with the management, education and ongoing care of a patient's chronic illnesses. In particular, wireless mobile technologies are well suited to support the remote self-management and self-monitoring of a chronic health condition with patient cohorts that are geographically dispersed or where cross-infection is a clinical risk. Other considerations include fees and costs associated with any telemedicine system. Internet based systems rely heavily on connectivity, access speeds, suitable ICTs in the home . There is also a need to consider the nature of the information to be made available to the health care team and the patients. If mentors supporting patients are better informed their ability to monitor and assess patient's progress with goals and action plans can be more improved . The remainder of the paper explores these issues.

Aims / objectives

The overall aim of this research project is to determine the impact of a mobile system on CF patient's ability to self manage and monitor their condition. The project also aims to examine the effectiveness of communication between patient's and health professionals through this mobile system.

The objectives of this research are;

1. To explore how effective the use of mobile technology is in supporting self-management and self-efficacy amongst CF patients.
2. To determine if the use of mobile technology improves information access and communication with specialised health care providers.
3. To capture any perceived or realised benefits gained by patient's from using the mobile system.

Methods

This research adopted a case study methodology and recruited participants from within the Tasmanian CF community. All potential participants received a letter outlining the study and asking for volunteers. Respondents willing to participate then attended their regular CF clinic for consent, baseline measurements and randomization. Recruitment was undertaken within the following selection criteria.

Information systems development

The mobile self-management system was developed to enable participants to closely monitor their own disease through an electronic patient diary and respond to changes based on self-efficacy skills learned through a mentoring process at the beginning of the trial. The intention is to conduct comparisons between participants in the intervention arms and those who have received usual care. There will also be comparison made between the two intervention arms, i.e. outcomes in those with the IT tool versus those without. This will allow determination of whether mentoring alone is sufficient to enhance self-efficacy or whether additional tools such as IT provision value add to the process, or even whether the IT tool itself is what most effectively facilitates self-efficacy and self-management.

This project develops a model of integrated care that promotes patient self-management and self-efficacy supported by an information system. It is anticipated that this will promote the participant's active involvement in their own management, health care decisions and improve quality of life for adolescents and adults with CF. The anticipation is that in the long-term, this will result in better and sustainable outcomes.

System development

The design of the mobile system was broken down into three core components.

1. The development of a suitable mobile phone application that captures and renders clinical information from patients.
2. The development of a mobile phone server application to capture and send clinical information to each patient involved with the mobile phone trial.
3. The development of a database with a web-based interface to store all phone data, action plans and progress notes.

Every day CF patients are asked to run a customise CF application on their mobile phones that poses a set of questions forming a daily symptom diary. Some questions were randomly generated to improve data quality. On average it takes a patient four minutes to complete the diary. A data packet is then sent to a messaging server for capture and passed on to a database for consolidation and interpretation. Mentors and researchers are able to access a real time feeds of the information as it is sent via an online interface. This means that mentors and patients can be located remotely from the data service but still interact with the system in real time. CF patients also have the facility to gain a summary of key data elements to provide indicative progress with their condition and to use for reflection and response as part of their development of self-management and self-efficacy skills. Mentors are able to review their patients remotely and are able to contact patients directly to review or revise action plans and goals.

Experiences and insights to date

To date a number of experiences and insights have been generated by this on-going project:

- The time required to capture daily symptom information is relatively short and the mobile system supports the rendering of progress information in real time.
- The messaging of clinical information via SMS is very cost effective and sustainable.
- The interface used in the mobile phone application is highly intuitive and has incurred only limited time and training cost with this patient cohort.
- The use of mobile phones does not inhibit the scope of the patient's daily activities and is successfully integrated into their other use of the phone.
- Patients enjoy the flexibility of being able to complete or review data as and when it is convenient for them.
- Early indications are that self-management will be improved in both active arms of the trial. It remains too early to make specific remarks about the impact of the mobile system per se.

Conclusion

This paper has presented some of the initial experiences and insights gained whilst developing and implementing technology for a project exploring how mobile technologies can be used to support the development of self-management and self-efficacy amongst cystic fibrosis (CF) sufferers across Tasmania. The project is ongoing and so the final results are pending.

Acknowledgments

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Professor Haydn Walters, Dr David Reid, Ms Jenny Busch, Dr Melanie Jessup, Ms Helen Cameron-Tucker, Ms Lyn Joseph and Ms Petya Fitzpatrick and the development team at Verdant Health.

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Local Medical System for Searching Medical Institutes and Communication

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[b] *Zenrin Datacom co. Ltd.*
c HumanMedia Creation Center /Kyushu

Abstract

Developments in the Internet environment have led to the creation of the Web2.0. Nowadays updating information is as easy as blogging and information can be automatically dispatched to selected websites through the simple use of RSS technology. We developed an information retrieval system for local medical institutions which allows them to offer a push-type information system as well as a map information system. Together these create a dynamic flow of information communication between medical institutions as providers and local residents as users.

Keywords:

medical information search, RSS, intenet communication

Introduction

We recently developed a Contents Management System (CMS) which uses RSS and we added an automatic mail system and a website offering push-type information communication. Any medical institution can now easily update information is automatically forwarded to related websites using RSS technology.

Materials and methods

System outline

A medical institution information retrieval function and a map function were made using XOOPS with CMS as an open source of this basic system. XOOPS has a bulletin board, a notice function, and automatic connection function using RSS. Therefore, when it is necessary to add or update information, mail and websites can be automatically informed.

Not only is the location of a specific medical institution indicated on a map system related to Googlemap but information on other medical institutions in the area is also indicated.

Results

Because the information is offered by the medical institutes themselves and promptly disseminated automatically, it is possible to provide the public with timely information on season-related illnesses, etc. It is easier for the local residents to get accurate information on their local medical institutes from the top page.

Discussion

Information offered on the Internet is recognized as a public notice though there are legal regulations governing the advertisement of medical institutions in Japan

There were some issues in the update of the information on the homepage and the bulletin board. We could improve the convenience of the medical information system and the medical institutions' ability to offer greater information by developing it further in the Web2.0 and building it around a CMS.

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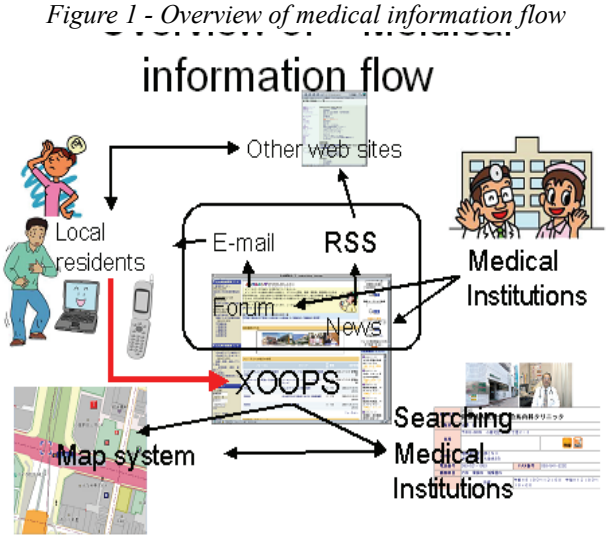
Figure 1 - Overview of medical information flow



Local medical system for searching medical institutes and communication

Katsuya Yahata[a], Yoshitaka Gohara[b], Michie Koga[c], Tetsuro Hada[c]

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Overview of Meidical information flow

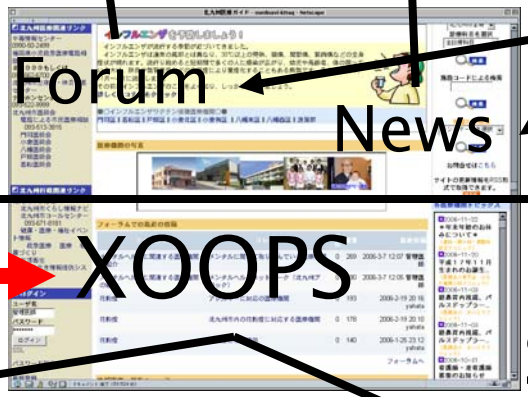
Other web sites

Local residents

E-mail

RSS

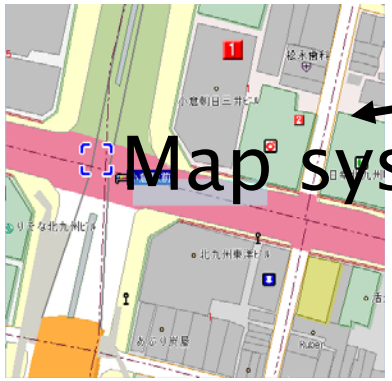
Medical Institutions



Forum

News

XOOPS



Map system

Searching Medical Institutions

System outline 2

- Not only is the location of a specific medical institution indicated on a map system related to Googlemap but information on other medical institutions in the area is also indicated.

Results

- Because the information is offered by the medical institutes themselves and promptly disseminated automatically, it is possible to provide the public with timely information on season-related illnesses, etc. It is easier for the local residents to get accurate information on their local medical institutes from the top page.

Top page

Search by
Area
Name
Specialism

RSS
relation

News
From
Members

Electronic discussion board

Medical clinics information

施設詳細 - Netscape

TOP 医療ガイド　MEDICAL NAVIGATION

施設名称	[1057] 医療法人　魚住眼科医院		
院長	魚住　博彦		
住所	〒808-0034　若松区本町２丁目３－２７		
	渡辺ビル２Ｆ	map / its-mo Navi	
アクセス	明治町銀天街前バス停そば		
電話番号	093-761-3090	FAX番号	
標榜科目	眼科		
診療時間	月曜	午前＝９：００～１２：３０　午後＝１４：３０～１８：００	
	火曜	午前＝９：００～１２：３０　午後＝１４：３０～１８：００	
	水曜	午前＝９：００～１２：３０　午後＝１４：３０～１８：００	
	木曜	午前＝９：００～１２：３０　午後＝休診	
	金曜	午前＝９：００～１２：３０　午後＝１４：３０～１８：００	
	土曜	午前＝９：００～１２：３０　午後＝休診	
	日曜	午前＝休診　午後＝休診	
休診日	日曜、祝祭日、木、土午後	往診	有
駐車場	有		
健診	乳幼児健診（３歳児視覚精密健診）		

ドキュメント:完了 (2.657 秒)

Location map of the clinic

Discussion 1

- Information offered on the Internet is recognized as a public notice though there are legal regulations governing the advertisement of medical institutions in Japan

Discussion 2

- There were some issues in the update of the information on the homepage and the bulletin board. We could improve the convenience of the medical information system and the medical institutions' ability to offer greater information by developing it further in the Web2.0 and building it around a CMS.

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An Instrument for Consumers to Discriminate Inaccurate Information on the Internet

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[b] *School of Health Information Sciences, The University of Texas Health Science Center, Houston, TX, USA*

Abstract

People retrieve health information from the Internet that is unfiltered and not always accurate. In order to assist health care consumers, we tried to develop a simple instrument to discriminate inaccurate information. We hypothesized that accurate statements were likely to be repeated and inaccurate statements were likely to be refuted when multiple results from the same search were reviewed. We investigated information on irritable bowel syndrome (IBS), which is common around the world. We identified inaccurate statements on websites displaying information about this syndrome and counted the number of websites supporting and refuting each inaccurate statement. For each inaccurate statement displayed on English and Japanese sites, there were more refuting sites than supporting sites retrieved by the same search (0.93 vs. 0.0 in English sites and 0.15 vs. 3.35 for Japanese sites).This indicates that health care consumers can confirm online information by comparing multiple sites found on the same search.

Keywords:

irritable bowel syndrome, internet, medical informatics, patient satisfaction

Introduction

Thirty two percent of patients in the United States [1] and 22% of patients in Japan retrieved health information from the Internet [2]. Information on the Internet affected the decision making of 70% of patients in the United States in 2000 [3]. However, information on the Internet lacks peer-review and is not always accurate. Thirty two percent of bladder cancer websites [4] and 14% of melanoma sites [5] were found to be inaccurate. One quarter of complementary alternative medicine sites displayed information that could lead to physical harm if acted upon [6]. Quality assessment instruments such as DISCERN and QUICK attempt to help users identify false or misleading health information online. However, none of them can help a user determine whether a specific statement is true or false. Lay persons cannot be expected to determine whether a particular statement is true and may act based on false or inaccurate information resulting in poor outcomes such as delay of diagnosis or refusal of conventional treatment.

We hypothesized that false information displayed by a website was likely to be refuted by other websites identified by the same consumer search. If our hypothesis is correct, then consumers can be taught to validate facts by looking for confirmation on a sample of websites rather than a single site. We investigated information on irritable bowel syndrome (IBS), a common condition around the world.

Methods

Keyword and website selection

The English and Japanese keywords related to IBS most frequently used by consumers searching for health information online in June 2006 were selected using the Overture keyword tools. Websites were identified using Google between 12 July and 9 August 2006. Twelve keywords in English and Japanese were selected. Since consumers are most likely to review only the first page of results [8], only the top 10 websites were reviewed for each keyword.

Numbers of websites that support and refute inaccurate statements

Statements were considered inaccurate if they contradicted the published literature [9-12]. The numbers of websites that supported and refuted each inaccurate statement were counted.

Statistics

Differences between the numbers of websites that support and refute each inaccurate statement were tested by two-sided Wilcoxon`s rank test on Statcel2 (OMS publishing Inc., Saitama, Japan). Difference with $p < 0.05$ was considered significant.

Results

After exclusion of duplicates, inaccessible, irrelevant, testimonial advertising, and foreign language sites, 48 English and 31 Japanese websites were extracted.

Definitely inaccurate statements were identified: 13 statements from 9 English sites in categories of diagnosis (7 statements), signs/symptoms (2), and treatment (4); 12 statements from 11 Japanese sites in categories of epidemi-

ology (1), pathophysiology (6), diagnosis (2), signs/ symptoms (1), prognosis (1), and treatment (1). For each inaccurate statement in both language sites, there were more refuting sites than supporting sites in the selected sites as well as in the same search results (Table 1).

Table 1 - Number of sites supporting and refuting each innaccurate statement

	(mean ± SD)	
	Supporting sites	**Refuting sites**
In the selected sites:		
English 48 sites	0.77 ± 0.73	5.07 ± 1.85
Japanese 31 sites	1.00 ± 1.48	11.75 ± 8.75
In the same search results:		
English sites	0.00 ± 0.00	0.93 ± 0.16
Japanese sites	0.15 ± 0.05	3.35 ± 2.12

Discussion

We found that websites are likely to confirm accurate information and refute inaccurate information. We have shown here, for the first time, that the number of websites supporting each inaccurate statement is smaller than that of websites refuting it. Our result indicates that lay persons can precisely assess the accuracy of a specific statement on the Internet by looking for confirmation by other sites within the same set of search results. Consumers cannot identify a specific inaccurate statement even using conventional quality assessment instruments such as DISCERN because they apply to whole websites rather than to individual statements.

Since we studied a single health topic (IBS), using a single search engine (Google), our findings must be considered preliminary and require confirmation. However, Google is the most popular search engine in the English-speaking world and is widely used in Japan: suggesting that our findings apply to typical searches requested by consumers in English and Japanese. Further, Overture keyword tools report the actual frequency with which keywords are used to search. Since we selected the most commonly used keywords, we retrieved websites that are likely to be encountered by lay persons.

Conclusion

Consumers may be able to validate statements by looking at websites retrieved by the same search. Statements with more refuting sites than supporting sites will be inaccurate.

Acknowledgements

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An instrument for consumers to discriminate inaccurate information on the Internet

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Abstract

People retrieve health information from the Internet that is unfiltered and not always accurate. To assist health care consumers, we tried to develop a simple instrument to discriminate inaccurate information. We hypothesized that accurate statements were likely to be repeated and inaccurate statements were likely to be refuted when multiple results from the same search were reviewed. We investigated information on irritable bowel syndrome (IBS), which is common around the world. We identified inaccurate statements on websites displaying information about IBS. The numbers of websites supportive for and opposed to each inaccurate statement were counted. The former was smaller than the latter in each inaccurate statement in both English and Japanese websites. This indicates that health care consumers can confirm online information by comparing multiple sites found on the same search.

Introduction (1)

Health information on the Internet is important

- ✧ Accounted 2% of all websites (http://www.nua/surveys/how_many_online/index.html 2002)
- ✧ Retrieved by 32% of patients in US and 22% of patients in Japan (J Med Internet Res 2001)
- ✧ Affected the decision making of 70% of patients in the US (Pew Charitable Trusts 2000)

The Internet contains inaccurate information

- ✧32% of bladder cancer sites (J Urol 2003)
- ✧6% of sarcoma sites (Cancer 1999)
- ✧14% of melanoma sites (J Clin Oncol 2002)

Introduction (2)

1. Existing quality assessment tools can not help consumers determine whether a specific statement is true or false.

2. To support consumers, we tried to develop a simple instrument to discriminate inaccurate information.

Methods

1. **Keywords related to IBS**

   selected by Overture keyword tools (English and Japanese)

2. **Websites**

   collected each top 10 sites retrieved by Google and selected

3. **Inaccurate statements**

   extracted from the websites above using published literature[1-5] as a standard

4. **Numbers of websites that support and refute each inaccurate statement**

   counted in the websites above as well as in the same search results

Table 1

Websites selection

	English sites	Japanese sites
Retrieved by Google	**120**	**120**
– **selected**	**48**	**31**
– **excluded**	**72**	**89**
• duplicated	45	55
• inaccessible	7	11
• irrelevant	11	15
• anecdotal information / testimonial advertising	5	3
• link page	2	1
• foreign language	2	4

Table 2

IBS information covered by websites and inaccurate statements

(# websites with inaccurate statements; # inaccurate statements)

	English 48 sites	Japanese 31 sites
Epidemiology	31 (0; 0)	11 (1; 1)
Pathophysiology	31 (0; 0)	28 (5; 6)
Diagnosis	20 (5; 7)	11 (2; 2)
Signs/symptoms	32 (3; 3)	30 (1; 1)
Prognosis	26 (0; 0)	8 (1; 1)
Treatment	41 (2; 3)	21 (1; 1)

Table 3

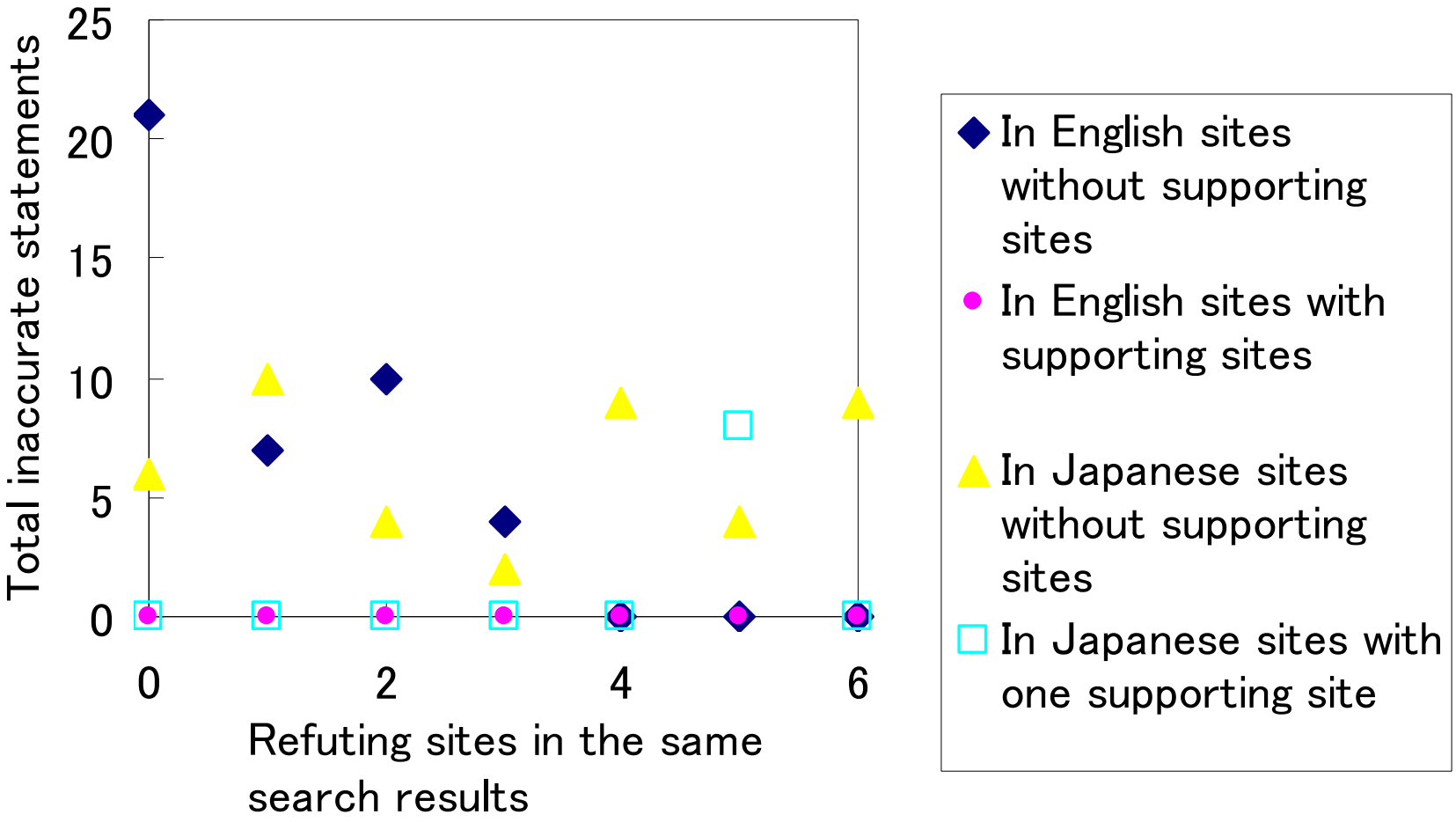
Number of sites supporting and refuting each inaccurate statement (mean ± SD)

	Supporting sites	Refuting sites
In the selected sites:		
English 48 sites*	0.77 ± 0.73	5.07 ± 1.85
Japanese 31 sites*	1.00 ± 1.48	11.75 ± 8.75
In the same search results:		
English sites*	0.00 ± 0.00	0.93 ± 0.16
Japanese sites*	0.15 ± 0.05	3.35 ± 2.12

* $P < 0.01$, difference between numbers of supporting and refuting sites (two-sided Wilcoxon`s rank test)

Figure 1

Inaccurate statements and refuting sites in the same search results



Results

1. From 120 sites each, 48 English and 31 Japanese sites were extracted for evaluation.
2. A total of 13 and 12 inaccurate statements were respectively contained in English and Japanese sites. At least one inaccurate statement was found at 20.8% of English and 35.5% of Japanese sites evaluated.
3. For each inaccurate statement, there were more refuting sites than supporting sites retrieved by the same search: 0.93 vs. 0.0 in English sites and 0.15 vs. 3.35 in Japanese sites.

Conclusion

Consumers may be able to validate statements by looking at websites retrieved by the same search. Statements with more refuting sites than supporting sites will be inaccurate.

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eHealth Consumer Attitudes in Greece and Denmark

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Abstract

This study examines the attitudes of people in Greece and Denmark towards innovative eHealth services. Although Internet use in general and more specifically Internet use for Health and Illness (H&I) is higher in Denmark than in Greece, survey data shows that people are equally interested in accessing their Electronic Health Record (EHR) online. Different attitudes between Greeks and Danes in regards to telemedicine and second opinion could be attributed to different levels of Internet maturity.

Keywords:

telemedicine, eHealth consumer trends, medical records, public acceptance of health care, public opinion

Methodology

An eHealth Consumer Trends Survey that investigates perceptions and attitudes towards use of the Internet for H&I began in 2005 and will be repeated in 2007 in order to establish eHealth consumer trends across Europe. The participating countries are Norway, Latvia, Germany, Denmark, Portugal, Greece and Poland. In telephone interviews conducted in October 2005, 1000 men and women from each country between ages 15-80 expressed their opinion on the use of the Internet for H&I. The sample was stratified for age, occupation, and residence. The questionnaire, based on earlier Norwegian surveys (2000-2002), was translated into national languages using the dual focus method. Additional questions, designed specifically for Greece and Denmark, explore the acceptance of innovative eHealth services: telemedicine, remote medical visits, teleradiology, and online access to one's personal EHR. Willingness to pay for eHealth was also considered in Greece.

Results

The attitudes towards telemedicine and second opinion in Greece and Demark differ considerably. 41% of the Danish respondents reacted positively to the idea of telemedicine in comparison to a mere 25% of the Greek respondents. 70% of the Greek respondents favourable to telemedicine, were willing to pay 10 euros for a remote medical visit by computer or video phone. When asked if they would be willing to grant remote access to their medical data in order to expedite diagnosis, more than half of the Greek respondents were hesitant, with just 44% willing to grant access to their test results. When the Danish respondents were asked a similar question, 73% pointed out that they would agree to have their xrays sent abroad for analysis by foreign doctors if this action meant they would receive a faster and more precise diagnosis and treatment. These attitudes can be explained by the different levels of Internet use (42,2% in Greece vs. 80,1% in Denmark) and of Internet use for H&I (22,9% in Greece vs. 60% in Denmark). According to the results of the survey, access to one's EHR appears to be the most attractive online service related to H&I. When asked if they would go online to access their EHR assuming they were given the opportunity, 61.7% of the Greek respondents were affirmative. It is worth noting that one third of all respondents in Greece are even willing to pay for such a service. Similar conclusions are drawn from observing the corresponding results of the Danish survey with 58% of the respondents interested in the EHR service. It is clear that there is a positive attitude among citizens in Greece and Denmark towards accessing their EHR online. Despite the positive perception of the Greek respondents, such services are not yet widely available in Greece. In Denmark, the Danish eHealth Portal was launched in 2003 to serve as a gateway to the public healthcare sector for patients and health professionals. Cooperation between health professionals across institutional borders is facilitated whereas patients have the ability to interact with health professionals as well as access phone numbers, waiting lists, and their own EHR data. 53.2% of Danish respondents were not aware of the portal's existence, thus suggesting that the campaign has not yet had the intended effect and more efforts towards raising awareness are required.

Conclusions

The presented results reflect the growing trend to use the Internet as a source of information on H&I, as a means to interact with health professionals to expedite diagnosis or to access one's own personal EHR. Different levels of Internet use and Internet use for H&I explain the different attitudes towards eHealth services in Greece and Denmark. People are inclined to access their EHR, but reluctant towards telemedicine and second opinion, perhaps due to their lack of experience with eHealth. The progress already made towards eHealth addressing current and future needs is a sign that the innovative ideas are being applied and in time accepted.

Application of a Web-based System to Screen for Hidden Depressive Patients

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Abstract and Objective

Although depression has been regarded as a major public health problem, many individuals with depression still remain undetected or untreated. The Internet may help to detect the hidden depressive patients. The study used the Internet-based Self-assessment Program for Depression (ISP-D) for people to freely screen depressive disorder online. The results showed that 73.9% of 1656 participants had some kind of depressive disorders and 56.2% of them never sought for professional help. We concluded that Web-based tools could help screen the hidden depressive disorders for whom could assess the Internet.

Keywords: Information Services, Psychiatric Status Rating Scales, Internet, Depression

Introduction

The World Health Organization Global Burden of Disease study in 1997 predicted that clinical depression will be the second most burdensome illness in the world by the year 2020. The prevalence of depressive symptoms is high, ranging from 20% to 41% of the total population. However, many individuals with depression remain undetected or go untreated. Computer-administered depression assessment programs have been developed to facilitate the administration and screening of depression, but they still require that people come to a clinical setting to take the test. The Internet provides advantages that may greatly improve the utility of computer-administered diagnostic programs and detecting hidden depressive patients.

In the present study, we used the Internet-based Self-assessment Program for Depression (ISP-D) for people to screen depressive disorders online and analyzed the results.

Methods

ISP-D was designed to detect major depressive disorder (MDD), minor depressive disorder (MinD), and subsyndromal depressive symptoms (SSD). Previous studies found that the test-retest reliability of the ISP-D was good within a 2-week interval and its criterion validity was comparable to that observed with written tests. The current study provided online ISP-D service for Internet users to assess depression by oneself in a short amount of time. The ISP-D can provide a continuously available depression screening method that is accessible to a large number of individuals across a broad geographic area. We analyzed the test results between Jan 2001 and Jan 2002 to understand the effect of ISP-D in the detection of people with hidden depressive disorders.

Results

There were 1656 tests performed during the period. The mean age for the participants was 25.3 ± 7.3 years and their mean education level was 14.7 ± 2.5 years. Most of the participants were female (75.1%), and single or separate (84.5%). The distributions of MDD, MinD, SSD, and no depression were 37.9% (n = 627), 12.9% (n = 213), 23.2% (n = 384), and 26.1% (n = 432), respectively. The mean Internet test time was 8.7 ± 6.4 minutes. Among the participant, 56.2% of them never sought for professional help.

We compared the participants who ever sought for professional help and those who never sought for professional help. We found that those who ever sought for professional help were significantly older, with higher educational level, with more depressive symptoms, with more comorbid medical conditions, with more family history of mental illness and more females than those who never sought for professional help.

Conclusion

In our one-year survey, more than 70% of people who performed the ISP-D tests were screened as having depressive disorders. More than half of them never sought professional help before. Therefore, Web-based screening tools may greatly facilitate people to detect the hidden depressive disorders.

Application of a Web-based System to Screen for Hidden Depressive Patients

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Introduction

- The World Health Organization Global Burden of Disease study in 1997 predicted that clinical depression will be the second most burdensome illness in the world by the year 2020.

- The prevalence of depressive symptoms is high, ranging from 20% to 41% of the total population. However, many individuals with depression remain undetected or go untreated.

Introduction

- Computer-administered depression assessment programs have been developed to facilitate the administration and screening of depression, but they still require that people come to a clinical setting to take the test.

- The Internet provides advantages that may greatly improve the utility of computer-administered diagnostic programs and detecting hidden depressive patients.

Objective

- We used the Internet-based Self-assessment Program for Depression (ISP-D) for people to screen depressive disorders online and analyzed the results.

Methods

- ISP-D was designed to detect major depressive disorder (MDD), minor depressive disorder (MinD), and subsyndromal depressive symptoms (SSD).

- The test-retest reliability of the ISP-D was good within a 2-week interval and its criterion validity was comparable to that observed with written tests.

Methods

- The current study provided online ISP-D service for Internet users to assess depression by oneself in a short amount of time.

- We analyzed the test results between Jan 2001 and Jan 2002 to understand the effect of ISP-D in the detection of people with hidden depressive disorders.

Results

- There were 1656 tests performed during the period.
- The mean age for the participants was 25.3 ± 7.3 years and their mean education level was 14.7 ± 2.5 years.
- Most of the participants were female (75.1%), and single or separate (84.5%).

Results

- **The distributions of MDD, MinD, SSD, and no depression were 37.9% (n = 627), 12.9% (n = 213), 23.2% (n = 384), and 26.1% (n = 432), respectively.**

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Results

- **We compared the participants who ever sought for professional help and those who never sought for professional help.**

- **We found that those who ever sought for professional help were significantly older, with higher educational level, with more depressive symptoms, with more comorbid medical conditions, with more family history of mental illness and more females than those who never sought for professional help.**

Conclusion

- In our one-year survey, more than 70% of people who performed the ISP-D tests were screened as having depressive disorders.
- More than half of them never sought professional help before.
- Web-based screening tools may greatly facilitate people to detect the hidden depressive disorders

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Value Added: Needs, Motivations, Hopes and Fears of Argentine Patients About the Development of their Personal Health Records

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Abstract and objective

The objective of the present work was to evaluate the needs, motivations, hopes and fears of argentine patients for a patient-centred personal health record development. Using inquiry methods and paper prototyping, we evaluated the different types of needs of 23 patients who were invited to take part in this study. Investigators grouped patients' needs into 11 categories. The meeting with final users developed a clear shared vision of the purpose of the product and brought new insight and clarity concerning the informatics needs of health consumers. The Group Discussion technique permits that, at very early stages of the development process, users' needs can be perceived and that this, conducted before the stage of initial design, results in high performance and low costs.

Keywords:

medical records systems, computerized; needs assessment; user-computer interface; software design; patient access to records; attitude to health

Introduction

Since Hurricane Katrina battered the Gulf Coast, more health care organizations have begun to think about PHRs as the best way to make personal health information portable. As an example The Centers for Medicare & Medicaid Services are exploring the creation of a national PHR for Medicare beneficiaries[1].

The Italian Hospital of Buenos Aires has developed a full scale Health Information System (HIS) has been gradually implemented, including ambulatory Electronic Medical Record (EMR), inpatient discharge summaries, administrative systems, scheduling systems, inpatient tracking systems, pharmacy systems and complementary studies report and visualization [2].

Currently we are working on the development of a PHR to support patient's access to different functionalities and services from HIS. To develop a product which will comply with the criteria of usability[3] you have to know, understand and work with the people who represent the current or potential users of the product[4, 5].

The purpose of the study was to understand those aspects of the product that are of most interest to and need for our users.

Materials and methods

We based our work on methods of contextual inquiry[4]. These techniques offer the possibility of generating ideas and taking user participation into account..

We invited patients of the HMO to participate in the activity "Internet Use: can it improve your health care?"

Two activities were carried out in two hours. After a brief introduction in which it was explained to the participants what a Personal Health Record (PHR) is, they were divided into groups so that at the end each of the groups told the others of its results.

To carry out the second activity, each group was given a canvas in the form of a monitor screen, and materials (scissors, markers, papers, cardboard, and stickers) and they were asked to design a portal which would provide the services and information listed in the previous activity. When they finished, each group presented its portal, explaining each of the components chosen and the function and/or information which each component should offer.

Finally, each patient completed an anonymous survey for us to get to know details of gender, age, educational level, access to Internet, and the perceived usefulness of the patient portal components which the literature suggests, on a Likert scale of 5 points.

Results

23 people voluntarily attended, of whom 16 (69.6%) were women and 7 (30.4%) men. Only 17 people fulfilled the survey. The average age was 60.4 years and 65% had completed university studies. 88% had a personal computer with Internet access in their homes, and 86.6% use it for work, communication or topics research. 76.6% at some time sought information on health on the Internet.

During the framework analysis of the collected data, investigators identified patients' needs and grouped them in the following 11categories.

1. Integrated information. The members of one group

proposed that the portal should be problem-oriented.

2. Interface flexibility. One of the groups insisted that guides or aids should be developed to help in navigating.

3. Immunization control. All the groups suggested having an age-based vaccination calendar.

4. Warnings, recommendations and reminders. All the groups agreed that having a space with recommendations on preventative practices and specific controls for each illness was fundamental.

5. Access to information sources. There was also agreement about having access to sources of contextualized information.

6. Communication. All the means of communication of information technologies were mentioned.

7. My medicines. All the participants reiterated underlined the need to be able to have access to a section with information about the medicines that each one is using, and be able to know about adverse effects and contraindications.

8. My results. All participants proposed the visualization of the results of complementary studies.

9. My records. Among the functions suggested, in two groups the idea came up of a space where they could see the records vital signs with the possibility of being able to complete the record with data obtained by the patients from controls in their home or in a pharmacy.

10. Accessibility. In this section we group participants' suggestions which might help to optimize patient flow in the health system and service accessibility.

11. Access to clinical histories, and data privacy. Naturally, the topic of confidentiality and privacy of data did not fail to come up.

The paper prototypes that the participants designed reflected the needs of the categories which we have mentioned. All the groups used the color red to make the categories Warnings, Reminders, Recommendations and Immunological Controls stand out. In spite of having been given several sheets of paper to simulate different windows, all the groups concentrated all the information on the initial screen.

Discussion

A meeting with the main stakeholders develops a clear, shared vision of the purposes of the product, brings new insights and clarity to the informatics needs of health consumers, such as access to reminders, recommendations, alerts, immunizations, medication, notes and vital signs, and even schedules and referenced maps.

The data gathered in the Discussion Group are consistent with the standard recommendations found in the literature on the functionality of PHR. However, consumers' needs, motivations, hopes and fears add a value necessary for any successful implementation[6].

This methodology is easy to put into practice, does not need too many resources, and is very valuable in that it contributes to an amplification of perspectives and a deepening in a variety of considerations that, at times, pass the software designer unnoticed. In future work, we plan to design and develop a PHR that will fulfill consumers' expectations, and to invite a wide range of people to test its usability.

Conclusion

Using simple methodology we have been able to identify the needs, motivations, hopes and fears of our patients in relation to PHR and to learn some principles for the design of this new tool. But we need more research to verify how it will be used and if we can meet our usability goals.

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Value Added: needs, motivations, hopes and fears of Argentine patients about the development of their personal health records

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Departament of Medical Informatics

Introduction

- Health care organizations have begun to think about PHRs as the best way to make personal health information portable.
  - →Centers for Medicare & Medicaid Services are exploring the creation of a national PHR for Medicare beneficiaries. [1]
  - →Department of Veterans Affairs is undertaking a PHR project.
  - →Commercially PHRs are arising.
- However, while personal health records are evolving quickly, research is in its infancy

Introduction

- The Hospital Italiano de Buenos Aires has developed a full scale Health Information System (HIS). [2]
- Currently we are working on the development of a PHR to support patient's access to different functionalities and services from HIS.
- To comply with usability criteria is necessary to understand user needs.
- The study purpose was to understand those aspects of PHR that are of most interest and need for our users

Materials and Methods

- Contextual inquiry methods.
- We invited HMO patients to participate in the activity “Internet Use: can it improve your health care?”.
  - ⟶Group discussion about what a PHR should offer.
  - ⟶Paper prototyping of that PHR.
  - ⟶Anonymous survey.

Results

- 23 people voluntary attended.
  - →69.6% (16) were women.
  - →Average age was 60.4 years
  - →65% completed university studies.
  - →88% had a PC at home.
- During framework analysis of the collected data, investigators identified patients' needs and grouped them in 11 categories.

Results

- ***1. Integrated Information***. The members of one group pro-posed that the portal should be problem-oriented.
- ***2. Interface Flexibility***. One of the groups insisted that guides or aids should be developed to help in navigating.
- ***3. Immunization Control***. All the groups suggested having an age-based vaccination calendar.
- ***4. Warnings, Recommendations and Reminders***. All the groups agreed that having a space with recommendations on preventative practices and specific controls for each illness was fundamental.

Results

- ***5. Access to Information Sources***. There was also agreement about having access to sources of contextualized information
- ***6. Communication.*** All the means of communication of information technologies were mentioned.
- ***7. My Medicines.*** All the participants reiterated underlined the need to be able to have access to a section with information about the medicines that each one is using, and be able to know about adverse effects and contraindications.
- ***8. My Results.*** All participants proposed the visualization of the results of complementary studies.

Results

- ***9. My Records.*** Among the functions suggested, in two groups the idea came up of a space where they could see the records vital signs with the possibility of being able to complete the record with data obtained by the patients from controls in their home or in a pharmacy.
- ***10. Accessibility.*** In this section we group participants' suggestions which might help to optimize patient flow in the health system and service accessibility.
- ***11. Access to Clinical History, and Data Privacy.*** Naturally, the topic of confidentiality and privacy of data did not fail to come up.

Paper Prototypes

- They reflected the needs of the categories mentioned.
- Red Color for

  →Warnings, Reminders, Recommendations and Immunological Controls .
- Icons for web actions
- Online Help button always available

Discussion

- Meeting the main stakeholders develops a clear, shared vision of the purposes of the product, brings new insights and clarity to the informatics needs of health consumers.
- The data gathered in the Discussion Group are consistent with the standard recommendations found in the literature on the functionality of PHR. [3]

Conclusion

- Using a simple methodology we have been able to identify the needs, motivations, hopes and fears of our patients in relation to PHRs and to learn some principles for the design of this new tool.
- More research is needed to verify how it will be used and if usability goals were met.

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Privacy and Security Issues in E-Health Services: a Review of HON Sites

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Abstract

E-Health involves new forms of patient-physician interaction and poses new ethical challenges and threats to patient privacy. This paper reviews HONcode accredited e-Health websites that provide online appointment services for compliance with basic principles of security and privacy. We selected the HONcode websites with online appointment service in the U.S.A to do the analysis. We found that 20 of 30 HON sites we reviewed are secure sites but only 9 of 20 secure sites state that it is secure. Most HON sites require patients to submit confidential data. 10 of 30 websites do not display privacy notice or statement of privacy policy on the web appointment request page. Even though there is a privacy notice, the reading level might be a problem for the patients who have lower education background. Regulations and guidelines do not ensure that privacy protection and data security is done appropriately or well. More attention to measures and procedures are needed to safeguard patients' privacy right.

Keywords:

health services, internet, privacy, confidentiality, computer security, ethical analysis, Health Insurance Portability and Accountability Act

Introduction

E-Health and Consumer Privacy

E-Health is "…the application of Internet and other related technologies in the healthcare industry to improve the access, efficiency, effectiveness, and quality of clinical and business processes utilized by healthcare organizations, practitioners, patients, and consumers in an effort to improve the health status of patients." [1] E-Health can provide healthcare consumers with opportunities to interact with their healthcare systems online and can provide new forms of patient-physician interaction.

Despite its advantages for healthcare consumers, e-Health poses new challenges and threats to their privacy. Many healthcare consumers are not aware that their use of Healthcare resources on the Internet may be tracked. Consumers may also not be aware of the personal information gathered about them when visiting a Web site [2]. For example, consumers may not be aware that their personal information may be collected without acknowledgment by cookies, nor how it may be used when it is collected by other mechanisms such as online surveys and assessments.

The HON Code of Conduct (HONcode)

The Health On the Net Foundation (HON) was founded in 1995 to promote "…the effective and reliable use of the new technologies for telemedicine in healthcare around the world."[3] The HON Code of Conduct (HONcode) was developed …to help standardise the reliability of medical and health information available on the World-Wide Web.

The HONcode is not an award system, nor does it intend to rate the quality of the information provided by a Web site. It only defines a set of rules to:

- hold Web site developers to basic ethical standards in the presentation of information;
- help make sure readers always know the source and the purpose of the data they are reading. [4]

Currently there are more than 120,000 health-related web sites that are HONcode accredited. [5] The HONcode principle regarding privacy and confidentiality states that

Your site must describe how you treat confidential, private or semi-private information such as email addresses and the content of emails received from or sent to your visitors. You must inform your visitors whether their data will be recorded in your own database, who can access this database (others, only you, nobody), if this information is used for your own statistics (anonymous or not), or if these statistics are used by third party or other companies.

A statement or a privacy policy page regarding confidentiality of data must be clearly displayed. [6]

Purpose of the Study

Rating and accreditation standards such as HONcode are critical to the success of e-Health. This study reviews HONcode accredited websites that provide online appointment services for compliance with basic principles of security and privacy.

Methods

We searched for HONcode accredited sites using the HON search engine [7] with the query "web appointment request" on Nov 16 2006 . The search retrieved 170 HONcode accredited sites. We reviewed the 30 USA websites that actually provided online appointment services. The 30 sites are listed in **Table 1**.

We reviewed each of the 30 sites to determine:
(1) Is it a secure site?
(2) Does it include a statement regarding its status as a secure site?
(3) Does it request confidential data elements from the user making an appointment?
(4) Does it include a privacy notice or statement of privacy policy?
(5) What is the reading level of the privacy notice or statement of privacy policy?

We considered a site to be secure if it used HTTPS, which is a "…combination of a normal HTTP interaction over an encrypted Secure Sockets Layer (SSL) or Transport Layer Security (TLS) transport mechanism." [8]

We used the SMOG Calculator [9] to assess the educational level needed to fully understand the text of the privacy notice or statement of privacy policy. We coded SMOG grade <12 (high school level) as low level (l), SMOG grade 12-16 (college level) as medium level (m), SMOG grade >16 (university degree) as high level (h).

Results

Table 1 shows the results of the review.

(1) Is it a secure site?
Among the 30 HON sites, 20 sites are secure sites, 10 are not.

(2) Does it include a statement regarding its status as a secure site?

Among the 20 secure sites, only 9 of them state that they are secure.

(3) Does it request confidential data elements from the user making an appointment?

Most HON sites require patients to submit confidential data such as Social Security number, date of birth, medical record number, medical information, insurance information, etc. Almost all of them require patients to provide birth date information. 6 of them require Social Security Number (SSN) along with birthday. The secure sites require more confidential data than non-secure sites.

(4) Does it include a privacy notice or statement of privacy policy?

10 of 30 websites do not display a privacy notice or statement of privacy policy, or a link to such a statement, on the web appointment request page.

(5) What is the reading level of the privacy notice or statement of privacy policy?

Among 20 websites that have a privacy notice or statement of privacy policy on their appointment page, 19 of them need higher than high school level to fully understand the privacy statement while 6 of them need higher than college level to figure out what the privacy statement means, only one needs high school or lower level to understand.

Discussion

Persons who use the Internet for health-related reasons have the right to expect that personal data they provide will be kept confidential and also have the right to be informed that personal data may be gathered, and to choose whether they will allow their personal data to be collected and whether they will allow it to be used or shared. The study of HONcode accredited medical and health Web sites reveals the gap between ideal and reality. In our sample, 1/3 of the HONcode accredited sites that provide online appointment service are not secure.

Including a privacy notice or statement of privacy policy on a site is very important. However, even though a site adopts security procedures and displays a privacy policy, users might still not trust it or may be misled unless there is a brief and understandable statement of security and privacy displayed on the site. In our study, we regarded the websites that have "https" within their URLs as secure sites as information exchanged with any address beginning with https is encrypted using Secure Sockets Layer (SSL) before transmission, but very few lay users realize the difference between "http" and "https". It is thus necessary to show that the Web site is secure by either displaying a secured seal or a brief statement. This is especially important for the users with lower education background, particularly when the site requires users to submit confidential data such as Social Security number, date of birth, medical record number, medical information, or insurance information.

Table 1 - Review of the HONcode accredited websites for compliance with basic principles of security and privacy.

	Criteria				
On-Line Appointment Site	**1**	**2**	**3**	**4**	**5**
https://epatient.muhealth.org/UMCWeb/idxpol/pslogin.asp	y	y	n	y	m
https://forms.mayoforms.org/forms/up/mcj013201.cfm	y	n	y	y	m
https://secure.childrensmemorial.org/kids_doc/apptForm.asp	y	n	y	y	m
https://secure.mcw.edu/appt_form.htm	y	y	y	y	l
https://secure01.cqservices.com/guthrie/FindAPhysician/Physicians/Default.asp?mode=new	y	n	y	y	h
https://transact.med.yale.edu/ynhhphysiciandata/apptrequestform.asp?inst=ynhh	y	n	y	y	h
https://www.brighamandwomens.org/forms/RequestAppointment.aspx	y	n	y	y	h
https://www.clevelandclinic.org/myappointment/form.asp	y	n	y	n	na
https://www.dfci.harvard.edu/pat/becoming/request/Default.asp	y	n	y	y	m
https://www.forsberg.com/sparrowsecure/preregister1.asp	y	n	y	n	na
https://www.geisinger.org/consumers/patients/appts/appt_form.html	y	y	y	y	h
https://www.lha.org/patientcare/requestappointment/chestxray.asp	y	n	y	y	l
https://www.marshfieldclinic.org/patients/pages/default.aspx?page=apptrequest	y	n	y	y	h
https://www.muschealth.com/patients_visitors/eservices/request_appointment/request_appointment.htm	y	y	y	y	m
https://www.reshealth.org/findadoctor/info_appointment.cfm	y	y	y	y	h
https://www.secure.summitprimarycare.com/register.asp	y	y	y	y	l
https://www.sleh.com/sleh/SectionSecured/index.cfm?PageName=PRForm&PageMD=PHYSICIAN%20REFERRALS&FormMD=On	y	y	n	y	h
https://www.ucihealth.com/secured/Appointments/aptform.html	y	n	y	y	h
https://www.ucplus.org/home/Appointment/forms/default.htmy	y	y	y	n	na
https://www.ucsfhealth.org/adult/patient_guide/request_primary_care.html	y	y	y	n	na
http://nmhphysicians.photobooks.com/Appointment.asp?disclaimer=Continue	n	na	y	y	h
http://www.calear.com/contact/appointment_form_650-494-1000.php	n	na	y	n	na
http://www.englewoodortho.com/new_pt_form.htm	n	na	y	n	na
http://www.depediatrics.com/appointment.php	n	na	n	n	na
http://www.evpeds.com/onlineappt.htm	n	na	y	y	l
http://www.ewebbmd.com/appointments.htm	n	na	y	n	na
http://www.mscenter.org/content/category/1/1/15/	n	na	y	y	m
http://www.orthopodsurgeon.com/appointment.html	n	na	n	y	l
http://www.ssdental.com/appointments/appointments_dw.asp	n	na	n	n	na
http://www.vasectomy.com/Appointment.asp?DoctorId=1967	n	na	n	n	na

Legend
n = no; y = yes; na = not applicable; l = low; m = medium; h = high

Criteria:
1: Is it a secure site?
2: Does it include a statement regarding its status as a secure site?
3: Does it request confidential data elements from the user making an appointment?
4: Does it include a privacy notice or statement of privacy policy?
5: What is the reading level of the privacy notice or statement of privacy policy? (SMOG grade)

Conclusion

Security, privacy, and confidentiality are major concerns in e-Health services. Health Insurance Portability and Accountability Act (HIPAA) regulations, eHealth Code of Ethics, HON principles, and other guidelines do not ensure that privacy protection and data security is done appropriately or well. There is a gap between ideal and reality. More attention to the spirit of existing measures and procedures are needed to safeguard patients' privacy rights.

To deal with the challenges to manage and ensure individual privacy, the following steps should be taken to maintain the Web site visitor's rights to privacy and the confidentiality of personal information:

1. Secure Web sites with user ID and password or using SSL Certificate Encryption and display the Secured Seal to let the user know that his or her transactions are secure.

2. Provide a statement or a link to the privacy policy of the Web site on the home page or the site navigational bar that is easily accessible and understandable to the user.

3. Do not collect name, birthday, phone number, e-mail address, or any other personal information unless voluntarily provided by the visitor after the visitor is informed about the potential use of such information.

4. Do not collect SSN, personal medical information (medical conditions, health-seeking behaviors and questions, and use of or requests for information about drugs, therapies, or medical devices) and other sensitive personal information without the express consent of the site visitor after explanation of the potential uses of such information.

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Online Survey of Consumer Health Information Privacy in Korea

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Abstract and objective

Health information should be acquired, disclosed and used only in ways that respect consumer's privacy & rights. The online survey on the consumers' attitudes towards health information privacy was done, and revealed the unique result that is somewhat different from Americans'. The consumers' need should be incorporated to the constitution.

Keywords:

privacy, consumer, health information

Introduction

Korean government recently announced that the master plan for the National Health Information Infrastructure will be on the way, and will set the Health Information Privacy Protection Law which is in equivalent to the HIPAA as soon as possible. The purposes of this research are: to survey the consumers' opinions about the health information privacy, to understand the consumers' privacy-protective behaviors out of the concern about the privacy breaches, to know the consumers' recognition about the constitution of the health information privacy law, to know the consumers' willingness to share their personal medical information.

Methods

The authors conducted the online survey. The questionnaire developed and conducted by the California HealthCare Foundation (CHCF) on "National Consumer Health Privacy Survey" was translated into Korean and reviewed by the authors to conform to the Korean situation. It was made as an online survey form, and uploaded, solicited the participation of the website visitors of a tertiary teaching hospital in Korea, and 281 responses were collected online. The results were analyzed for the descriptive statistics.

Results

- Consumers concerned about the privacy of their personal health information. 79% were concerned about the privacy, and this was higher percentage than the US consumers' which was 67%.
- Recent privacy breaches have raised the level of concern. 56% of Korean respondents were aware of such privacy breaches, which was also higher than that of the US consumers' of 24%.
- Consumers are unfamiliar with health information privacy law. Only 37% were aware of the related law, and 80% didn't have a chance of notification that there are such laws.
- Consumers think that the paper medical records are more secure than electronic medical records.
- Employees concern about the misuse of medical claim information. Sixty percent of the respondents concerned about the disclosure of their medical information to their employers.
- Privacy-protective behaviors exist, however, not so much as US consumers. Not so many Korean consumers practice the privacy-protective behaviors even though they worry about the misuse of the health information.
- Consumers will share their personal medical information with limited others such as family members and physicians involved in their care. In contrast, they are not willing to share their health information with drug companies, government agencies or employers.

Conclusions

Most of the consumers answered that the information could be shared when necessary, however, the ownership and the right to decide the disclosure should belong to patient, and patient should be allowed to access their own information with certain degree of regulation. These kind of awareness were strengthened by the implementation of EHR. In detail comparative analysis between Korean and American consumers' attitudes will be done if the American data be available.

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Patient Empowerment: A Measure of Patient Empowerment Received by the German Health Card

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Abstract

Problem: Patient Empowerment is a major aim of the German Health Card project. Up to now, it is unclear how patient empowerment can be measured. Methods: Literature review, development of patient empowerment indicators (PEI), design of a questionnaire to measure PEI for electronic prescription, validation of the questionnaire, analysis of indicators that can be determined by Health Card Terminals (HCT). Results: Six basic requirements for patient empowerment. and a questionnaire with 39 items. Conclusions: Patient Empowerment is difficult to measure. The suggested questionnaire has to be validated again by a representative sample. Then it can be used for a pilot study.

Keywords:

patient empowerment, measurement, qualitative research, electronic prescription, patient behaviour

Introduction

"To empower" means to give (someone) the power or legal right to do something[1]. Known empowerment concepts base on the principle of strengthening the mental power of the individual. The approach is already realised in disciplines like sociology, psychiatry or marketing. Empowerment is also a major aim of Germany's electronic health card project. The patient is enabled to continuously check all medical data on the card with the help so called Health Card Terminal (HCT). The objective of the paper is to define indicators for patient empowerment in the context of electronic prescription on the German Electronic Health Card (GEHC) and to introduce methods to measure them.

Materials and Methods

The aim of patient empowerment is to better integrate the patient in decisions e.g. by providing more individualized information. He is better involved in his treatment and more responsible for his health. Our working definition is based on Gibsons definition: „empowerment is a process of helping people to assert control over the factors which affect their lives. This encompasses both the individual responsibility in health care and the broader institutional, organizational or societal responsibilities in enabling people to assume responsibility for their own health." [1]. In addition we use the dimensions of empowerment developed by Zenz in his paper "Evaluating Empowerment: The world vision area development programme"[2].

We developed a process model for the prescription process and carefully analysed sub-processes in which the patient can be involved. To identify items that characterise patient empowerment in each of the processes we conducted a moderated brainwriting with 16 scientists. We enhanced the resulting item list by patient empowerment indicators (PEI) from literature e.g. "Satisfaction with quality of care" or "Desire for more information" and by technology acceptance indicators e.g. "Response time" and "Compatibility". We developed a 39-item questionnaire and performed a first iterative validation with more than 30 participants.

Results

The Dimensions of patient empowerment

We matched Gibson's definition with Zenz's model [2] to make sure that it can be used for the patient empowerment problem. Applying Zenz's statement in health care resulted in four our basic requirements for patient empowerment: Literacy, creative power, independence, self-efficacy. They apply, when the patient has access to his medical data by his GEHC.

Modelling the prescription process

Modelling the workflow of prescriptions we defined seven processes: Consulting the physician, Patient deletes the prescription (Action at the HCT), Patient hides or reveals the prescription (Action at the HCT), Dispensation, Reading prescription (Action at the HCT), No action, (the prescription is not valid any longer after a certain time span.), Advice (pharmacy). This process is not necessarily

1 Longman Dictionary of Contemporary English DCE, 1987

linear. Functions can be omitted or can be performed repeatedly.

Items for describing empowerment and IT-acceptance

We conducted a brainwriting to analyse for each step in the process, which decisions of a patient could be expected and which influence patient empowerment would have. We matched all answers with our four core requirements. The Matching resulted in two new requirements: exogenous empowerment, endogenous empowerment.

In a final step the resulting items were completed by items for measuring IT-acceptance, known in the literature [2]-[13]. We organised our item list in four tables: a) Description of the population, b) Description of medical background, and c.) descriptive data of terminal use and usage. The fourth table contains the six prerequisites mentioned above.

Measuring empowerment

Planning controlled trials for measuring patient empowerment should first of all start with determining the inclusion criteria, like that the patient is an owner of a GEHC. For measuring the items introduced in table a)-c) different methods have to be used. Items which are part of the Health Card data (e.g. age, sex) could be collected in a log file, if data protection laws are followed. as well as data like length of HCT consultation. Other items cannot be measured objectively, but have to be investigated by questioning patients. We designed a questionnaire for patient attitudes with four parts and 39 items. Part A is demographic data of table 1, Part B Medical Background – table 2, Part C is attitude towards HCT and Part D is behaviour. Some items in the questionnaire are requested by statements to be judged by the patient. For this personal judgement the 4-point Likert-Scale is used for questions like ‘by using a HCT I feel more independent from the general practioner and the pharmacist’.In a first validation phase, the questionnaire was validated by 30 participants.

Discussion

A potential of the HCT is that additional information about the prescribed drug can be presented. If this is formulated in a way, which can be well understood by the patient, this could positively influence patient compliance [14]. Nevertheless we can cannot guarantee that the empowered patient makes clinically sound decisions.

We will validate our approach in the real setting of patients using the HCT, when the GEHC and the terminals are available. For this it is necessary that the patients have their own cards and used the HCT. Questions about the satisfaction with the functionality can be used to improve the system. The aim of our further research is to present individualized information about the drugs during HCT encounter and to analyse if the patient is empowered by this.

Conclusion

To measure patient empowerment precisely and to finally define the indicators that determine patient empowerment, further research is necessary. Our questionnaire is a first step and considers the problems patients may have with Health Card Terminals. It can be adapted to other telematics applications and may hopefully lead to empowered patients and accepted technologies in healthcare.

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Patient Empowerment

A measure of patient empowerment received by the German Health Card

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Background: German Health Card

The patient is enabled to continuously check the data on the card. For this the introduction of the so called Health Card Terminal (HTC) is necessary.

Aims of the project:

- improving the communication between all partners in health care (faster access, trans-institutional provision of data, better access for patients)
- lowering costs (easier workflow for prescription, reducing prescription errors, avoiding double measures and faster access to emergency data)
- **empowering the patient**.

→ It is unclear how patient empowerment can be measured.

Empowerment

Definition

Gibson (1991):

„empowerment is a process of helping people to assert control over the factors which affect their lives. This encompasses both the individual responsibility in health care and the broader institutional, organizational or societal responsibilities in enabling people to assume responsibility for their own health.” [1]

Dimensions

Zenz developed 2001 a model of empowerment. It consist of four dimensions[2]. For our research we adapted it to **patient** empowerment:

Dimensions of Patient Empowerment

- Literacy

  competency which comprises several skills, which enable the individual patient to handle information competent, efficiently and responsibly. The patient can identify relevant information for his health in different contexts, he can understand, interpret and communicate this information.

- Creative power

  competency which enables to define individual aims, define strategies to reach these aims and to act according to these strategies. I.e. that the patient can influence decisions, discussion results or general changes.

- Independence

  Independence is the ability of a patient to make decisions concerning his health state and health care on his own.

- Self-efficacy

  With self-efficacy the patient is able to believe in skills to act independently with regard to his health

→ **Our core requirements for patient empowerment**

Prescription process

Involved processes (patient view):

- Consulting the physician
- Patient deletes the prescription - Action at the HTC
- Patient hides or reveals the prescription - Action at the HTC
- Reading prescription - Action at the HTC
- Dispensation
- No action
- Advice

→ The modelled process is not necessarily linear. Functions can be omitted or can be performed repeatedly

Workshop

Analysing the modelled process in a moderated workshop:

→ Which decisions of a patient could be expected?

→ Which influence have patient empowerment?

Matching the answers with the our core requirements resulted in two new requirements:

- Exogenous Empowerment

  Did the behaviour of the health care professional towards the empowered patient?

- Endogenous Empowerment

  How sustainable is the empowerment of a patient and is the patient motivated to critically reflect the treatment results.

IT-acceptance

The HCT is a new technology for the patient. Functionality or ease of use can improve the patient‘s behaviour and empowerment at the first time.

Items taken from the literature[3]:

- Compatibility
- Ease of use
- Information
- Perceived usefulness
- Relative advantage
- Satisfaction
- Voluntariness

Items for describing patient empowerment

The items resulting from the analysis in the workshop and items for measuring IT-acceptance were completed by items in the literature [4]-[15] and organised in four tables:

- Table A. Description of the population
  - e.g. gender, age, education, IT knowledge
- Table B. Description of medical background
  - e.g. satisfaction with quality of care, desire for more information
- Table C. Descriptive data of terminal use and usage
  - e.g. ease of use, respond time, no. of errors, compatibility
- Table D. Expected Empowerment
  - contains the six prerequisites

We divided the resulting list of indicators in two parts:

- objective data which can be assessed by analysing the **logfiles** of health card terminals
- subjective data from **questionnaire**

Questionnaire

For items witch cannot be measured objectively a questionnaire was designed. It consists of four parts and 39 items:

- Part A is demographic data of table 1,
- Part B Medical Background – table 2,
- Part C is attitude towards HCT and
- Part D is behaviour.

Most of the items of the questionnaire are requested by statements to be judged by the patient. For this personal judgement the 4-point Likert-Scale is used:

I agree - ... - I do not agree.

e.g. “I haven’t any problems to access my data.“

Measuring patient empowerment at the HCT

Summary:

- Controlled randomised trial
- Inclusion criteria e.g.
  - patient is older than 18 years
  - patient had not been deprived of his right of decision
- Two methods are used to measuring the items
  - Logfile
  - Questionnaire
    - was validated by 30 students and scientist which resulted in a reworked version of the questionnaire

Discussion

- A potential of the HCT...

  ...is that additional information about the prescribed drug can be presented. If this information is presented and formulated in a way, which can be well understood by the patient, this could positively influence patient compliance [15].

- But...

  of course, a restriction of our measuring methods is, that we can cannot guarantee that the empowered patient makes clinically sound decisions.

- Next valuation phase:

  When the German Health Card and the terminals are available we will validate our approach in the real setting of patients using the HTC.

- The aim of our further research is to present individualized information about the drugs during HTC encounter and to analyse if the patient is empowered by this.

→ **To measure patient empowerment precisely and to finally define the indicators that determine patient empowerment, further research is necessary.**

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Goal-Oriented Blogging: A Case Study of a Dutch Commercial Website For Tracking Weight Loss Online

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Abstract

Blogs, short for "web logs," together with podcasts and wikis are currently important foci of internet research. These three applications are often addressed together as comprising "Web 2.0." Within the area of health care, however, little attention has been devoted to understanding these technologies and how they are being used by lay health publics. In this article, I will discuss the idea of "goal-oriented" blogging using the case of a Dutch commercial weight loss website. Because this research project is still in preliminary phases, I will address the topic based on an analysis of the website and discuss the relevant informatics questions that such a case raises.

Keywords:

blogs, Web 2.0, patients, lay health practices, health promotion

Introduction

Web applications such as podcasts, wikis and online web logs (more commonly referred to as "blogs") are currently important foci of internet research. These types of web-based applications (collectively dubbed "Web 2.0") are considered to give credence to well-known claims about the democratizing nature of internet technologies because they give users easy avenues to produce/publish information, experiences, opinions, etc. and reflect bottom-up regulation of that published information. Within the area of health care, however, little attention has been devoted to understanding these technologies and how they are being used by lay health publics. Discussants in both the Consumer Health Informatics and Knowledge in Motion Working Groups at the AMIA 2006 Annual Symposium pinpointed the need for more research devoted to alternative avenues for managing both information and experiences with respect to individual health.

Although much has been published on blogs, bloggers and the practice of blogging more generally, the literature on blogs with respect to health care has been quite limited. Most of what has been written are editorials, are written from the perspective of doctors who are blogging, or are discussing the potential roles for blogs in educating nurses and medical students.[1-3] Little attention has been given to how patients blog with respect to their health.

The closest relation is found in work on Personal Health Information Management, such as the studies conducted by Pratt et al. [4] As Pratt et al discuss, Patients are increasingly expected to play a more active role as managers in their own care. The central role afforded to patients means that they must store, maintain and retrieve many different kinds of information from different sources using different media. Pratt et al suggest that patients need tools that address information gathering and sharing challenges, thereby enabling them to be more involved in their health care. Specifically, they emphasize the need to create tools that are easy to use *and* allow for the integration of different information interfaces in one.

Although health-related blogs do not completely meet the idea of integration, they do allow patients to utilize open space to actively manage their own care. They can assemble information from different sources as they choose and repackage it for others, who not only read the blog posts, but also have a chance to respond. This latter function also helps patients to communicate any news or developments they want to share with those in their readership communities. Investigating under which circumstances individuals do or do not choose to use this broadcast format could provide helpful insights into how individuals use technology to resolve the communication difficulties to which Pratt et al refer. Under the idea of "push button publishing" (all you have to do is fill in a text box and click submit), blogs are incredibly easy for individuals in the general public to use, thereby further lowering the barriers to publication/ distribution of various types of information.

Blogs are generally defined as personal web sites with content displayed in reverse-chronological order. [5] They can deal with personal or private issues or aim to situate themselves within the public discourse on a given topic. [6] New posts are placed at the top of the page instead of the bottom, making changes easily identifiable. They generally have an identifiable author, sometimes even with pictures. Site visitors can usually leave comments for others to see. Blogs are loosely joined to each other through hyperlinks and the global network of blogs is referred to as the "blogosphere". [5] Blogs are often thought of as analogous to online diaries, but this is a misconception. [7] Blogs began as lists of links to (or web logs of) other interesting web content but have evolved to include many different forms of multimedia content, including combina-

tions of links, text, photographs and other web materials. The format and tools used to produce the blog are more defining than the content itself. [7-8]

Information about an individual's health care can be both implicit and explicit in existing personal blogs. Implicit would refer to texts that are on general topics or consist of links to different types of websites, but that refer to health-related issues or practices as part of a larger body of topics. In this case, one would have to search blogs for instances of links, thoughts or experiences related to health care. Explicit would refer to blogs that are set-up with a particular health situation in mind. An example would be coping with a chronic disease such as leukemia, self-management of a disease such as diabetes[9], documenting a specific (limited) trajectory such as pregnancy, or to support attempts to achieve specific health care goals such as losing weight or smoking cessation.[1]

In this article, I will discuss the idea of "goal-oriented" blogging using the case of the Dutch-based "valt af" ("is losing weight") website. This commercial website allows individuals to keep an online journal, collect and/or register information and other resources, and communicate with others through discussion boards and chats on the parent site and through a function that allows readers to post responses to individual blog posts on personal sites. This space enables users to use their blogs to document the process of achieving a specific health goal. After describing the features of the site, I will use the discussion to raise important questions that are relevant for future informatics research.

Materials and methods

This is a case study description of the Dutch-based, Dutch-language commercial website, Valtaf.nl. It is based on a content analysis of the website and also garners information from the website of the company that provides the commercial site.[2] This website is an interesting case because it has received a lot of attention in the popular press and because it represents a unique approach to helping people achieve difficult health goals.

1 Combinations of implicit and explicit are also possible. An example of a hybrid of these two types of health representation is the blog maintained by sociologist and internet researcher Eszter Hargittai. [10] Hargittai posts interesting links with comments, and also tells about her personal life and experiences in journal format. The archives of her posts are tagged according to topic. The part of her blog tagged for "health and fitness" refers to a post about her goal to run a 5K marathon

2 Interviews with users are currently being conducted. However, not enough interviews have been completed to allow using that data and making any detailed claims here.

Results

The Valtaf website is provided by a commercial company, Sofit Wellness, which develops software and content about healthy habits, nutrition and exercise. Sofit Wellness provides Valtaf.nl for Dutch users and Valtaf.be for Flemish-speaking Belgian users. On its corporate site [11], Sofit also explains that the valtaf sites are an example of the software and content services they provide – in this case, the technological basis for companies interested in establishing a weight loss portal under the brand name of said company for use by customers, readers or employees. The websites provide "personal web pages" to individual users and includes diverse automatic content and social support functions that support participants in the weight loss process.

The parent page for valtaf.nl provides general information about the site. It begins with the claim, "Lose Weight Online!" and contains a sentence in the web-browser that identifies the site as "Your free, personal weight graph and food diary." It informs site visitors that "Losing weight on the internet really works! If you participate with www.valtaf.nl , then you'll receive your own website where you can keep track of what you weigh, what you've eaten and how much you still have to lose in order to reach your target weight." It continues, "Thanks to the support and encouragement you'll receive from buddies and thanks to the professional supervision from a nutrition expert and dietitian, you can successfully lose weight and keep it off."

Through their links to the parent website, these "personal web pages" offered to individuals who join contain more content options than do blogs, but the individual pages are be built, at least partially, with the same easy-to-use functions as popular blogging websites and they include the unique combination of materials that is common to present-day web logs. In addition to submitting data about their daily food intake and exercise, weight, fat percentage, BMI, and physical measurements using a form that allows push button publishing, users can also post personal photo's and write journal entries with (animated) emoticons. The journal entries are listed in reverse chronological order, with the newest on top, and allow for commentary from others. Their other entries are then repackaged in helpful charts and graphs that track progress over time, while the journal provides a compendium for understanding the trends reflected in the graphics by providing insight into specific factors in their daily lives that may have affected eating/exercise habits.

Users also have contact with buddies they have met (mostly) through the site and they can also join clubs with similar characteristics (live in the same city, are in the same age group) or with similar sub-goals (such as losing weight following a certain diet program or losing weight and remaining smoke free). Once on the site, they can eas-

ily see who is actively participating (that is, which sites were recently updated), who is online at the same time that they are and what each participant's individual progress is. In the general participation list, weight loss is signified with a green arrow pointing down while weight gain is signified with a red arrow pointing up. New users are easily identifiable because they haven't yet entered enough information to indicate weight gain or loss.

The personal web pages are interlinked with the primary valtaf website, which offers both asynchronous discussion boards and real-time chat, as well as articles from the experts behind the site. It also contains its own separate blog, which presents news and other relevant materials related to weight loss. The parent site also has direct communication with individual users. Submission of measurements and data is supported with e-mail reminders and all participants also receive weekly newsletters. For a fee, users can receive personal supervision with one of the health care consultants that works with the site.

A final interesting aspect of the site is the personal nature of the information that individuals choose to display. Web-based communication is often thought of as anonymous and faceless. This is called into question with applications such as blogs. In the case of valtaf, users generally register with a pseudonym as their user name, but their websites are not necessarily private/protected or anonymous (although they can be either or both). Many users write an introductory text wherein they reveal their name (at least their first name) and then reveal more personal information as they document their daily lives. Furthermore, the photograph policy on the sites requires that the photos be of the user and pictures of others can only be included when the registered user is also in the picture. Thus, a blog about an otherwise private and personal health issue becomes a public, social activity.[12]

Discussion

The different features offered by the valtaf website transcend different web categories (home pages, discussion boards, chat, text, video, pictures, news, opinion, experience, etc.) and broadcast genres (one to one, one to many, many to many, etc). Bridging different genres has been argued as one of the important defining elements of blogs. [13] Because of the nature of the personal sites and the structure of the journals that are located on these sites, I would argue that the individual pages are incorrectly labeled as personal home pages and should be considered as health-related, goal-oriented blogs.

Herring et al [13] suggest the importance of documenting the individual characteristics of journal authors, the purpose of keeping the blog, a structural analysis of the blog, and temporal information for when specific information is added to a blog. Additionally, I suggest it is important to understand how blogging as an activity fits into an individual's past and present uses of other documentation and communication media, both in general and specifically with respect to health. For example, is an online journal easy to use because the person has kept journals in the past – or is there no discernable relationship? Has blogging for health care purposes led to other online practices? Understanding how users utilize (or have utilized) related on- and offline tools enables us to answer the question of where can blogs be placed in relationship to other methods of keeping records, such as diaries and autobiograhies and other forms of support, such as online and offline groups.

Because sites such as valtaf are gaining recognition in the popular press in the Netherlands, it will be important and interesting to examine from a user's perspective what aspects of the blogging tools and site options are most important and why/how these are effective. This indicates the need to typify who exactly is using these commercial sites, as well as why and how different individuals use various options they offer. It also raises the question of whether online tools are as effective as they are portrayed in popular media to be, which points to the need for quantitative studies in addition to qualitative studies.

Many users keep a daily or weekly chronicle of their experiences, which is a rich source of data about how individuals construct their own (health) identities. How does keeping an online record of one's progress motivate users to stick to the routines that are necessary to achieving their personal goals? Because interactions are not limited to online instances but also reflect blending with respect to online and offline communication, another important question which deserves more attention is one that leads to understanding how Web 2.0 technologies are configured within existing and new (health) networks. Where are the lines between online and offline relationships and how do these shift when patients begin documenting specific health care practices for which they need support?

One final area of interest is learning from users how they integrate their blogging practices into encounters with health care professionals. Do they utilize the services offered by the professionals that support the site? Do they discuss their attempts to lose weight, their blogging activity to this effect or the issues that they document in their online journal with their personal physicians? How does using such a tool "democratize" the health care process? What is the relationship between lay and expert knowledge on such a site and how do individual users view the expert opinions and advice vis-à-vis information they receive from buddies or other peers who share the same space? Related to this is investigating whether they would like to receive a similar service from their own health care provider organization in addition to or rather than a commercial website. Investigating these points could be

useful to health care institutions that are looking for new avenues for reaching their users for promotion and prevention purposes.

Conclusion

New and emergent technologies and tools are important topics of discussion. New applications that are available via the still very much rapidly changing internet are of special importance. In many respects the technologies and ideas discussed here are not exactly new. Certain categories of patients have been encouraged to keep diaries for years and more recent research has shown the effectiveness of, for example, online discussion boards as support groups. The uniqueness of these technologies comes, of course, in the fact that so many different tools are being blended together in and through one easy-to-use interface and that information retrieval and management are combined with interactive communication with both peer and expert contacts. In this paper I have used a single case study to identify several important questions that can be raised about these new combinations and applications. In the next phases of my research among individuals who explicitly blog for their health, I will address these questions more thoroughly.

In the United States, much research interest has been devoted to usable, functional Personal Health Records provided from Health Care Providers/Institutions. In the Netherlands, this has been much less of an issue, although one hospital is currently exploring what the creation of this type of tool would mean for its consumers. However, private companies are providing individuals with defined space on the internet that combines the idea of personal websites with easy to use blogging tools. Although these are not the same as personal health records, they can arguably be seen as fulfilling a similar function, at least with respect to specified health goals. What can we learn from the fact that patients are taking it upon themselves to utilize these publicly available (commercial) technologies for health purposes? More research is needed into these sites and the respective practices of the individuals who use them. This line of research is important for increasing our understanding of how "new" and "alternative" avenues for managing health information fosters healthy practices and how health care providers can capitalize on these easy-to-use applications in patient education or disease prevention and health promotion.

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A Study of the Decision-making Process of the Medical Consumer based on Description Analysis of Personal Experiences of Illness

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Abstract and objective

Medical professionals offer medical information to the medical consumer in various forms. However, the medical consumer is considered to be isolated from such medical information before and after medical treatment. This research aimed to examine medical consumer's decision about whether to seek a medical consultation by performing description analysis of the personal experiences of illness. It became clear that there were various thought patterns, which deny their certain symptom. It became clear that the viewpoint, which pushes out the medical consumer to medical consultation, is indispensable at offer of medical information to them.

Keywords:

decision-making, narration, negation, patients

Introduction

It is thought there are fundamental differences in the types of disease information needed by the consumer. Here, we analyzed medical consumers' own descriptions of their decision-making processes in cases of rectal neoplasms.

Methods

We examined patients' own accounts of their struggles against rectal neoplasms. As consumers of medical information, they described their thought processes from the onset of symptoms, before they had decided whether or not to seek medical advice. We unified descriptions based on "The Merck Manual of Diagnosis and Therapy", and analyzed:

- the time when the symptoms had appeared, and the condition of the patient at that time

- the use of logic to deny recognition of the condition

- the action taken to search information in order to resolve their uneasiness

- the point at which the patient sought medical consultation

We used the following books as the information source of the personal experiences of illness:

Books; Toubyo-ki (described the thought process before a medical consultation)

Records; 24 gross records from 12 books by 24 patients

Illness; rectal neoplasms

Author; medical consumers (excluded medical professionals), Japanese

Results

The typical symptoms of rectal neoplasms were frequently extracted as shown in Figure 1. A lot of patients recorded initial and typical symptoms in their descriptions before medical consultation. For example, "bleeding with defecation", "stool frequency", and "constipation". Such three symptoms had become the key symptoms led to consultation behavior. Common symptoms like "nausea" and "weight loss" were also extracted from descriptions.

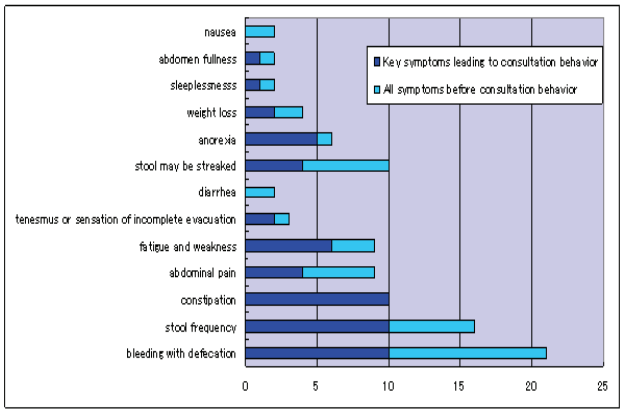
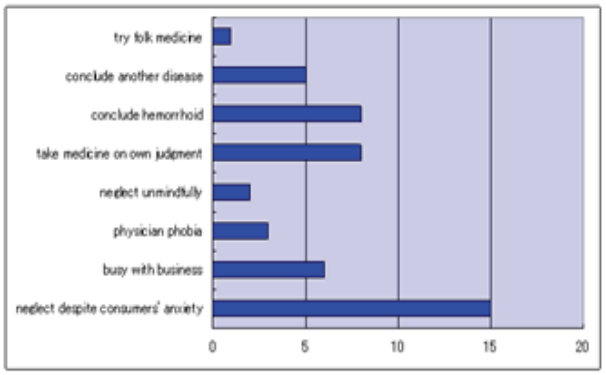


Figure 1 - Key symptoms of patients in all symptoms

The reason that these symptoms were neglected was shown in Figure 2. These were able to be greatly divided into two groups based on the reason and action. The first group consisted of patients who do no action irrespective of the existence of a reason, though it felt nervous on their symptoms. The second group consisted of patients who devised the disposal of their own judgment, without receiving medical consultation. Furthermore, informational participation was also accepted as a trigger to take

medical consultation behavior. Their information sources were poster, library, newspaper, or friends.

Figure 2 - Reasons for neglect symptoms and action



The decision-making actions taken by medical consumers are shown in Figure 3. The Figure shows the types of thought processes used to deny the symptom and also the initial triggers for seeking a consultation behavior.

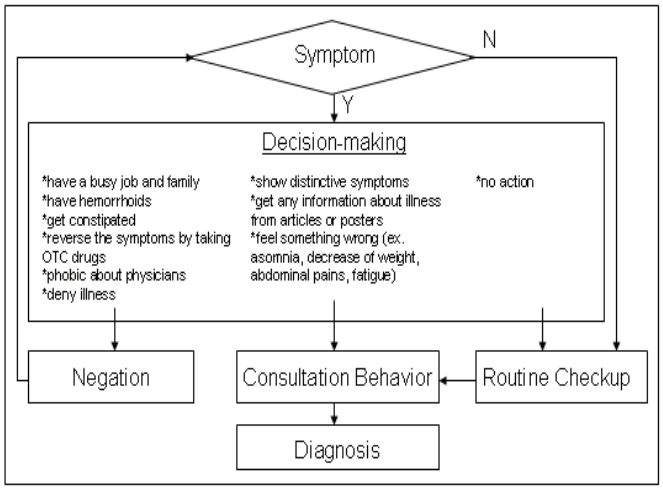


Figure 3 - Decision-making actions of medical consumers

Conclusion

Currently, medical information is offered mainly at the time of medical treatment, and the medical consumer is isolated from medical information before and after medical treatment. However, consumers need to make decisions by using information-seeking behavior before treatment. This need to seek prior information is thought to be a serious consequence of consumers' isolation from medical information.

In this research, from patients' personal experiences of illness we extracted their illusions and the causes in relation with medical consultation. We also illustrated the process of decision-making used by the medical consumer before medical consultation. By using these results to develop ways in which medical information is offered to medical consumers, we should be able to prevent problems such as delays in initiation of medical treatment, or the misguided use of folk remedies, in advance. These points are valuable to such research.

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A Study of the Decision-making Process of the Medical Consumer based on Description Analysis of Personal Experiences of Illness

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Medical Information and Medical Consumers

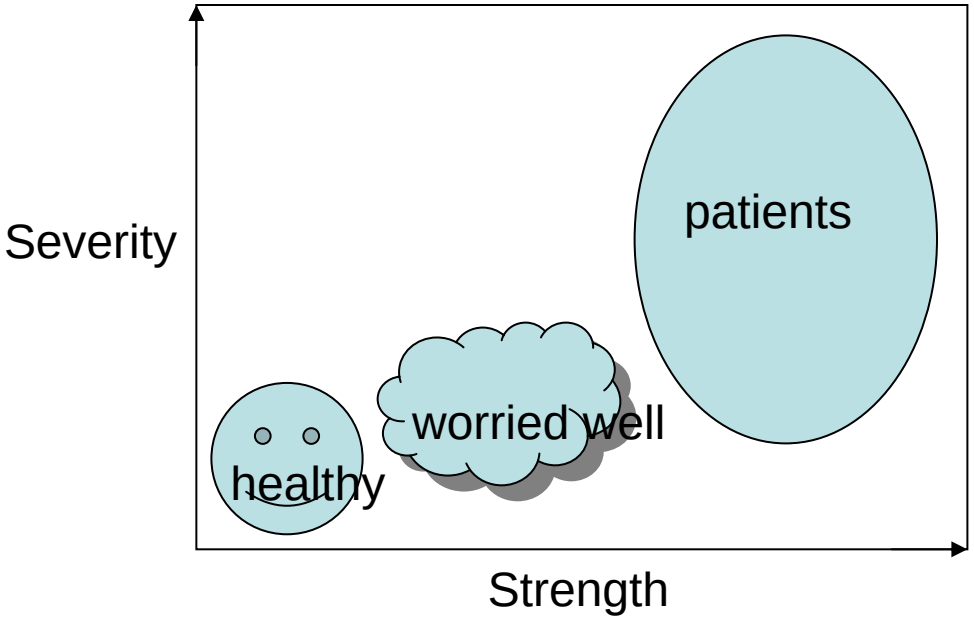
- Type of Medical information
  - Individual information provided by co-medicals during consultation
  - Public information placed on any public information networks
    ex. Medical Guidelines, Drug Package Inserts, Medical Textbooks

- Quality of Medical Information
  - Higher reliability; Evidence Based Information
  - Lower reliability

- Target of Medical information
  - Healthy human
  - Worried well, Underlying patient
  - Patient

Medical Information Needs of Medical Consumers

- Variation of medical information needs
  - strength of information needs
  - kind of information
  - dependence on the situation of the medical consumers
- Are certain symptoms caused by serious diseases?

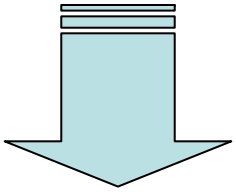


２． Objective

Medical Information for Decision-making

- What is Decision-making point of Medical Consumers？
  - Certain symptoms
  - Information
  - Families

- What is total negation point of Medical Consumers ?
  - living environment
  - self-diagnosis



- To clear the viewpoint to support medical consumers by information, which pushes out the medical consumers to medical consultation

Medical Information and Medical Consumers

- Information Source of the personal experiences of illness
  - Books;　described the situation before the medical consultation
  - Records; 24 gross records from 12 books by 24 patients
  - Illness;　rectal neoplasms
  - Author;　medical consumers (excluded co-medicals), Japanese

- Extraction of description about decision-making
  - Symptoms
  - Patients' thought process before medical consultation
  - Judgment to medical consultation

- Unification of description
  - Based on The Merck Manual of Diagnosis and Therapy
  - Based on The Merck Manual--Home Edition

- Interpret the behaviors

3. Methods

Symptoms and Signs

The right colon has a large caliber, thin wall and its contents are liquid; thus, obstruction is a late event. Bleeding is usually occult. Fatigue and weakness caused by severe anemia may be the only complaints. Tumors sometimes grow large enough to be palpable through the abdominal wall before other symptoms appear.

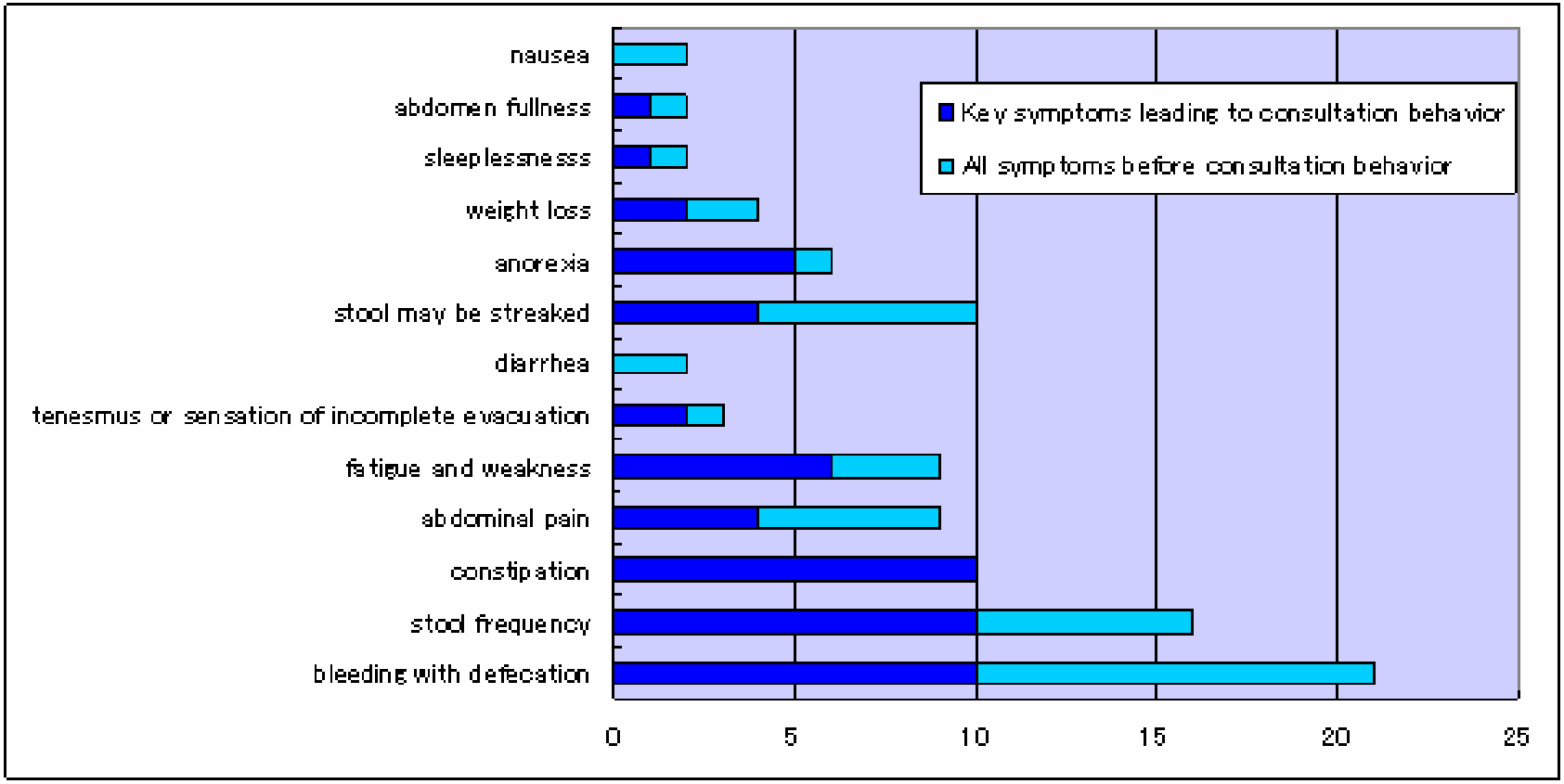
The left colon has a smaller lumen, the feces are semisolid, and cancer tends to encircle the bowel, causing alternating constipation and increased stool frequency or diarrhea. Partial obstruction with colicky abdominal pain or complete obstruction may be the presenting picture. The stool may be streaked or mixed with blood. Some patients present with symptoms of perforation, usually walled off (focal pain and tenderness), or rarely with diffuse peritonitis.

In rectal cancer, the most common presenting symptom is bleeding with defecation. Whenever rectal bleeding occurs, even with obvious hemorrhoids or known diverticular disease, coexisting cancer must be ruled out. Tenesmus or a sensation of incomplete evacuation may be present. Pain is common with perirectal involvement.

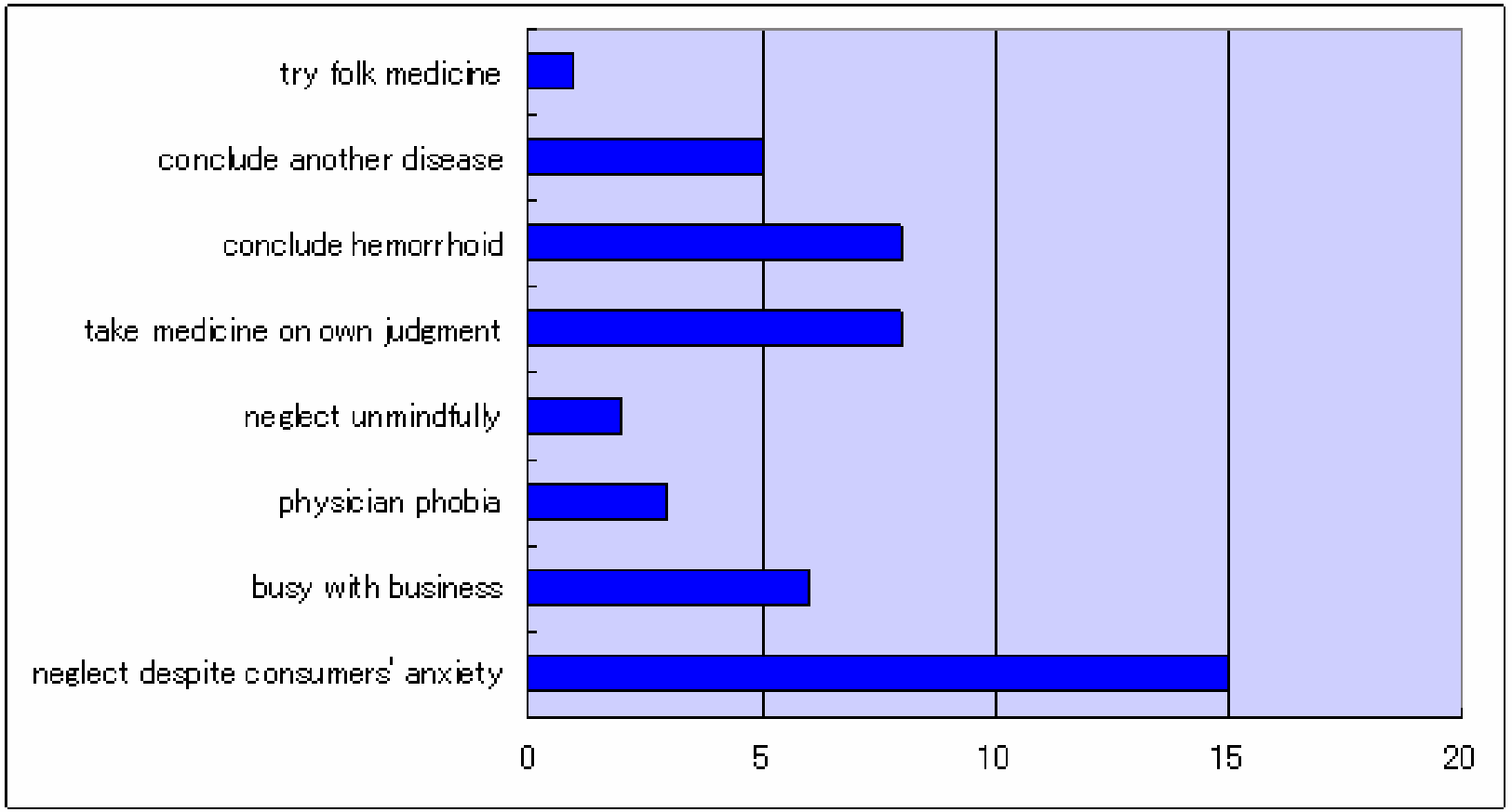
(Source: The Merck Manual of Diagnosis and Therapy)

4． Results

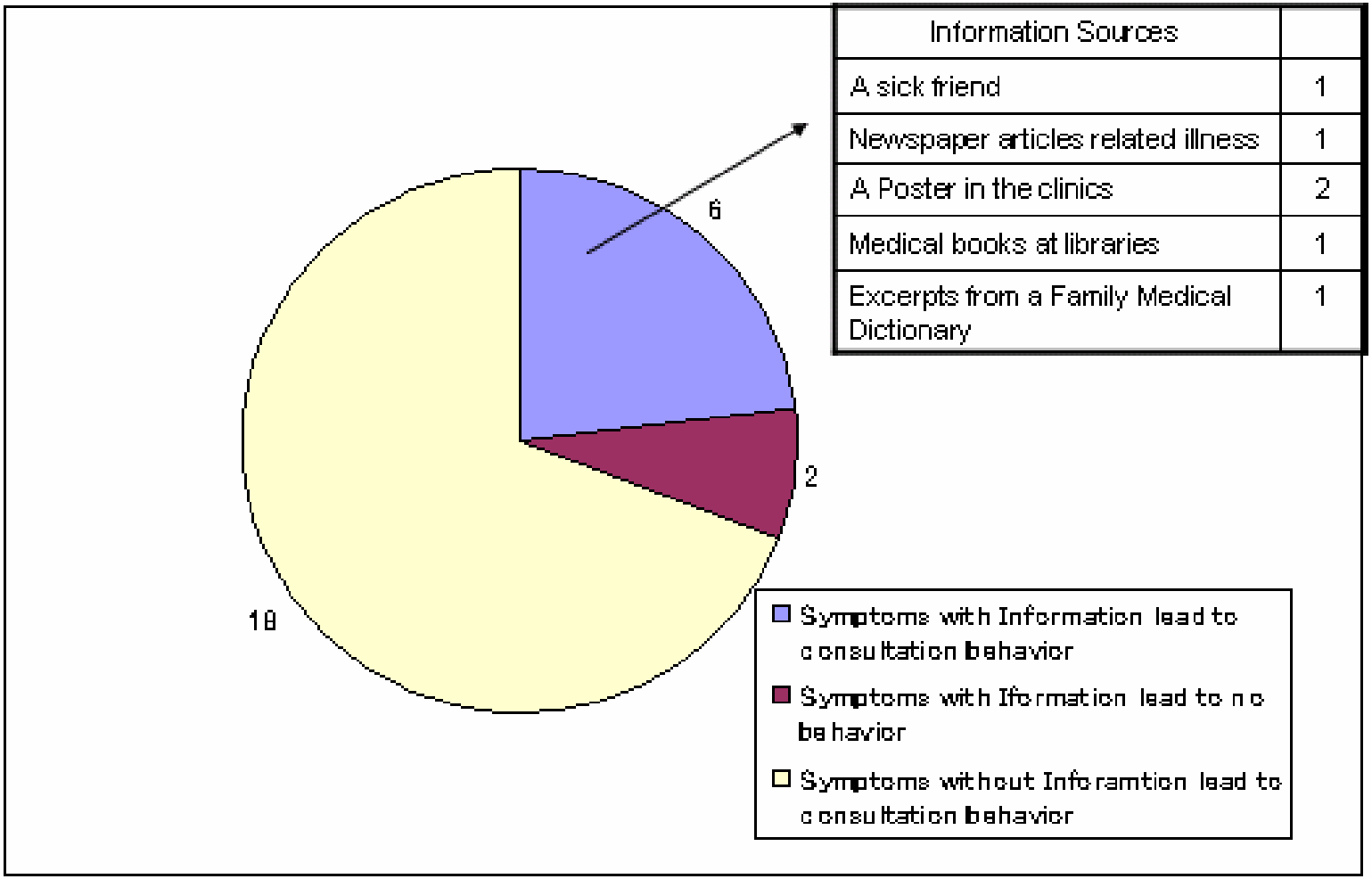
Key symptoms of patients in all symptoms



Reasons for neglect symptoms and action



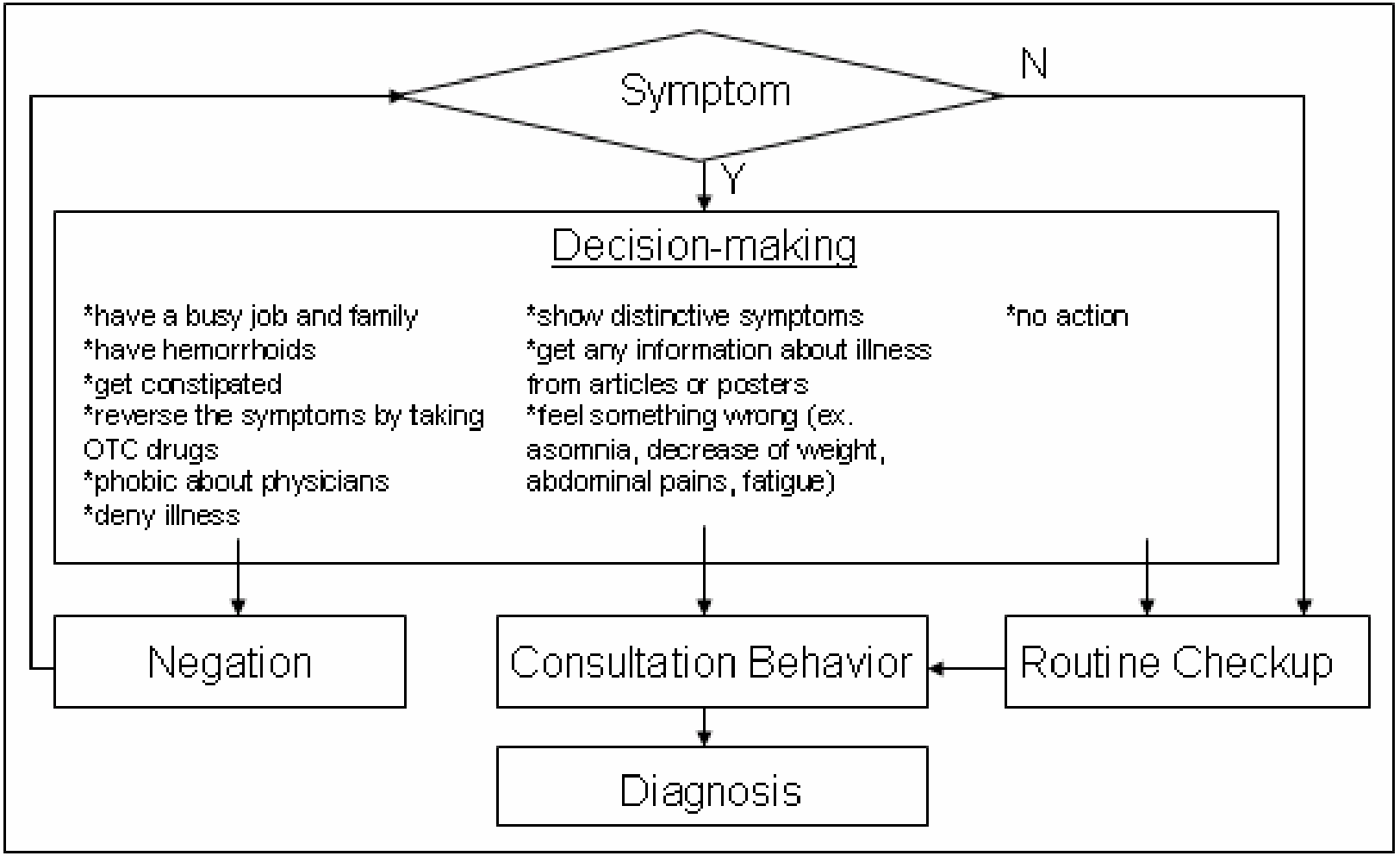
Influence of information on consultation



Information Sources	
A sick friend	1
Newspaper articles related illness	1
A Poster in the clinics	2
Medical books at libraries	1
Excerpts from a Family Medical Dictionary	1

4. Results

The behavior pattern and decision-making



Conclusion

Summary of results

Number of symptoms lead to consultation behavior	24 /64
Number of symptoms did not lead to consultation behavior	40 /64
Number of negation with or without any anxiety and reasons	26 /48
Number of trying any medicine on own judgment	22 /48
Case of Information with symptoms lead to consultation behavior	06/24

Conclusion

Currently, medical information is offered mainly at the time of medical treatment, and the medical consumer is isolated from medical information except medical treatment. However, consumers have a need to make decisions by using information-seeking behavior before treatment. This need to seek prior information is thought to be a serious consequence of patients' isolation from medical information.

In this research, from patients' personal experiences of illness we extracted their illusions and the causes in relation with medical consultation. We also illustrated the process of decision-making used by the medical consumer before medical consultation. By using these results to develop ways in which medical information is offered to medical consumers, we should be able to prevent problems such as delays in initiation of medical treatment, or the misguided use of folk remedies, in advance.

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Assessing the "Hyvis" Enquiry Service by Applying the Process Model of Information Management

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Abstract

Internet-based services in the field of health care are one potential response to technological development. Nowadays people of different ages use the Internet to seek health-related information. The aim of this study was to assess how well the "Hyvis" Enquiry Service fulfils users' information needs, and also how the Hyvis Enquiry Service impacts on the use of health care services, by applying Choo`s Process Model of Information Management. A qualitative approach was used and the data were collected using semi-structured interviews (n=14). The results of this study show that in the view of both health care professionals and users, the Enquiry Service fulfils users´ needs, and that users usually obtain the specific information they require for the problem they have. Further, health care professionals believe that the information is accurate for the answer and is filtered by a health care professional before delivering the information to the users. These were also the expectations of the users who decided on using the Enquiry Service.

***Keywords**:*

delivery of health care, internet, consumer participation

Introduction

The number of Internet users in Finland has been growing rapidly, and people of different ages increasingly use Internet services in their daily life. As use of the Internet has become more popular among health care users, the Internet has also had an effect on the delivery of health care services. According to Åkesson et al. technical interventions provide the users with support, help and information. Although information and communication technology can enhance the nurse – patient relationship, it cannot entirely replace it. [1] The traditional 'office visit' model used in health care fails to meet clients´ heterogeneous needs. Nowadays, services should be delivered by offering multiple entry paths into health care services. [2] Consequently, new ways of accessing health services and information should be introduced.

Internet-based services, such as the "Hyvis" portal, are relevant options. The Hyvis portal is a free Internet-based service, intended for inhabitants of the Etelä-Savo Hospital District, that complements regional health services and promotes the welfare of inhabitants by offering information about health and health care services. An enquiry service for users to consult a health care professional is included in the portal. Questions can be presented either in the portal's public forum, allowing universal access to the information, or in a private forum access to which is secure and only the person who asks the question can read the answer. Clients usually, receive their answer within one or two days. [3]

The process model of information management

The process model of information management is a continuous cycle of six closely related activities: identification of information needs, information acquisition, information organization and storage, development of information products and services, information distribution and information use. [4]

The aim of this study was to assess how well the Hyvis Enquiry Service fulfils users' information needs and also how the Hyvis Enquiry Service impacts on the use of health care services, by applying Choo`s information management model.

Methods

This study employed a qualitative approach. The data were collected through semi-structured interviews. Five users of the Hyvis Enquiry Service and all the nine health care professionals who answer users' questions via the Internet were interviewed for this study. Six of the interviews were carried out by telephone. The users of this service were requested to participate in the study by advertising the study on the front page of the Hyvis portal. All the interviews were tape-recorded, and the researcher also took notes. The interviews were typed up and the data analysed by using inductive content analysis. [5]

Results

The results of this study will be presented in the order followed in the Information Management Model applied.

Information needs

The users of the service expect to obtain reliable information filtered by a health care professional. Frequently asked questions are problem-based questions relating to

health, diseases or the health care services. Also, self-care for a specific disease is often enquired about. Typically, the information is needed to support users' decision-making processes.

Answers given by health care professionals are based on the information given in the question. Sometimes the user fails to give enough background information, or the question is very wide and general. In such cases it is almost impossible to give a specific answer in writing. For that reason part of the users and the health care professionals thought that structured questionnaire might be helpful in formulating a question.

Information acquisition

All health care professionals use electronic databases for seeking information. The most widely used database is a portal called 'Terveysportti' [Health portal]. Interviewed professionals also mentioned evidence-based recommendations as a means of applying information. In addition, health care professionals use their own experience and tacit knowledge in formulating the answer to the users´ enquiries.

Users of the service initially search for health-related information by using search engines such as Google. Three interviewees mentioned that they seek information from reliable Internet pages such as the Hyvis portal. In seeking information, users and health care professionals use different primary sources, but according to the health care professionals, users may still find the same information on the Internet. However, the selection of accurate information and sources, and also the application of the information to the user's own situation, are problematic without the relevant experience and education.

Information use

In this study, four of the five users obtained the required information. Although users trust the information received from the Enquiry Service, and most of the users received assistance with their problems, more specific answers were desired. At present, some of the answers are presented too generally, and the information offered in the answer would have been easily available from other sources. However, most users felt that they had been given the answers to their questions, and that the enquiry service helped users to make decisions about whether to visit a doctor immediately or to treat themselves.

Adaptive behaviour of the users

At present, the Enquiry Service complements health care services by offering easily available health-related information, but does not substantially reduce the use of health care services. Even through the service offers useful information to the users, some of the five interviewees contacted the health care call-centre or health care organization to make an appointment because self-care failed to bring relief. Both users and health care professionals are of the opinion that the Enquiry Service has a positive effect on users' self-care habits, and assists users to take care of their health. According to the users, the information received from the Enquiry Service has enhanced their knowledge of health and disease.

Conclusions

The results of this study suggest that the Hyvis Enquiry Service benefits some inhabitants and that users usually obtain the information they need. According to Choo´s applied information management model, identification of information needs is vital, as information needs form the basis for information acquisition. When communication between inhabitants and professionals is based on typed text, there also exist certain threats with respect to the identification of users' health-related needs. Firstly, health care professionals can interpret questions in a different way from what was intended, which leads to the user not receiving the information required. Secondly, users sometimes fail to supply all the necessary background information which should be taken into account in the answer. Accordingly, the information in the answer may be inappropriate, and the user still needs to contact the health services by telephone and make an appointment. For users who need less urgent help and do not want to spend time in a telephone queue, this will be a useful service model in the future providing that the problems concerning the identification of information needs are solved. According to this study, one option for the future could be structured questionnaires, which would help users to formulate their questions.

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The Department of Health Policy and Management

Assessing the "Hyvis" Enquiry Service by Applying the Process Model of Information Management

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Klemola Liisa MSc
Saranto Kaija PhD

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University of Kuopio, Finland

Background

The Department of Health Policy and Management

- Use of the Internet has become more popular among health care users
- The Internet has also had an effect on the delivery of health care services ➔ services should be delivered by offering multiple entry paths into health care services
- New ways of accessing health services and information should be introduced: e.g. Hyvis Enquiry Service
- Technical interventions provide support, help and information to users
- Information and communication technology enhance the nurse -– patient relationship

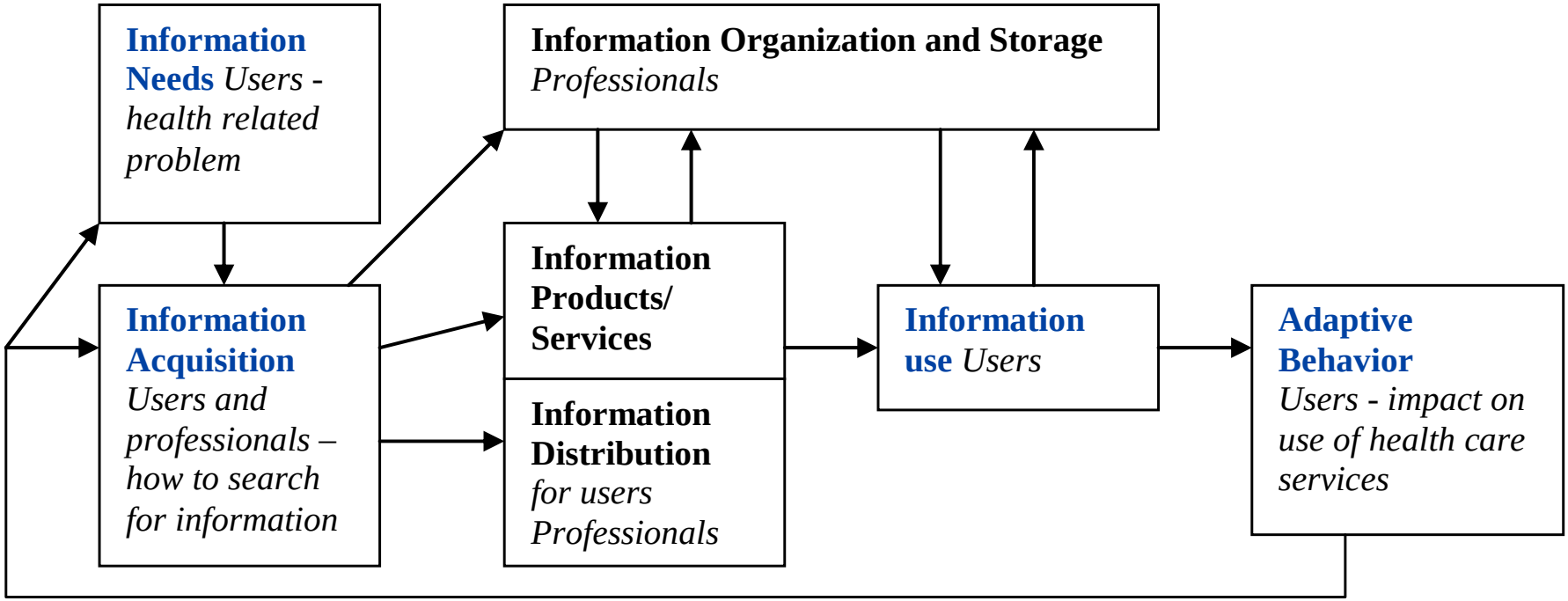
Hyvis Portal & Enquiry Service

The Department of Health Policy and Management

- A free Internet -based service intended for inhabitants of the Etelä-Savo Hospital District
- An enquiry service for users to consult a health care professional is included in the Hyvis portal
  - Public forum
    - allows universal access to the information
  - Private forum
    - secure connection
    - only the person who asks the question can read the answer

Process Model of Information Management Applied to Health Care

The Department of Health Policy and Management



Modified from Choo 1998

Research Questions

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- How well the Hyvis Enquiry Service fulfils users' information needs?

- How the Hyvis Enquiry Service impacts on the use of health care services, by applying Choo's information management model?

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Methods

- A qualitative approach was used
- The data were collected through semi-structured interviews:
  - five users of the Hyvis Enquiry Service
  - all the nine health care professionals who answer users' questions via the Internet
- The data analysed by using inductive content analysis

Results

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Information needs

- The users expect to obtain reliable information
  - filtered by a health care professional
- The information is needed to support users' decision-making processes

Results

The Department of Health Policy and Management

Information acquisition

- Health care professionals use:
  - electronic databases and evidence based guidelines
  - own experience and tacit knowledge
- Users of the service search health-related information:
  - by using search engines such as Google
  - from reliable Internet pages such as Hyvis portal

Results

The Department of Health Policy and Management

Information use

- The users trust the information that is received from the service
- Some of the answers were presented too generally
  ➔ more specific answers were wished for
- Four of the five users obtained the required information

Results

The Department of Health Policy and Management

Adaptive behaviour of the users

- Completes health care services by offering easily available health related information
- Does not substantially reduce the use of health care services
- Has a positive effect on users' self-care habits, and assists users to take care of their health

Conclusions

The Department of Health Policy and Management

- The Hyvis Enquiry Service benefits some inhabitants
- Users usually obtain the information they need
- Identification of information needs is vital for the process
  - misunderstood questions
  - sometimes users fail to supply all the necessary background information
- The Enquiry Service seems not to be reducing the use of health care services at the moment
- A useful service model in the future for users who do not need urgent help

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Combining Web, Email and Telephone Counseling for Behavioral Change

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Abstract and objective

Proactive telephone counseling is one of the most effective non-pharmacological approaches for smoking cessation. This study examines the effectiveness of combining proactive telephone counseling with web/email counseling to improve efficiency and reduce costs. In a randomized trial of 219 smokers with Internet and email access at home and interested in web based support, we observed low rates of use of Internet methods in practice (45%) but no statistically significant difference quit rates (31% at 6 months among respondents.)

Keywords:

smoking cessation, computers, telephone, Internet, counseling, behavior therapy, randomized trial

Introduction

Proactive telephone counseling is one of the most effective tools available for smoking cessation. However, this approach is expensive. Proactive methods require counselors to repeated initiate calls to smokers, many of which are missed, incomplete, etc. Even so, a large part of the effectiveness of proactive protocols is this outreach and the sense of accountability it creates in clients. The purpose of this study was, within the established workflow of a busy telephone helpline, to create an integrated system web-based and email methods with telephone counseling, in the hopes of improve efficiency.

Methods

We created series of web based systems including a client site, a counselor site, and an automated email messaging system to alerted was designed to present a tailored experience to the client based on the stage of their smoking cessation effort. To support modular and reusable systems for tailoring of web sites to clients in a federated environment, we created middleware for dynamic assembly of web pages. The specifications for tailoring of the site, including tailoring based on data in either of the two databases, were represented in XML in an external file. This approach allowed us to rapidly change the nature of interactions on the site without rebuilding all of the linkages and other tools for state maintenance. The counselor site was design allowed counselors to review their panel of assigned clients on the left hand bar, and activities on the right-hand side. This included automated email messages that could to be edited before delivery by system, messages from clients, and scheduled appointments with clients. Counselors would be able to view and edit these messages for 24 hours before delivery. When a message was delivered to a client or counselor, they were notified by open email (nonsecure) of the message. They could then log into the web site and read the message on the secure email server portion of the site and then respond.

Results

219 smokers were randomized to receive either Web/email only follow up counseling, ad hoc telephone/web, or telephone counseling. The demographics of enrollees were surprisingly similar to Internet studies with a high educational level among participants (70% with some college education), a preponderance of female subjects (69%), and of younger subjects (64% under 45 years of age). Among smokers randomized to web access, about 45% logged in and access web/email tools for smoking cessation and communications with counselors. Amongst enrollees, 67% responded to request for follow up information 6 months after enrollment in the program. Only a few participants had used other web based cessation services (11%). Most subjects reported being satisfied with services received (more than 75%). Smokers receiving Internet counseling tended to believe that the right mix was a equal proportion Internet and telephone counseling (50% of respondents) The overall quit rate among respondents was 31% and there were not statistically significant differences between groups.

Discussion

This study was among the first studies to attempt to combine web/email and telephone counseling. It was difficult toconvert helpline callers Internet communications with counselors. However, most participants thought that telephone counseling had a place in communications (even though they may not have used it). While this study was not powered to detect small differences in quit rates, com-

bined modality counseling appeared as effective as telephone counseling alone.

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XML Data Structures for Tailoring of Web Sites to Promote Behavioral Change

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Abstract

Web sites should use theoretically-based individually tailored content to maximize their effectiveness in promotion of behavioral change, Personal tailoring of content is difficult in computer systems and infrequently linked to theoretical models. This poster describes an approach for creating tailored content that combines an external XML representation of the tailoring process with a run time interpreter and content management system. The approach offers a robust and explicit method for personalization of the content of web sites.

Keywords:

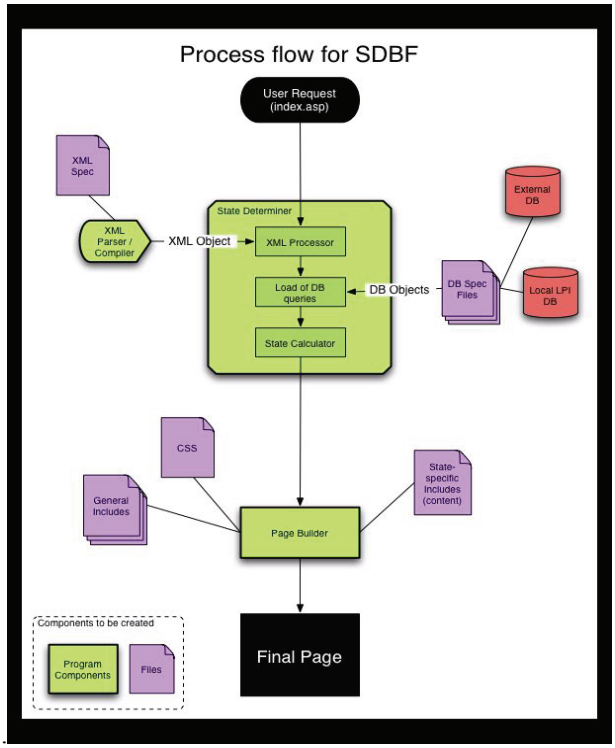
internet, behavioral medicine, Extended Markup Language (XML), content management system

Introduction

A large body of research has shown that personally tailored educational materials are far more effective in the promotion of behavioral change than untailored materials, regardless of the underlying theories for tailoring (Stages of Change, Health Belief Model, Motivational Interviewing, etc.). Tailoring of the content of web sites is a difficult task and the specific strategies for tailoring, along with linkages to formal models, are rarely described. In this paper we describe an approach for explicit representation of tailoring protocols that separates the knowledge and algorithm for tailoring from its implementation.

Methods

We designed a system where the complete specifications for tailoring of a web site, including tailoring based on personal data multiple external databases and tailoring the stage of an experimental protocol, were represented in XML in an external file. This approach allowed designers to rapidly change the nature of interactions on the site without rebuilding all of the linkages and other tools for state maintenance. Under this architecture, when a user requests a page, the XML specification for was read in, parsed by a compiler program creating an XML object. The XML object included specifications for database transactions with both of the project databases to compute the state of the system for tailoring. Based on the XML instructions and queries to the external databases, the appropriate state for the web site was computed. Based on the state, a software module called the page building assembled a tailored web page using cascading style sheets, html components, and custom built programmable Flash (Macromedia) objects. This final page was presented to the user. The advantage of this system is that the entire process for tailoring is explicitly represented within the external XML file. This explicit process may aid linkage to the web site with an ontology representing the interventions used in the web site. It also reduces maintenance effort.



The approach combines the explicitness of XML representations with the robustness of a content management system. Using this model, we created a large web site for a randomized trial of web based communications intervention for smoking cessation. Performance on a Linux APACHE P4 Pentium web server was not an obstacle for a research scale (n=220 subject) implementation.

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AboutKidsHealth: A Unique Initiative in Pediatric Consumer Health Informatics

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Abstract

The Hospital for Sick Children, Toronto (SickKids), has launched AboutKidsHealth, a project that promotes and delivers evidence-based information and programs according to a determinants of health model arising from the understanding that health extends beyond the absence of disease. Accordingly, AboutKidsHealth takes an inclusive approach to the enhancement of quality of life that embraces the home, the greater community, the education system, and the health system. The project employs innovative communication strategies supported by state-of-the-art technology to deliver evidence-based information and programs in all major areas influencing child health and family quality of life. The web-based infrastructure is also used to provide enhanced communication for families of children with complex conditions and health professionals, and to develop web-based research projects in collaboration with SickKids scientists.

Keywords:

consumer health informatics, parents' health information needs, sources of health information, typically developing children

Introduction

Consumers of online health information are concerned with issues of quality and trust. No sites presently offer comprehensive child health information and tools for families seeking solutions to complex questions that may involve disease, lifestyle, behavioral, and educational issues. Parents of children with complex health issues, as well as parents of typically developing children, need a trusted, comprehensive online resource to inform and guide.

Families of children with complex conditions frequently have unmet needs for trusted health information. A large gift to The Hospital for Sick Children from TD Securities, a Canadian investment bank, made possible a unique initiative in consumer health informatics that would strive to meet the information needs of these families.

Methods

In recognition of families' concern with psychosocial and adult outcomes of complex

paediatric conditions in addition to their needs for reliable medical information concerning diagnosis and evidence-based treatment, we hypothesized that a determinants of health model would best meet their needs. We tested this model and an information architecture based on the concept of a family journey.

We conducted initial proof-of-concept and needs assessment qualitative research with families and clinicians concerning the online information needs of families of children with complex conditions. Subsequently, we used wire frames to assess the proposed information architecture and content of resource centres with families and clinicians.

In collaboration with clinical programs, we developed resource centres for Brain Tumour, Diabetes, and Heart Conditions. We describe the initial research and development of the centres, and usability testing conducted after launch.

Initial qualitative research

We conducted unstructured interviews with clinicians, observed families interacting with caregivers in clinic, and conducted unstructured interviews with families.

A series of initial proof-of-concept, semi-structured interviews with site schematics was performed with parents of children with complex conditions in Toronto, and parents with typically developing children in Toronto, Atlanta, and Portland, Oregon.

A second set of semi-structured interviews with wire frame schematics of resource centres for brain tumour, diabetes, and heart conditions was conducted with families and clinicians.

Development of the resource centres

The resource centres were built with five main sections: About (Condition), Understanding Diagnosis, Treatment, At Home, and Looking Ahead. Creating each resource centre represented an 18- to 24-month collaborative effort

among the medical writers, medical illustrators, designers and developers of the AboutKidsHealth team and the health professionals of The Hospital for Sick Children clinical programs. As part of the development process, original narrated animations concerning anatomy, disease knowledge and management, and health for children and youth were created to support each resource centre.

In December 2003, the hospital launched the first phase of AboutKidsHealth. This phase included The Family Health Centre, a 1000 square foot site supporting families' health information and medical decision making needs. The site, staffed by trained health professionals and volunteers, includes a library of books, brochures, and multimedia resources, 12 computers, and two multimedia/counseling rooms equipped to handle telehealth consultations. A 50 inch plasma monitor and 10 foot pixel board facilitates coordination of messaging and campaigns with AboutKidsHealth.

In June 2004, three resource centres were published as the initial web component of the AboutKidsHealth: Brain Tumour, Heart Conditions, and Diabetes. Additional resource centres that have been published include Pain, Epilepsy, Pregnancy & Babies, Premature Babies, Attention Deficit Hyperactivity Disorder, and Learning Disorders. Other resources include the A-Z Health Library, News (Online magazine), How the Body Works (Child Physiology), and Just for Kids.

Usability testing

Usability testing of the initial three resource centres was conducted with 12 families. Following an initial interview with a questionnaire to gather demographic information and patterns of internet use, parents completed a 1.5 hour, task-based, think-aloud protocol in a usability laboratory followed by a 24-item evaluative questionnaire containing questions with a 7-point Likert scale.

Results

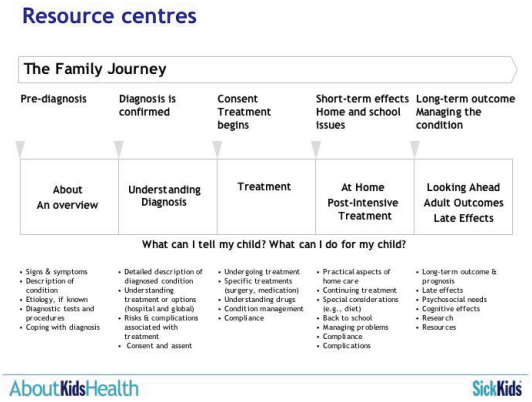
Initial qualitative research

Results of the initial qualitative research supported the utility of a determinants of health model for meeting families' health information needs. Furthermore, an information architecture for resource centres based on the family journey from the time a child was diagnosed with a complex condition through adult outcomes was seen as appropriate and useful by both parents and clinicians.

Resource centres

Each AboutKidsHealth resource centre consists of 45,000 to 325,000 words of level I content and 5000 to 1000 words of level II content. There are over 160 original medical illustrations, animations and other images. The material is comprehensive, incorporating not only medical information, but also addressing safety, nutrition, psychosocial, educational, and quality of life issues.

The resource centres are complemented with tools for families with typically developing children and



a range of articles on general child health issues. These articles focus on child and youth health from a determinants of health perspective and feature articles, expert columns, and series concerning healthy living and prevention, family living skills, understanding and managing common and complex conditions, safety, community-based systems and advocacy, and learning and education.

The A-Z Health Library contains 575 everyday health topics written at less than grade 7 reading level. This syndicated material has been reviewed by SickKids staff and complemented with original illustrations.

News comprises series, feature articles, news items and columns. Approximately 10,000 words are published each month.

How the Body Works contains interactive, animated illustrations that describe the brain, the heart and sexual development.

Just for Kids contains over 150 minutes of original narrated animations for children and youth. There are downloadable materials including games. Just for Kids supports all resource centres and provides general heatlth and safety information as well.

Usability testing

The overall mean response (6.1/7) to the questionnaire and analysis of qualitative responses indicated a very positive response to the design and utility of the resource centres and AboutKidsHealth.ca overall.

Conclusion

AboutKidsHealth is an innovative and unique paediatric consumer health informatics initiative from several perspectives: utilization of a hybrid public/private business model within the Canadian health care system; integration of a physical site for families with a virtual child and youth

health site and telehealth capacity; development of programs in the context of a comprehensive, determinants of health model; and the use of offline, social marketing campaigns to increase traffic to the online site while promoting awareness of child and youth health issues.

AboutKidsHealth: A unique initiative in paediatric consumer health informatics

Ross Hetherington PhD, Andrew James MBChB MBI, Kimberly Meighan RN, Angela O'Neill, Brian Shaw PhD for the AboutKidsHealth Team

Medinfo 2007, Brisbane, Australia

AboutKidsHealth: Mission statement

We will work to improve child and youth health and quality of life for families around the world. We will accomplish this working within a determinants of health model, using state-of-the-art information design and communication strategies to ensure effective transfer of evidence-based information and tools.

"Quality of health information sites on the Internet; however, has less to do with whether the sites meet a list of static criteria. Rather, quality can be understood as the degree to which Web health information positively affects a user's health outcomes, quality of life, or disease-specific clinical endpoints."

Risk & Patterson, *Journal of the American Medical Association, 2002*

Initial qualitative research: methods

- Unstructured interviews with clinicians
- Observations in clinic and unstructured interviews with families
- Initial proof-of-concept, semi-structured interviews with site schematics
- Second set of semi-structured interviews with schematics of resource centres for brain tumour, diabetes, and heart conditions
  - Clinicians (2 from each of 3 programs)
  - Families (3 from each of 3 programs)

Patient family comments and questions: Diabetes as an example

- "A central place to go and look up information [would be] great."
- "Tell me in plain English what's going to happen."
- "When you're upset, you don't retain it all. It's good to have a place to go to get all the information after the diagnosis."

Common questions included:

What is insulin?
How does the pancreas function?
What are the long term effects of the condition?
What lifestyle changes will be required?

- Despite oral instruction in clinic, parents needed to know:

What signs and symptoms should we watch for?
How do you treat high and low blood sugar?
What are appropriate insulin doses and injection techniques?
What are insulin pumps and how do we use them?

Resource centres: information architecture

The Family Journey

Pre-diagnosis	Diagnosis is confirmed	Consent Treatment begins	Short-term effects Home and school issues	Long-term outcome Managing the condition
About *An overview*	**Understanding Diagnosis**	**Treatment**	**At Home** *Post-Intensive Treatment*	**Looking Ahead** *Adult Outcomes Late Effects*

What can I tell my child? What can I do for my child?

- Signs & symptoms
- Description of condition
- Etiology, if known
- Diagnostic tests and procedures
- Coping with diagnosis

- Detailed description of diagnosed condition
- Understanding treatment or options (hospital and global)
- Risks & complications associated with treatment
- Consent and assent

- Undergoing treatment
- Specific treatments (surgery, medication)
- Understanding drugs
- Condition management
- Compliance

- Practical aspects of home care
- Continuing treatment
- Special considerations (e.g., diet)
- Back to school
- Managing problems
- Compliance
- Complications

- Long-term outcome & prognosis
- Late effects
- Psychosocial needs
- Cognitive effects
- Research
- Resources

Resource centre: content characteristics

- Level I content
  - less than Grade 10 reading level (accuracy *vs* readability), Browsealoud enabled
  - supported with glossary and illustrations
  - secondary and tertiary sources
  - process: consult -> write -> review -> revise -> review -> revise -> QA
- Level II content
  - plain language treatment of current research from primary sources
  - 600 – 1200 words each
  - review and comment on relevance by clinician

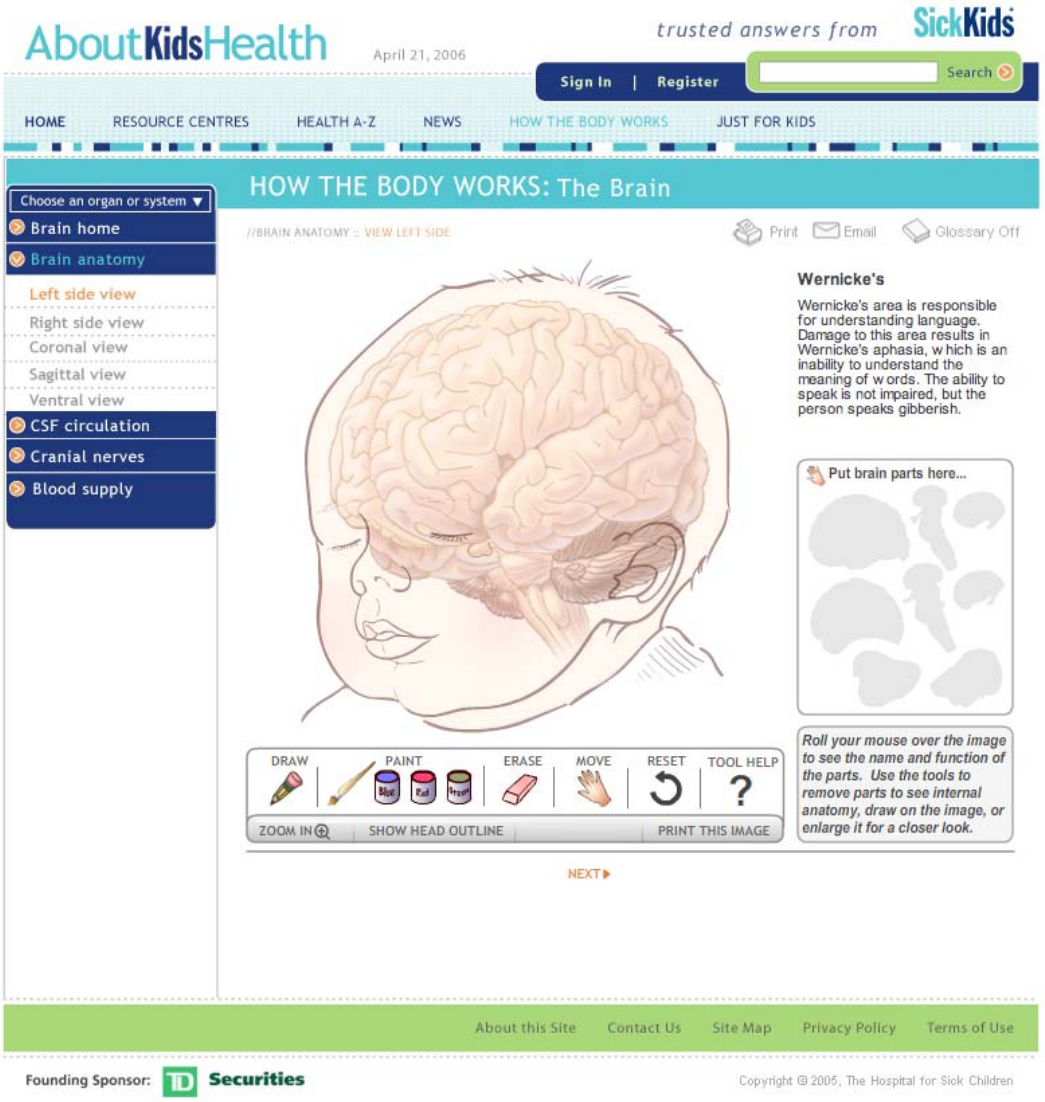
Content and features: Resource Centres

- Seven Resource Centres: Brain Tumour, Diabetes, Epilepsy, Heart Conditions, Pain, Pregnancy & Babies, Premature Babies
- 45,000 to 325,000 words of Level I content
- 5000 to 15,000 words of Level II content
- Over 160 original medical illustrations, animations, and other images
- Comprehensive, interactive, family focused

Content and features: A-Z Health Library

- **A-Z Health library**
  - 575 everyday health topics
  - less than Grade 7 reading level
  - Syndicated content but reviewed and revised by SickKids staff — original illustrations added
  - Complete rewrite currently underway
- **Online magazine**
  - Publish ~10,000 words/month
  - Series, feature articles, news items, and columns

Content and features: How the body works



Content and features: Just for Kids

- Over 150 minutes of original narrated animations for children and youth
- Downloadable material: desktops, games
- Supports all Resource Centres with condition management information and tools
- General health and safety information as well
- Just for Kids was recently re-designed, 3 new modules launched

Usability testing

- Parents of 12 children with complex conditions
- 1.5 hour, task-based, think-aloud protocol
  - "Can you please find information on how to adjust the insulin dose?"
  - Semi-structured interview sought qualitative information on content and design during testing
- Post-test site evaluation questionnaire — 24 questions, seven point Likert scale from 1 (strongly disagree) to 7 (strongly agree)
- Overall response was 6.1

AboutKidsHealth: A unique initiative in paediatric consumer health informatics

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Sustainable Caregiving Families: Addressing the Ethno-Cultural-Linguistic Needs of Chinese Immigrant Caregivers for a Web-based Support Portal

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Abstract

Background: Family caregivers are fundamental members of a sustainable health care system. In a multicultural society, family caregivers have different ethnic, cultural, and linguistic support needs. Purpose: To develop and evaluate the design enhancements of a Personalized Support for Family Caregivers (PSFC) web-based portal for Chinese families. Method: Through the portal, 33 participants received caregiver-therapist email support and had access to an information website. After in-depth interviews of 10 users, data were analyzed using qualitative thematic, user profile and requirement analyses to conceptualize the redesign. Results: Traditional family values, information needs, familiarity with English and computer literacy had an impact on the usage of the PSFC. The portal functions was enhanced by: 1) building a sense of presence of the PSFC, 2) engaging more members in a family rather than only a primary caregiver, 3) assisting users with English communication, and 4) delivering information in the form of narratives. Conclusion: Information communication technologies, when well designed and implemented, can meet the ethno-cultural-linguistic needs of caregiving families in a multicultural society.

Keywords:

alzheimer disease, clinical informatics, Canada, Chinese, culture, family caregivers

Introduction

Family caregivers are fundamental members in a sustainable healthcare system. In a multicultural society, the pluralistic ethnic, cultural, and linguistic landscape creates many different caring environments. A number of studies have evaluated the use of communication technologies to support family caregivers [1-4], but few investigated ethno-cultural-linguistic barriers to accessing technology-based support programs. This paper will report on the ethno-cultural-linguistic ehealth needs of Chinese Canadian family caregivers and the design enhancements of a web-based portal that offers Personalized Support for Family Caregivers Support (PSFC) to them.

Methods

This research is a substudy of a larger research being undertaken [5]. The main study provided caregiver support through a web-based portal in both Chinese and English. The portal consisted of 1) a 400-page caregiving information website and 2) a personalized caregiver-therapist email support.

A mixed methods design was used in this substudy. We selected a purposive sample of ten participants from the main study. The sample had varied caregiving characteristics and usage patterns of the caregiver portal. Participants were interviewed by phone or in-person, in a language of their choice (90% in Chinese). The in-depth interviews were audio-taped, translated, and transcribed verbatim. The data were coded, and a thematic analysis conducted [6].

A user-centered design methodology [7] was used to develop the design concept. There were five processes: 1) thematic analysis of the interview data, 2) the construction of user profiles, 3) the stakeholder analysis, 4) the requirement analysis, and 5) the conceptualization of the system enhancements.

Results

The caregiving context and usage experiences

The participants provided care in a caregiving context that had the following salient themes: 1) embracing the traditional family values, 2) living with worries and emotional struggles, 3) seeking external help and reflecting on self, and 4) sharing the care while caring for the family.

Within this caregiving context, the participants had varying usage experiences of the caregiver portal. They 1) talked in Chinese, typed in English, and preferred to hear stories, 2) needed help to access their accounts in an unfamiliar portal, 3) ranged from liking all information in one place to favouring human contacts, and 4) ranged from expressing self freely to not knowing what to say in an email

Enhancement requirement analysis

The requirement analysis [7] focused on the unmet needs of participants who were occasional or non-users. The results showed that these non-adopters typically:

- were not fluent in written English
- did not know what to ask; were unsure which problems were part of the illness
- did not know how to ask; unsure how much to tell
- preferred learning from stories of other caregivers
- preferred notifications and reminders; forgot the user name and password
- felt that they could manage the care on their own
- had difficulty expressing in an email
- felt that going to a support group, asking the doctor, browsing the internet, or reading a book was better

Conceptual design of an enhanced system

The non-adopter characteristics, thematic analysis and requirement analysis were used to conceptualize the redesign. The enhanced system, called PSFC, expanded the original functions to include four new features:

1. Building a sense of presence of the PSFC
2. Expanding from a primary caregiver to a caregiving family
3. Using narratives to inform and educate
4. Addressing multilingual needs with a digital solution

Figure 1 - Screen shots of Short Stories (Chinese version), Family Forum; and Telling More

Conclusion

Ethno-cultural-linguistic needs of family caregivers are complex. Information communication technologies, when well designed and implemented, have the capacity to address the special needs of these caregivers who live in a multicultural society. This study illustrates the iterative design and redesign of such an application based on usage experiences and user preferences. The redesign is currently being evaluated using usability testing and a quantitative analysis of user engagement. The concepts, if proven to be useful, could benefit families from other ethnic or cultural groups that value close family relations, needs assistance in English communication, and prefer narratives to receive information. If caregivers are better supported, caregiving families can be sustained, which in turn can contribute to sustainable health care systems in the 21st century.

Acknowledgments:

Special thanks go to the Alzheimer Society of Canada, Canadian Institutes of Health Research Fellowship, Dr Chignell, Dr Cockerill, Dr Marziali, Dr Colantonio, Dr Carswell, M Grunier, M Tang, R Chan, C Tse, R Samavi, Yee Hong Centre for Geriatric Care, and the caregiver participants.

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[1] Czaja SJ, Rubert MP. Telecommunications technology as an aid to family caregivers of persons with dementia. Psychosomatic Medicine. 2003. 64 (3): 469-476.

[2] Eisdorfer CA, Czaja SJ, Lowenstein DA, Rubert MP, Arguelles S, Mitrani VB, Szapocznik J. The effect of family therapy and technology-based intervention on caregiver depression. Gerontologist. 2003 43 (4): 521-531.

[3] Mahoney DF, Tarlow BJ, Jones RN. Effects of an automation telephone support system on caregiver burden and anxiety: Findings from the REACH for TLC intervention study. Gerontologist. 2003 43 (4): 556-567.

[4] McClendon MJ, Bass DM, Brennan PF, McCarthy C. A computer network for Alzheimer's caregivers and use of support group services. J. Mental Health & Aging. 1998. 4 (4): 403-420.

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Sustainable Caregiving Families:
Addressing the Ethno-Cultural-Linguistic Needs of Chinese Immigrant Caregivers for a Web-based Support Portal

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d *Centre for Global eHealth Innovation, University Health Network, Toronto General Hospital, Toronto, Canada*

Purpose

- This paper will report on
  - the ethno-cultural-linguistic ehealth needs of Chinese Canadian family caregivers
  - the design enhancements of a web-based portal that offers Personalized Support for Family Caregivers Support (PSFC) to them

Background

- Family caregivers are fundamental members in a sustainable healthcare system
- In a multicultural society, the pluralistic ethnic, cultural, and linguistic landscape creates many different caring environments
- A number of studies have evaluated the use of communication technologies to support family caregivers [1-4]
- But few investigated ethno-cultural-linguistic barriers to accessing technology-based support programs

A Mixed Methods Evaluative Study

- A substudy of a larger research that provides caregiver support through a web-based portal [5].
- The portal
  - Offers in both Chinese and English
  - Is consisted of 1) a 400-page caregiving information website and 2) a personalized caregiver-therapist email support.
- A mixed methods evaluative design
  - In-depth interview
  - User-centered design

In-depth Interview

- A purposive sample of 10 participants from the main study was selected
- The sample had varied caregiving characteristics and usage patterns of the caregiver portal
- Participants were interviewed by phone or in-person, in a language of their choice (90% in Chinese)
- The in-depth interviews were audio-taped, translated, and transcribed verbatim. The data were coded, and a thematic analysis conducted [6]

User-centered design

- The portal redesign was conceptualized using a user-centred design method [7]:

1. thematic analysis of the interview data
2. the construction of user profiles
3. the stakeholder analysis
4. the requirement analysis
5. the conceptualization of the system enhancements

Results:
Caregiving Context & Usage Experiences

- Caregiving context:
  - embracing the traditional family values
  - living with worries and emotional struggles
  - seeking external help and reflecting on self
  - sharing the care while caring for the family.
- Usage experiences of the caregiver portal:
  - talked in Chinese, typed in English, and preferred to hear stories
  - needed help to access their accounts in an unfamiliar portal
  - ranged from liking all information in one place to favouring human contacts
  - ranged from expressing self freely to not knowing what to say in an email

Results:
Enhancement Requirement Analysis

Participants who were occasional or non-users typically:

- were not fluent in written English
- did not know what to ask; were unsure which problems were part of the illness
- did not know how to ask; unsure how much to tell
- preferred learning from stories of other caregivers
- preferred notifications and reminders; forgot the user name and password
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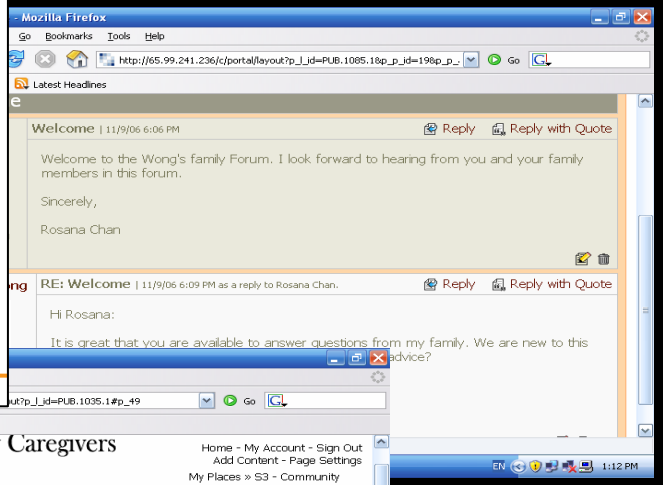
- felt that going to a support group, asking the doctor, browsing the internet, or reading a book was better

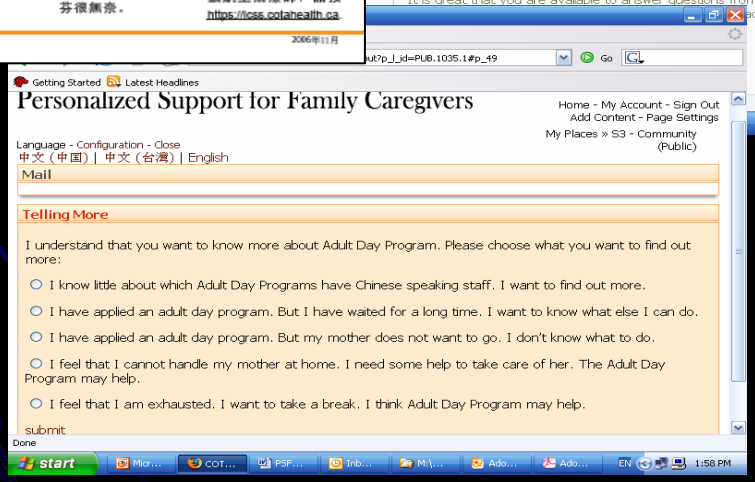
Results:

Conceptual Design of an Enhanced System

- The non-adopter characteristics, thematic analysis and requirement analysis were used to conceptualize the redesign
- The enhanced system, called PSFC, expanded the original functions to include four new features:
  1. Building a sense of presence of the PSFC
  2. Expanding from a primary caregiver to a caregiving family
  3. Using narratives to inform and educate
  4. Addressing multilingual needs with a digital solution

Screenshots of the Enhanced Features





Conclusion

- Ethno-cultural-linguistic needs of family caregivers are complex
- ICT has the capacity to address the special needs of these caregivers
- This study illustrates the redesign process of a caregiver portal based on user preferences and usage experiences
- The redesign is currently being evaluated using usability testing and a quantitative analysis of user engagement
- The design concepts may benefit families from other ethnic or cultural groups that value close family relations, needs assistance in English communication, and prefer narratives to receive information
- If caregivers are better supported, caregiving families can be sustained, which in turn can contribute to sustainable health care systems in the 21st century.

Acknowledgments Contact and References:

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1) Czaja SJ, Rubert MP. Telecommunications technology as an aid to family caregivers of persons with dementia. Psychosomatic Medicine. 2003. 64 (3): 469-476.
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Three Month Trial of Networked System that Improves Quality of Life of the Elderly

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Abstract

Japan has a rapidly aging population, and is now facing various problems related to nursing care. One key problem, the rapid increase in insurance payments for long-term care, was tackled by reforming the insurance system to emphasize preventative care in April, 2006. It has become increasingly urgent to prevent elderly people from falling ill or needing nursing care, and thereby reduce doctor visits, and ultimately to contain the expenditure on medical care for the elderly. However, we don't have enough preventative-care specialists. In order to offset the shortage of these specialists, we have developed a support system to provide the elderly with scientifically proven instruction using broadband and video-communication technologies. A three month trial of the system at a day-care center for the elderly people in need of care is described. The results show that the support system provides effective exercise guidance.

Keywords:

nursing care, prevention, Internet, video-communication

Introduction

Japan's aging society continues to grow. Last year, the number of people 65 or older reached 25.60 million or 20.04％of the population [1] . It has become increasingly urgent to prevent elderly people from falling ill or needing nursing care. However, we don't have enough preventative-care specialists.

The proposed system aims to prevent the elderly from becoming bedridden due to the "old-age syndrome", which frequently triggers falls, broken bones, poor nutrition, incontinence, and home confinement[2]. The shortage of care-givers means that only a small percentage of the elderly are receiving the support they need. In response, we had developed a support system that exploits the features of video-related technologies including video streaming and multipoint videoconferencing. This system is an extension of a home-participation type care-prevention system developed in 2003 that was geared to self-sufficient elderly persons. The effectiveness and usefulness of the system led to the work described in this paper.

Methods

The support system

The support system consists of the care-prevention servers and the client PCs (including PC for management). The servers include a database server (A), a content-storage server (b), a WWW server (C), a video –delivery server (D), and a Video conferencing server (E), as in Fig. 1. Scientifically proven instruction contents are stored in the content-storage server and delivered to each client by the video-delivery server over the Internet at the appointed time.

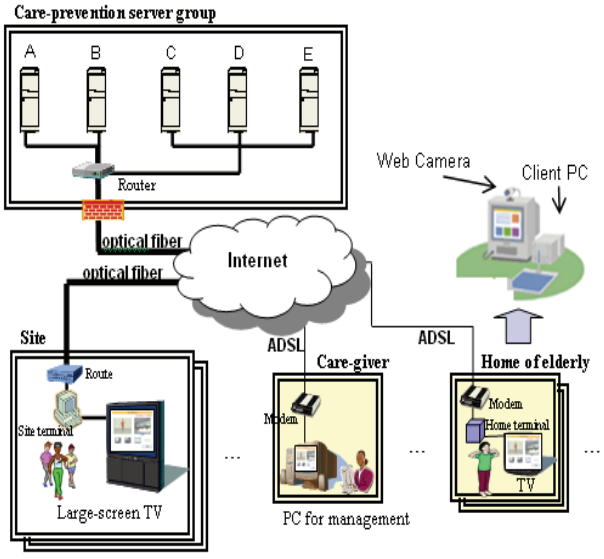

Figure 1 - Configuration of the system

The exercise for people requiring nursing care has 8 levels. The initial level is very relaxed, and the increments in difficulty are small. This allows training without strain.

1 http://www8.cao.go.jp/kourei/english/annualreport/2006/06wp-e.html

2 S. Murata, T. Tsuboi,T. Ito, K. Fujimura and H. Sato, " Development of System for Reducing the Need for Nursing Care," NTT Technical Review, Vol. 4, No. 2, p.60, 2006

The exercise contents are tagged with metadata enabling the exercise scenarios delivered to each site to be optimized to suit the current physical condition of the participant. In particular, the system can ask each participant for back pain, knee pain, and pain in the thighbone before the exercise session and then select exercises that do not overburden the knee, for example, for individuals experiencing knee pain. It can also deliver content with commentary targeting individuals or sites that desire more detailed exercise scenarios.

The client system consists of a web camera, a microphone, a speaker, and a PC. The web camera is used not only for video-conferencing but for recording of the user's movements. The recorded video is sent to the database server when the PC is shut off. Care-givers at remote locations can monitor the exercise classes and review the exercise videos of participants so they can offer them encouragement or tips via net-consultation or video mail.

Sometimes, elderly people or care-givers are not accustomed to PCs. To solve usability problems, the client system starts automatically when the user powers up the client PC. In addition, most operations require only simple button pushing.

Three month trial

To test the effectiveness of the system, we held a three month trial. Trial participants were the attendees of a day-care center, Care Port Yahata, Shizuoka, Japan. The 20 minute classes were held after lunch and each class consisted of exercises that were to be performed while sitting on a chair.

Check-up items were as follows:

1. Measurement of physical fitness:
- grip strength
- balance on one foot (with eyes open)
- walking speed (5 meters)
- knee extension power
- functional reach

2. Interview: iADL according to the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG Index of Competence[3])
- Basic self-sufficiency: the ability to go out by bus or by train alone, buy articles for daily use, prepare a meal, pay bills, deposit and withdraw money
- Intellectual activities: the ability to fill out forms, on a routine basis, read newspapers, read books or magazines, and demonstrate interest in TV programs or news articles on health issues.
- Social role: visit people, offer advice to family and friends, go to see someone in the hospital, speak to younger people.

Results

Outline

Forty seven people (men and women) participated; they were given check-ups before and after the trial. Over the 3 month trial, the average participant used the support system 12.6 times (about once a week).

Results of the measurement of physical fitness

There was a significant improvement in leg strength (knee extension power). Leg strength improved by 30% on average; about 60% of the participants showed some improvement. Fig. 2 shows the results of the measurement.

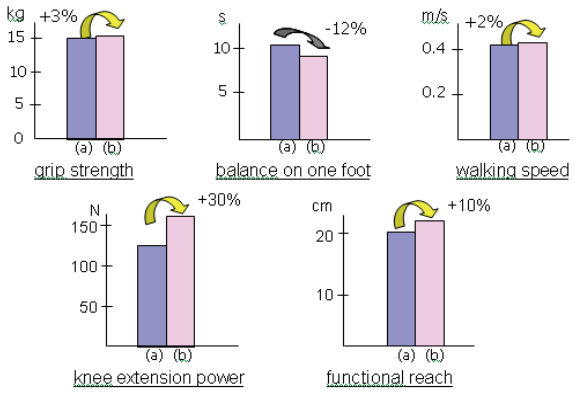

Figure 2 - Results of the measurement of physical fitness

Results of the interview (iADL)

Almost all interview items showed some improvement as shown in Fig. 3; the improvement in intellectual activities was significant at 13%.

3 Koyano W, Shibata H, Nakazato K, Haga H, Suyama Y, "Measurement of competence: reliability and validity of the TMIG Index of Competence." Arch Gerontol Geriatr, 13: 103-116,1991

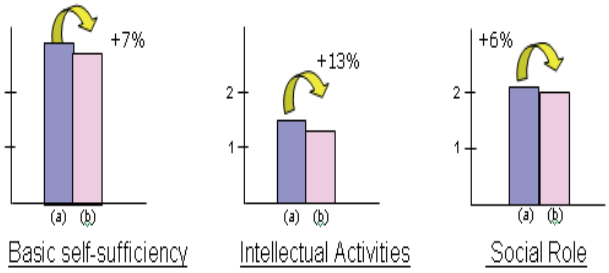

Figure 3 - Results of iADL

Conclusion

While it is hard for the elderly who need nursing care to keep up their strength, the results demonstrated a significant improvement in leg strength and iADL after the three month exercise.

The proposed support system has been proven to be effective for those who need nursing care. It can be expected to not only solve the shortage of preventative-care specialists but also reduce the need for and costs of nursing care.

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The Factors Influencing Intention to Use Ubiquitous Healthcare Services[1]

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Abstract

Through the investigation into the studies of information technology acceptance and human act theory, the factors influencing in using the Ubiquitous Healthcare Service (UHS) are clarified and the relationship of them are empirically verified. As a result of analyzing a total of 760 effective sample groups, Perceived Risk, Perceived Cost, Perceived Usefulness, Perceived Ease of use, Social Influence, and Personal Character have shown to influence noticeably for the UHS Intention to Use. This paper's significance lies in producing a theoretic model must be contemplated while developing a new service. UHS's success is not guaranteed without consideration of social behavioral factors.

Keywords:

healthcare service, ubiquitous, intention to use, perceived risk, TAM, TRA

Introduction

Ubiquitous healthcare that improves the personal health at anytime and anywhere, manages the chronic diseases while forecasting the acute disease is expected to take the core part of the next generation health medical informatization that there are active undertakings of information technology including the infra of national wide projects, development of essential technology and others. Notwithstanding such a social and technological demand, it is true that the health medical informatization has been assessed as relatively vulnerable. There are various analyses for the causes, but one of the main causes has been the neglect of user based approach that reflects the unique characteristics of health medical in the development and accommodation of the new information technology. In fact, it is evident from the fact that there are numerous cases where many costs and hours are invested to realize great medical information system yet to have users and medical staffs turning away from them. With the development of the information technology, the needs of individual change ceaselessly that the core of success is to find out the demand of customers promptly or anticipate in advance providing the system and service accordingly. Therefore, in this study, the analysis is to be made for what factors influence on the socio-behavior point of view as well as the acceptance of the information technology in determining the services provided under the u-healthcare environment in a way of presenting the theoretical foundation in service development later.

Materials and methods

The ubiquitous computing is a new concept advocated by Mark Weiser in his thesis of 1991 that has relatively short history. Most of the study is focused on the technology development basis that the research outcome based on the consumer recognition or behavior is relatively insufficient. Therefore, through the survey analysis process that included the existing studies on the relationship of the e-service use and the attitude or recognition of users, the review on adaptability under the ubiquitous service environment was made. Davis proposed the technology accommodating model to describe the service factors of the information system and as the important factors to use the information technology for users; it presented perceived ease of use and perceived usefulness. Fishbein and Ajzen is the model that describes the relationship among behavior, behavior intention, attitude, subjective norm, and belief, and in this model, the behavior is caused by the behavior intention, and the behavior intention is determined by the attitude factor and social factor. In another study, Dodds and Monroe presented the theoretical model to select the product for users on the basis of the Means-Ends Chain Theory that describe the recognized action of human of Tolman. According to their studies, the concept of value presented by Tolman is defined by the objective evaluation used by users in selecting the product, measured by the perceived value, and influenced by the perceived sacrifice to obtain the desired product of customers for the perceived value, and influenced on the behavior pattern, and it presented the theory for influencing on the willingness to pay. In the meantime, T.M. Lee has proven the influence of the variables in ubiquitous connectivity, contextual offer, perceived usefulness, and perceived ease of use makes the influence on the attempt of accommodating the ubiquitous mobile commerce in his study. There are various advance studies on the perceived risk of users and service use, and according to Bauer who first introduced the concept of risk perception on the user behavior field, the perceived risk is distinguished from the objective and probable risk that it is the risk perceived by

1 Corresponding Author: Nam-Hyun Kim

user under the situations like trademark selection, store selection, purchase method selection and others.

On the basis of the above theoretical contemplation, the model proposed under this study is shown on Figure 1.

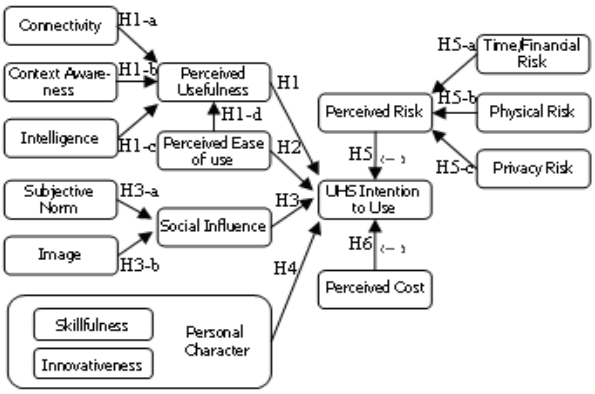

Figure 1- Research model

The questionnaire survey was implemented from Aug. 15, 2006 to Sep. 14 with 789 copies of questionnaires distributed and 784 copies recovered. A total of 760 copies was selected as the final valid sample group, and by using SPSS 12.0, the frequency analysis and factor analysis for reasonableness proof, reliability analysis, and regression analysis for hypothetical proof have been implemented.

Results

For the hypothetical proof of this study, the multiple regression analysis by using the enter method was implemented. This work was undertaken in the total of four stages as follow, and the outcome is specified in the following Table 3.

Table 3 – Outcome of hypothetical proof

Model		Beta	Sig.	Hypothetical proof
1	Context-Intelligence	.099	.000	Selection
	Connectivity	.119	.000	Selection
	Perceived Ease of Use	.639	.000	Selection
*Dependent Variable: Perceived Usefulness				
2	Subjective Norm	.588	.000	Selection
	Image	.254	.000	Selection
*Dependent Variable: Social Influence				
3	Time/Financial Risk	.290	.000	Selection
	Physical Risk	.140	.000	Selection
	Privacy Risk	.744	.000	Selection
*Dependent Variable: Perceived Risk				
4	Perceived Usefulness	.186	.000	Selection
	Perceived Ease of Use	.159	.000	Selection
	Social Influence	.400	.000	Selection
	Personal Character	.374	.000	Selection
	Perceived Risk	-.299	.000	Selection
	Perceived Cost	-.230	.000	Selection
*Dependent Variable: UHS Intention to Use				

Discussion & conclusion

As a result of formulating the factors influencing on the intent for use and its empirical verification for the ubiquitous healthcare service, Perceived Usefulness, Perceived Ease of Use, Social Influence, Personal Character, Perceived Risk, and Perceived Cost have been showing the influence noticeably for the intent of use. Several discussed matters are mentioned herein as follows. First, as a result of fact analysis, the Context Awareness and the Intelligence variable are combined as one variable as Context Awareness-Intelligence. Second, for the Perceived Risk, the influence of private risk was shown to be 74% or higher compared to that of Time/Financial Risk or Physical Risk that there is a high demand and concern on the medical information protection that if these problems are not resolved, it would be a basis of unclear future of the u-healthcare industry. Third, in the willing to accept UHS, the social influence from the people around and others, or the personal character that displays the personal skill of information technology or innovative tendency of individual impact more than the concern on information disclosure or costs, service usefulness, convenience and the like.

This study was undertaken based on the questionnaire survey with the targeting on the UHS yet to be generalized, and it has the innate problems of lack of advanced research outcome, generalized reasonableness of the u-healthcare scenario, level of understanding by the respondents and others. Notwithstanding such problems, the verification of various factors influencing on the intend of use for the UHS would bring the implication in having the research on the point of view of user, and it is expected that this

research outcome will be the useful data for the actual service development and the business strategy for the success in u-health industry.

Acknowledgments

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Developing a Taxonomy to Categorize Patient Falls

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Abstract

A patient fall can result in life-threatening injuries. In order to reduce or mitigate the negative impact of patient falls, a number of risk assessment tools have been developed to identify patients who are likely to sustain a fall. The following study describes the development of the KU Patient Fall Taxonomy. It was derived from four patient fall risk assessment tools. Nine concepts emerged from the fall assessment tools as specific risk factors. Formation of the taxonomy hierarchy is based on Rosch's three-tiered hierarchy of events. The taxonomy will be utilized to systematically analyze patient fall error reports. The taxonomy is the first step in developing an ontology of patient falls.

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Background

- Patient falls in hospitals continues to be a patient safety issue.
- A fall in any setting is a life-threatening event for an older person because of the catastrophic consequences such as fractures or death.
- In an effort to reduce falls, a number of fall risk assessment tools have been developed to prospectively identify patients at risk to sustain a fall.
- Therefore the purpose of this study was to develop a patient fall taxonomy derived from the four risk assessment tools.

Background

Morse Fall Risk, Morse 1985	Fall Risk Assessment Tool (FRAT), Peninsula Health Fall Prevention Service, 1999	Hendrich II Hendrich, Bender, Nyhuis, 2003	STRATIFY, Oliver, Britton, Seed, Martin, Hopper, 1997
History of falling immediate or within the last 3 months	Recent falls	Confusion/ Dis-orientation	Did the patient present to hospital with a fall or has fallen or has she or he fallen on the ward since admission?
Presence of secondary diagnosis	Medications	Depression	Do you think the patient is agitated?
Use of ambulatory aid	Psychological	Altered elimination	Visually impaired to the extent that everyday function is affected?
IV/Heparin lock	Cognitive Status	Dizziness/ vertigo	In need of especially frequent toileting
Gait/ Trans-ferring	Vision	Gender (male)	Transfer and mobility score of 3 or 4?
Mental status	Mobility	Any administered antiepileptics (anti-convulsants)	
	Behaviors	Any prescribed benzo-diazapenes	
	Activities of daily living (A.D.L.) Environment Continence Other	Get-up-and-go Test	

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Methods

- Design: A retrospective analysis of four previously published risk assessment tools.
- Data Analysis: Each criterion was inductively analyzed using line-by-line coding and constant comparison.
  - Data analysis was supported using NVivo.
  - If a new risk concept was identified it was coded and added to the list of categories.
  - The iterative process was carried out until no new risk concepts were identified.

Findings

- Nine concepts emerged from the fall assessment tools as specific risk factors.
- The categories of risk factors are as listed:
  - History of fall
  - Cognitive status
  - Psychological status
  - Medical conditions
  - Medications
  - Body system involvement
  - Personal independence
  - Environmental conditions

KU Patient Fall Taxonomy

Contributing Factors	Risk Factors
History of Falls	Immediate Within last 3 months None Home in last 3 months Fall while an inpatient/resident Fall within last 12 months
Cognitive	Forgets own limitations Intact Mildly impaired Moderately impaired Severely impaired
Psychological	Agitation Depression Confusion Disorientation Decreased cooperation Decreased insight Decreased judgment Difficulty following directions Non compliant
Gender	Male
Medical Conditions	Secondary diagnosis
Medications	IV/heparin lock Type
Body System Involvement	Excretory Musculo-Skeletal Visual impairment Digestive Neurologic
Personal Independence	ADLs Use of ambulatory aid Get up and go out of chair
Environmental	

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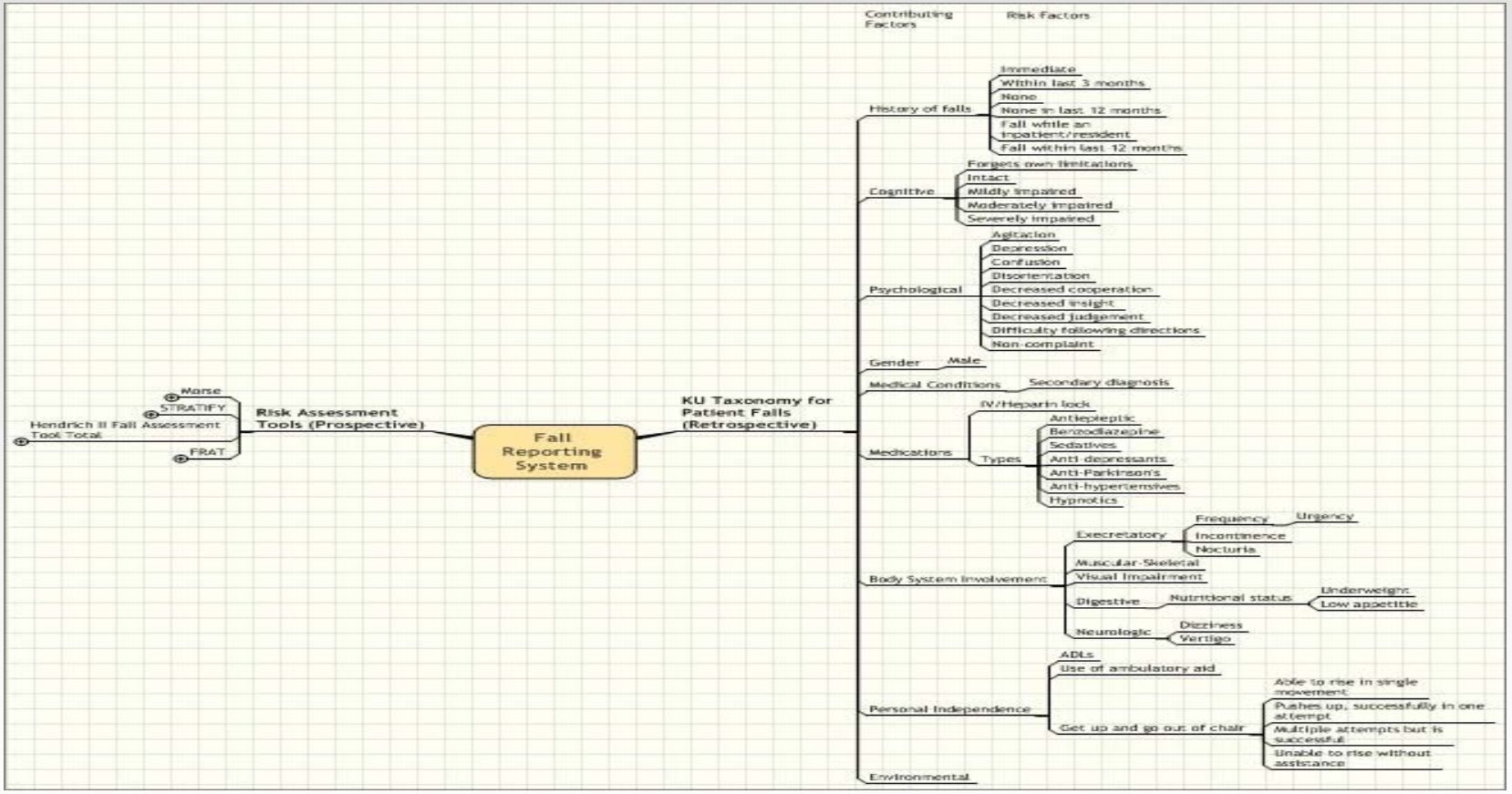
Patient Fall Risk Taxonomy



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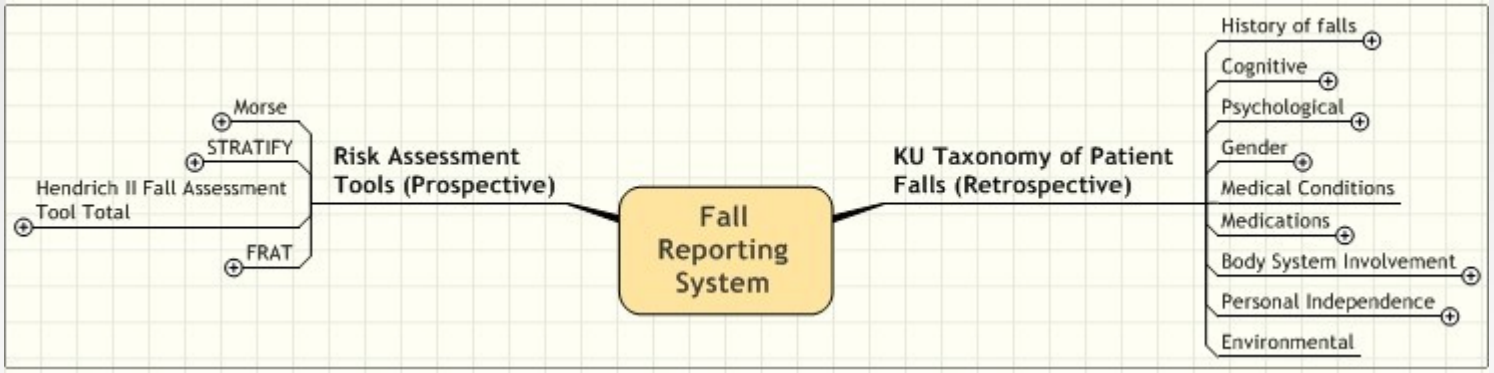
Future Studies: Patient Fall Reporting System



Discussion

- An inductive method of identifying and structuring the risk factors categories into a taxonomy was enhanced using Rosch's hierarchical structure for concepts.
- The hierarchy is a two dimensional structure composed of:
  - a vertical axis which corresponds to the level of abstraction.
  - a horizontal axis depicts the typicality of members represented in the category.

Conclusion

- Nine concepts emerged from the fall assessment tools as specific risk factors.
- The taxonomy is the first step in developing an ontology of patient falls.
- The taxonomy would be utilized to systematically analyze patient fall error reports.

Acknowledgements

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Developing a Taxonomy to Categorize Patient Falls

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Abstract

The KU Patient Fall Taxonomy was derived from four patient fall risk assessment tools. Nine concepts emerged from the fall assessment tools as specific fall risk factors. The taxonomy will be utilized to systematically analyze patient fall error reports.

Keywords:

taxonomy, patient falls, risk assessment

Introduction

Patient falls in hospitals continues to be a patient safety issue. [1] In an effort to reduce falls, a number of fall risk assessment tools such as those in Table 1, have been developed to prospectively identify patients at risk to sustain a fall. [2-5]Each tool is designed to assess a patient and calculate a risk score. Using the risk score, interventions are implemented to reduce or mitigate the likelihood that the patient will experience a fall. In spite of these efforts, falls continue to occur. The purpose of this study was to develop a patient fall taxonomy derived from four risk assessment tools.

Table 1 - Previously published patient fall risk assessment tools

Morse Fall Risk, Morse 1985	Fall Risk Assessment Tool (FRAT), Peninsula Health Fall Prevention Service, 1999	Hendrich II Hendrich, Bender, Nyhuis, 2003	STRATIFY, Oliver, Britton, Seed, Martin, Hopper, 1997
History of falling immediate or within the last 3 months	Recent falls	Confusion/ Dis-orientation	Did the patient present to hospital with a fall or has fallen or has she or he fallen on the ward since admission?
Presence of secondary diagnosis	Medications	Depression	Do you think the patient is agitated?
Use of ambulatory aid	Psychological	Altered elimination	Visually impaired to the extent that everyday function is affected?
IV/Heparin lock	Cognitive Status	Dizziness/ vertigo	In need of especially frequent toileting
Gait/ Transferring	Vision	Gender (male)	Transfer and mobility score of 3 or 4?
Mental status	Mobility	Any administered antiepileptics (anticonvulsants)	
	Behaviors	Any prescribed benzodiazapenes	
	Activities of daily living (A.D.L.)	Get-up-and-go Test	
	Environment		
	Continence		
	Other		

Methods

Design A retrospective analysis of four previously published risk assessment tools using techniques of line-by-line coding and constant comparison. [6]

Findings

Nine concepts emerged from the fall risk assessment tools. The concepts were arranged as categories using Rosch's three-tiered hierarchical structure for concepts (Fig 2).[7]

Figure 2 – KU Patient Fall Taxonomy

Contributing Factors	Risk Factors
History of Falls	Immediate
	Within last 3 months
	None
	Home in last 3 months
	Fall while an inpatient/resident
	Fall within last 12 months
Cognitive	Forgets own limitations
	Intact
	Mildly impaired
	Moderately impaired
	Severely impaired
Psychological	Agitation
	Depression
	Confusion
	Disorientation
	Decreased cooperation
	Decreased insight
	Decreased judgment
	Difficulty following directions
	Non compliant
Gender	Male
Medical Conditions	Secondary diagnosis
Medications	IV/heparin lock
	Type
Body System Involvement	Excretory
	Musculo-Skeletal
	Visual impairment
	Digestive
	Neurologic
Personal Independence	ADLs
	Use of ambulatory aid
	Get up and go out of chair
Environmental	

Discussion

An inductive method of identifying and structuring the risk factors categories into a taxonomy was enhanced using Rosch's hierarchical structure for concepts. The hierarchy is a two dimensional structure composed of a vertical and a horizontal axis. The vertical axis corresponds to the level of abstraction. The horizontal axis corresponds to the typicality of members represented in the category.

Conclusion

The KU Patient Fall Taxonomy was derived and grounded in the risk assessment tools. The taxonomy provides a consistent set of categories and attributes by which will be used in future research to retrospectively code patient fall error reports.

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Initiators of Interruption in Workflow: The Role of MDs and RNs

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Abstract

The healthcare environment has been characterized as interrupt-driven with medical doctors (MDs) and registered nurses (RNs) receiving many interruptions during a shift. Previous research studies have focused on the recipient because of the negative impact on task performance. It is equally important to understand the initiator of an interruption to help design strategies to lessen the number of interruptions and the possible negatives consequences. The purpose of this instrumental study was to examine MDs and RNs as initiators of interruptions. Results of this study indicate that MDs and RNs initiate interruptions most often through face-to-face situations and use of the telephone. Strategies to successfully manage interruptions must consider both the role of initiator as well as the recipient in an interruption event.

Keywords:

Interruption, workflow, emergency medicine

Introduction

The healthcare environment has been characterized as interrupt-driven. An interruption is defined as a break in the performance of a human activity initiated by a source internal or external to the recipient, with occurrence situated within the context of a setting or a location. This break results in the suspension of the initial task by initiating the performance of an unplanned task with the assumption that the initial task will be resumed. [1] Medical doctors (MDs) and registered nurses (RNs) are the recipients of many interruptions during a shift resulting from face-to-face conversations with co-workers, telephone calls, email messages, and alarms and alerts from medical devices. These examples depict a role-based event between a recipient and an initiator. The recipient takes the role of accepting the interruption. Consequently, the recipient is affected by the interruption event because of the unexpected intrusion of a secondary task. For that reason, research studies in healthcare have examined the role of recipient because of the negative impact on task performance. [2-6] Moreover, the Joint Commission for Accreditation of Healthcare Organizations (JCAHO) [7-9], the Institutes of Medicine (IOM) [10, 11] and Morbidity and Mortality [12] report that interruptions contribute to preventable medical errors. It is equally important to understand the role of the initiator.

The initiator has the role of originating the interruption in workflow. Hence, they play an active role in the event. Moreover, the successful delivery of an interruption entails that the initiator forms the intent to interrupt and that the interruption be announced by some physical signal. That physical signal must pass a threshold test of detection by the recipient's sensory system so that the recipient is stimulated to respond to the initiator. Therefore, a successful interruption depends on the detection and acceptance of the impending interruption task by the recipient. [1]

A review of the literature found a limited number of studies that considered the role of initiator in an interruption event. [3, 4, 13, 14] Coiera and Tombs categorized a communication event as either sent or received for nine different MD and RN clinical roles. Findings from the study showed RNs initiated more paging and telephone calls than they received. In contrast, MDs initiated almost all communication events using the telephone. Medical doctors designated as house officers initiated more telephone calls when compared to consultants, senior registrars, or senior house officers. Specifically in the ED, Spencer and Logan categorized a communication event as sent or received by the MDs and RNs. [3] The MDs were classified as either registrars or junior medical officers. Registered nurses were categorized as either coordinators or having a patient load. [15] This study is limited to attending MDs and staff RNs. Therefore, the purpose of this instrumental study was to examine the role of MDs and RNs working in a level one trauma center as initiators of interruptions. An understanding of the initiator will help in the design of strategies to reduce or mitigate the negative outcomes of interruptions.

Methods

Study Design: The design was an instrumental case study. An instrumental case study is used to gain an in-depth understanding of a phenomenon as well as to generalize from an observational, inductive approach. [16]

Subjects: A convenience sample of MDs and RNs in a level one trauma center. Participation was voluntary and written consent and community consent was obtained.

Setting: All observations were made in the trauma section of a large teaching hospital. The hospital is part of a major medical center located in the Gulf Coast region of the United States of America (USA). The Emergency Department occupies 51,000 square feet (4738 square meters) and contains major trauma and cardiac resuscitation rooms. Annually, the organization provides care to approximately 52,000 patients.

Study Protocol: The MDs and RNs were shadowed with observations being recorded on a minute-by-minute basis using an automated semi-structured field note form.

Data Collection: Observers typically worked in teams of two and recorded their observations using a semi-structured field note form implemented on Tablet PCs. Subjects were shadowed for a minimum of 2 hours but not more than 12 hours. Recording of observations began when the subject had completed the informed consent. Observations were recorded on a minute-by-minute basis.

Data Analysis: Data analysis of the field notes was supported using NVivo© [17] and MacSHAPA [18].
The data was analyzed using the Hybrid Method to Categorize Interruptions and Activities (HyMCIA). [19] HyMCIA was developed through the hybridization of a deductive *a priori* classification framework with the provision of adding new categories discovered inductively in the data using grounded theory [20]. Two coders analyzed the data for agreement of tasks and interruptions. A percent agreement score was calculated.

Results

Demographics: Five attending trauma physicians were observed for a total of 29 hours, 31 minutes. The physicians were pre-selected based on scheduling and a willingness to participate. Observations were made on either the 0700–1500 or the 1500-2300 shift. These shifts were selected because they were known to be periods of time characterized as high activity.

Eight RNs were shadowed for a total of 40 hours 9 minutes. Observations were made on either the 0700–1500 or the 1500-2300 shift. The charge nurse for the shift preselected which subject would participate in the observation and the willingness of the subject to participate.

Roles in the interruption event: The major roles of initiator and recipient of an interruption emerged during categorization of the field notes. The following examples are taken from the coded field notes:

Initiator – RN initiates a telephone call.

Initiator Blocked – RN initiates a telephone call but no answer.

Initiator Delayed – RN initiates a telephone call and put on hold.

Intended Recipient – MD paged for new trauma patient

Indirect Recipient – MD talking with resident when resident is interrupted to speak with the RN.

Unintended Recipient – MD answers telephone but call is for the RN.

Recipient Delayed – Nurse practitioner waits until MD acknowledges her to receive report for a patient.

Recipient Blocked – RN waits to talk with MD but leaves after a few minutes. MD did not acknowledge.

The precise roles that were identified within the categories are shown in Table 1.

Table 1 - A Role-Based Taxonomy of Interruption

Initiator	Recipient
Initiator – a person who initiates an interruption	**Intended Recipient** - the person to be interrupted
Initiator Blocked - the initiator is blocked from initiating an interruption	**Indirect Recipient** – the incidental recipient of an interruption; i.e., talking with another in conversation when the intended recipient suspends the original activity
Initiator Delayed – the initiator is delayed in initiating an interruption	**Unintended Recipient** - not the intended recipient of an interruption; i.e., receiving a phone call that was incorrectly dialed
	Recipient Delayed – the intended recipient postpones an interruption
	Recipient Blocked – the intended recipient does not accept the interruption

As each new category was identified from the field notes, all previously coded data was reviewed. If an instance of the new category was identified the observation was coded

to the new category. This iterative process ensured that all observations recorded in the field notes were accurately coded. These categories formed a role-based taxonomy of interruptions derived from the data.

Medical doctors initiated 2.1 interruptions per hour. However, as the recipient of an interruption, MDs were found to have 25.19% of all activities interrupted. Consequently, MDs received 10.58 interruptions per hours. As shown in Figure 1, MDs were more likely to be the recipient of an interruption compared to the initiator.

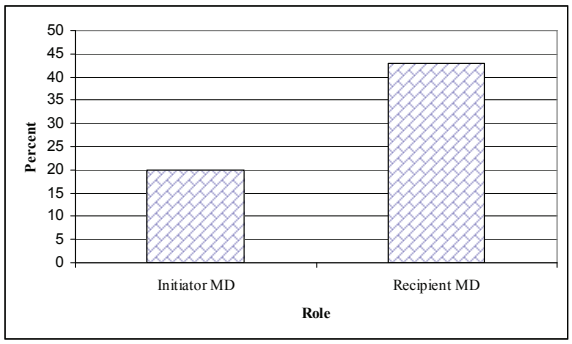

Figure 1 - Role for MDs in the interruption event

Similarly, RNs were more likely to be the recipient of an interruption rather than the initiator as reported in Figure 2.

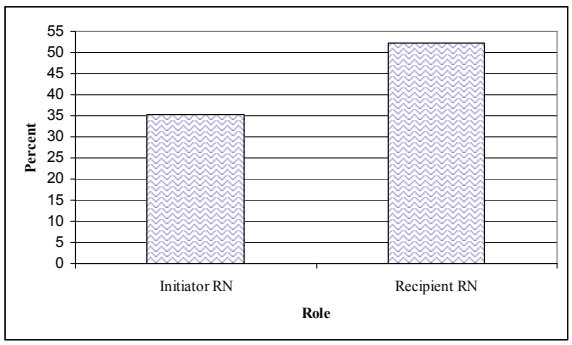

Figure 2 - Role for RNs the interruption event

In contrast, 16.45% of all RN activities were interrupted. What's more, RNs were interrupted at a rate of 11.65 per hour. When compared to MDs, RNs were more likely to initiate an interruption. This could be attributed to difference in role responsibilities. For instance, RNs may initiate an interruption to give report to another nurse when transferring a patient to another unit or when requesting a physician assess a patient because of a change in condition.

Analysis of the field notes indicated that MDs and RNs most often used face-to-face encounters to initiate an interruption. The telephone was also used as a medium to deliver an interruption. Mobile telephones were used by MDs in addition to traditional land-line telephones. Mobile telephones were not available for use by staff RNs. Therefore, RNs used only land-line telephones to initiate an interruption.

Discussion

This study systematically identified and studied the role of initiator for MDs and RNs in an interruption event. Findings from this study indicate that MDs initiated an interruption less often than receiving an interruption. Similarly, RNs took the role as initiator of an interruption less often than that of recipient. However, both MDs and RNs most often initiated an interruption as a communication event in a face-to-face encounter. The telephone was found to be the second most often used medium through which to deliver an interruption. Telephones included both land-line and mobile telephones.

It should be understood that some interruptions are necessary in the ED to deliver critical information to the MD or RN via technology. Moreover, the initiator needs to know when and how to deliver the interruption to lessen the negative impact on task performance for the recipient. This is an emerging challenge as mobile technology such as mobile telephones and personal digital assistants (PDAs) become more common in the ED. In a recent study, mobile telephones were reported as improving patient safety through the rapid delivery of communication between MDs. [21] However, the study did not report how the delivery of information via a mobile telephone interrupted the recipient's workflow.

The initiation of interruptions is not limited to mobile technologies. Real-time clinical notification systems can initiate interruptions for the MD or RN. Delivery of a notification such as a laboratory value is initiated by set of rules. Once a threshold is met the rule fires and the notification is sent regardless of the recipient's workload.

The recipient of an interruption has few choices in how to manage the instant accessibility as mobile technologies may have few features to delay receiving the interruption as opposed to older technologies such as pagers and land-line telephones. The mobile telephone lacks a voice mail feature which would allow the recipient to delay the interrupting telephone call. With a pager, the recipient page did not need to need to immediately attend to the page message as it was stored in memory of the devices. A clerical person is usually designated to answer the land-line telephone. This person could intercept the interruption by taking a message or possibly provide information to the initiator of the call. In this study only MDs had mobile telephones in contrast the RNs did not. However, as mobile technology comes into widespread use in the clini-

cal setting, there will be a need to study the roles of initiator and recipient in the interruption event.

Research is needed to understand how the new types of interruptions change workflow for MDs and RNs. It is imperative that future research studies identify the types and consequences of interruptions introduced by technology. It is suggested the role based taxonomy presented in this paper be used to classify interruptions in future studies. Findings from the studies can be used to design strategies to mitigate or decrease the negative effects of interruptions must consider the role of the initiator.

Conclusion

A role-based taxonomy of interruption was derived from the recorded field notes using grounded theory. The categories within the taxonomy show that MDs and RNs initiate interruptions as well as receive them.

This study suggests the need to develop strategies to decrease or mitigate the negative effects of interruptions and must consider the interaction between the initiator and the recipient of an interruption. Failure to consider why the interruption was initiated will lead to the formulation of ineffective strategies to manage interruptions. The introduction and use of technology in the clinical setting to manage interruptions must be critically evaluated so that MDs and RNs do not initiate unnecessary interruptions.

Acknowledgement

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Initiators of Interruption in Workflow: The Role of MDs and RNs

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Abstract

The healthcare environment has been characterized as interrupt-driven with medical doctors (MDs) and registered nurses (RNs) receiving many interruptions during a shift. Previous research studies have focused on the recipient because of the negative impact on task performance. It is equally important to understand the initiator of an interruption to help design strategies to lessen the number and the possible negatives effects of interruptions. The purpose of this instrumental study was to examine MDs and RNs as initiators of interruptions. Results of this study indicate that MDs and RNs initiate interruptions most often through face-to-face situations and the telephone. Strategies to successfully manage interruptions must consider both the role of initiator as well as the recipient in an interruption event.

Background

- The healthcare environment has been characterized as interrupt-driven.
- MDs and RNs are the recipients of interruptions through:
    - face-to-face conversations
    - with co-workers
    - telephone calls
    - email messages
    - alarms and alerts from medical devices.
- Research studies have examined the role of recipient because of the negative impact on task performance.

Purpose

- To examine the role of MDs and RNs working in a level one trauma center as initiators of interruptions.

Methods

- Study Design: The design was an instrumental case study.
  - An instrumental case study is an inductive approach used to gain an in-depth understanding of a phenomenon.
- Subjects: A convenience sample of MDs and RNs.
  - Participation was voluntary.
  - Written consent and community consent was obtained.
- Setting: All observations were made in the trauma section of a large urban teaching hospital.
- Study Protocol: The MDs and RNs were shadowed with observations being recorded on a minute-by-minute basis.
  - Observations automated using a semi-structured field note.

Methods

- Data Analysis: Data analysis of the field notes was supported using NVivo© and MacSHAPA.
- The data was analyzed using the Hybrid Method to Categorize Interruptions and Activities (HyMCIA).
  - HyMCIA was developed through the hybridization of a deductive *a priori* classification framework with the provision of adding new categories discovered inductively in the data using grounded theory.
- Two coders analyzed the data for agreement of tasks and interruptions. A percent agreement score was calculated.

Methods

- Data Collection: Observers typically worked in teams of two and recorded their observations using a semi-structured field note form implemented on Tablet PCs.
- Subjects were shadowed for a minimum of 2 hours but not more than 12 hours.
- Recording of observations began when the subject had completed the informed consent.
- Observations were recorded on a minute-by-minute basis.

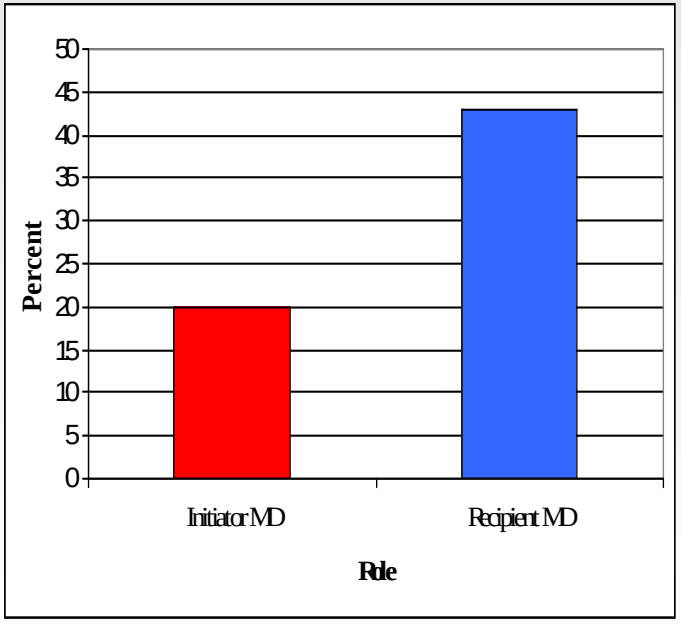
Findings

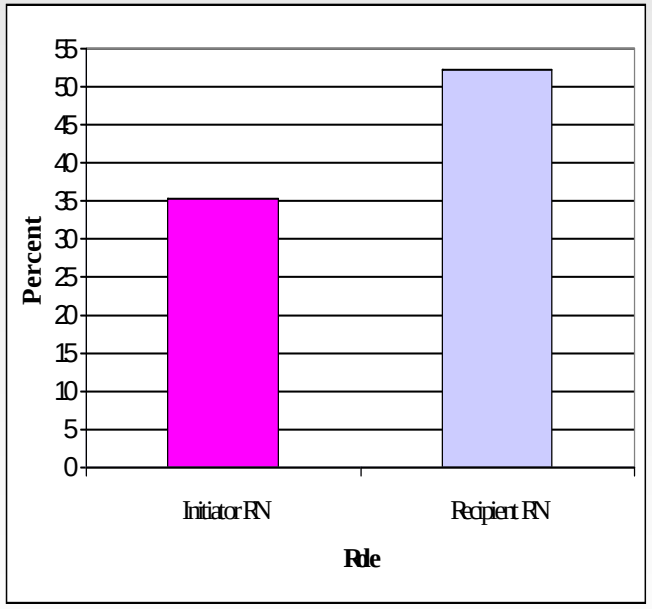
- Five attending trauma physicians were observed for a total of 29 hours, 31 minutes.

- Eight RNs were shadowed for a total of 40 hours, 9 minutes.

Findings

Initiators and Recipients of an Interruption





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Findings

A Role Based Taxonomy of Interruption

Initiator	Recipient
Initiator – a person who initiates an interruption	Intended Recipient - the person to be interrupted
Initiator Blocked - the initiator is blocked from initiating an interruption	Indirect Recipient – the incidental recipient of an interruption; i.e., talking with another which conversation suspends the original activity
Initiator Delayed – the initiator is delayed in initiating an interruption	Unintended Recipient - not the intended recipient of an interruption; i.e., receiving a phone call that was incorrectly dialed
	Recipient Delayed – the intended recipient postpones an interruption
	Recipient Blocked – the intended recipient does not accept the interruption

Conclusions

- These results show that MDs and RNs both initiate and receive interruptions.
- The development of strategies to decrease or mitigate the negative effects of interruptions requires a better understanding of why the interruption was initiated.
- Failure to consider why the interruption was initiated will lead to the formulation of ineffective strategies to manage interruptions.
- The introduction and use of technology in the clinical setting to manage interruptions must be critically evaluated so that MDs and RNs do not initiate more interruptions.

Acknowledgement

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Identifying Potential Human Errors in the Medication Label Reading Process using FMEA

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Abstract

Poor labelling is a contributing factor of medication errors. To predict potential human errors in the process of reading the container labels for injectable medications, Failure Mode and Effects Analysis (FMEA) was applied to the label reading process. The implementation of FMEA involved various challenges including difficulties in representing a context-sensitive process, defining the failure modes, their causes and effects and developing rating scales for criticality. The identified failure modes were rated via a focus group of healthcare professionals. The results of the FMEA will be applied to improve existing label designs to prevent potential medication errors that may result from human errors in the label reading process.

Keywords:

medication errors, drug labelling, risk assessment, FMEA

Introduction

Medication errors leading to harm are a significant cause of adverse medical events [1, 2]. Poor labelling of injectable medications can be a contributing factor to medication errors. According to a survey of 687 anesthetologists in Canada, the misidentification of the drug ampoule or vial was cited as one of the most common causes of medication error (46.8%) [3]. To identify potential human errors that can arise in the label reading process, their causes, their effects and possible interventions, modified process Failure Mode and Effects Analysis (FMEA) was applied to the label reading process. FMEA is a proactive technique designed for predicting potential system failures, their causes and effects for developing mediations to prevent the failures.

Methodology

The research team consisted of a pharmacist, a nurse/ human factors psychologist, a human factors engineer, and a graduate student in human factors engineering.

The FMEA methodology developed by the Institute for Safe Medication Practices Canada (ISMP Canada), for use in healthcare, was selected as the basic framework. First, the label reading process was defined and flowcharted. There is no single established procedure for optimal reading of labels by healthcare professionals, and the process is fluid depending on the context. Therefore, an "ideal" label reading process was developed in consultation with practicing nurses. Secondly, the research team identified failure modes and their effects. The failure modes were defined as any failure in the human user's perception/cognition when reading the labels, and their effects were defined as potential types of medication errors that could result from the failure modes. Plausible causes of the failure modes were then identified with a focus on the users and existing label designs. To prioritize the failure modes, the failure modes were ranked by a focus group of 9 healthcare professionals: 6 pharmacists, 1 registered nurse, 1 educator in medication safety and 1 administrative staff in healthcare. The failure modes were rated in terms of their severity, frequency, and detectability, the rating scales for which were derived by integrating the rating scales from the Health Care Failure Mode and Effects Analysis [4] and a medication error category index [5]. For each failure mode, the median value of each type of the criticality ratings was calculated from the aggregated participant results. The three median values were multiplied together to derive a Risk Priority Number (RPN) value for each failure mode. The higher the RPN value, the more critical is the failure mode.

Results and discussion

A total of 24 failure modes were identified for the label reading process. The criticality ratings from two participants were excluded from the analysis; one pharmacist's ratings were incomplete, and the administrative staff's expertise was inadequate for the purposes of the study. The criticality ratings from the remaining 7 participants yielded RPN values ranging from 12 to 45 with an average of 30.

The process of reading the drug brand name, common name, concentration, total amount of drug ingredient per total volume and route of administration had associated failure modes with relatively high RPN values (30 or

higher) as shown in Table 1. The standard for Labelling of Drug Ampoules, Vials, and prefilled syringes developed

Table 1 – Failure modes with RPN values of 30 or higher

Failure Mode Description	RPN
User misperceives the brand name of a wrong drug as the common name of the correct drug.	45
User misperceives a different common name as the correct common name.	45
User misperceives the concentration as the total amount of the drug ingredient or vice versa.	45
User misperceives the values of the concentration/ total amount of the drug ingredient.	45
User does not read the route of administration.	45
User does not read the common name.	36
User does not read the multi-dose information.	36
User does not read the formulation type.	36
User does not read non-medicinal ingredient	36
User cannot read the concentration or the total amount of the drug ingredient.	30
User cannot read the route of administration.	30

by the Canadian Standards Association International defines the first three items as 'critical information', and a large portion of the standard is devoted to ensuring the legibility of these label contents [6]. Although not defined as critical information in the standard, route of administration is important for injectable drug use. Medication errors involving wrong route of administration were found to be the second-highest type of medication errors causing harm in the USP MEDMARX analysis of reported medication errors in 2003.[7].

In general, the participants found it difficult to rate the failure modes without a specific scenario. The detectability of failure modes, in particular, is highly dependant on the stage in the medication use process (e.g. dispensing, administration) where the failure mode occurs.

Conclusion

Applying FMEA to predict potential human errors in the process for reading the container labels for injectable pharmaceuticals required the use of a combination of several existing FMEA frameworks. Defining the failure modes, their causes and their effects was challenged by the cognitive/perceptual nature of the reading process and the fact that it is only a small link in the complex chain of events in the medication delivery process. Nevertheless, the criticality ratings of the failure modes collected via a focus group of healthcare professionals identified contents on the label that are important to end users in order to safely deliver medication to patients. The results of the analysis are being applied to improve existing label designs as interventions to reduce the likelihood of medication errors that may result from the identified critical human errors.

Acknowledgement

This study is funded by the Canadian Patient Safety Institute. We would like to thank Professor John Senders, members of ISMP Canada and the nurses at the University of Ottawa Heart Institute for their valuable time and expertise.

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Medication Errors

- Drug complications are the most common single type of adverse medical events [1]

- Adverse drug events are estimated to cost a teaching hospital in the U.S. **$5.6 million** annually [2]

Poor labelling – a contributing factor

- Cited by **33%** of the medication errors reported to the United States Pharmacopoeia (USP) from 1996 to 1997 [3]

- A standard for Labelling of Drug Ampoules, Vials, and Pre-filled Syringes developed by the Canadian Standards Association International to address poor labelling issues [4]

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Objectives

- Identify potential human errors in the process of reading the container labels for injectable pharmaceuticals
- Prioritize potential failures in terms of their criticality
- Address critical failures by redesigning existing labels

Method - FMEA

- Prospective analysis technique to identify and avoid potential failures from a system or a product
- A reliability engineering technique
- Becoming widely accepted in healthcare

Method

1. Define & flowchart the label reading process
2. Brainstorm for potential failure modes and their effects.
3. Identify causes of failure modes.
4. Rate & prioritize the failure modes
5. Develop mediations for failures modes with high priority.

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Results

- 24 failure modes identified
- Severity, frequency, and detectability ratings for each failure mode from a focus group of healthcare professionals
- Risk Priority Number (RPN) values derived from the criticality ratings

Results

Table 1: Failure modes with the highest RPN value

Failure Mode Description	RPN
User misperceives the brand name of a wrong drug as the common name of the correct drug.	45
User misperceives a different common name as the correct common name.	45
User misperceives the concentration as the total amount of the drug ingredient or vice versa.	45
User misperceives the values of the concentration/ total amount of the drug ingredient.	45
User does not read the route of administration.	45

Discussion

Label contents related to high RPN values

- Brand name
- Common name
- Concentration & total amount of drug ingredient

Defined as critical information in the CSA Standard [4]

- Route of administration → **Critical for proper administration**

Discussion

Challenges with applying FMEA

- Difficulties in
  - representing a context-sensitive process
  - defining the failure modes, and their causes & effects
- Customized rating scales developed from an existing FMEA framework & a medication error category index

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Conclusions

- Applying FMEA to a cognitive/perceptual process such as the label reading process can be challenging
- Identified the label contents for injectable pharmaceuticals that are important to the end users
- Results being applied to improve existing label designs.

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Examining Senior Residents' Willingness to Adopt Smart Home Sensor Technologies

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Abstract

The goal of meeting the desire of older adults to remain independent in their home setting while controlling health care costs has led to the conceptualization of "smart homes." A smart home is a residence equipped with technology that enhances safety of residents and monitors their health conditions. The study aim is to assess older adults' perceptions of specific smart home technologies (i.e., a bed sensor, gait monitor, stove sensor, motion sensor, and video sensor). The study setting is TigerPlace, a retirement community designed according to the Aging in Place model. Three focus group sessions with 14 participants were conducted to assess perceived advantages and concerns associated with specific applications, and preferences for recipients of sensor-generated information pertaining to residents' activity levels, sleep patterns and potential emergencies. The findings indicate an overall positive attitude towards sensor technologies for non-obtrusive monitoring. However, specific concerns about privacy and usability were also raised.

Keywords:

home care services, frail elderly, telemedicine, telemetry

Introduction

The ongoing growth of the elderly population and increase in life expectancy have led to new models of positive aging, empowering older adults to longer maintain functionality, autonomy and higher quality of life. Independence is a critical issue for many older adults as they age and face health-related challenges such as falls, sensory impairment, immobility, and isolation. The twin goals of meeting the desire of older adults to remain independent in the home setting while controlling health care costs has led to the conceptualization of "smart homes." A smart home is a residence equipped with technology that enhances safety of patients at home and monitors their health conditions.

Worldwide, smart home initiatives are demonstrating the potential of technology to support aging. The Aware Home developed by Georgia Tech in the US, for example, is a project developed in two identical independent living spaces that allow for controlled experiments with technology and enable inhabitants to live on one floor while demonstrating prototypes of assistive technologies on the other floor[1]. In Sweden, the SmartBo project explores technology for elders with mobility impairments and cognitive disabilities, such as dementia and developmental disability. Devices and sensors are tested that control lighting, windows, doors, locks, water outlets, electrical power, and stoves. The project also explores visual and tactile signaling devices, speech synthesizers, and Braille displays[2]. The PROSAFE project in France utilizes devices and infrared sensors to identify abnormal behavior that can be interpreted as an accident and to collect representative data on Alzheimer's patients' nocturnal and daily activity[3]. The "Hospital Without Walls" in Australia is a project that includes a wireless fall monitoring system in which patients at home wear small sensors that measure heart rate and body movement[4].

The study presented here is part of the TigerPlace project. This project is facilitated by the framework of Aging in Place, a new model of long-term care for older adults[5]. This model aims to allow older adults to age in the least restrictive environment of their choice. Clients' needs determine the timing and intensity of health and personal care services, delivered to them in their residence. Unlike the traditional continuum of care model, where clients move to progressively more intensive health care settings, in the aging in place model the health system organizes delivery of services to the client in his or her residence. Home health, community-based clinics, and other health system services allow clients to 'age in place.' A demonstration site of this model is Tiger Place, a 34,000 square foot facility in Columbia, Missouri, developed by the University of Missouri-Columbia with Americare Systems, Inc., of Sikeston, Missouri. TigerPlace opened in Spring 2004 and includes 32 apartments. Emphasis has been placed on a state of the art building and apartment design that supports independence, therefore helping residents to age at home and not in a nursing facility[6]. This paper is a part of a larger investigation of the use of smart home technologies in this setting as tools that can support the Aging in Place model. The focus of the larger project within TigerPlace is to investigate the use of sensors to monitor and assess potential problems in mobility and cognition of elders in their home. The emphasis is on sensing alert con-

ditions such as falls, and changes in daily patterns that may indicate problems. The components of the system include an in-home monitoring system, an event-driven anonymized video-sensor network, and a component for activity analysis and behavior reasoning.

The In-Home Monitoring System (IMS)[7] consists of a set of wireless infrared proximity sensors that detect motion, and pressure switch pads (sensor mats) that can be used to infer specific activities. Furthermore, a stove temperature sensor and switches on cabinet doors are being used. The system is also augmented with a bed sensor capable of detecting presence, respiration (normal/ abnormal), pulse (low, normal or high) and movement in the bed. Finally, the system includes a passive gait monitor that relies on a highly sensitive displacement sensor which can detect small deflections in the floor induced by a person walking up to ten feet away from the sensor on both carpeted and uncarpeted wooden and concrete floors. The gait monitor processes the raw vibration signal and extracts features of significance. It also provides basic gait characteristics by analyzing the extracted data[8].

The event-driven anonymized video sensor network complements the IMS as the visual information helps reduce false alarms generated by the motion sensor or gait monitor. In order preserve the privacy of the residents, algorithms are used to identify a person in the image and extract a silhouette[9] and inanimate objects are tracked that are manipulated by the residents.

The final component of the system is an activity analysis and behavioral reasoning system that distinguishes a typical pattern for an individual from an abnormal pattern. In this context, we are investigating Hidden Markov Models (HMMs) for learning and recognizing short-term activity patterns. The output of each Activity Analysis process is a descriptor or a set of descriptors that report the likelihood of an activity.

In previous work[10], the research team investigated older adults' attitudes and perceptions of smart home technologies in general, asking older adults in the community (not TigerPlace residents) to identify what activities of daily living could be enhanced by technology; what types of technologies they were familiar with; and what technologies they would be willing to accept. This work indicated that older adults were concerned about falls and that they perceived technologies that monitor activity levels and sleep patterns as useful. They emphasized the need for non-obtrusive systems. This work informed the design of specific technologies that were chosen to be installed in the TigerPlace apartments.

The study presented here is a follow-up of this previous work and is aimed at investigating the following: older adults' perceptions of the specific smart home technologies employed by the TigerPlace project (i.e., a bed sensor, gait monitor, stove sensor, motion sensor, and video sensor); perceived advantages and concerns associated with these types of technology; willingness to adopt such technologies in their own residence; and preferences about recipients of sensor-generated information pertaining to their activity levels, sleep patterns and potential emergencies. This study provides insight into older adults' attitudes towards specific sensor technologies and captures the level of willingness to allow installation of such technologies and to share associated personal data with other stakeholders.

Materials and methods

We conducted a series of focus group sessions to assess older adults' perceptions and expectations of specific smart home technologies, including perceived advantages and disadvantages and degree of willingness to adopt such technologies in their homes. The sessions were facilitated by members of the research team and followed facilitation guidelines for focus groups by Krueger[11]. Special considerations for elderly focus group participants as suggested by Barrett and Kirk[12] were followed. In order to avoid fatiguing participants and conflicts with their usual activities, the sessions were scheduled to last approximately one hour. At the beginning of each session, the facilitator introduced the purpose of the study. The sessions were audiotaped for later analysis by team members. We used purposeful sampling in the recruitment of focus group participants. An invitation to participate was placed in residents' individual mailboxes and posted at several locations within TigerPlace.

The focus group protocol included questions about participants' perceptions of the usefulness of specific devices and sensors. These included a bed sensor, a motion sensor, a gait monitor developed by the University of Virginia, a kitchen sensor and a video based fall detection sensor. Table 1 depicts examples of these sensors and describes their intended use and Table 2 depicts the gait monitor and describes its use. For each sensor the facilitator explained briefly its purpose by describing its function and providing an example of usage. The facilitator showed and passed around the actual sensors, allowing participants to touch and directly observe the devices. The examples used by the facilitators were chosen to increase understanding as recognition, comprehension and memory for information in older people have been shown to benefit from prior context cues[13]. Questions pertained to perceived advantages and disadvantages associated with the usage of such systems, participants' willingness to allow installation in their residence, and opinions about who should be receive the data produced by the sensors.

In order to ensure the protocol's validity, the questions were reviewed by a team consisting of researchers experienced in instrument development and knowledgeable about health care providers. The protocol was also pilot-tested for readability with a senior resident in a different facility following Krueger's recommendation to test the wording of questions with people similar to the target participants[11].

The audiotapes were transcribed and a content analysis was performed. The content analysis was data-driven; thus, a pre-determined coding scheme was not used for coding the data[14]. Data codes were inductively generated by the data collected. The goal of the qualitative content analysis was to summarize the information gleaned from the analyses of the content. Analyses were performed by assigned members of the research team and consensus in interpretations was achieved through discussion between these members. The validity of interpretations was then discussed and agreed upon with other members of the research team[15].

Table 1 - Assistive Technologies used in this study

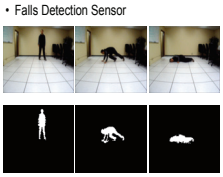
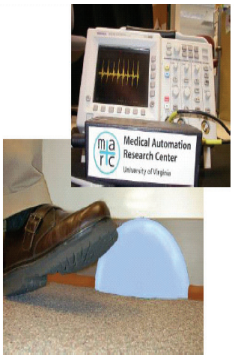
Type of Technology	Description/ Intended Use
Bed sensor 	Bed sensors are designed to monitor heart rate, respiration, and restlessness and compare readings with personal norms.
Kitchen sensor 	Kitchen or stove top sensors are designed to detect when a stove burner has been left on accidentally when no one is present in the kitchen. This sensor combines a heat sensor with a motion sensor
Motion sensor 	Motion sensors are designed to detect motion within a room. One potential use could be detecting increases in nocturnal trips to the bathroom.
Video sensor (Fall detection) 	Video-based fall detection sensors are designed to recognized different patterns of resident movement including walking, falling down, staying down and getting up. These patterns are recognized from residents' silhouettes. Messages sent from these sensors do not contain image data.

Table 2 - The Gait Monitor

Gait monitor 	The Medical Automation Research Center (MARC), at the University of Virginia developed a passive Gait Monitoring Device that comprises a highly sensitive and selective sensor technology that is capable of measuring footfalls on the floor. The sensor's output signal creates a unique signature based in part on the individual's weight, gait, stride and average pace. Analysis and comparison of gait patterns can be made over time.

Results

A total of 14 older adults over the age of 65 participated in three focus group sessions (4 in the first, 3 in the second, and 7 in the third session). Each session lasted approximately one hour (the average length was 64 minutes). Five participants were male and nine were female. All participants were older than 65 years of age.

The bed sensor was perceived overall as useful. Two participants asked questions about the installation on top of the mattress. One participant stated that she relied on her spouse to detect restlessness or problems during the night and felt no need for technology-based monitoring. The stove sensor was perceived by some participants as useful, but most responded that they do not use the stove as they receive meals prepared by the facility and, therefore, are not concerned about accidentally leaving the stove turned on. The sensor mat was also perceived as useful by most participants. The motion sensor was perceived as an application that could provide ease of mind. Participants focused primarily on the usefulness of such a device in

detecting intruders and thus providing additional security, more so than on its usefulness in monitoring their activity levels. The gait monitor was perceived overall as very useful, as most participants expressed concerns about falling and being helpless or not detected in a timely manner. Finally, the video sensor was seen as beneficial in detecting health emergencies, particularly falls, but raised greater privacy concerns than the other technologies. Ten participants stated that they would not want to have a video sensor installed in their residence.

Findings suggest that participants focused on the potential of smart home features to detect emergency situations rather than their potential for prevention through early detection of potential health problems. Their comments emphasized the technologies' function of emergency detection rather than their function of proactive monitoring. Some participants addressed the issue of stigmatization resulting from installing the technology. One participant stated *"as long as it is installed in the others' [apartments], as long as it would be something they were going to use all over and I would not be different…"*

Many subjects found the technology useful for residents with greater levels of frailty than themselves. One participant stated, *"I don't need this now, but perhaps at a later point-I have friends who'd benefit from this a great deal, I am not there yet...."* In this context, readiness to adopt the technology resulted from perceived need and some participants found that their functional and physical status was such that there was no need for monitoring at the time.

Two participants expressed concerns about privacy violation resulting from the use of the technology. One subject stated *"I don't like for anyone to know that I went out and didn't get back until midnight or something like that-I don't think anyone needs to know that."*

When asked who should have access to the data generated by the sensors, participants stated that they would want their health care providers to receive this information. Six participants also added that they would like their close family members to be recipients of the datasets. Four participants said that they, themselves, would like to see the information. One participant followed up indicated that residents should have control of the amount and frequency of information distribution, stating that he would *"need to see the information first, before anybody else is bothered"*.

Preferences for specific sensors were based on different criteria. For some participants the size of the device played a role. One participant made a comment about the motion sensor:

"I like this one the best; it's so small, really not intrusive…" Other participants determined the usefulness of the devices based on previous personal adverse health events. One participant stated, "If you had told me two months ago [about these technologies] I'd say who needs it, but after what I have been through, I see the benefits." This participant had experienced a fall in the apartment and had felt helpless until someone discovered the event. Participants also addressed the issue of integration of the technology in the residence and its degree of visibility to visitors. One participant stated, "If you can hide them and you don't really see them but you know that they are there, that would be my preference."

Two participants expressed concerns about the accuracy of the devices. One of them specifically addressed the issue of false alarms that could prove burdensome to both residents and facility staff members. Other participants, however, expressed the need to balance safety with privacy and that they would be willing to allow others to monitor their activity levels if that provided an added layer of safety and enhanced their well-being.

Discussion

Overall, participants had a positive attitude towards smart home technologies in general. As previously stated, their perceptions of the potential of the technology focused on a reactive role (detecting emergencies) rather than a proactive one (monitoring a situation to detect trends or predict issues or concerns). Fall detection was a function that appeared to be uniformly supported as important. Participants felt that none of the technologies presented to them would interfere with daily activities. Half of all participants (seven) specifically stated that they would agree to having these technologies installed in their own apartment. Most participants deemed the technologies useful for other older adults with greater levels of frailty than themselves.

Overall, participants saw a balance to be struck between the benefits of such monitoring, determined by level of need, and the concomitant perceived intrusion into privacy at home. Participants also emphasized the need to customize how the information resulting from the monitoring systems would be handled (who and how often would be receiving the data).

From a methodological point of view, our study confirms the challenges of conducting focus groups with older adults, identified by Barrett and Kirk[12]. These include the fact that older people show a lowered ability to focus attention over longer periods of time, or to suppress irrelevant information[13,16]. Our protocol was designed so as not to overload the working memory of older adults during the sessions since these require simultaneous maintenance and manipulation of spoken information[13].

This study provides useful feedback about specific smart home sensor technologies that can be organized into general themes. This research also suggests additional, potentially fruitful areas of inquiry. For example, was the

participants' focus on the technologies' benefit in reaction over prevention, a basic orientation or a matter of not having learned or considered enough about the potential preventive benefit? The potential mediating role of control also poses interesting questions, such as, does perceived control (e.g., ability to turn technology off) mediate the level of privacy concern? Finally, the question of what is perceived as "obtrusive" in these types of technologies presents a fertile area of study.

.Acknowledgments

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A Study of Nurses' Interaction with an Alerts and Reminders System of a Nursing Documentation Application

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Abstract

Alerts and reminders can keep nurses aware of pending actions or procedures for patients and provide warnings on abnormal conditions or potential health hazards for patients. An alerts and reminders system can provide added value to an electronic medical records system (EMR) facilitating its adoption. This paper describes a study of nurses' interaction with an alerts and reminders system of a nursing documentation application. The system provides alerts on critical patients' conditions and reminders on pending nursing activities such as medication administration, physician orders and patient treatments. The nurses' interaction was analyzed in terms of task completion times, number of items found and subjective user satisfaction. Results revealed a wide variability in nurses' completion times which correlated with nurses' age. Younger nurses exhibit better performance than older nurses. Nurses are able to identify most alerts and pending activities on the system. However, the lack of experience with the system is a factor that affects their ability to identify some alerts and pending services. Nurses were very satisfied with the system and demonstrated a strong preference for it over the traditional paper-based system.

Keywords:

electronic medical record systems, nursing documentation, alerts and reminders, usability engineering

Introduction

The benefits of Electronic Medical Records (EMR) are well established and documented. Successful implementations of such systems have shown to improve patient care in terms of safety, effectiveness, and efficiency. However, in spite of the proven and potential benefits of electronic medical records, paper-based records are still predominant. The reasons for the lack of a widespread adoption of electronic medical record systems are also well documented in the literature. Factors such as cost, user resistance, complexity and poor usability, have contributed to the slow implantation of these systems.

The design, development, and deployment of an electronic medical record is a complex endeavor. An EMR must integrate the unpredictable, complex, and information intensive nature of the health care environment into the clinician workflow in a timely, easy to use, and effective manner [1]. Knowing this, it then becomes important to research mechanisms and alternatives that facilitate the adoption of these support systems.

Alerts and reminders can be an added value to an EMR system that can facilitate its adoption. Alerts and reminders are typically useful to inform clinicians of events, such as the correct time to administer medication, the arrival of test results, or other more urgent events such as an overdue procedure [2]. The key is in providing these alerts in an intuitive manner, one that is tailored to the clinician using the system. The systems display must be straightforward, offering as much useful information as possible without being cluttered or awkward.

A study by Krall [3] determined that physicians are most concerned with efficiency, usefulness, information content, user interface and workflow when asked about an alerts and reminders system. Efficiency was found to be the most important and fundamental criterion for success as perceived by the physicians. A similar study [4] used questionnaires sent out to community family physicians to determine their needs regarding electronic medical records. The topic of interest from the results of this study were the respondent's comments regarding what information is important enough to be included in the electronic records' "front page". Most mentioned among the replies were laboratory results, medication information, consultations, hospital follow-up and health maintenance. More specific atoms of information that were deemed important included allergies, flags for abnormal lab results, patient age, an active problem list, notifications if any screening procedures were recommended, and other data.

Usability [5] is one of the most important considerations in the design of any electronic health care system. It can has a significant impact on the acceptance, learnability, efficiency, and satisfaction of the users. Conducting usability tests with users is the most effective mechanism to evaluate the usability of a system. This is precisely

what this paper is about. It presents a usability study in which nurses interacted with the alerts and reminders system of a nursing documentation application of a prototype of an EMR. This alerts and reminders system evolved from a system called SAAS [6], conceived to track patients in an Emergency Room setting and provide status information about pending services for each patient. The study focuses on the usability attributes of learnability, efficiency and subjective user satisfaction.

The alerts and reminders system

The alerts and reminders system described in this section is part of the nursing documentation module of a prototype of an EMR system called hPad. The system allows efficient navigation between patient records, reduces nurses' memory load, and serves as a workflow management tool. The categories or selection of alerts, reminders, warnings, messages, pending services, and any other item of information to be referenced in this system could be customized for the specific needs of a particular health organization. Potentially, the system could be the basis to manage and assist in other health environment concerns mentioned in the medical literature. It could be used to assist the patient transfer or sign-out process [7,8], to enhance the adherence to guidelines [9] and documentation, and to provide timely information for clinical decision making [10].

The initial interface of the nursing documentation module is presented in Figure 1. The user is identified at the top left of the header of the user interface. A dropdown menu at the top right allows the user to select the clinical area in which she/he will be working. However, the system starts by default with the clinical area normally assigned to the nurse. A list of the patients in the clinical area selected is displayed below the header. Each entry of the list provides the name of the patient and his/her room number. Alerts and reminders for a specific patient are indicated with circular or oval icons to the right of the room number in the patient's row. These icons are aligned in columns and each column represents a specific type of reminder or an alert. The type of alert or reminder is specified with the pictorial icons at the heading of the table. The pad with the blue strip refers to physicians' orders reminders, the capsule to medication reminders, the test tubes to laboratory reminders, the chest x-ray to diagnostic studies reminders, the phone to physician consultations reminders, the yellow pad to pending documentation reminders, and the yellow triangle to general alerts.

Figure 1 - Initial Interface of the Nursing Documentation Module

The level of urgency of an alert or reminder is indicated with the icon color as well as its shape. These two ways of distinguishing the urgency of an alert or reminder were adopted to support colorblind users. The green circle indicates the lowest level of urgency. It means that a service or an action needs to be performed soon. The small yellow oval indicates that a service or an action is reaching the time it needs to be performed. The large red oval indicates that a pending service or action has exceeded the time when it should had been performed. In cases when there are more than one instances of a specific alert or reminder for a patient a number is displayed inside the corresponding icon indicating the number of instances. Placing the pointer over an alert or reminder icon for a few seconds activates a small tool tip-type window that provides additional information about the alert or reminder.

A double click on a patient's name opens a nursing documentation window like the one shown in Figure 2. This window facilitates the documentation of typical nursing tasks such as handling physicians' orders, medication administration, drip type medication administration, taking vital signs, writing nursing notes, performing daily assessment, collecting I/O measurements and assessment of pain. Access to a specific documentation category is accomplished by clicking on the corresponding keyword of the tab bar provided on the window. By default the nursing documentation window opens on the physicians orders tab when a patients name is double clicked on the window that lists the patients and the pending alerts and reminders (see Figure 1). However, if the user clicks on one of the alerts or reminders icons on the patients' lists window, the nursing documentation window will open on the documentation tab that corresponds to the particular alert or reminder.

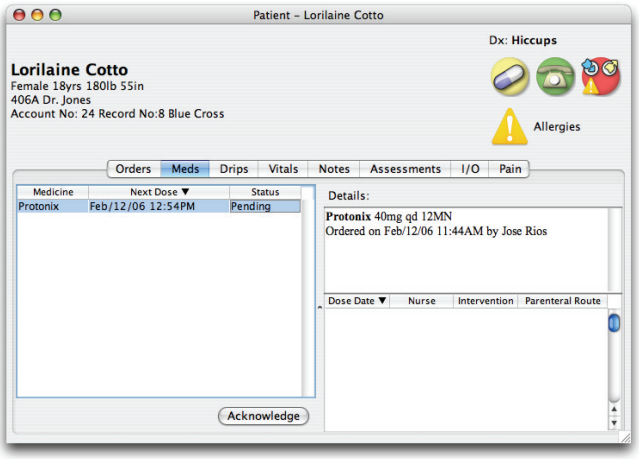

Figure 2 - Nursing Documentation Window

The nursing documentation window indicates the name of the patient and some relevant information at the top left side. Pictorial icons with a circular background are displayed at the top right of the window. These icons correspond to the pending alerts and reminders for the patient. The color of the circular background indicates the urgency of the alert or reminder. Double clicking on a pictorial alert or reminder icon will open the documentation tab on which the alert or reminder can be managed. The pictorial icons will disappear from the nursing documentation window as soon as the pending action or service that it represents is performed and documented. Similarly, the corresponding circular or oval icon will disappear from the patients' list window.

The alerts and reminders system allows efficient navigation between patient records and between specific items requiring attention. At a glance, the system provides a snapshot of the specific ward or floor, which can help nurses coordinate and manage their activities.

Methods

Participants

Twenty staff nurses from a hospital serving only a cardiovascular clientele participated in the study. They were selected on a first-come first-serve basis from those that responded a call for participation and were compensated for their participation. Their experience as staff nurses ranged from 0.2 to 27.4 years (M=8.5 years). Experience with computers ranged from 0 to 28 years (M=3.5 years). None had prior experience with the hPad system, nor with any other electronic patient record system.

The tasks

Each participant was asked to perform the nine tasks listed below on the hPad system. All the tasks began with the hPad system displaying the patients' list window (figure 1).

1.Indicate the patients with pending lab orders.

2.Indicate the pending alerts and reminders for a specific patient.

3.Indicate the pending services for a specific patient.

4.Determine the time a physician submitted a consult order for a specific patient.

5.Acknowledge the consult orders for a specific patient.

6.Open a pending note for a specific patient, add a specific text to it and save it.

7.Acknowledge the pending reminders for a specific patient.

8.Identify the rooms in which there are patients with pending medication orders.

9.Acknowledge all pending medication for the patients in the clinical area.

During the execution of task 9 one new alert and one new reminder is generated.

Research design

Before proceeding with the test the, participants were asked to sign consent forms and fill out a background questionnaire. All received a short tutorial of about 15 minutes on the hPad system. The participants were asked to perform the nine tasks indicated in the previous section. The patients' records used in the study were realistic in terms of their content but did not belong to real patients.

After performing the tasks the participants were asked to fill out a subjective user satisfaction questionnaire. The questionnaire asked them to rate five aspects of the hPad system using a 1-5 scale (see Table 3). The participants were also asked to indicate their system preference for the hPad or the traditional paper-based system.

Data analysis

Descriptive statistics were used to analyze the results. Average, standard deviations, maximum and minimum values were used for analyzing the completion times of all the tasks. Percentages were used to analyze the number of items asked to identify or act on by nurses while performing tasks 1, 2, 3, 8, and 9. Average ratings were used to analyze the users' responses to the subjective satisfaction questionnaire.

Results

A summary of the completion time results for all the tasks is presented in Table 1. The table indicates the average completion time, standard deviation, and maximum and

minimum times recorded for each task. The results exhibit a very wide variability in completion times. In most of the cases the maximum time recorded was more than ten times the minimum recorded.

Table 1. Completion Time Results

	Average (seconds)	Std. Dev. (seconds)	Min (seconds)	Max (seconds)
Task 1	30.4	22.0	6	77
Task 2	39.5	21.5	11	90
Task 3	31.8	19.2	7	91
Task 4	26.2	29.5	6	120
Task 5	39.2	28.0	11	92
Task 6	83.7	61.5	13	253
Task 7	52.1	34.1	12	125
Task 8	34.7	19.5	9	70
Task 9	103.5	95.1	17	480

A summary of the percentages of items found in response to questions posed for tasks 1, 2, 3, 8, and 9 is presented in Table 2. The results show that the participants found the large majority of the items they were asked to look for.

Table 2 - Percentage of items found

	% Found
Task 1: *Patients that have pending lab orders*	73.3
Task 2: *Pending alerts and reminders for patient Lorilaine Cotto*	82.5
Task 3: *Services pending for patient Rafael Cajigas*	98.3
Task 8: *Rooms where patients await for pending medication*	86.7
Task 9: *Pending medication for the patients in the clinical area*	78.8

Table 3 provides a summary of the average ratings given by the participants to various aspects of the hPad system and their system preference (item 6). The ratings given to the different aspects were very favorable to the hPad system. The participants overwhelmingly preferred the hPad system over the traditional paper-based system.

Table 3 - User satisfaction results

Aspect	Meaning of scale	Rating
1. Did you understand the functionality of the system?	1= not understood 5= understood	4.85
2. How did you find the meaning of the icons?	1= very confuse 5= very clear	4.55
3. How easy was to find the patients requiring the most urgent attention?	1=very difficult 5= very easy	4.75
4. How easy was to find the pending actions of a patient?	1=very difficult 5= very easy	4.90
5. How easy was to handle the different windows of the program?	1=very difficult 5= very easy	4.55
6. Which system would you prefer, the hPad or the traditional paper-based system?	1= paper-based 5= hPad	4.80

Discussion

The results for task completion times exhibit a wide variability (see Table 1). These results suggest that there exists a notable difference in the participants' ability to perform the tasks. In order to understand what may account for the variability in the participants' performance a correlation analysis was performed between the overall completion time for each participant and the participants' age, work experience and computer experience. A correlation was found between the overall completion time and the participants' age but not with the participants' work experience or computer experience. A correlation analysis was also performed between individual task completion times and the participants' age, work experience and computer experience. Correlations were found only between the participants' age and the completion times for tasks 1,3,4,6 and 8. These results suggest that age is a key characteristic in the participants' ability to perform the tasks on the hPad system. In general younger nurses exhibit better performance than older nurses. Thus, special attention should be given to older nurses when training them to use the system.

For tasks 1, 2, 3, 8 and 9 participants were asked to find, identify or perform actions on several items present on the initial window of the hPad system. The results show that the participants were able to identify the majority of these items (see Table 2). However, under normal circumstances nurses should be able to find all these items. The fact that the participants did not have any experience with the system other than a 15 minutes tutorial certainly played an important roll on the participants' ability to identify the requested items. Nevertheless, given the lack of training and exposure to the systems the results are very encouraging.

Although the participants did not know the system very well they were very satisfied with it. The results for the user satisfaction questionnaire were very favorable for the hPad system. The participants gave relatively high ratings to all the aspect considered (items 1 to 5 of Table 3). They understood the functionality of the system and the meaning of the icons very well, and found the windows of the program very easy to handle. The participants' perception of the system is consistent with their observed interaction with the system. It was evident that the participants understood the functionality of the system because 95% of them were able to assess pending services without having to open the patient's record window. In addition all the participants clicked on the alerts or reminders icons instead of the patient's name in the initial window (see Figure 1) in order to open the documentation tab that corresponds to

the particular or alert or reminder. The participants also indicated that it was very easy for them to find the patients requiring urgent attention and to find the pending actions on a patient. In addition the participants indicated a strong preference for the hPad system over the traditional paper-based system used in the hospital (item 6 of Table 3).

Conclusion

Nurses exhibit a wide variability in performing tasks with the alerts and reminders system. This variability correlates with the age of the participants. In general, younger nurses exhibit better performance than older nurses. Thus, in order to learn to use a system like the hPad older nurses may required more training time than younger nurses.

Nurses are able to identify most alerts on pending activities and reminders on the system. However, the lack of experience with the system is a factor that affects their ability to find, identify or perform actions on several items present on the initial window of the system, but the fact that they were able to identify most of them is an encouraging result. With minimum training nurses should be able to identify all pending activities and alerts indicated by the system.

Even though nurses exhibit a wide variability in performing tasks on the alerts and reminder system they were very satisfied with it. They felt they understood the functionality of the system and the meaning of the icons, and found the windows of the systems very easy to handle. In addition, they felt it was very easy to find the patients requiring urgent attention and to find the pending actions on a patient. Nurses also evidenced a strong preference for the alerts and reminders system over the existing paper-based system.

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Using PDA to transform the long MDS-HC evaluation form into a favored system

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Abstract

The MDS-HC has been an effective home care evaluation form. However it was not yet accepted in Taiwan because it is too long for our over-burdened home care nurses. We used a self-developed PDA information representation model to design the PDA MDS-HC support system and used the Technology Acceptance Model to examine its potential acceptability. The results showed a well-designed PDA could greatly improve the usability of a originally un-favored paper system.

Keywords:

MDS, home care, PDA, information representation

Introduction

The Resident Assessment Instrument, consisting of a Minimum Data Set (MDS) evaluation form, Client Assessment Protocols (CAPs) and Triggers, has been well internationally known, applied, and even used for the insurance claim, in the long term care [1]. The MDS-HC is vary complete and covers 17 main categories and as many as 64 evaluation items. However, currently its professional completeness doesn't make it a formal evaluation form for the home care in Taiwan because it is too long for our over-burdened home care nurses.

PDA has been a potentially useful tool for mobile nursing, especially for those in home care settings. But its interface features, such as difficult data entry in writing and small display screen, still confine its use. We developed a PDA information representation approach which had been practically proven to be easy to use by nurses [2][3]. A modified version was latter developed for the long forms.

The purpose of this study was to use the modified PDA information representation approach to design the PDA-based MDS home care evaluation support system and to examine the home care nurses' acceptance of the PDA-based MDS-HC system.

Methods

The modified PDA information representation approach is mainly composed of 4 principles:

1. The screen display area is separated into three sections for the users to clearly see and to easily navigate through the form.

2. User should be able to switch to any item in less than 3 taps.

3. The hand-writing should be replaced, if possible, by tapping for data entry.

4. User should be well reminded what tasks have been done.

A team of nursing user, nursing programmer and experienced PDA programmers was organized and the prototyping approach was used to develop the system. A convenient sample of 24 subjects, who were trained of the MDS, was used for testing. 3 representative home care scenarios were written for users to test the PDA system. Davis' Technology Acceptance Model was used to evaluate users' acceptance of the system in terms of their perceived ease of use and usefulness.

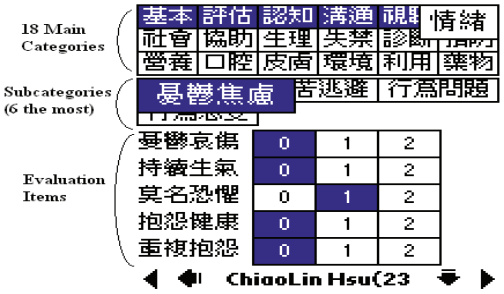

Figure 1. The representative screen shot.

Results

The representative PDA screen was shown in Figure 1, in which uses could navigate the system through tapping the upper main category and subcategory buttons, and enter data in the lower half data entry area. The highlighted buttons mean answered questions.

58% of subjects never used the MDS-HC form. Most of the subjects have BS degree and aged from 20-50. 100% agreed the system was easy to use and 92% agreed the system was useful.

Conclusions

Our study showed that a well-usability-engineered PDA system can well improve the usability of both the professional forms, which was too long to be practically accepted, and PDA, which small-display interface usually hinders its popularization.

References

[1] Morris JN, Fries BE, Bernabei R, Steel RK, Ikegami N, Carpenter GI. RAI-Home Care (RAI-HC) assessment manual for version 2.0. Boston: Inter RAI; 1999.

[2] Chang P, Hsu YS, Tzeng YM, et al. Development and Pilot Evaluation of User Acceptance of Advanced Mass-Gathering Emergency Medical Services PDA Support Systems. MedInfo 2004 Symposium, p:1421-1425.

[3] Chang P. Tzeng YM, Wu SC, et al. Development and Comparison of User Acceptance of Advanced Comprehensive Triage PDA Support System with a Traditional Terminal Alternative System. American Medical Informatics Association 2003 Symposium, p:140-144.

Using PDA to transform the long MDS-HC evaluation form into a favored system

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Brisbane, Australia
August 21, 2007

5A0A Lab
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Backgrounds

- Basing on a ***well-developed and multi-purpose*** homecare evaluation instrument
- Looking for a ***simple and cost-effective*** mobile solution
- First Candidate: ***Palm-based PDA*** *(due to battery and robustness factors)*
- Challenge: ***Easy-to-use Interface*** from users' perspective

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Methods: Instrument

- The international ***InterRAI*** Instrument[1]
- A 20-A4-page-paper-based ***long form*** composed of 225 assessment questions from18 categories, such as cognition, physical functioning and structural problems

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Methods: Mobile Solution

- Palm-based Sony NX70V/TJ37(wireless)/Treo 600 series(phone)
- Development:
  - A development team of nursing users, nursing programmers and PDA programmers
  - prototyping approach
  - NSBasic 5.0
- Evaluation
  - a convince sample of 24 subjects
  - Davis' Technology Acceptance Model

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Mobile System Structure

Outside Institutions *Vs.* *Inside Institutions*

Handheld Center

Palm-based
Treo 600/650
Smart Phone

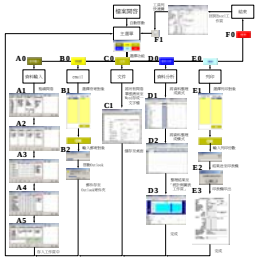
Palm-based *802.11b*
Sony TX
70/TJ37/Palm T|X
PDA

GPRS
802.11b
BTooth

GPRS/GSM

802.11b

Toshiba
TabletPC



Excel-based
Monitoring
Center

Mobile Center

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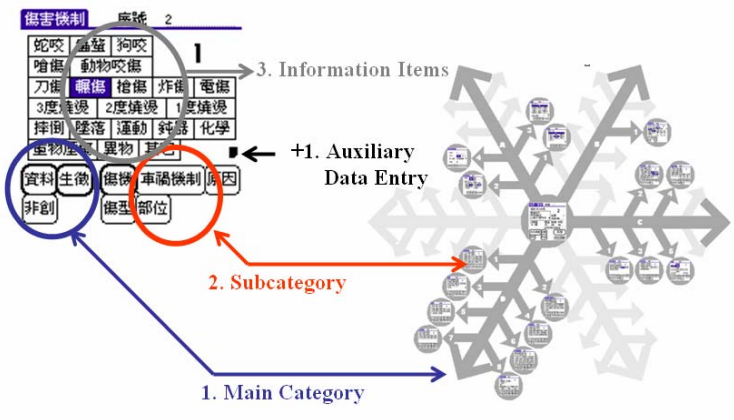
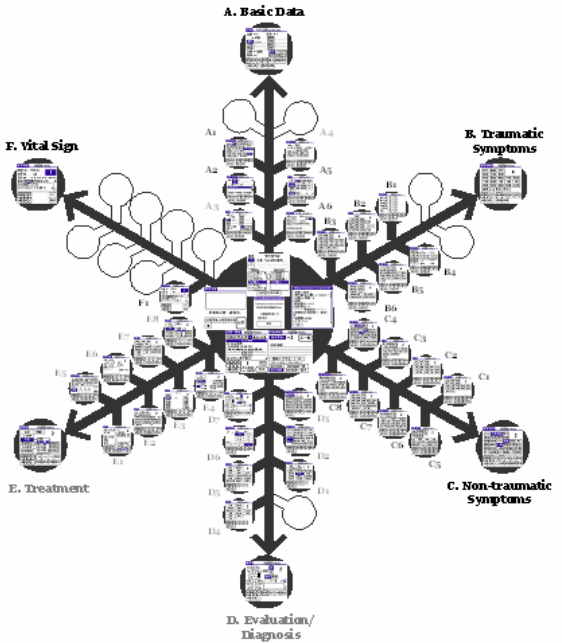
PDA Interface Design

- Practically proven effective design protocol[2,3]





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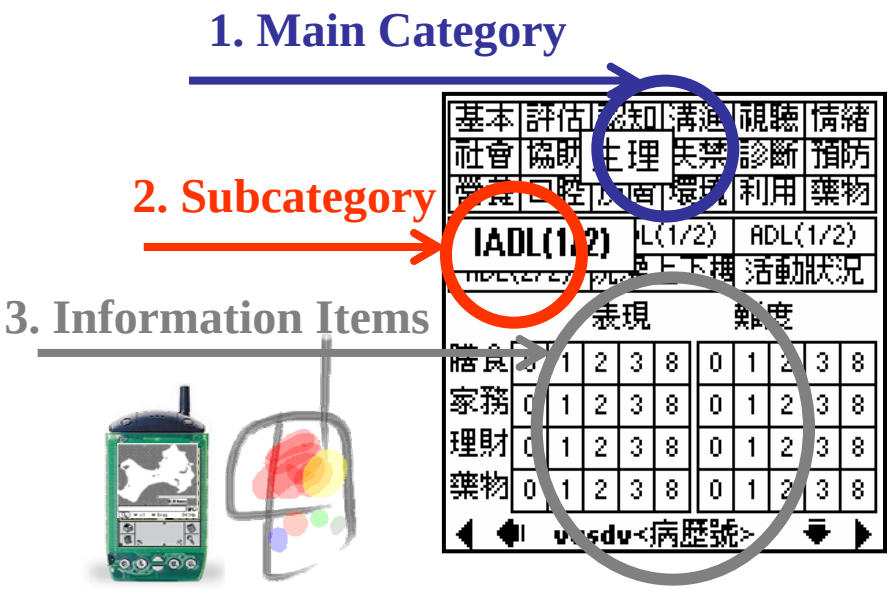
New Version: *3+ Grid Representation Approach©*



- To cover ***more*** Information ***items*** for a ***long form***
- To enhance **data entry, *ease of use*, *navigation***
- To better fit into user's ***workflow***

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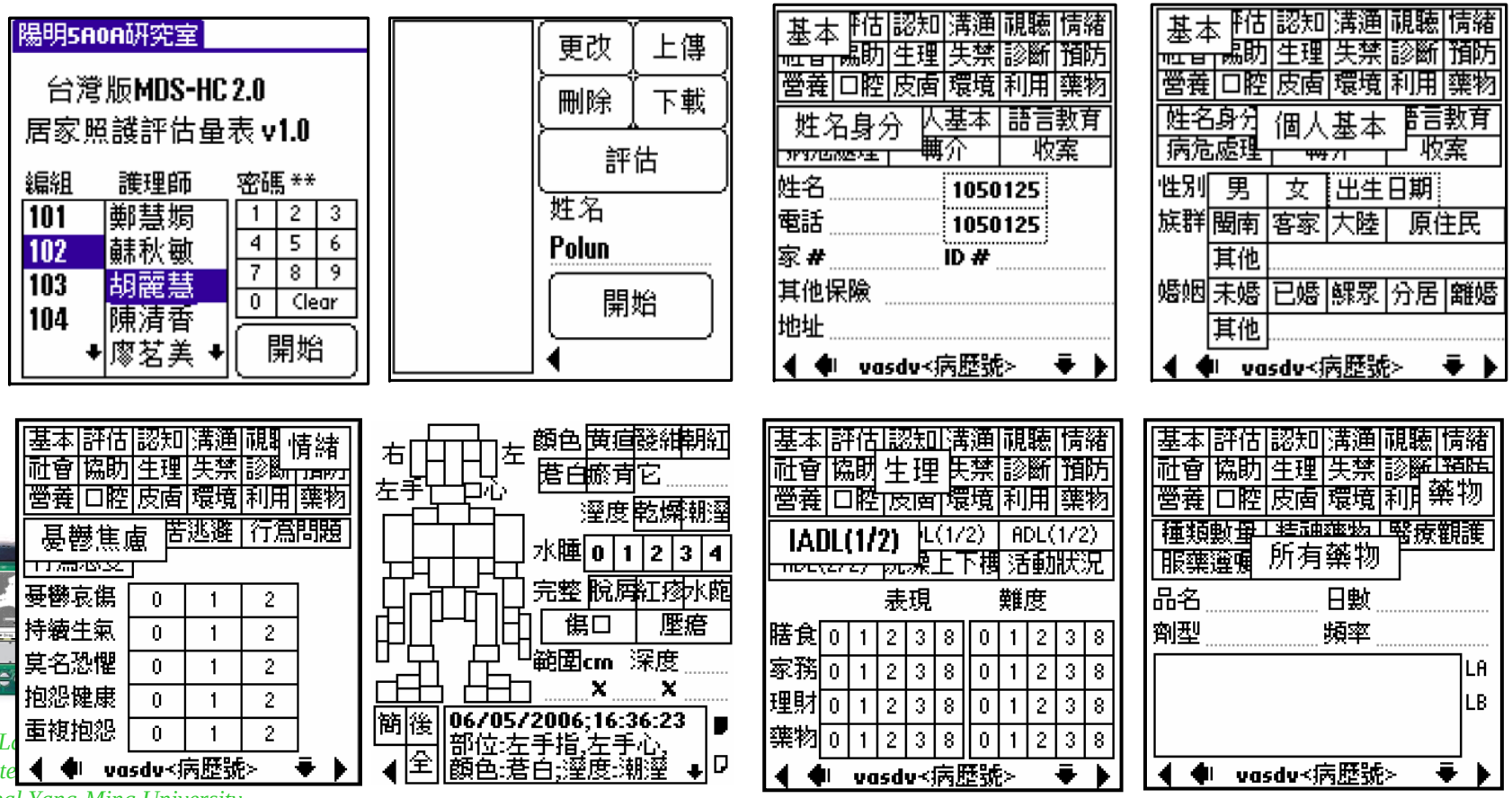
Results: Sample Screen Shots



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Results: Evaluation

- Average working experiences: 12.5 yrs
- 7 home-care nurses with 4.3 yrs of experiences and visiting more than 20 case per month
- ***100%*** agreed that system ***easy to use*** and ***75%, usefulness*** for their work

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Discussions and Conclusion

- ***Short and satisfying learning curves*** for both system and assessment instrument
- ***Satisfied with*** the solution
- ***Effective*** PDA interface design protocol[5]
- ***New project initiated*** to consist more assessment instruments and to extend into the institutional homecare service

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New Project for Longer Form

- ***15 extra*** assessment instruments added, such as
  - MOS SF-12
  - Geriatric Depression Scale
  - Mini-mental State Examination
  - The Pittsburgh Sleep Quality Index
  - Suicide Ideation Screen
  - Suicidality, etc.
- ***252 more*** questions

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[1] Morris JN, Fries BE, Bernabei R, Steel RK, Ikegami N, Carpenter GI. RAI-Home Care (RAI-HC) assessment manual for version 2.0. Boston: Inter RAI; 1999.

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[3]Chang P, Hsu YS, Tzeng YM, et al. Development and Pilot Evaluation of User Acceptance of Advanced Mass-Gathering Emergency Medical Services PDA Support Systems. MedInfo 2004 Symposium, p:1421-1425.

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Unanticipated Workflow Characteristics after Implementing a Computerized Vaccination Reminder System: A Case Study

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Abstract

Computerized reminder systems can increase vaccination rates in the outpatient setting. Achieving a high level of system integration may support busy clinicians and result in higher compliance. After successful implementation of a closed-loop, informatics-based pneumococcal vaccination reminder infrastructure in the ED, we discovered several, unanticipated workflow details that may have impacted the implementation approach. Despite the participation of the ED staff in designing the workflow of the vaccination reminder system, the workflow details would have been challenging to predict.

Keywords:

emergency medicine, pneumococcal vaccines, case reports

Introduction

Pneumococcal vaccination is recommended for all patients older than 65 years and those younger than 65 with a co-morbid illness. Current vaccination rates remain far below the Healthy People 2010 target of 90%. The Emergency Department (ED) has been suggested as a suitable environment to offer vaccination and feasibility has been demonstrated. We implemented an end-to-end computerized vaccination reminder system in the ED using four different information systems, including the ED triage application, the computerized provider order entry (CPOE), the order tracker system, and the longitudinal electronic medical record system (EMR).

Unanticipated workflow details

With close participation of the ED staff a workflow for the pneumococcal vaccination program was mapped out using flow diagrams, which were repeatedly reviewed and discussed during the weekly team meetings. To design a system that would fit into the existing ED workflow, our goal was to create a sustainable system that would require limited additional data entry by ED clinicians. As part of designing the system, we conducted a survey of ED physicians and nurses to evaluate their beliefs, opinions, and interest in a vaccination reminder system. The survey results helped us to identify clinician education foci and guide design aspects.

The initial implementation phase included observation periods to elicit complaints and discover system issues. We discovered several subtle process and procedure variations that were originally not accounted for: (a) Nurses were able to short-circuit the reminder system and preemptively order the vaccine with physician approval prior to the physician prompt. (b) As the reminder was tied to the first CPOE session, it occurred that physicians completed the first session prior or during the nurses vaccination screening task. (c) More patients than expected seemed to decline vaccination during the triage process, a result of triage nurses' workload leading the triage nurse to decline on behalf of the patient without completing the actual screening task. (d) Despite several educational communications with the physicians, they remained unclear that patients consent was already obtained at triage, which we were able to clarify with a small wording change in the physician reminder. (e) Some eligible patients consented to receiving the vaccine, but their reason for the ED visit did not require the use of the CPOE system. (f) During an information system upgrade, the infrastructure for capturing the physicians' refusal reasons got disconnected during a limited time period.

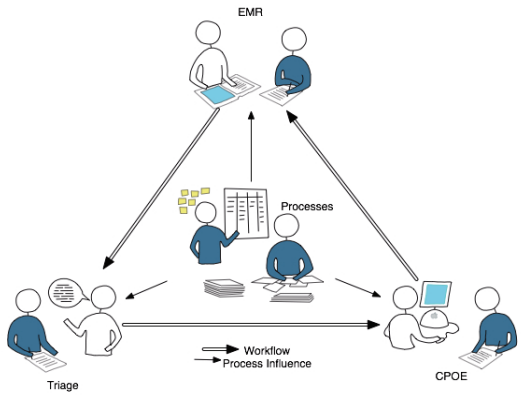

Figure 1 – System design and processes

Discussion

Although we discovered several unanticipated workflow details immediately after implementation, the close communication with the clinicians allowed us to modify the

system so that it remains part of the ED workflow. After 12 months the computerized reminder system seems to be a sustainable informatics approach improving vaccination rates in the ED.

Acknowledgments

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User-Computer Interface Design of a Family Support Web-based Portal: The Use of Scenarios and Low Fidelity Prototype

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Abstract

This paper describes the user interface design of a web-based portal for middle-aged novice internet users to receive multilingual family caregiver support. We used a scenario-based analysis technique and low fidelity prototype to create and iteratively refine 46 scenarios that characterized 4 portal functions, supporting 5 stakeholders and quality attributes. This technique has several advantages when applied to this case example: It enabled clinician participation, facilitated team communication, saved cost and time, sped up subsequent design steps, and validated assumptions in the user interface design process.

Keywords:

clinical informatics, Chinese, family caregivers, middle-aged, multilingualism,user-computer interface

Purpose

This paper describes the user interface (UI) design process of a web-based portal for middle-aged novice internet users who speak English as a second language to receive multilingual family caregiver support service [1]. The functions of the portal allow the caregivers to: (1) communicate with and support from health professionals online, (2) involve multiple family members in the communication process, (3) receive alerts to trigger usage of service, and (4) receive information needed to support their caregiver role. The portal consists of 4 features for use by 5 types of stakeholders.

Methods

We modified a standard requirement analysis practice to identify, specify, and validate the functions of the portal. The original version of the portal consisted of simple functions to provide information on web pages and therapist-caregiver email communication for personalized support. We collected field work data to determine the enhancement needs the original portal functions.

Enhancements of the functions were analyzed based on a stakeholder analysis (Fig. 1). Ten caregivers who had used the original version of the portal participated in in-depth interviews. They had been caring for their family member who had dementia for a range of 2 to more than 10 years. The interviews allowed us to understand the daily caregiving situation and their experiences of using the original basic portal design. The caregivers were typically female in their 40s and 50s and had other major roles in life such as being a mother, working full time.

Next, we used a scenario-based analysis technique to: 1) critically analyze the UI design, 2) bridge the design concepts to physical design, and 3) document the finalized design for implementation. Figure 1 shows how the scenario-based analysis, Step 2, is related to the other 4 UI design steps.

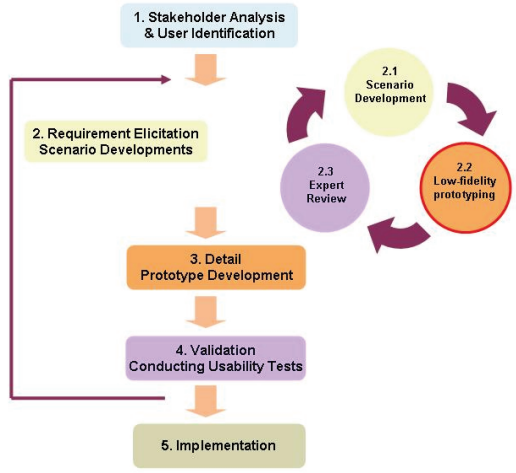

Figure 1 - Methodology for user interface design

In Step 2, we used an iterative process to (2.1) develop the scenarios, (2.2) create low fidelity prototype (LFP), and (2.3) conduct expert reviews. We created and iteratively refined 46 scenarios that elaborated the UI of all four portal features. The scenarios detailed the UI design that supported different stakeholders' needs and quality attributes such as usability, accessibility, performance, and security. The scenarios were built using LFP (Fig 2) in MS Word documents with a template and narratives. A heuristic evaluation was conducted using the LFP.

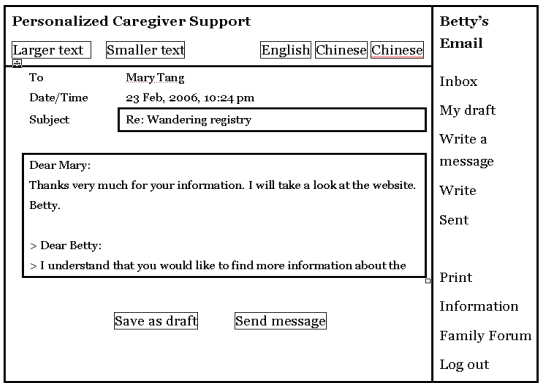

Figure 2 - Low Fidelity Protocol using MS Word Document

The scenarios were iteratively refined through these three sub-steps. The LFP facilitated the evaluation of the design against established usability standards, the validation of the design choices against functional requirements, and the identification of needs for improvements.

Results

The evaluation and analysis procedures resulted in eight important design decisions:

First, three functional enhancements to be added to the portal:

- a family message board to allow members in the same family besides the principal user to communicate with the online practitioner
- the use of narratives to describe issues in caregiving situations to increase the awareness of the caregivers to reflect on their own caregiving situations
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Third, for users who are in their middle age and not technically savvy, using affordance familiar to them can improve the ease of use. For example adding buttons of "next page" and "previous page" helps with navigation like reading a book.

Fourth, buttons with only icons can be problematic for novice users. Icons with words can improve the understanding of semantic.

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Sixth, to ensure security and confidentiality without compromising usability, a traditional email system design is used. The email module is used as an internal communication system; i.e., users cannot email to people not in the system.

Seventh, each family has one principal user and different collaborators and observers. The permission of each role is different. Various options of UI design was explored to examine the optimal way to present different combinations of permissions (i.e. full permission and read only). Tab sheets, toggle buttons listed in a row on the top of a window, are found useful to support this design decision.

Eighth, the portal requires supporting English, Traditional and Simplified Chinese. We chose to use language toggle buttons that allow the change of language in each page. We also have chosen a system that support Unicode encoding.

Discussion and conclusion

How to translate requirements of diverse users with competing special needs into UI design can be a challenge. Using scenarios in early design step is a well-established method in software design [2]. When applied in this case example, we have identified 5 advantages: 1) The LFP allowed team members who were clinicians and unfamiliar with advanced prototyping applications to actively take part in the process; 2) The scenarios facilitated the communication of the interdisciplinary multilingual team members; 3) The LFP allowed us to express each interaction explicitly at low cost and to quickly and easily apply the changes for expert review; 4) The iterative scenario development in Step 2 sped up the detail fidelity prototyping in Step 3; and 5) The detailed prototyping ensured the design would not use assumptions that may work in general practice but not the end users, e.g., buttons with icons preferred by experienced but not new users. The use of an inclusive, cost-effective UI design process can contribute to a sustainable ehealth practice in the long run.

Acknowledgements

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References

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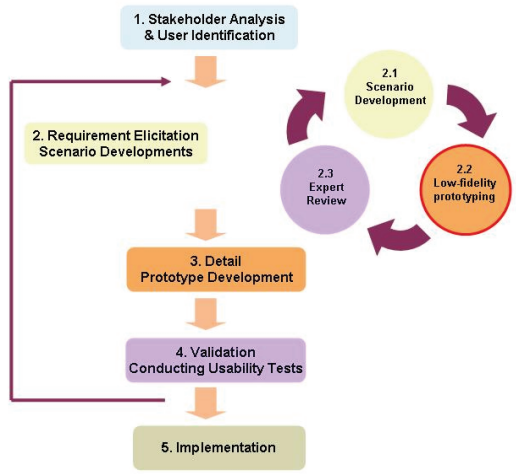

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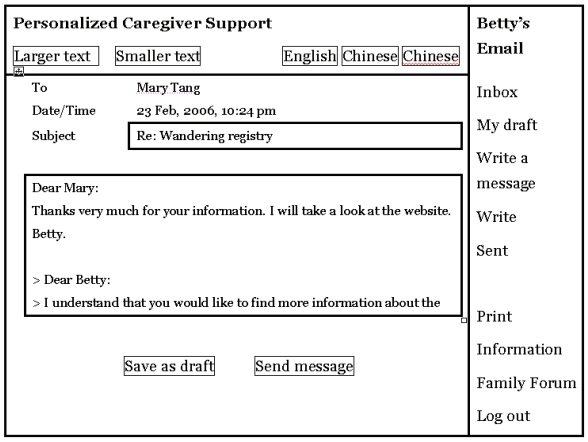

Figure 2 - Low fidelity protocol using MS word document

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References

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User-Computer Interface Design of a Family Support Web-based Portal: The Use of Scenarios and Low Fidelity Prototypes

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MEDINFO 2007, Brisbane, Australia

Aug. 20-24, 2007

Purpose

- Describe the design process of the user interface (UI) of a web-based portal [1]

- Principal Portal users:
  - family caregivers of a family member who have dementia
  - middle-aged, novice internet users
  - speak English as a second language

Type of Portal Users

Principal users	• Daughters or sons of a person who has dementia • 40 to 50 y.o. • Working full time and very busy caregiving.
Collaborators	• Active caregivers • Collaborate with the Principal User to give care and to use the portal
Observers	• Family members who review the information posted on the portal • But do not actively participate in the communication
Practitioners	• Regulated professionals • Use the portal to communicate with and offer interventions to the family caregivers

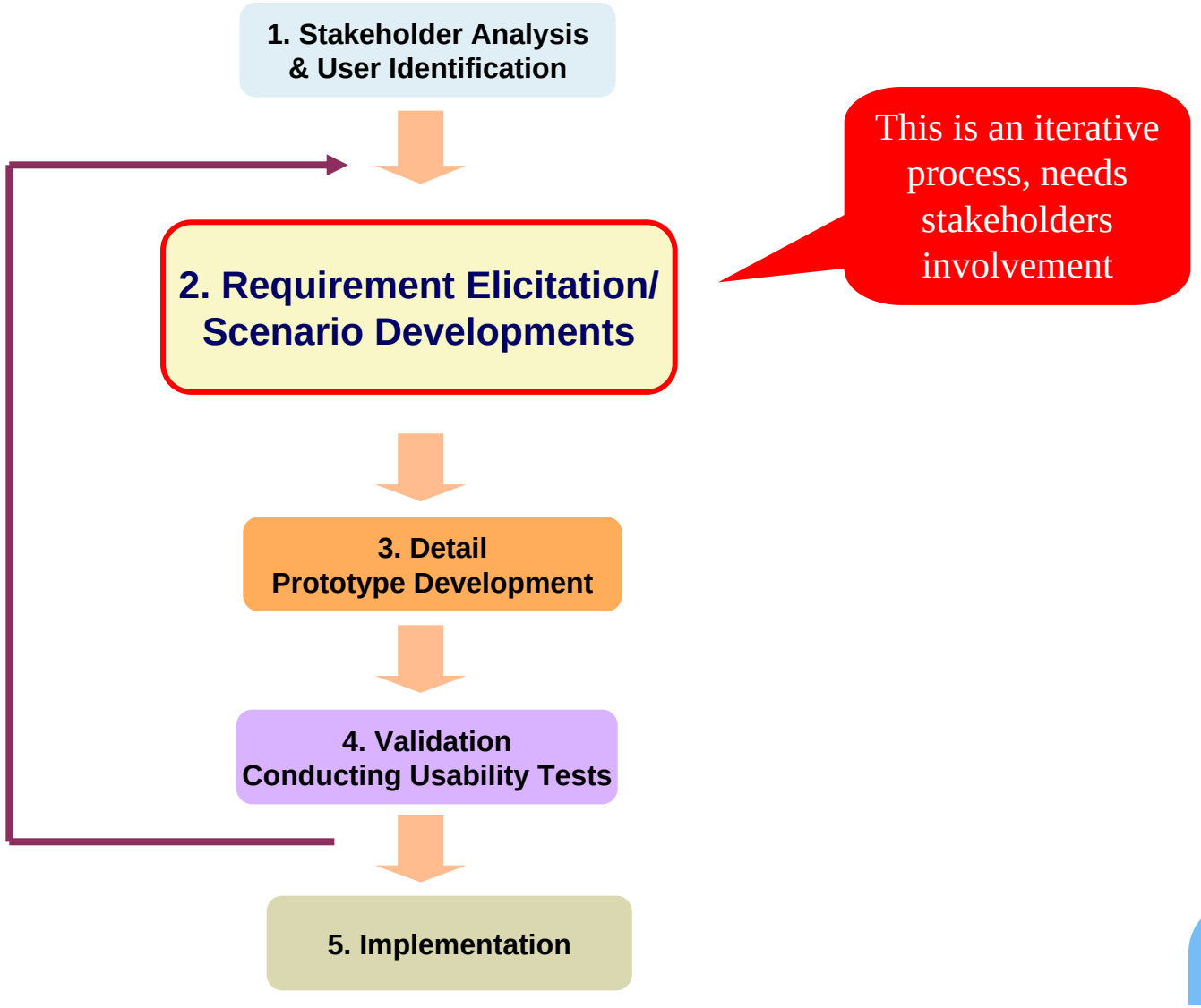
Portal Functions

- To support users to
  - Communicate with and support from health professionals online
  - Involve multiple family members in the communication process
  - Receive alerts to trigger usage of service
  - Receive information needed to support their caregiver role

Portal Features

1. Personalized Email Support	Allows the Principal Users to communicate with their Online Practitioner on a one-to-one basis
2. Family Message Board	Provides an online forum for principal users and family members to discuss caregiving issues
3. Short Stories	Provides narratives for family members to learn more about family caregiving
4. Telling More	Supports Principle Users to compose an email related to a specific topic

From stakeholders and functions to implementation – an Overview



The Extended Requirement Elicitation Process

- 2.1 Developed 46 scenarios
  - Elaborated scenarios of the 4 portal features
- 2.2 Created low fidelity prototype (LFP)
  - The scenarios were built using narratives and Low Fidelity Prototype in MS Word documents with a template
- 2.3 Incorporated expert review

Intensive, Iterative Requirement Elicitation

2. Requirement Elicitation/ Scenario Developments

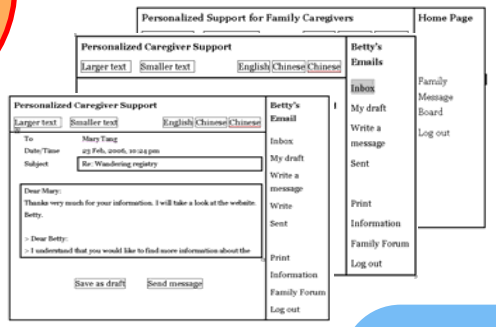
46 scenarios of

1. **Personalized Email**
2. **Family Forum**
3. **Short Stories**
4. **Telling More**

2.1 Scenario Development

2.2 Low-fidelity prototyping

2.3 Expert Review



Heuristic Evaluation & Iterative Refinements

- Heuristic Evaluation
  - The LFP scenarios were used to conduct expert reviews
- Iterative refinements:
  - Ensured that each function supported different stakeholders' needs
  - Checked quality attributes: usability, accessibility, performance, and security

5 Advantages of Scenario-based Design

1. The LFP allowed team members who were clinicians and unfamiliar with advanced prototyping applications to actively take part in the process
2. The scenarios facilitated the communication of the interdisciplinary multilingual team members
3. The LFP allowed us to express each interaction explicitly at low cost and to quickly and easily apply the changes for expert review
4. The iterative scenario development in Step 2 sped up the detail fidelity prototyping in Step 3
5. The detailed prototyping ensured the design would not use assumptions that may work in general practice but not the stakeholders

Conclusion

- This paper documented how to use scenarios and LFP to conduct an inclusive, cost-effective UI design
- Scenario-based design is a well-established method in software design [2]
- We have experienced several advantages after applying this technique to design the UI of a family caregiver portal
- The technique can contribute to a sustainable ehealth practice in the long run

Acknowledgements
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& Contact

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A Model of Distributed Information Search on Relational Data

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Abstract

Searching relational data such as lab results in patients' chart can be a distributed search task where information is presented in different places and formats. Guided by a human-center process, we proposed a model of distributed information search for this type of data. In this model representation dimensions, data scales and search tasks types are the main factors considered for the search efficiency and effectiveness. The model is designed to serve as a foundation for the analysis of search tasks and effective design of search interface for relational data.

Keywords:

information search, lab result, information display

Model description

According to cognitive theory, the represented dimensions of a relational information display refer to the dimensions of an original domain in the world represented by various Relational Information Displays(RIDs). The representing dimensions refer to the physical dimensions of RIDs representing the dimensions of the original domain in the world. These two dimensions have to be matched in scales so as to guarantee the efficient and accurate representations between the display and the world. The information needed for carrying out a search task should also be matched in scales which are nominal, ordinal, interval and ratio and they have different strengths in operations. For example, if a search task is to find any abnormal triglyceride values on patient's chart, the representing dimension can be nominal scale; if a task is to find how much the patient's triglyceride is higher than normal, the representing dimension should be ratio scale.

Searching patients' records can be a comparison task within one patient or between different patients. The strategies are accordingly various if the search contents are different. A patient record contains both free text description and relational data which exists typically in the lab results section. The model contains localization, comparison and calculation, the three operations allowed by the properties of data scales. In this study, we employed lipid panel data to investigate the types of search tasks shown in the figure and the operations allowed by the power of data scales.

Discussion

For a type of clinical trial data, certain types of display are superior to other isomorphic representations in terms of search performance. A variety of studies have identified that the users such as clinicians and medical researchers may use the same data set in different ways. Search task efficiency can be improved by several factors that characterize human information behaviors. The focus of this research is on cognitive factors and their implications on human-computer interaction. Our model is particularly based on the interactions between user and computer-based information systems. This is because the computer system has the flexibility to generate isomorphic displays for the identical set of relation data.

There is no good display independent of tasks. The model with an inclusion of representation and tasks has its practical use for analyzing the search tasks of relational data. The analysis could provide a foundation for a better designed human-computer interface where data mapping, search content and search action are fully considered.

Understanding search task in scales helps explain task complexity, provide the proper representing data scales fornterface design and predict the search task feasibility on relational data.

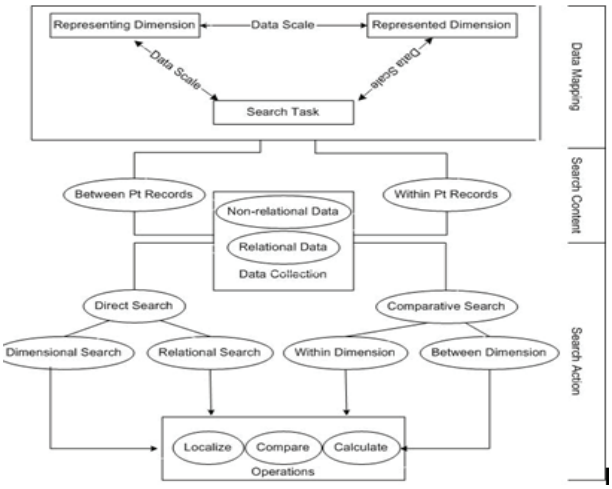

Figure 1 - Search model for relational data

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A Classification of the Behaviours of Doctors, Patients and Computers in the Family Practice Consultation

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Abstract

General Practice (Family Practice) in Australia has rapidly computerised over the past ten years. Currently over 90% of General Practitioners (GPs) have a computer on their desk, and use it for clinical functions. One of the key elements of General Practice is the doctor-patient relationship, and survey work has suggested that both doctors and patients have concerns about the impact of computers on this relationship. This study describes how the doctor-patient-computer relationship is enacted in Australian General Practice. By dealing with the relationship as a triadic one we can see how the computer acts as an equal partner. As a precursor to more detailed analysis, we have described for each player in the consultation two overarching styles and three categories of behaviour exhibited at different times of the consultation. An understanding of these styles is needed before moving on to an analysis of the flow of information and power in the consultation.

Keywords:

computers, physician patient relationship, communication skills

Introduction

Computerisation of the general practice/primary care space is now almost complete in Australia, with 91% of doctors now using a computer on their desktop for prescribing. This is a figure that has come about rapidly, with only 60% reporting the same level of computing five years ago [1, 2]. computerisation occurred due to a combination of government initiatives and GP driven demand for computer prescribing [3]. This represents the most significant computerisation of the clinical encounter since the mass computerisation of the United Kingdoms National Health Service in the 1980's. Computers are now used in all facets of the consultation – prescribing, recall systems, progress notes and decision support [4]. Surprisingly, there is little literature on the direct effects of this computerisation on the doctor-patient relationship itself. Both surveys of the level of computerisation in Australia registered significant concerns by doctors to the effects of the presence of computers on the doctor-patient relationship [2, 5], although this concern is not necessarily reflected by patients [6, 7]. With a significant emphasis in primary care on the doctor-patient relationship[8, 9] , it is important the computers role in the relationship be studied.

Methods

The method has been described in detail elsewhere[10]. Twenty GPs generated 128 consultations for analysis.. The use of video allows the combining of both speech and body language in the analysis, as well as taking into account the interplay between all three players.

Results

We have been able to describe several classifications of behaviour across the various players (doctors, patients and computers) in the consultation. Central to the framework is the type of classificatins of the interaction provided by the players in the consultation. We described two for each player. The second element is the categories of behaviours exhibited during the consultation, which can occur independent of the classifications

The Classifications

Classifications apply overarching themes to the behaviours exhibited by the actants in the relationships (see table 1 for a summary). Doctors are either *Unipolar* or *Bipolar*. *Unipolar* doctors are characterised by the doctor seemingly being driven by the needs/presence of the computer. Their lower body orientation is predominantly towards the computer, and they often ask questions motivated by the computer or input information during the consultation. By contrast, *bipolar* doctors clearly indicate switches of focus with significant lower body shifts – using these shifts to indicate "computer" time vs. "patient " time. Patients are either *dyadic* (view the interaction with the doctor as prime, with the computer as a tool) or *triadic*, where the patient is happy to deal with the computer as an integral, if not equal, partner in the consultation. Similarly with the computer we can describe either *active* or *passive* styles of behaviour. Doctor styles generally remain consistent throughout each consultation and across consultations. Patients are only seen for one consultation, so although they are consistent across that consultation, no conclusion

can be made as to whether this is consistent across all consultations, either with that doctor or all doctors. The computer can change its style during the consultation, according to the directions of its programming.

The Conceptual Framework maps the overarching styles with the observed behaviour categories (or macro behaviours). An example of the framework in use is given in the example at the end of the paper..

The Behaviours

- Engaging behaviours: Refers to those behaviours when the doctor needs to engage with the patient in the consultation
- Disengaging behaviours; Conversely, refers to those behaviours when the doctor wishes to shift *away* from the patient, towards the computer.
- Cogitation: Refers to those behaviours related to the doctor staring at the computer for no clear reason. May include grazing (brief stares) to quite long periods of attention.
- Screen controlling: A patient behaviour where they try to bring the computer (through its surrogate, the screen) into play in the consultation. This is a more active process than the next category
- Screen watching: The patient uses the screen as a focus of attention in the consultation
- Screen excluding: Deals primarily with the doctor, not the computer, and may exhibit behaviours that actively excludes the computer.
- Informative: The first computer behaviour; where the computer provides important information for either patient or doctor.
- Distracter: Where an action by the computer (passive or active) acts to distract one of the other actants.
- Prompt: Where the computer acts to remind either of the actants of an action that needs to be attended toAuthor affiliations

Discusson

This classification of behaviours is similar in many ways to what has occurred in previous studies. Other work has taken a particularly doctor centric view, and had described specific doctor styles, such as managerial/interpersonal/informational [11] or behaviours such as “magic box”[12]. However my study extends on the previous work in several ways. I have attempted to be value neutral in my observations, I make no attempt to judge what may be “better” or “worse” in what is observed. Secondly, I am treating the relationship as an interaction between three players – describing and classifying not just doctor (the most usual observation) behaviour but also the patient and the computer. Patient centredness [9] requires us to take into account the patient perspective, therefore in the new consultation we should take into account the role and behaviours of the computer. Scott and Purves[13] have described the relationship as a triadic one, the sum of the interactions between three players. This work represents the first attempt to characterize the relationship from all three perspectives. This framework will allow further analysis/tagging of the video files. Thus a video of bipolar doctor/dyadic patient will be tagged according to the presence of screen watch behaviours, allowing a picture to be created as to what those behaviours are. This triadic perspective, and the application of the theoretical approach allows us to now take these classifications to the next step – reviewing the consultations to look at the flow of information in the consultation, how the triadic relationship works in the first minute, and the role of printing in the new consultation.

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A Classification of the Behaviours of Doctors Patients and Computers in the Family Practice Consultation

Doctor's, Patients and Computers, The New Consultation

Dr Christopher Pearce PhD, MFM, MBBS, FRACGP, FACRRM

This Study:

20 GPs and 134 useable consultations
7% patient refusal
33% doctor refusal
20% lost due to technical reasons

- Rural and Urban
- Female and Male
- Solo and Group Practice
- *ALL* use computers for clinical functions and progress notes.

The Study used a hermeneutic framework, with Goffman's dramaturgy as a methodology, to underpin a video observation method. The 134 videos were viewed by two reseachers, and from those observations a classification framework was derived, and then tested on repeated viewings. Other researchers have attempted to classify some behaviours, usually from the doctor's perspective. This is the first time all three players in the consultation have been so viewed.

We view the consultation as a performance, in that both doctors and patients adopt specific roles. The computer also has quite specific roles, which invariably shape the consultation. Doctors are described on the basis of whether the pole of their lower body remains fixed on the computer (unipolar), or rotates between patient and computer (bipolar). Patients similarly are seen to be inclusive of the computer (triadic) or focused on the doctor (dyadic). Within the consultation the computer is passive, or active. Several classes of behaviours have also been described.

Consulting Styles vs Behaviours

Doctors

- **Styles**
  - Unipolar: always has lower pole of body facing computer
  - Bipolar: alternates lower pole of body between computer/patient
- **Behaviours**
  - Disengaging
  - Engaging
  - Cogitating

Consulting Styles vs Behaviours

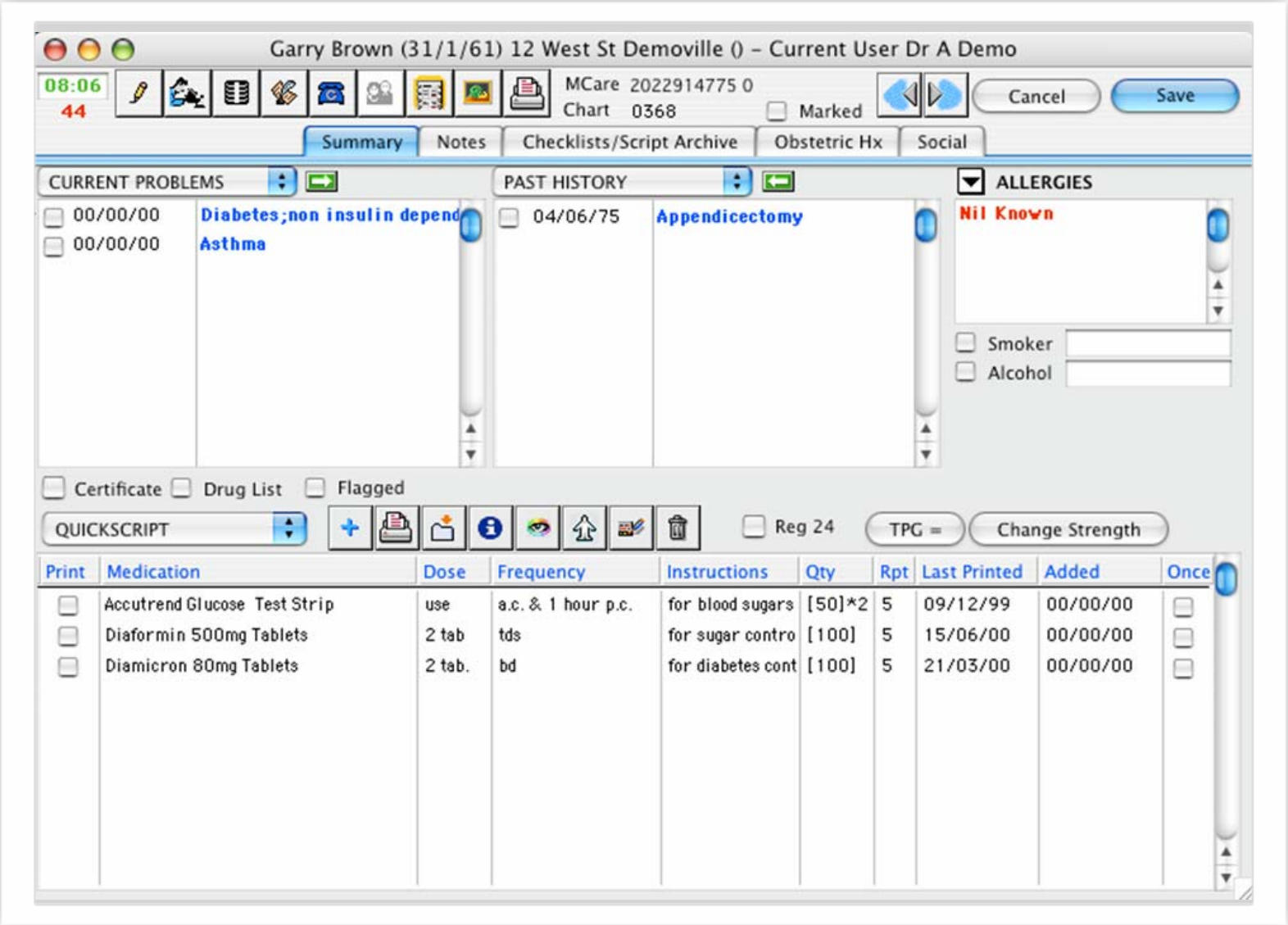
Patients

- **Styles**
  - Dyadic: inclusive of doctor
  - Triadic: inclusive of doctor *and* computer
- **Behaviours**
  - Screen-excluding
  - Screen-watching
  - Screen-controlling

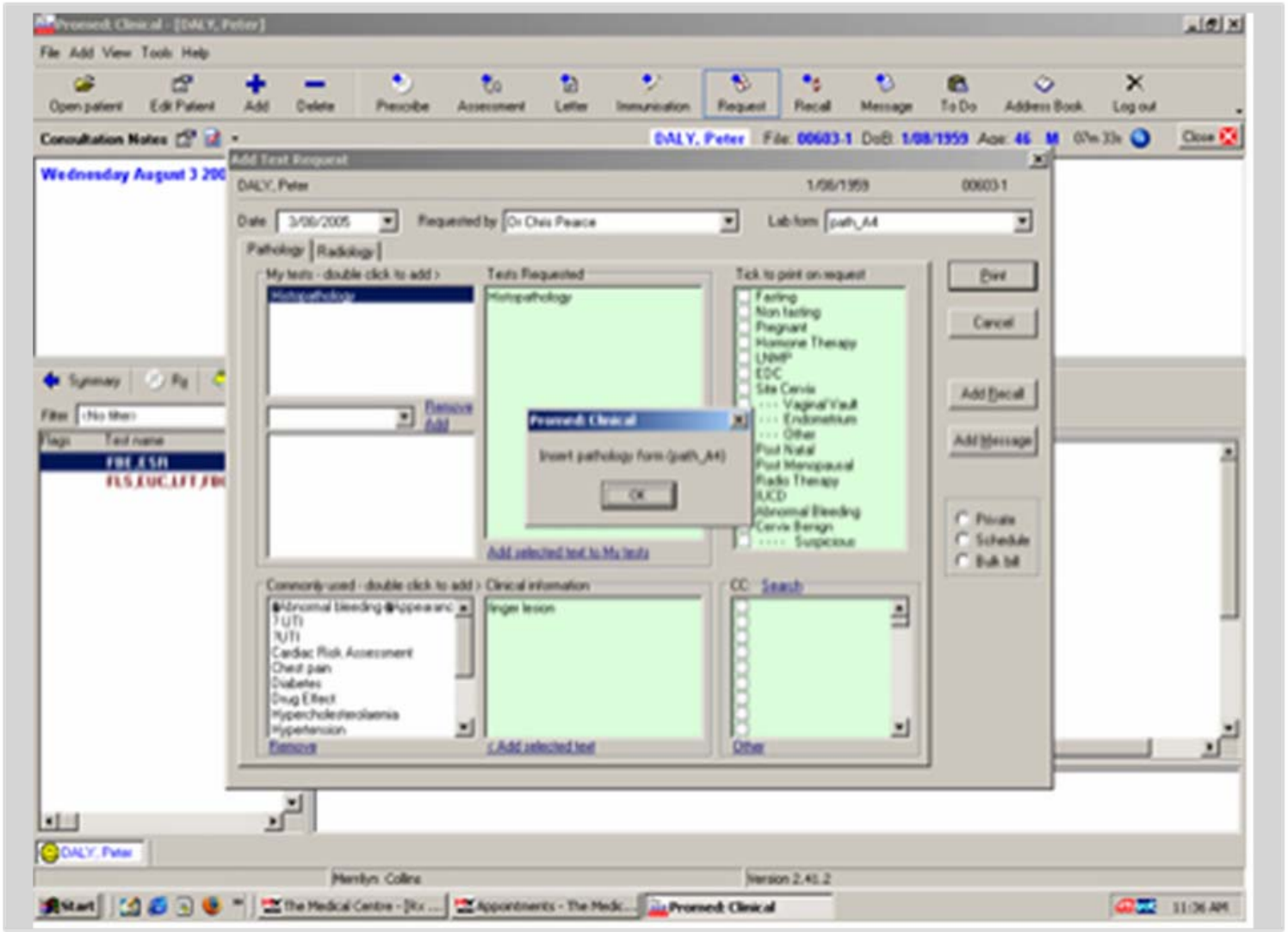
Consulting Styles vs Behaviours

Computers

- **Styles**
  - Active: forces the computer into consultation
  - Passive: Computer involved by humans.
- **Behaviours**
  - Prompting
  - Distracting
  - Informative



Passive Computer



Active Computer

DOCTORS	***Unipolar or Bipolar***
Engaging	*Engages the patient in the triad*
Disengaging	*Disengages the patient from the triad*
Cogitation/Evaluation	*Using computer as an aid*
PATIENTS	***Dyadic or Triadic***
Screen controlling	*Introduces computer into the consultation*
Screen watching	*Attends to the computer*
Screen excluding	*Ignores the computer*
COMPUTER	***Active or Passive***
Informative	*Provides Information into the consultation*
Prompt	*Reminders*
Distracter	*Distracts from the consultation*

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This Poster is part of the PhD: Doctors, Patients and Computers, the new consultation

An observational study into how doctors, patients and computers interact in the medical consultation.

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DEPARTMENT OF GENERAL PRACTICE

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Personalized Patient Education for Cardiovascular Risk Management: A Synergy of Behavioural Modelling, SCORE and Compositional Information Personalization Methods

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Abstract

Personalized patient educational programs offer the opportunity to empower patients to self-manage Cardiovascular Disease (CVD) risk. In this paper, we present the PULSE project—Personalization Using Linkages of SCORE and behaviour change readiness to web-based Education—that provides personalized patient education for CVD risk management. Our personalization approach leverages behaviour modelling to ascertain the patient's readiness to uptake any educational interventions and behavioural attitudes towards self-management/improvement. The PULSE framework involves the calculation of the patient's CVD risk using the Systematic COronary Risk Evaluation (SCORE) algorithm, the estimation of readiness to change using the Transtheoretical Model (TTM) of intentional behaviour change, and the representation of personalization logic as Medical Logic Modules (MLM). The educational interventions were derived from evidence-based staged lifestyle modification materials and Canadian clinical guidelines for CVD risk management.

Keywords:

patient education, cardiovascular, risk assessment, behavior modelling, information personalization

Introduction

Patient education, especially for chronic health conditions, is an integral component of disease management at the patient level. In practice, patients are empowered through educational programs that enable them to make informed choices about therapeutic options, risk assessments and lifestyle modification to ensure healthy lives [1].

In general, patient education is practiced through the provision of 'generic' health educational material in the form of print materials (pamphlets or booklets) and/or Internet based health portals. However, despite both the perceived and demonstrated benefits of patient education, there is a noted lack of uptake of conventional patient education programs, despite the apparent ease of access, because the educational material is generally designed to cover the needs of a wider patient population. Patients prefer to receive information that is personalized to their individual needs and situation [1]. Personalized educational interventions are more likely to be read, remembered, experienced as personally relevant, and in turn are more effective in changing health outcomes [2].

We believe that personalized patient educational programs can be made more impacting if we take into account the patient's underlying (a) perceptions and attitudes towards his/her health risks; and (b) behavioural disposition towards the uptake of any risk modification information. Therefore, we argue that the personalization of patient education material should be guided by patient's behavioural readiness to uptake educational interventions (in addition to the patient's health profile). We pursue personalized patient education by (a) *determining* the patient's attitude towards his/her health condition and then establish their readiness level to make lifestyle changes to avoid risky behaviours; (b) *educating* the patient so that he/she contemplates lifestyle changes; and (c) *modifying* the patient's lifestyle through personalized educational material that targets both the patient's behaviour and health conditions.

Our research addresses the generation of personalized patient education programs for CVD risk management. The PULSE project personalizes educational material based on the patient's (a) 10-year risk of fatal CVD calculated using the SCORE algorithm [3]; and (b) readiness to change risky behaviour, which is determined using the TTM of intentional behaviour change, also known as Stages of Change [4]. We developed a novel compositional information personalization method that involves the dynamic composition of a personalized educational package by (i) systematically selecting multiple, topic-specific *snippets* of information based on the patient's behavioural and health profile [5]; and (ii) synthesizing the selected snippets based on a patient-specific presentation template. The personalization logic is derived from Canadian clinical guidelines and behaviour change literature, and is represented using MLMs. The educational material covers both medical and psychosocial aspects of CVD risk management, and is derived from a combination of staged lifestyle modification [6] and non-staged messages based on Canadian clinical guidelines. Finally, a web-based interface is used to present the personalized education material to the patient.

Materials and methods

We pursue fine-grained composition of a patient-specific educational package. Therefore, the entire educational material is decomposed into multiple individual educational messages, called *snippets*, where each snippet addresses a particular health issue, targets a specific set of patient parameters and is relevant to a specific Stage of Change. Our strategy is to construct a document by systematically selecting a set of snippets that are related to the patient's health conditions and behavioural Stage of Change. The patient-specific snippets are then intelligently synthesized to yield a seamless PDF-based personalized educational package. Our compositional information personalization strategy allows a fine distinction between patients and ensures that each patient receives educational interventions that are fine-tuned to his/her health needs and behavioural disposition towards risk management.

Behavior change model

We use the TTM [4] as it guides the patient through the process of modifying problem behaviour(s) and acquiring positive behaviours. We designed educational interventions that correspond to patient's needs at different Stages of Change.

Patient data capture template

The Data Capture Template (DCT) records patient information to guide the generation of personalized educational material. We used the Wellsource Coronary Risk Profile, with some modifications to meet (a) SCORE requirements, and (b) Canadian healthcare standards. The DCT was divided into four distinct sections: (1) Demographic Data; (2) Health History Data; (3) Clinical Data; and (4) Risk Behaviour Data.

Patient profile

The patient profile includes: (a) patient information collected via the DCT; (b) new patient information calculated using the DCT data; (c) the computed SCORE value; and (d) the patient's Stage of Change for each risk behaviour. The profile comprises three components: (i) CVD Risk Profile; (ii) Staged Risk Factor Profile and (iii) Non-staged Risk Factor Profile.

Message library

The message library contains a large volume of topic-specific educational interventions that are represented as 200 *snippets* of information, originating from multiple Canadian sources. At a highest level the snippets were categorized as staged and non-staged. At the next-level, the staged material was categorized into five categories, corresponding to the five Stages of Change. The non-staged material was categorized into six snippet categories—i.e. introductory (opening statements), informational (suitable action), definitional (meaning), motivational (incentive), factual (evidence), and gender-specific.

Personalization decision logic

The personalization decision logic determines the selection of the relevant snippets based on a given patient profile. To establish the decision logic, we first developed a mapping matrix that contained the 14 risk conditions identified in the DCT and potential messages targeting these risk conditions. Next, the matrix was translated into a set of symbolic decision rules—i.e. if-then statements—that map the profile elements in the IF part of the rule to specific messages in the THEN part of the rule. We used MLMs to represent the medical knowledge. In total, we developed around 300 rules and a forward reasoning rule-based engine to execute the rules.

Information presentation template

The information presentation template served as an information-structuring guide to determine the order in which the selected snippets are to be integrated. The template was divided into four sections: (1) The *Introductory* section providing patient's name, date, clinic name and the contents of the personalized document; (2) The *CVD Risk Profile* section providing both textual information and a graphical display of the patient's absolute CVD risk as computed by SCORE. (3) The *Progress* section provides a graphical display of changes in a patient's modifiable risk factor values over time; and (4) The *Risk Factor Management* section provides information on each risk factor relevant to the patient.

Delivery method

In PULSE, the educational material is presented as a PDF file that can be both viewed online (in a web browser) and printed as a document. Interaction with the PULSE system is initiated by a healthcare professional in a primary care setting. The practitioner enters the patient data into the DCT whilst consulting with the patient. Next, the PULSE system generates the personalized educational package for the patient.

Concluding remarks

The PULSE approach presents a personalized patient education system that purports a unique synergy between evidence-guided CVD risk assessment and the TTM for behaviour change readiness. We have developed a novel information personalization method that maps the patient profile to specialized educational interventions that correspond to the patient's physiological data, risk category and behavioural predisposition to lifestyle modifications. PULSE system has been qualitatively evaluated by CVD experts in a clinical setting.

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Applying Tailoring Techniques for the Development of Consumer-focused and Clinician-focused Adult Depression Management Systems

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Abstract

This abstract describes the utilization of tailoring techniques for the development of evidence-based disease management systems for adult depression. TIDES is a consumer-focused system for self-care management of depressive symptoms. MODS-AD is a PDA system designed for clinicians to support depression screening and treatment planning decisions.

Keywords:

tailoring techniques, adult depression, self-care management

Introduction

With symptoms ranging from mild but chronic to more severe episodes, depression has been constantly reported as under-diagnosed and under-treated. The purpose of this abstract is to describe the application of tailoring techniques to develop two evidence-based adult depression management systems, tailored interventions for management of depression symptoms (TIDES) and mobile decision support for adult depression (MODS-AD), and to identify the important considerations while utilizing the same principles for system development.

Methods

TIDES and MODS-AD focus on different aspects of adult depression management. The development of these two programs has followed to the five steps of the tailoring process that were proposed by Kreuter and colleagues [1].

Results

1. Analyzing the problem and identifying determinants

TIDES is intended to assess the level of depressive symptoms of an individual while using the system independently. It helps to identify individuals at high risk and provide self-care management strategies for depressive symptoms. The program cannot make official psychiatric diagnoses. For MODS-AD, the program is designed to be used at the point of care in the clinical encounter in order to increase depression screening rates and adherence to guideline-based care. Clinicians have control over the final diagnostic decisions and treatment plans based on principles recommended by MODS-AD plus their clinical knowledge and experience.

2. Developing a program framework & assessment

The tailoring framework of TIDES was based on social cognitive theory [2]. The initial CES-D assessment divides TIDES users into three major groups using the cut-off points of 8 and 16 [3]. By comparing the score of the CES-D sub-scales, users with moderate risk are further divided into three groups. The secondary assessments were focused on physical activity, type of thoughts, or interpersonal relationships. On the other hand, MODS-AD is used to assist clinical depression screening and treatment planning. The framework is guideline-based [4, 5] and supported by recent published evidence. The two-step screening process (PHQ2 and PHQ9) is designed to fit into the busy clinical workflow and to avoid response burden of the patients.

3. Creating tailoring messages

The content readability and its length are two major considerations of the message composition for TIDES. In order to decrease the operational difficulties and assist the independent operation, the number of pages was increased. The prototype of TIDES consists of 74 messages with an average of 102 words per page at the readability level of 6.0. Regarding MODS-AD, because the plans of care that result from the tailoring process are designed for use by clinicians and implemented in PDA which has limited space for content presentation, they are composed in brief nursing/medical terms. Some parts provide more detailed information via help buttons.

4. Creating tailoring algorithm & automating the program

The tailoring algorithms reflect the key decision making points in the program. For TIDES, the user path has been tailored through the interactive assessment and goal-setting process. The linear design of TIDES limits the user's activity within the tailoring section. Individuals who may not fit into the purposes of TIDES are excluded at the

beginning of the system usage. The algorithm of MODS-AD includes the critical elements to reflect the clinical decision making flow of generating a depression-related diagnosis. Clinicians can choose the treatment plan options from the section tailored to a specific score on the PHQ9 plus level of functional impairment or suicidality.

5. Implementing the program and evaluation

TIDES is PC based and pilot tested with end-users. MODS-AD is PDA based and is under evaluation in a randomized control trial. The iteration of the program design is necessary to keep the information and tailoring rules updated.

Discussion

The definition of tailoring techniques highlights the two features that set it apart from other commonly used approaches to facilitate health care services. It is assessment-based at the individual level. As a result, the content of its communication can be highly individualized, going beyond risk status to develop personal plans to modify complex health problems by addressing the specific characteristics of an individual. Yet at the same time, it is truly a population approach with a potentially limitless reach for highly individualized communication among large populations.

In a recent series of well-designed studies, computer-assisted tailored programs have been shown to be more effective than conventional health communication approaches in helping some patients quit smoking, maintain balanced diet, increase their level of physical activity, and get mammograms and childhood immunizations [6-10]. The advances in information technology facilitate the utilization of tailoring information to meet the needs of individuals and health care providers. Consequently, the tailoring decision support system for clinicians in primary care settings (MODS-AD) and the tailoring self-care management system for consumers (TIDES) are possible adjunctive solutions for screening and management of adult depression.

However, although the assessment-feedback structure of tailoring programs makes them somewhat interactive, they don't come close to approximating the interactivity, intimacy, and immediacy of interpersonal communication. Tailoring communication programs such as TIDES should be viewed as complementary to the clinic encounters – a potentially powerful tool to enhance their work, not replace it. Similarly, MODS-AD was developed to assist the clinician in the detection and management of depression, not to replace clinical judgment.

Conclusion

In the area of mental health management, clinician encounters are usually the preferred service for improving health-related behaviors, due to the interpersonal contact, interactivity, and immediate feedback that can be provided with one-on-one counseling. However, the impact of such counseling on the health of populations is limited by cost and the relatively small number of individuals who can be reached by an even smaller number of trained professionals. Technology allows tailored communication programs to have broad reach and individual specificity, at a relatively low cost. As strategies for addressing low screening and treatment rates for depression, programs with tailored designs seek to identify alternative approaches that might be better suited to that person's needs or abilities and to assist primary care clinicians in achieving better health care quality.

Acknowledgments

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[9] Skinner CS, Strecher VJ, and Hospers H. Physician recommendations for mammography: do tailored messages make a difference? Am J Public Health 1994: 84: 43-49.
[10] Strecher VJ, Shiffman S, and West R. Randomized controlled trial of a web-based computer-tailored smoking cessation program as a supplement to nicotine patch therapy. Addiction 2005: 100: 682-688.

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Applying Tailoring Techniques for the Development of Consumer-focused and Clinician-focused Adult Depression Management Systems

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Introduction

- Depression has been constantly reported as under-diagnosed and under-treated.
- Purpose of this paper:

  To describe the application of tailoring techniques to develop two evidence-based adult depression management systems and to identify the important considerations while utilizing the same principles for system development

  – TIDES: Tailored Interventions for management of DEpression Symptoms
  – MODS-AD: MObile Decision Support for Adult Depression

Methods

- Five Steps Tailoring Process: Kreuter and colleagues [4]

  1) Analyzing the health problem to be addressed and understanding its determinants

  2) Developing the program framework and an assessment tool to measure a person's status on these determinants

  3) Creating tailored messages that address individual variation of determinants of the problem

  4) Developing algorithms and a computer program that link responses from the assessment into specific tailored messages

  5) Implementing the program and evaluation

Results – I

Analyzing the problem and identifying determinants

- TIDES:
  - User: individual consumer
  - System operation: PC/Laptop independently at home/clinic
  - Purposes: enhance independent self-care management
    - assess the level of depressive symptoms
    - Identify individuals at high risk but cannot provide psychiatric diagnoses
    - Provide self-care suggestions
- MODS-AD:
  - User: clinician
  - System operation: PDA at the point of care
  - Purposes: increase depression screening rates and adherence to guideline-based care
    - have control over the final diagnostic decisions and treatment plans
    - based on principles recommended by MODS-AD plus their clinical knowledge and experience

Results - II

- **Developing a program framework & assessment**
- TIDES:
  - Framework: based on the social cognitive theory [2]
  - The initial assessment: CES-D
  - The secondary assessments:
    - Physical activity
    - Type of thoughts
    - Interpersonal relationships
- MODS-AD:
  - Framework: guideline-based [4, 5] and also supported by recent published evidence
  - Two-step screening process: PHQ2 and PHQ9
  - Other considerations:
    - Suicidal ideation
    - Functional impairment

Results - III

- **Creating tailoring messages**
- **TIDES**
  - **Content: readability level 6.0**
  - **Length: 74 messages with an average of 102 words per page**
- **MODS-AD**
  - **Content and length: brief medical and nursing terms**
  - **Some parts provide more detailed information via help buttons**

Results - IV

- **Creating tailoring algorithm & automating the program**
- TIDES:
  - Linear design of TIDES limits the user's activity within the tailoring section
  - No return back to the pre-assessment points
  - Goal setting through the interactive process
- MODS-AD:
  - Flexible multi-layered algorithm
  - Include the critical elements to reflect the real clinical decision making flow
  - Free choices of treatment planning options within the diagnosis section

Results -V

- **Implementing the program and evaluation**
- TIDES
  - PC based
  - Pilot tested with end-users in the usability lab
- MODS-AD
  - PDA based
  - Under evaluation in a randomized control trial

Discussion

- MODS-AD and TIDES are possible solutions for management of adult depression. Reasons include:
  - Through the multiple level assessments, the content of tailoring communication can be highly individualized.
  - It is truly a population approach with a potentially limitless reach for highly individualized communication among large populations.
  - Computer-assisted tailored programs have been shown to be more effective than conventional health communication approaches [6-10].
  - The advances in information technology facilitate the utilization of tailoring information to meet the needs of individuals and health care providers.

Limitations

- TIDES:

  To enhance the regular clinical work, not replace it
- MODS-AD:

  To assist the clinician in the detection and management of depression, not to replace clinical judgment

Conclusion

- Technology allows tailored communication programs to have broad reach and individual specificity, at a relatively low cost.
- Programs with tailored designs seek to identify alternative approaches that might be better suited to that person’s needs or abilities and to assist primary care clinicians in achieving better health care quality.

References

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A Care Assessment System to Support Community-Based Healthcare

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EHEALTH RESEARCH CENTRE

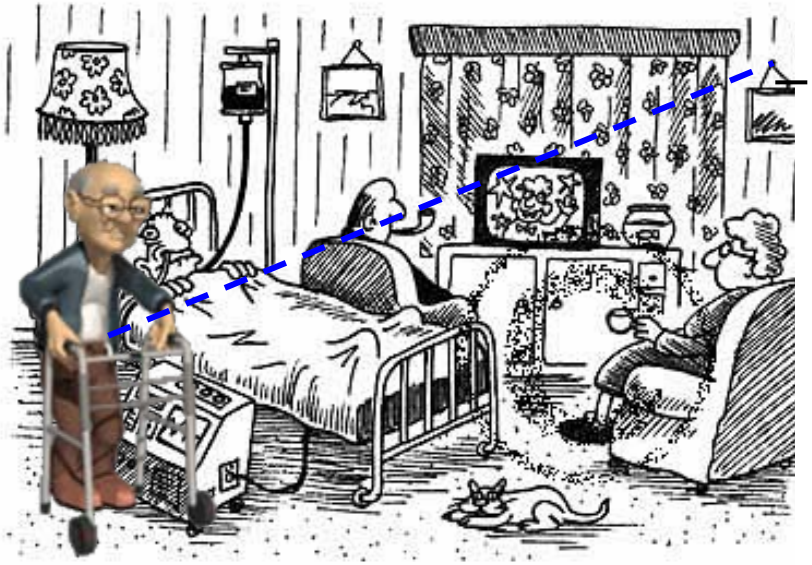
Background

- Pressures on health care delivery models because of:
  - Ageing population
  - Prevalence of chronic diseases
  - Diminished workforce

-> **Solution to improve care process :** Community based health care setting including multi-disciplinary care teams and detailed care plans

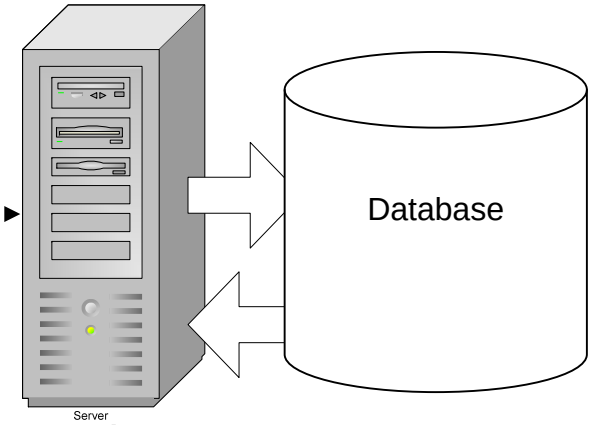
- Requirements:
  - Patient's health data should be collected and monitored also at home
  - Information on patient's health status should be available to care personnel at any time also outside the normal care circle

-> **Technology solution:** Software platform that provides monitoring and assessment information to the care team in the community care environment



Patient monitoring at home

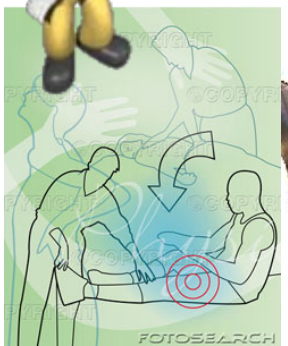
Health data transfer



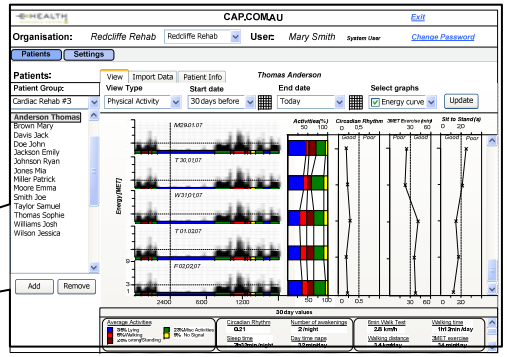
Centralized Server for data processing and storage

Community-based Healthcare

Assessment of patient condition and treatment



Web based GUI to display relevant health information to the care team

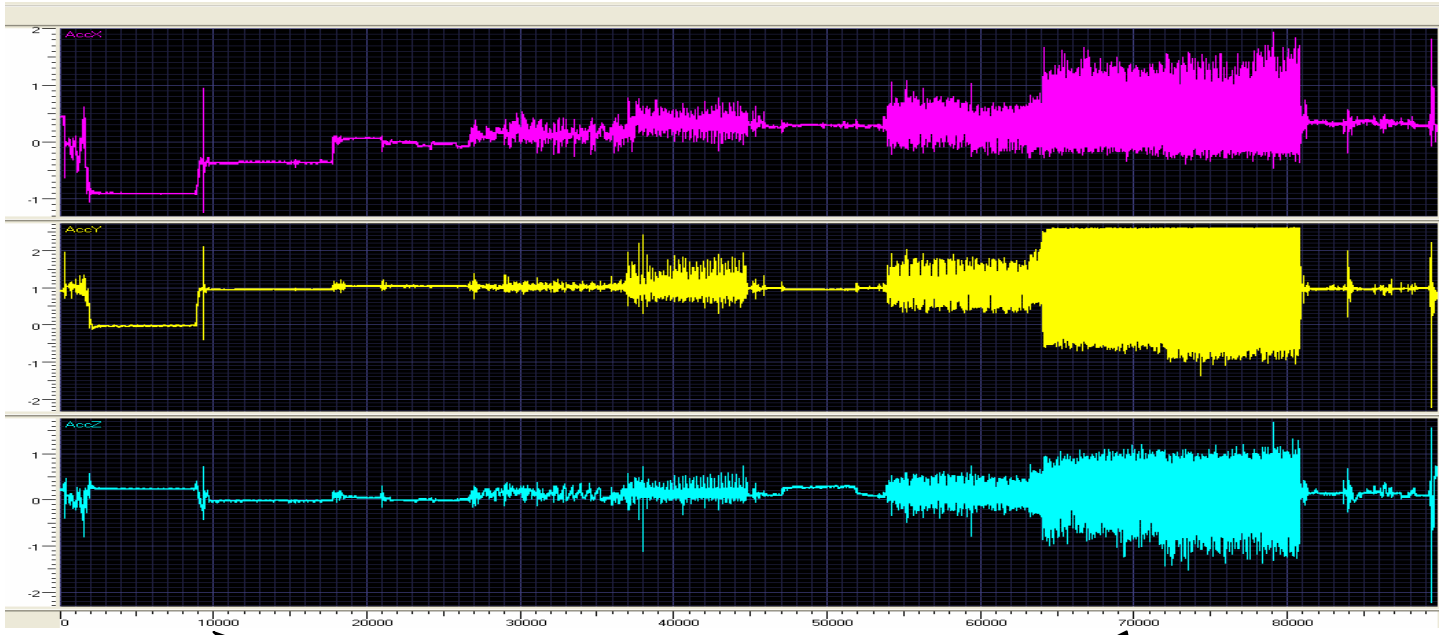


Methods

- Development of software platform technology that provides:
  - Ambulatory monitoring capabilities to collect patient data at home
    - Accelerometer, heart rate, and other health data
  - Calculation of clinically significant measures from the measured data to enable health assessment of the patients
  - Continuous availability of the measures for assessment to be performed at different time points and to monitor patient's progress according to their care plan
- Clinical trial to develop measures to assess patients with chronic diseases such as Cardiovascular Disease (CVD) and Chronic Obstructive Pulmonary Disease (COPD)
  - Trial employs ambulatory monitors worn by the patients to measure their physical movement activity and ECG
  - Measurement data is downloaded to a PC which analyses the data and displays clinically relevant information that the care team will use to assess the patient's condition

Ambulatory monitor: Waist worn accelerometer

Records X-, Y- and Z- axis acceleration



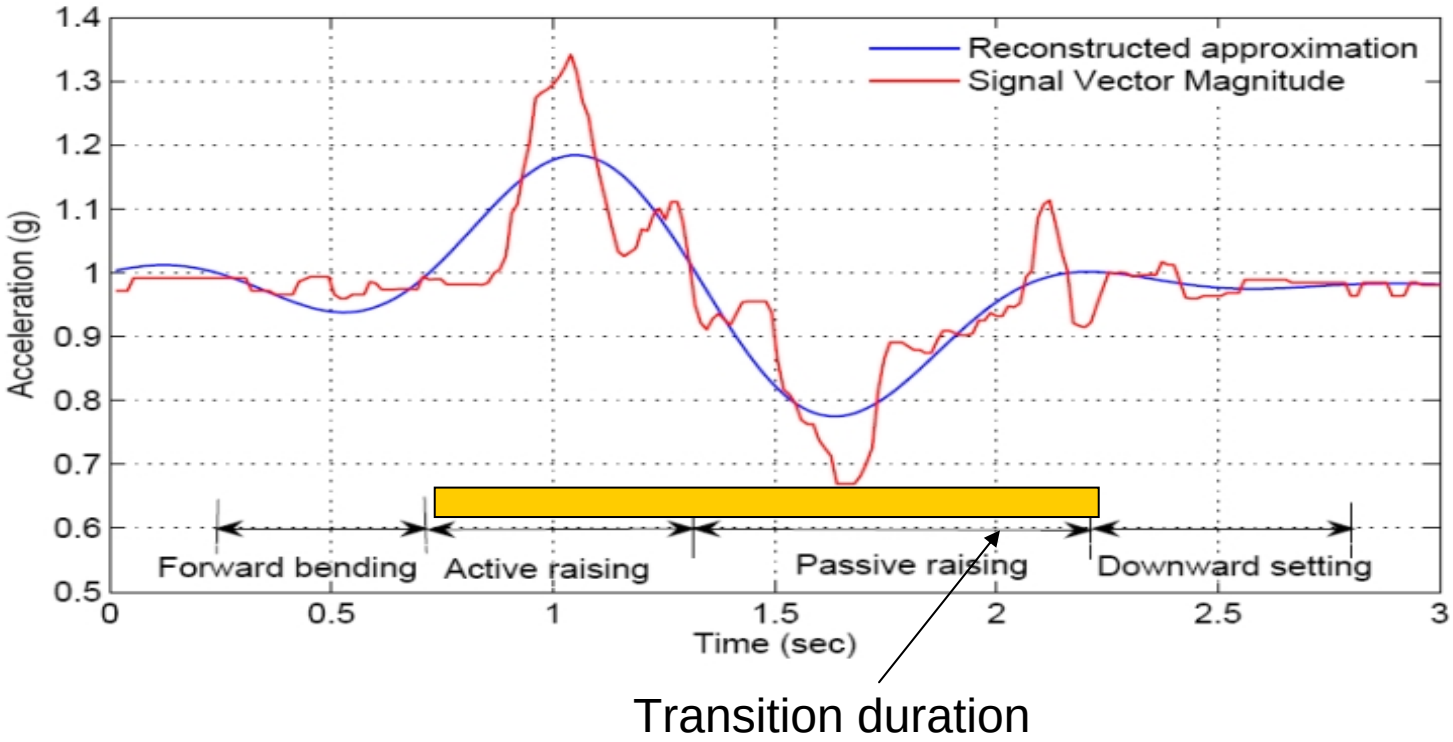
Movement patterns:

Sit to stand transition

Walking

Signal processing example

- Sit to stand transition duration can be calculated from accelerometer data by using wavelet transformation [1]



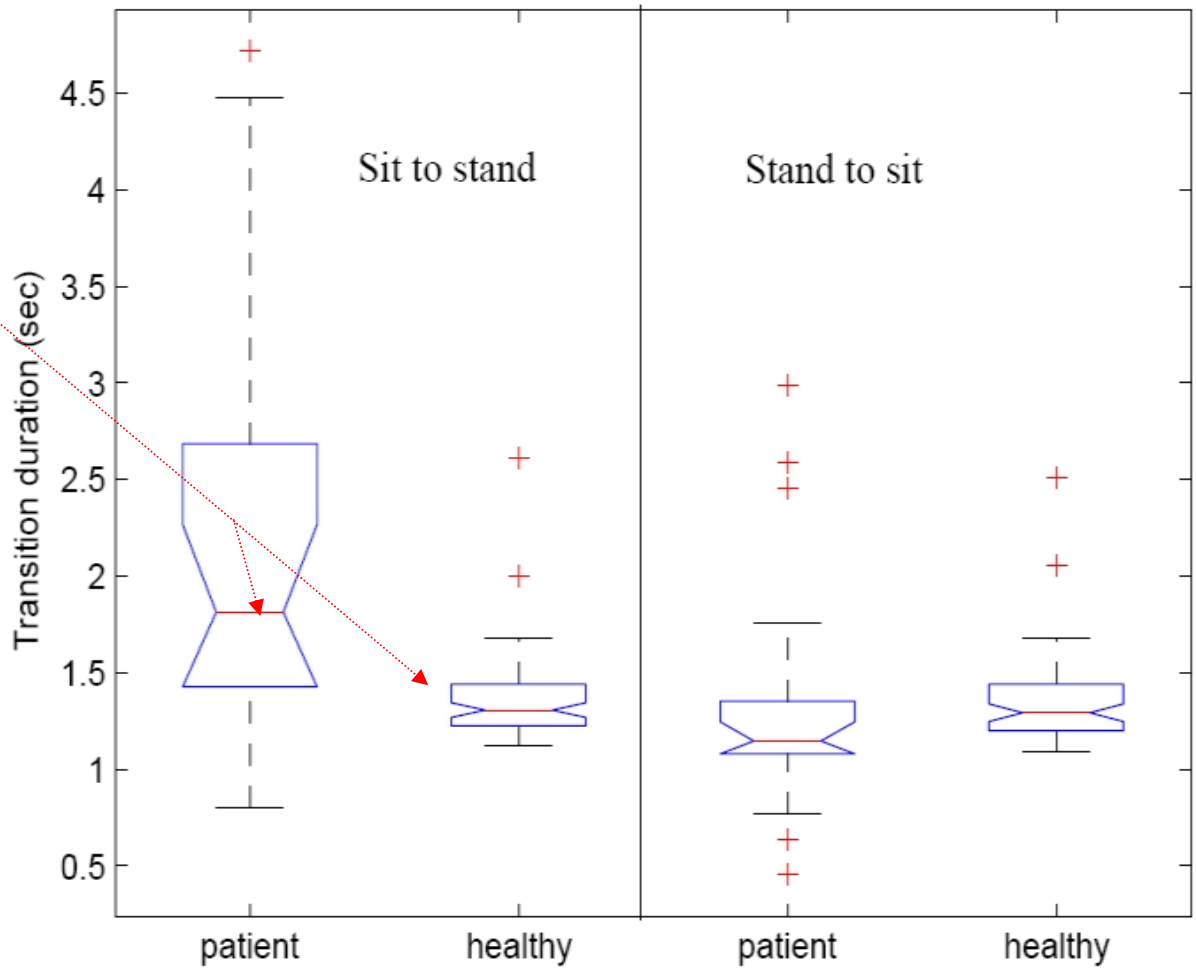
Transition duration significance

Sit to stand duration

- Statistically significant difference between healthy persons and elderly patients with medical conditions
- Sit to stand transition is also a good indicator to assess mobility of patients with heart diseases [2]

Stand to sit duration

- No significant difference observed

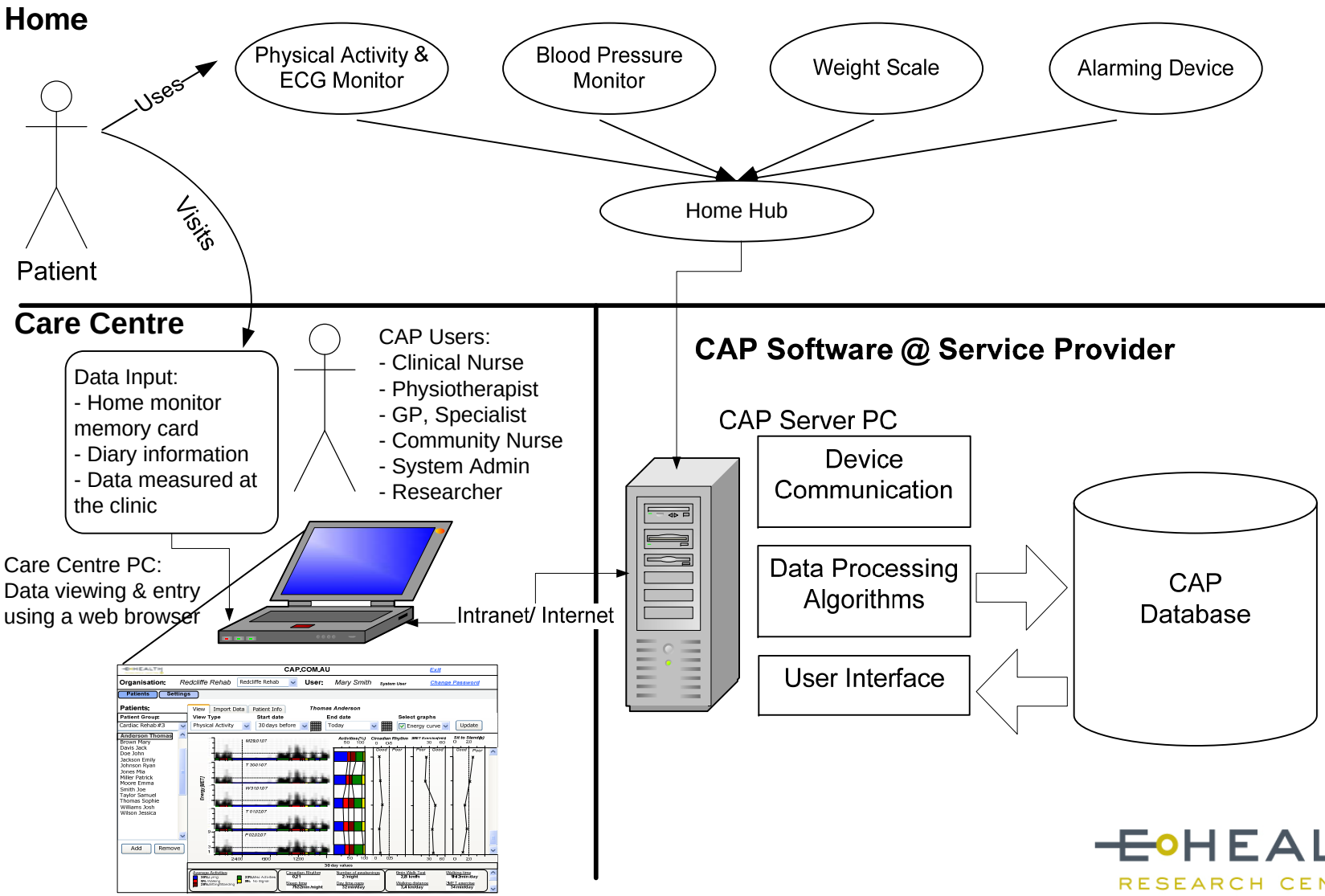


Data source: Princess Alexandra hospital, Brisbane

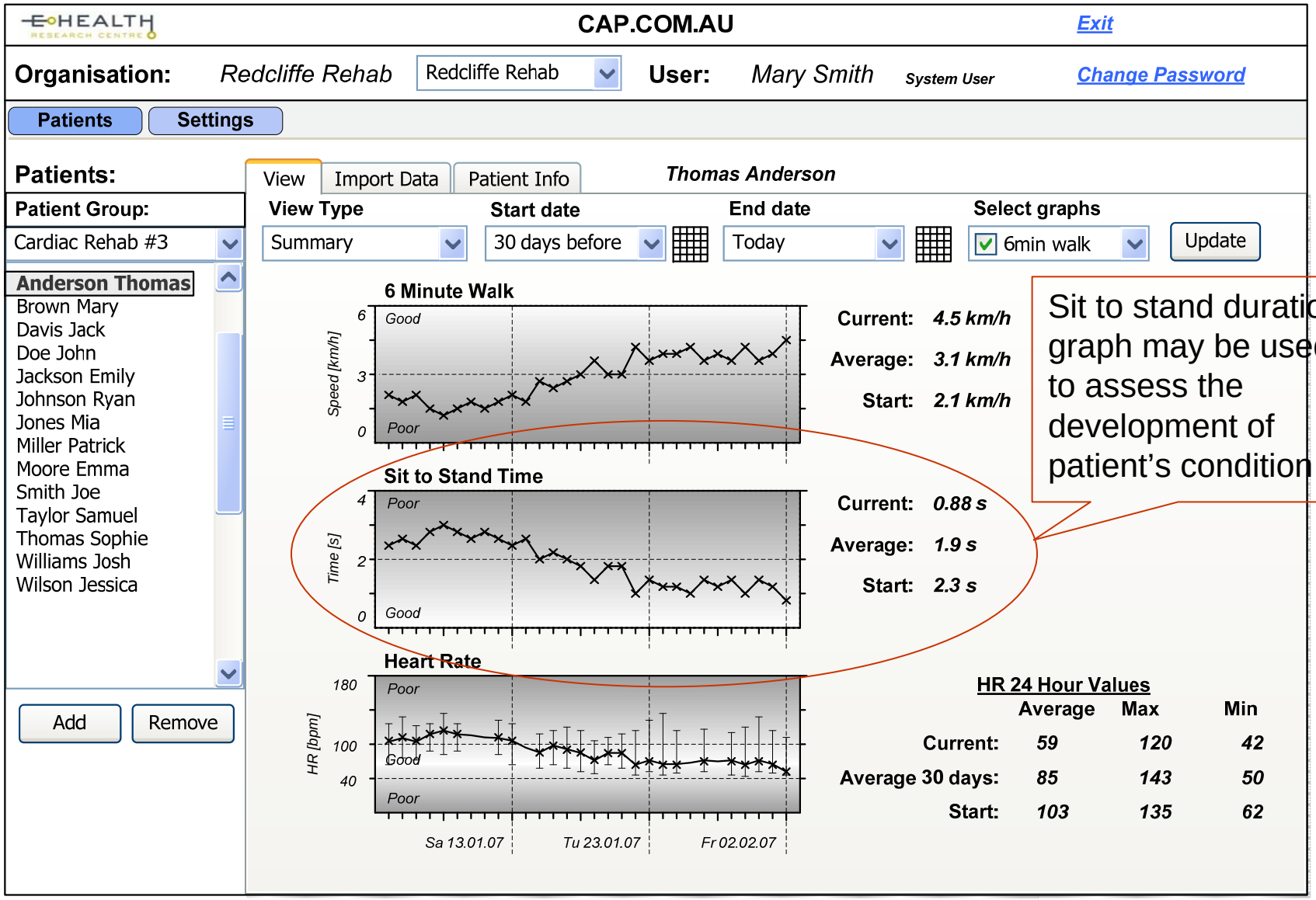
Care Assessment Platform (CAP) Software

- Main features
  - Convert and manage data form ambulatory devices fitted on patients
  - Perform data analysis to provide clinical measures that describe the patient's health condition
  - Store measurement data and related health information in a database
  - Provide a GUI for health care personnel to access the stored and analysed data
- Design principles
  - Open data exchange interfaces to connect various ambulatory monitoring devices
  - Highly modular structure to enable easy development of future applications and enhanced data analysis
  - GUI designed together with health care professionals to present clinically relevant information

CAP System Architecture



CAP GUI Summary View



Conclusion

- A care assessment software platform is being developed through a clinical trial conducted with ambulatory monitoring of COPD and CVD patients in a community care environment
- Clinical measures such as sit to stand transition time, metabolic expenditure and walking speed can be calculated and displayed to assist care team in assessment of patient's physical condition
- Future work:
  - Measure the effectiveness of the software platform in terms of health care benefits such as the ability to reduce hospital admissions
  - Incorporate the creation and monitoring of individual care plans to the software platform

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A Care Assessment System Supporting Community-Based Healthcare Environment

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Abstract and objective

Due to the large demands on the health system caused by factors such as the ageing population, prevalence of chronic diseases and shortage of healthcare worker, the trend has been to move the healthcare system into the community. A community based care setting encompasses a multi-disciplinary care team who would need to interact regularly between themselves and with patients at home. To enable such interaction, monitoring of patients need to be made regular and assessments made from such monitoring need to be accessible to the respective member of the care team at different timepoints of their care. The aim of this project is to develop a software platform technology that would provide such monitoring and assessment information in a community care environment. The development will incorporate clinical trial in which patient activity and physiological measures will be monitored with ambulatory devices, and the information being processed by the software platform to provide clinical measures for assessment to the multi-disciplinary care team. The outcome of the trial will establish the effectiveness and the benefits in provide chronic disease management in community care setting.

Keywords:

community care, chronic diseases management, health assessment

Introduction

It is well established that there are severe current pressures on our health systems caused by diverse factors such as ageing population, burden of chronic diseases, shortage of resources, diminished health workforce. Changes in healthcare delivery mechanisms by adopting new workforce models and workplace practices have been widely advocated to ease these pressures. Recent trends towards making such changes include *patient-centric care models* incorporating extended carer teams and detailed care plans, an*d place-based care initiatives* which permit care delivery to be conducted in community-based settings away from hospitals.

These approaches present a number of challenges on the human front. They require learning of new skills and protocols involving coordination of a large and diverse group of participants, only some of whom will have team skills and health systems domain knowledge. They also require substantial amounts of health information on the patient to be gathered and monitored, to ensure that care is proceeding beneficially, and allowing adjustments to be made to the care plan on an individual patient level. In addition, they need to respond to an expectation that comprehensive, updated and reliable information on all aspects of the patient's care progress should be available in future episodes involving clinicians and facilities outside of the normal care circle.

Methods

All of the above human issues can be addressed in part by use of platform software technology that provides:

- Monitoring capabilities to assess patient/disease status.
- Clinical measures derived from monitoring to enable health assessment of patient and also generate care plans
- Availability of these clinical measures for assessment to be performed at different timepoints and monitor patient progress against their care plan.

Development of such software platform technology has been taken by our research center through a clinical trial being conducted at a Brisbane community-based care setting. The clinical trial focuses on two areas of chronic diseases: chronic obstructive pulmonary (COPD) and cardiovascular diseases (CVD), which are most prevalent to the community of that setting. The trial employs ambulatory monitors worn by these cohorts of patients to measure their physical activity and vital signs. Information is either downloaded or streamed wirelessly to a PC with the software platform, which analyses the data for clinical assessments of physical activity and vital signs such as heart rate and respiratory rate. These clinical assessments are made available to the multi-disciplinary care team involved in care of the patients being participating in the clinical trial. From the clinical assessments used to measure against the care plan, a more perceivable feedback will be provided to patient to enable self-management.

Results

In the course of the clinical trial, the software platform technology will derive and adopt:

- Computational tools for the relevant clinical measures which provide immediate feedback of patient assessment for clinical decision making.
- User interface for easy interaction by the multi-disciplinary team
- Information flow that adapts to existing workflow of the community-based healthcare setting
- Key performance indicators used to contributes to care planning and its progress.

Following the development of the platform, the trial will establish its effectiveness and the engagement of the multi-disciplinary care team in providing care to chronic disease patients at various points of care in the community care setting. It will also establish the effectiveness of the platform to provide chronic disease management at different levels of risks of the CVD and COPD diseases (primary prevention, secondary prevention, and tertiary prevention).

Conclusion

The shift in the current health system to community care requires a change in workforce, workflow and interaction with the patients at homes to provide better quality of care. To address this change, a care assessment software platform technology is being developed through a clinical trial conducted with ambulatory monitoring of COPD and CVD patients in a community care environment. The trial will establish the effectiveness of the software platform to provide: care assessment of COPD and CVD patients through ambulatory monitoring technology, the accessibility of clinical information to the respective members of the care team, and the capabilities to create and monitor care plans. This effectiveness will be measured in accordance with healthcare benefits such as the ability to reduce hospital admissions, individualized care plans, elimination of duplication of assessment, and encouraging self-management.

Prevention and Treatment of HIV/AIDS patients through ICT, A Pilot Study in AIIMS, New Delhi INDIA

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Introduction

ICT is revolutionizing the medical science that tremendously improved the patient education as well as case and management system.. India is having 3.97 million people living with HIV/AIDS, which is 2nd height in the world next to South Africa. It has been seen that the HIV/AIDS patients are poor in knowledge about HIV/AIDS. We studied 150 HIV/AIDS patients in our medical clinic: where we observed that 90%(135) patients know what is Internet, 33.3%(50) uses the computer out of which 14.7%(22) patient uses in work place, 12%(18) at home and 6.6%(10) at cyber café. 3.3%(5) patients use Internet to update knowledge. 73.3%(110) patients want to communicate to the doctor through email. 93.3%(140) patients feel comfortable to communicate doctor through email. 80%(120) patients thinks that doctor/hospital visit could be reduce if the doctor's available or response in the internet or email So Information technology can help to reduce hospital visit, improve batter care and management of HIV/AIDS patients in developing country if proper recourses are provided to the institutions.

Methods

Key ward: Internet, Knowledge, HIV/AIDS patients

Multimedia effect on preoperative Knowledge and postoperative recovery of patients undergoing laparoscopic cholecystecomy

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Patient education

- Patient education is defined as the process of influencing patient behavior and producing the changes in knowledge, attitudes and skills necessary to maintain or improve health. The more educated a patient is, the more likely he is actively engaged in communication.
- Many different approaches to pre-operative education have been used including:

(a) group lectures,
(b) individual teaching,
(c) printed information,
(d) learning packages
(e) audio-visual presentations and
(f) combination of the above

Materials and Methods

- Aim of this study is the evaluation of of the impact of a multimedia CD (MCD) on patient's undergoing elective Laparoscopic Cholecystectomy preoperative knowledge, anxiety and postoperative recovery.
- One hundred and twenty consecutive candidates for elective LC were assigned randomly to four groups.

  (1)Group A included 30 patients preoperatively informed regarding LC through the MCD presented by Registered Nurse (RN).

  (2)Patients in group B (n=30) were informed through a leaflet.

  (3)Patients in group C (n=30) were informed verbally from a RN.

  (4)The control group D included 30 patients informed conventionally by the attending surgeon and anesthesiologist, as every other patient included in groups A, B, C.

The Multimedia CD

- The CD was designed in order to be flexible, dynamic, portable and cheap, permitting easy navigation even to someone unfamiliar to a computer machine. Screen design is consistent. Fast access to menus and screens are possible. Regarding controls, exit, backward, forward and skip functionality are available all the time.
- The multimedia program contains information concerning fundamental elements of bile anatomy and physiology, aspects of the disease (cholelithiasis), details on the procedure (LC), and the alternative options (open cholecystectomy), possible complications, duration of hospital stay and advices about recovery and life after LC.

Preoperative and Postoperative Questionnaire

- All patients after the structured informative session and before the operation fulfilled a preoperative questionnaire which contained eleven knowledge questions and an anxiety scale. All knowledge questions scored equally with others and the anxiety scale was conducted using the translated Amsterdam Preoperative Anxiety Scale and Information Scale (APAIS) on which scores could range from 6 to 30.
- As soon as the operation ended postoperative pain and nausea scores were measured using a Numerical Rating Scale (NRS) scale, 8 and 16 hours after the patient had returned to the wards.

Table 1 Multiple regression analysis for the variable “Knowledge score”.

Variable	Knowledge score P value (Adj.R^2) A, B(CI of B)
Group C	*0.009 (0.3)* *9.119,- 0,662 (-1.156_-0.168)*
Age	*0.05 (0.30)* *9.119,- 0.490 (-0.980_-0.0)*

Table 2 Multiple regression analysis for the variable "APAIS II".

Variable	APAIS II P value (Adj.R^2) A, B(CI of B)
Group C	*0.001 (0.206)* *2.697,-1,667 (-2.595_-0.739)*
Educational level	*0.001 (0.206)* *2.697, 0.331 (0.140_0.523)*

Table 3 Multiple regression analysis for the variable "APAIS ".

Variable	APAIS P value (Adj.R^2) A, B(CI of B)
Gender	*0.03 (0.133)* *19.279, -2.341 (-4.452_-0.23)*
Age	*0.007(0.133)* *19.279, -2.353(-4.064_0.642)*
Group D	*0.003 (0.133)* *19.279, 3.561 (1.215_5.907)*

Table 4 Multiple regression analysis for the variable "Pain score".

Variable	Pain score P value (Adj.R^2) A, B(CI of B)
Gender	*0.000 (0.147)* *4.028, -0.899 (-1.363_-0.434)*
Group D	*0.013(0.147)* *4.028, 0.658 (0.144_1.172)*

Conclusions of multiple regression analysis

- In the multiple regression analysis, structurally informed patients and specifically groups A and B, achieved a better knowledge score regarding LC, answering correctly to more questions comparing to study group C and of course control group D, ($p=0.009$), as it is shown in Table 1. This finding suggests that knowledge gain during conventional informative sessions is suboptimal.
- Not surprisingly, patients older in age, achieved lower knowledge score than younger patients independently of the educational tool used with $p=0.05$
- Our results, in the multiple regression analysis, proved that conventional information provided in patients of group D increases patient anxiety. Specifically, patients informed only by their doctor had a higher APAIS score than the patients of groups A, B, C ($p<0.05$, see Table 3). Also older and male patients expressed lower anxiety levels than the younger female ones with pvalue=0.007 and pvalue=0.03 respectively.

Conclusions of multiple regression analysis

- According to the study, patients who were informed verbally expressed a lower need for preoperative information comparing to the rest of the groups (p value=0,001) and this need is higher for patients who were better educated (p value=0,001)(Table 2). We can assume that at least in Greece, patient's preoperative need for information is not full filled during conventional informative sessions.
- Patients who were informed appeared to feel less pain than those who were informed conventionally (p value=0,013). Especially male patients found postoperative pain less disturbing and recovered faster than women who spent more time in bed (p value =0,000)(Table 4).

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Multimedia Effect on Preoperative Knowledge and Postoperative Recovery of Patients Undergoing Laparoscopic Cholecystecomy

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Abstract

Objective: Aim of this study is the evaluation of the impact of a multimedia CD (MCD) on patient's undergoing elective Laparoscopic Cholecystectomy (LC) preoperative knowledge, anxiety and postoperative recovery.

Methods: One hundred and twenty consecutive candidates for elective LC were randomly assigned to four groups. Group A included 30 patients preoperatively informed regarding LC through the MCD presented by a Registered Nurse (RN). Patients in group B (n=30) were informed through a leaflet. Patients in group C (n=30) were informed verbally from a RN. Finally, the control group D included 30 patients informed conventionally by the attending surgeon. Preoperative assessment of knowledge about LC was performed after each informative session through a questionnaire. Evaluation of preoperative anxiety was conducted using Amsterdam Preoperative Anxiety Scale (APAIS). Postoperative pain was measured using a Numerical Rating Scale (NRS).

Results: In multiple regression analysis, group C achieved the lower Knowledge score comparing with Group A and B ($p=0,009$ $r^2=0.3$).

Conclusions: It is believed that multimedia should be incorporated and not replace the traditional relationship between health professional and patient.

Keywords:

Laparoscopic Cholecystectomy, Multimedia CD, Patient education, Preoperative Information

Introduction

Patient education

Patient education is defined as the process of influencing patient behavior and producing the changes in knowledge, attitudes and skills necessary to maintain or improve health. As it is well known patients and their families express the need to communicate and understand the events that occur throughout the course of their disease as Hannah et al say.[1] The more educated a patient is, the more likely he is actively engaged in communication. [3],[4]. Patient education can empower patients to become full participants in their care through enhanced communication and a strong patient-provider relationship. Educational materials designed to deliver information and promote active participation in health care decisions can be effective tools for empowering patients. Consumers are faced with an economic climate that scrutinizes health care services in terms of their outcomes. [4],[5].

Materials and methods

Aim of this study is the evaluation of a structured informative session using a Multimedia CD (MCD) in patients undergoing elective LC. The study focuses on the impact of preoperative informing on (a) patient's preoperative anxiety and (b) patient's postoperative pain [6].

The multimedia CD

The Multimedia CD is a specifically developed multimedia health educational product based on Toolbook Asymetrix, version 8.5, Macromedia Company on an AMD 2000+ 1,6GHz multimedia computer under Windows XP professional. The preoperative session performed in the patient ward with the use of a laptop computer. The MCD contains animation, narration and photographs which can reinforce patient's understanding and decrease anxiety.

Participants and data collection

From July 2005 to July 2006, 120 consecutive patients, candidates to elective LC for cholelithiasis, were considered for enrolment in the trial. Exclusion criteria were: (a) patients older than 75 years and younger than 18, (b) patients with an American Society of Anaesthesiologists (ASA) physical status score greater than 2, (c) patients unable to understand Greek, (d) patients with serious sight and deaf impairment. Informed consent for participation in the trial was obtained and the trial was approved by the Administrative and Scientific Council of the Patras University Hospital, Patras, Greece and the "Attiko" University Hospital, Athens, Greece.

Patients were assigned randomly to four groups: **Group A** included 30 patients, preoperatively informed about the scheduled operation through the MCD, presented by the Registered Nurse (RN). **Group B** included 30 patients pre-

operatively informed through the leaflet which was delivered to the patients without the presence of the RN. In **Group C,** there were 30 patients who were informed verbally from the RN and finally, the control **Group D** included 30 patients, who had the conventional preoperative information by the attending surgeon and anesthesiologist, as every other patient included in groups A, B, C. The information leaflet and the MCD was available to patients for 20-30 minutes. Four hours after the completion of each informative session of each group, RN collected the completed patients' questionnaires which had given to them, earlier. Patients in group D fulfilled the same questionnaire. All the data were collected in a randomized way.

Assessment of preoperative knowledge about cholelithiasis and LC, was performed, using "closed, true-false" questionnaire, specifically developed. Each question was scored equally with the others yielding a maximum score of eleven. Evaluation of preoperative anxiety was conducted using the six items of the translated Amsterdam Preoperative Anxiety Scale and Information Scale (APAIS) – subdivided by Anxiety Scale (APAIS I) and the Need-for-Information Scale (APAIS II) [7],[8]. Postoperative pain score were measured using a Numerical Rating Scale (NRS) scale, 16 hours after the patient had returned to the wards. The NRS scale consists of 11-points (where 0 indicates no pain at all, and 10 the most severe pain imaginable) [9],[10].

Results

There were 77 (64,2 %) women and 43 (35,8 %) men enrolled in the trial. Eighty one patients (67,5%) had a previous operation in their history. Seventy nine (65.8%) patients with ASA I and 41 (34.2%) with ASA II were included in the study, respectively. The mean age of patients was 53.07 years (range: 18-75). Thirty six patients (30 %) were familiar with the use of computers. In multiple regression analysis, the dependent variables "Knowledge score", "APAIS II", "APAIS", "Pain Score", were inserted. Those dependent variables were related with the independent variables in order to seek for any statistical significance.

Discussion

Effective informative sessions provided by the health professional, require specifically developed educational tools. In this study, we investigate the effect of MCD on patient's postoperative recovery. In the multiple regression analysis, structurally informed patients and specifically groups A and B, achieved a better knowledge score regarding LC, answering correctly to more questions comparing to study group C and of course control group D, ($p<0.009$, $r^2=0.3$). This finding suggests that knowledge gain during conventional informative sessions is suboptimal. Not surprisingly, patients older in age, achieved lower knowledge score than younger patients independently of the educational tool used with p value=0.05 and $r^2=0.3$. In the current paper, there was no extra study for long-term benefits of patient education as it was believed that according to the study of Triggs et al, there would be none [11]. Patients who were younger in age and were informed by the leaflet and the MCD achieved greater knowledge score comparing with the older patients who were being informed by the doctor or only by the RN. Ng SKS et al[12] found that provision of preoperative information regarding the recovery process leads to significant anxiety reduction. It is also known that preoperative information would reduce preoperative anxiety[13]. Our results, in the multiple regression analysis, proved that conventional information provided in patients of group D increases patient anxiety. Specifically, patients informed only by their doctor had a higher APAIS score than the patients of groups A, B, C ($p<0.05$, $r^2=0.133$). Also older and male patients expressed lower anxiety levels than the younger female ones with p value=0.007 and p value=0.03 respectively. Higher APAIS score means that the patient felt more preoperative anxiety. Choi-Kwon et al [14] underlines in his study that health professionals do not know what exactly patients want to know about stroke. Specifically, the Need-for-Information Scale (APAIS II) is lower in patients informed verbally by the RN ($p=0.001$, $r^2=0.206$) and higher in patients who were better educated (pvalue=0.001, $r^2=0.206$). The patients with a high APAIS II score feel that they have not been informed adequately. In our study, patients who were informed through a structured informative session and especially patients in group C expressed smaller need for preoperative information than the patients of control group D. We can assume that at least in Greece, patient's preoperative need for information is not full filled during conventional informative sessions. It is widely accepted that preoperative information induces rapid postoperative recovery. Giraudet et al[15] reports a strong positive effect of patient education to the reduction of postoperative pain. In our study, patients in groups A, B, and C reported less postoperative pain during the first 16 hours ($p=0,013$ $r^2=0.147$). It is also mentioned that in multiple linear regression analysis men appear to feel less pain than women ($p<0.001$, $r^2=0.147$). This aspect is strongly suggested by Keogh et al[17] also confirming significant differences in pain responses regarding gender. Morin et al [16] has also shown that women seem to find post-operative pain more intense than males, although men are more disturbed than women by the low levels of persitent pain.

Conclusion

The multiple regression analysis did confirm the statistical knowledge significance for the MCD. It seems that both

MCD with the presence of the RN and the leaflet can improve the quality of health care increasing learning transfer. On the other hand, specifically developed MCDs for different populations (regarding gender, age or educational level) have to be tested in clinical practice to provide a therapeutic approach to personalised needs. However, the impact of MCD on preoperative anxiety and postoperative pain is less obvious. As this study has not finished yet, we feel that this significant relationship will become more evident in the near future.

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Feasibility Study of Incorporating Personal Digital Assistants (PDAs) into a Problem-Based Learning Approach to Medical Education at the University of Wollongong

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Abstract

Objective: To determine the key functionalities of personal digital assistants (PDAs) applicable to medical education. Study design: Interview and focus group were designed. The in-depth interviews were conducted with the medical school stakeholders in order to gather the needs and interpretation about the PDAs functionalities in medical education. Results: Based on a comprehensive review and findings from interviews, four significant functionalities of PDAs were found, these being (i) a clinical log, (ii) a personal portfolio (or e-portfolio), (iii) reference information, (iv) communication and connectivity. Conclusion: There is considerable potential for employing PDAs as a learning tool in medical education.

Keywords:

personal digital assistants, medical education, problem-based learning

Introduction

The University of Wollongong (UOW) established a Graduate Medical School (GSM) and accepted students for graduate entry in 2007. The medical curriculum was designed to use 93 clinical problems based on the contents of the core curriculum. The core delivery strategy is case-based learning by monitoring the students' progress through a whole course as an independent learning exercise. The use of IT is integrated into the course in order to assist in course delivery. Students start to practice in the regional area from year 1, and are required to practice in clinical placement in a rural setting for a 40-week period. IT will be integrated and facilitate learning while the students are practicing in the clinical placement.

The purpose of this research is to study the feasibility, applicability and functionalities of incorporating PDAs into medical education especially for the UOW GSM. Accordingly, the research question for this study is: what are the key functionalities of PDAs applicable for medical education in a problem-based learning (PBL) curriculum? To answer this, it is essential to understand the general context of PDAs, their functionalities, how they have been applied in the medical and nursing professions, and barriers to using such devices therein. It is necessary to understand the roles of using PDAs in medical and nursing curricula, how they have been used in medical and nursing curricula, and what functionalities have been integrated into medical education.

PDAs have been used for clinical references, tracking clinical encounters and clinical decision making and e-learning in medical education, and they can provide a user friendly interface and multimedia tools enabling students to learn at their own pace [1-3]. Furthermore, using PDAs as an educational tool has a high degree of acceptance from clinical students. The important barriers for incorporating PDAs into the healthcare sector are data security, patient privacy, privacy protection and interception [4-6]. Moreover, data access, data storage and retrieval and the loss of data [7] are major concerns in the use of PDAs in clinical practice. On the other hand, usability, interference and security are not a problem if the systems are well designed and free from the barriers previously mentioned [5]. Other important problems are interoperability, interference, patient privacy, scalability, and connectivity [5, 6, 8]. The use of PDAs in medical education can help medical faculty to monitor student performance and bridge the gap between student education and their clinical experiences, as students can take PDAs into clinical placements while having contacts with patients. Almost two-thirds of US medical schools integrate PDAs into residency programs [9]. Various uses of PDAs in medical education are student patient log systems, classroom assessment systems, teaching and interaction evaluation, objective structured clinical examinations (OSCE) and medical research [7, 9, 10].

Methods

Interviews and focus groups were designed accordingly. At this stage in-depth interviews with 15 stakeholders, have been undertaken; these aim to bring out information about the meaning, complication and interpretation from participants [11]. Moreover, they allow new understandings and theories to be formulated during the research process [11-13]. Results from these interviews have yet to be analyzed into different themes using `NVivo` software. These themes will then be used to conduct focus groups in the next phase of the project.

Interviews

Relevant medical stakeholders were contacted and interviewed face-to-face. The open-ended questions were asked about the appropriate PDA functionalities for students to use during their study years, what kind of information needed to be stored in the PDAs, how PDAs can be used in PBL approach, how to synchronize data back to servers, and what type of network connection is used. The interviews lasted approximately 30 minutes for each participant. All interviews were transcribed and analyzed based on content analysis [12, 13]. The interview answers were analyzed and categorized.

Results

Four major functions have been identified to date, these being: (i) clinical logs, (ii) personal portfolio (or e-portfolio), (iii) reference information, (iv) communication and connectivity.

Discussion

Mainly PDAs are to be used as a learning tool because of their portability and accessibility to information anywhere and anytime. The stakeholders express many needs of incorporating PDAs to GSM. Security and confidentiality are important concerns when using PDAs in the real world, particularly when recording patient logs and e-portfolios. Furthermore, stakeholders want PDAs to have the ability to access medical references. In addition, to fulfill the needs of using PDAs in medical education, PDAs must be well equipped with the standard IT systems, particularly for communication and data synchronization back to the central servers or data on demand (DOD) [14]. On the other hand, PDAs need to be connected to GSM systems for data transmission from remote locations to central servers. Currently UOW has access to medical databases such as AccessMedicine, MDConsult and Medline. Having PDAs in hand will assist students in referencing material.

Conclusion

PDAs can facilitate learning in medical education particularly in a PBL approach by using clinical logs and e-portfolios in order to keep track of students' progress. Wired or wireless PDA connectivity and communication functions would support and enhance students to learn as well as communicate with faculty while away in clinical placements. In the future, we plan to continue this study by conducting focus groups with medical, nursing and IT experts in order to gain a better understanding of how *best* to incorporate PDAs into a PBL-based medical curriculum.

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Feasibility Study of Incorporating Personal Digital Assistants (PDAs) into a Problem-Based Learning Approach to Medical Education at the University of Wollongong

Introduction

Background

The University of Wollongong (UOW) established a Graduate Medical School (GSM) and accepted students for graduate entry in 2007.

The medical curriculum was designed to use 93 clinical problems based on the contents of the core curriculum.

The core delivery strategy is case-based learning by monitoring the students' progress through a whole course as an independent learning exercise.

The use of IT is integrated into the course in order to assist in course delivery. Students start to practice in the regional area from year 1, and are required to practice in clinical placement in a rural setting for a 40-week period.

IT will be integrated and facilitate learning while the students are practicing in the clinical placement.

Aim

To study the feasibility, applicability and functionalities of incorporating PDAs into medical education.

Research questions

What are the key functionalities of PDAs applicable for medical education in a problem-based learning (PBL) curriculum?

- How PDAs have been applied in the medical and nursing professions, and barriers to using such devices?
- What are the roles of using PDAs in medical and nursing curricula?
- How PDAs have been used in medical and nursing curricula?
- What functionalities have been integrated into medical education?

Introduction

PDAs have been applied in medical and nursing professions as well as medical education including

- clinical guidelines
- clinical references
- tracking clinical encounters and medical curriculum
- e-learning in medical education
- clinical decision making
- exchanging information between physicians during changeover of wards
- ordering additional clinical tests and checking test results
- Exchange information between physicians during changeover of wards
- ordering additional clinical tests and checking test results
- accessing medical images
- recording patient information [1-4]

Introduction

At present, many medical schools use PDAs in medical education, such as

- The Department of Family Medicine,
- University of Rochester,
- George Washington University,
- Johns Hopkins School of Medicine,
- Thomas Jefferson Medical College,
- Georgetown University,
- Columbia University,
- Stanford University,
- Medical College of Wisconsin and
- Wayne State University [5-12].

Example of how PDAs are used in medical professions.

PDAs have been used in various clinical placements such as the Canadian intensive care unit for wireless data transmission between the clinical staff, clinical data capture using pen-based PDAs [13], accessing medical images, clinical encounters and medical findings via their web-based interface [14].

Having medical information stored on PDAs means it is easy to use and access by clinicians and medical students at the point-of-care, moreover data can be downloaded to a central computer. Clinicians also use PDAs for recording patient information [15]. As a result, they can easily focus on their education [3, 6, 16].

Introduction

The roles of using PDAs in medical and nursing curricula

A major issue in the clinical area is errors in medication [15, 17].

Use of PDAs in the medical profession has the potential to decrease medical errors and increase efficiency [16].

Using PDAs to issue prescriptions result in less errors than with handwritten prescriptions. Therefore PDAs can play an important role in electronic prescription [15].

The Important Barriers for Incorporating PDAs into Healthcare Sector [4, 10, 13]		
• Data Security	• Patient Privacy	• Privacy Protection
• Interception	• Data Access	• Data Storage and Retrieval
• Loss of Data	• Usability	• Interference
• Interoperability	• Scalability	• Connectivity

Summary of PDA Applications in Medical Education [10, 18, 19]

- Student-patient Log
- Classroom assessment systems
- Gernal software applications
- Teaching and interactive evaluation
- Reference software applications
- Evaluation of medical training
- Communication software applications
- Monitoring clinical experiences of medical students
- Special software applications in other areas
- Objective structured clinical examinations (OSCE)

Methods

Methods

The objective of this study is to find the key functionalities of PDAs that are applicable for medical education. Interviews and focus groups were designed accordingly. In-depth interviews with 15 stakeholders, have been undertaken; these aim to bring out information about the meaning, complication and interpretation from participants [20].

Results from these interviews have yet to be analyzed into different themes using NVivo software. These themes will then be used to conduct focus groups in the next phase of the project.

Interviews

Relevant medical stakeholders were contacted and interviewed face-to-face. The open-ended questions were asked about …

- the appropriate PDA functionalities for students to use during their study years,
- what kind of information needed to be stored in the PDAs, how PDAs can be used in PBL approach,
- how to synchronize data back to servers, and what type of network connection is used.

The interviews lasted approximately 30 minutes for each participant. All interviews were transcribed and analyzed based on content analysis [21, 22]. The interview answers were analyzed and categorized.

Results

Four major functions have been identified to date, these being:

(i) Clinical logs,

(ii) Personal portfolio (or e-portfolio),

(iii) Reference information,

(iv) Communication and connectivity.

Clinical logs

Clinical logs contain patient contacts and information gathered over time.

The purpose of using a clinical log is to record the student interactions with patients during the four-years of their medical study.

For instance,

- Basic demographic information,
- Hospital locations where and when students see them,
- Signs and symptoms of clinical problems based on the 93-clincial problems,
- Medical treatments and physical examinations, and how comfortable patients are with what students have done with them.

Results

Four major functions have been identified to date, these being:

(i) Clinical logs,

(ii) Personal portfolio (or e-portfolio),

(iii) Reference information,

(iv) Communication and connectivity.

Personal portfolio (or e-portfolio)

The purpose of using an e-portfolio is to record student assessments, clinical attachments together with results of mini-examination, feedback, difficulties that students have encountered, learning needs and medical errors based on root-cause analysis.

Reference information

Reference information is an important functionality that students are able to have in PDAs, for instance

- Medical database
- Current clinical guidelines and
- Core medical textbooks.

Using available software applications can enhance students to access relevant clinical information any time while practicing in clinical setting in remote locations.

Results

Four major functions have been identified to date, these being:

(i) Clinical logs,

(ii) Personal portfolio (or e-portfolio),

(iii) Reference information,

(iv) Communication and connectivity.

Communication and connectivity

Communication and connectivity functionality is to be used for sending and receiving information, particularly for

- Clinical logs,
- e-portfolios,
- GSM weekly calendars,
- Changes in clinical placement and also including
- E-mail and Internet functions.

Discussion

We have studied the feasibility of incorporating PDAs into medical education.

Mainly PDAs are to be used as learning tool because of their portability and accessibility to information anywhere and anytime.

The stakeholders express many needs of incorporating PDAs to GSM.

Discussion

Security and confidentiality are the important concerns when using PDAs in the real world, particularly when recording patient logs and e-portfolios.

Furthermore, stakeholders want PDAs to have the ability to access medical references, e.g.

- medical dictionary,
- clinical guidelines,
- drug databases or even the core medical textbooks.

In addition, to fulfill the needs of using PDAs in medical education,

PDAs must be well equipped with the standard IT systems particularly for communication and data synchronization back to the central servers or data on demand (DOD) [23].

On the other hand, PDAs need to be connected to GSM systems for data transmission from remote location to central servers.

Currently UOW has access to medical databases such as AccessMedicine, MDConsult and to Medline. Having PDAs in hand will assist students in referencing material.

Conclusion

PDAs can facilitate learning in medical education particularly in a PBL approach by using clinical logs and e-portfolios in order to keep track of students' progress.

Wired or wireless PDA connectivity and communication functions would support and enhance students to learn as well as communicate with faculty while away in clinical placements.

In the future, we plan to continue this study by conducting focus groups with medical, nursing and IT experts in order to gain a better understanding of how *best* to incorporate PDAs into a PBL-based to medical curriculum.

References and Acknowledgement

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Computer Assisted Learning is an Effective Way of Teaching and Learning in Medical Education

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Abstract

The aim of the study is to define computer assisted learning as the teaching and learning tool and environments facilitated through computers and to assess the effectiveness of teaching and learning by using computer assisted learning programme in medical education and computer assisted learning provides teachers with various teaching information when teaching medical students. Evaluation of CAL as an intervention is difficult, involving impact assessment studies of a variety of combined initiatives which seek to influence large and diverse populations. This is particularly true when evaluating attitude change and professional practice with a fast moving field like information technology. Computer assisted learning is an effective way of increasing knowledge in teaching medical students in medical education. In the future we will see more sophisticated software with virtual medical education who can communicate and interact with the medical students in a very realistic way.

Keywords:

computer assisted learning; medical education; information technology; multimedia; computer; training

Introduction

The aims of the study are to define computer assisted learning as the teaching and learning tool and environments facilitated through computers and to assess the effectiveness of teaching and learning by using computer assisted learning programme in medical education and computer assisted learning provides teachers with various teaching information when teaching medical students.

Design and methods

The design used for this study was a systematic review of published materials obtained from four large online databases, namely EMBASE, Blackwell Synergy, MEDLINE, and the *Cochrane Library* database. This review is largely a personal reflection on recent changes in computer assisted learning in medical education and demonstrates that the use of computer assisted learning programme is effective and easy to use. Research has been supplemented by email discussions with colleagues based in the United Kingdom.

Results

Computers have been available in medical education since the 1960s.[1] Computer assisted instruction enhances learning, allowing the student to decide content, time, place and pace of instruction. Evaluation of CAL as an intervention is difficult, involving impact assessment studies of a variety of combined initiatives which seek to influence large and diverse populations. This is particularly true when evaluating attitude change and professional practice with a fast moving field like information technology.[1, 2] It was shown that CAL provided the medical students with a popular and effective way of learning. Computer assisted learning systems' development in medical education in future years will be concentrated on the following areas:

- **Increasing systems' performances:** This includes higher speed of processing capacity and stronger computer software. This is a normal continuance to current computer assisted learning systems and their development's policy. [2, 3]
- **More distributed systems:** Nowadays modern world wide networks and high speed digital and mobile communications create a strong context for design and implementation of more distributed computer assisted learning systems. In the near future teleconferencing and non-centralised classrooms will be usual.[2]
- **Simulation and virtual reality:** New technology allows us to create 3 dimensional near-toreal environments for simulator systems. In practice, current applications of such systems are only on flight or sailing training systems. However, in the near future they will have a more important role, especially for blind and nearly blind people's education.[3]

Discussion

The quantity of applied research design and production of computer assisted learning application in medical field is growing rapidly and the quality is improving. There is good evidence supporting the use of computer assisted learning in medical education lowering all costs related to production and use. Development of guidelines and consensus statements issued by conventional medical organisations have recommended computer assisted learn-

ing application in medical education.[1] Computer assisted learning is increasingly practised in comparison of conventional teaching settings. There is a more open attitude to computer assisted learning application in medical education among conventional health professionals; this is partly explained by the rise of problem-based learning environment. Furthermore, the computer assisted learning should be seen as complementary to other traditional contact teaching, which may be more suited to clinical skills and attitudes.

Conclusion

Computer assisted learning is an effective way of increasing knowledge in teaching medical students in medical education. The potential of computer assisted learning is vast and its principles, application and practices need to be explored in detail. In the future we will see more sophisticated software with virtual medical education who can communicate and interact with the medical students in a very realistic way. However, at present computer assisted learning should not replace traditional medical education, but rather be used more as a supplement and for self-directed studies.

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COMPUTER ASSISTED LEARNING IS AN EFFECTIVE WAY OF TEACHING AND LEARNING IN MEDICAL EDUCATION

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Aims and Objectives

- To define computer assisted learning as the teaching and learning tool and environments facilitated through computers
- To assess the effectiveness of teaching and learning by using computer assisted learning programme in medical education
- To provide teachers with various teaching information when teaching medical students.

Methods

- **Systematic review of published materials obtained from four large online databases, namely EMBASE, Blackwell Synergy, MEDLINE, and the *Cochrane Library* database**

- **Personal reflection on recent changes in computer assisted learning in medical education and demonstrates that the use of computer assisted learning programme is effective and easy to use.**

- **Supplemented by email discussions with colleagues based in the United Kingdom.**

Results

- Computer assisted instruction enhances learning, allowing the student to decide content, time, place and pace of instruction.
- Evaluation of CAL as an intervention is difficult, involving impact assessment studies of a variety of combined initiatives which seek to influence large and diverse populations. [1]
- CAL provided the medical students with a popular and effective way of learning. Computer assisted learning systems' development in medical education

- **It would be concentrated on the following areas in the future years:**

  - **Increasing systems' performances:** This includes higher speed of processing capacity and stronger computer software. This is a normal continuance to current computer assisted learning systems and their development's policy. [2, 3]

  - **More distributed systems:** Nowadays modern world wide networks and high speed digital and mobile communications create a strong context for design and implementation of more distributed computer assisted learning systems. In the near future teleconferencing and non-centralised classrooms will be usual. [2]

  - **Simulation and virtual reality:** New technology allows us to create 3 dimensional near-toreal environments for simulator systems. In practice, current applications of such systems are only on flight or sailing training systems. However, in the near future they will have a more important role, especially for blind and nearly blind people's education. [3]

Table 1: Comparison between CAL and Traditional Teaching Methods in Medical Education

Tradition Model	Alternative Model	CAL Implications
Classroom lectures	Individual exploration	Networked PCs with access to information
Passive absorption	Apprenticeship	Requires skills development and simulations
Individual work	Team learning	Benefits from collaborative tools and e-mail
Omniscient work	Teacher as guide	Relies on access to experts over the network
Stable content	Fast changing content	Requires networks and publishing tools
Homogeneity	Diversity	Requires a variety of access tools and methods

RECENT PROGRESS AND ADVANCES

These are outlined CAL in medical education below:

- **The quantity of applied research design and production of CAL application in medical field is growing rapidly and the quality is improving**
- **There is good evidence supporting the use of CAL in medical education lowering all costs related to production and use**
- **Guidelines and consensus statements issued by conventional medical organisations have recommended CAL application in medical education**
- **CAL is increasingly practised in comparison of conventional teaching settings**
- **There is a more open attitude to CAL application in medical education among conventional health professionals; this is partly explained by the rise of problem-based learning (PBL) environment**

Discussion (1)

- The quantity of applied research design and production of computer assisted learning application in medical field is growing rapidly and the quality is improving.
- There is good evidence supporting the use of computer assisted learning in medical education lowering all costs related to production and use.
- Development of guidelines and consensus statements issued by conventional medical organisations have recommended computer assisted learning application in medical education.[1]

Figure 1: Details of Educational Institutions, which Offer Courses on CAL

- **Association for the Advancement of Computing in Education** The purpose of the AACE is to encourage scholarly inquiry related to information technology in education and the dissemination of research results and their applications through Publications, Conferences, Divisions/Societies/Chapters and Inter-Organizational Projects.
- **Support Initiative for Multimedia Applications (SIMA)** The Support Initiative for Multimedia Applications (SIMA) was funded by the JISC New Technologies Initiative through the Advisory Group on Computer Graphics (AGOCG). The initiative funded projects in a range of areas, demonstrating the use of new technology to the higher education community through example, setting up services, training, and dissemination of good practice.
- **Computers in Teaching Initiative (CTI)** The CTI (Computers in Teaching Initiative) comprises 24 subject-based centres working to encourage the use of learning technologies in UK higher education. The CTI Support Service, based at the University of Oxford, coordinates the work of the centres, and acts as a focal point for activities relating to the use of communications and information technology in university teaching.
- **Advisory Group on Computer Graphics (AGOCG)** The Advisory Group on Computer Graphics (AGOCG) is an initiative of the Joint Information System Committee (JISC) of the Higher Education Funding Councils and the Research Councils. AGOCG provides a single national focus for computer graphics, visualization, multimedia and virtual environments within the UK higher education community and is concerned with the handling and processing visual information in all its forms.
- **The British Computer Society** The Society is concerned with the development of computing and its effective application. Under its Royal Charter granted in 1984, it also has responsibilities for education and training, for public awareness, and above all for standards, quality and professionalism.
- **Computer Assisted Teaching and Learning: The CASTLE Project** "Providing freely available tools for creating on-line multi-media assessments quickly and easily. Requires no prior knowledge of HTML, CGI or other scripting or mark-up language".
- **Institute for Computer Based Learning** The Institutes overall objectives are to pursue research in computer-based learning and its impact on teaching and training; to develop computer based learning environments for use in teaching and training and to promote the transfer of technology-based training to industry and commerce.
- **Educational Technology Information and Resources** Edu-Tech is also growing in its sections for authoring resources, to aid awareness and use of multimedia/hypertext authoring software (such as ToolBook), HTML- the language for authoring WWW pages, and computer-assisted assessment.
- **Centre for Gastroenterology** Royal Free Hospital, the creation and implementation of a Computer-aided Learning platform called RadioVision, which is accessible by students using their home-based PC or suitable equipped university computers.
- **Epidemiology and Education Unit** Centre for Adult and Paediatric Gastroenterology, Barts and The London, Queen Mary's School of Medicine and Dentistry, Queen Mary, University of London

Discussion (2)

- Computer assisted learning is increasingly practised in comparison of conventional teaching settings.

- Furthermore, the computer assisted learning should be seen as complementary to other traditional contact teaching, which may be more suited to clinical skills and attitudes.

Conclusion

- Computer assisted learning is an effective way of increasing knowledge in teaching medical students in medical education.
- The potential is vast and its principles, application and practices need to be explored in detail.
- More sophisticated software with virtual medical education who can communicate and interact with the medical students in a very realistic way in the future.
- Be used more as a supplement and for self-directed studies.

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Haptic Rendering for Blind and Severely Visually Impaired Children

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Abstract and objective

The prevalence of severely visually impairment (visus < 0,1) to the point of blindness (visus < 0.05) is in industrialised countries approx. 0.2%, i.e., in Germany approx. 160,000 people suffering from notable visual deficiency. 6% of the affected persons (approx. 8,700) are younger than 18 years, most of which attend school. The concept intuition is to provide visual information by tactile analogies. In the present study, a haptic device is used, i.e., a hardware device that helps present tactile information. A haptic device along with prototypical software (`make2Dhaptic`) is used to present tactile representation of geometric objects and physical bodies. First tests show that more than 50% of the blind and severely visually impaired students tested get an idea of the tactile representation when a haptic device is used. Approx. 25% prefer it over traditional „swell paper".

Keywords:

hapticrRendering, phantom device, visual impairment

Introduction

Carl-Strehl-Schule (Marburg, Germany) is one of the few schools providing an opportunity for blind and severely visually impaired students to get a boundless University-entrance Diploma ("Abitur"). For blind and severely visually impaired students the visual components must now be transferred to be interoperable with other senses, preferably the acoustical and touching sense.

Methods

Using one of the main common haptic-devices we take the PHANTOM® Desktop^{TM} Haptic Device (SensAble Technologies, Inc., Woburn, MA, USA) which possesses six degrees of freedom in its possibilities of movement (Fig. 1).

Figure 1 - PHANTOM® Desktop^{TM} Haptic Device (SensAble Technologies, Inc., Woburn, MA, USA)

This haptic device can represent kinaesthetics and tactility to feel the surface texture. The computation of the forces fed back by the device is essential. We use the ability of generating physical powers to guide the user through the scene. Respective requirements have been met by developing the prototypical software `make2Dhaptic`

(applicable to chemistry, physics, biology and mathematics; Fig. 2).

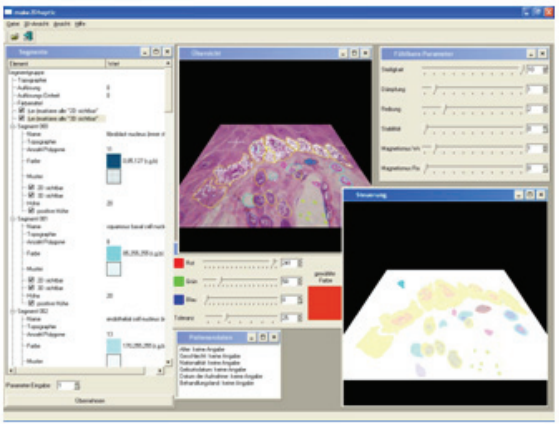

Figure 2 - The prototypical software make2Dhaptic (screenshot)

For a tactile representation of an output of a gas chromatograph (real time) the measured values are transferred into temporary or permanent forces. The values are represented as movements along the y-axis of the haptic device. In order to transform histological slides (medicine, biology) appropriately, the images were transferred into a 3D Surface Mesh, at which the spatial orientation (z-coordinate) is defined by the specific grayscale values of the image (Fig. 3).

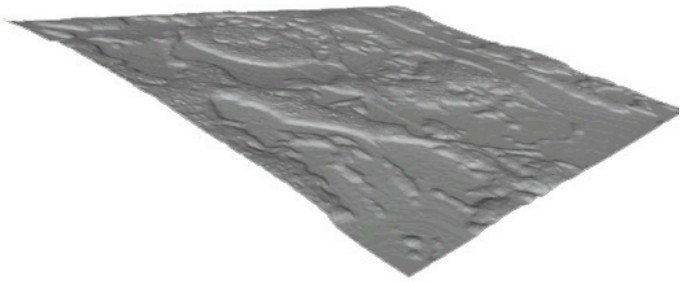

Fig. 3 - 3D Surface Mesh generated by make2Dhaptic

A gender mixed group of 21 sixth formers, who were partly blind from birth, were available for a trial. None of the group has ever used or touched a haptic device before. After the first

exploration of a standard parabola the users were asked to determine the form of the curve, and answered questions on the cells and the tissue samples presented to them. The replies of the users were mapped to a 1 to 6 Likert scale (1 = exactly right; 6 = absolutely wrong).

Results

For the graph, everyone answered directly “parabola”. 60% of the test persons billed the statement “I can follow the line without loosing contact.” with “1” and 40% with “2”. All persons approve the statement “More lead time is wise.” with 2 or higher. Approx. 25% prefer the haptic device over traditional „swell paper“. The representations of histological slides (medicine, biology) were judged similarly.

Discussion and conclusion

The current surface mesh is generated by interpreting the greyscale values as the spatial orientation (z-coordinate). By this, an extreme closed surface mesh is given and as a consequence the memory requirements for the mesh is proportional to dimension of histological slide but independent from the level of detail of the slide. Using a meshing algorithm based on the delaunay triangulation a more efficient representation is given. Another drawback of the current mesh is that it is only a pseudo 3D mesh.

Therefore the next step is to integrate an algorithm for generating a volume mesh of the histological slides. The advantage of this is the option to “manipulate” the slide, *e.g.*, cell division could be represented. This allows teaching blind and visually impaired people dynamic processes. Another drawback of many haptic systems, as well as the current is, that physical properties are not correct arranged. This means that it is typically impossible to differ between different materials in the haptic scene in a realistic way, *e.g.*, soft rubber feels like metal. To avoid this undifferentiated feeling we intend to build up a data base for different materials and their physical properties to adjust the settings of the haptic engine.

Beside these drawbacks a first exploration implies that already today students may benefit from the application of a haptic device along with the prototypical software `make2Dhaptic`. Further studies are needed for systematic evaluation.

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The Need for Secure Computer-based Assessment-Software

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Abstract and objective

Most of the computer-based assessment software available is web-based. While there are many advantages, for instance the possibility to use the same software for learning and assessment, there are legal and technical risks with this approach such as a network failure or the missing proof for the correctness of the collected data. Therefore a new software was developed at the Heidelberg University Hospital focusing on fault-tolerance and certainty of law. It uses a client-server architecture for real-time result display but through using different layers of logging a failure of the server will neither end the test nor any data will be lost. The system has been used for testing students of medicine at the Heidelberg University Hospital since the end of 2004.

Keywords:

assessment, medical education, security

Introduction

In Germany computer-based tests of students of medicine are rare. The main problems are the missing amount of computers for the assessment and the certainty of law.

Accordingly, most of the exams are paper-based although the need for case-based testing and the possibility to use multimedia, the key feature approach [1] or advanced question types such as 'long menu' [2] or 'hotspot' is attractive for medical education.

Most of the computer based assessments have been carried out with browser-based assessment software such as WebCT [3], .LRN [4] or Ilias [5]. These are web-based learning management systems used in the student's everyday work. Despite advantages like familiarity and the absence of client-side software installation, this approach has many problems when using that software for official examinations.

One problem is that every data is collected at the server. If the connection between the client (browser) and the server breaks, data will be lost. Software bugs in the software, a server-side hardware failure or a corrupted database will end the examination and can cause a loss of data.

The second main problem is the missing certainty of law of the test. As all data is just collected digitally at the server, a bug in collecting the student's data or incorrect data storage cannot be verified afterwards. Some systems demand a student signature on a hardcopy afterwards but this will raise the time need and could lead to discussions between the examiner and the student.

Implementation of a secure assessment software

On top of the CAMPUS [6] e-learning shell, which offers a simulative and a card-based player for students of medicine, a separate software module was created using the same authoring system.

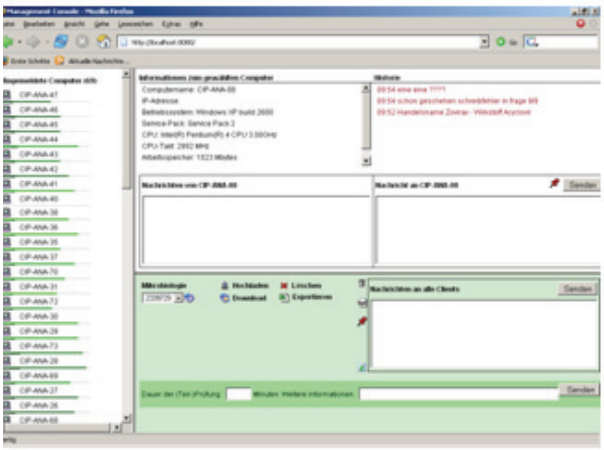

Figure 1 - The Management Console

The software consists of a PostgreSQL database, a server application, called "Management Console" (see Figure 1) and a client software (see Figure 2), all written in the Java programming language for best portability.

The Management Console is used by the examiner through a web-based interface. It controls the spreading of the test data and supervises the attached clients so that problems with them can be detected just in time. Additionally, a bidirectional messaging system can be used.

The client software acts as a normal desktop application (except it can be distributed and updated automatically via a webbrowser using the Java Webstart technology [7]). As it isn't bounded to the browser restrictions, the client can

be protected through an exclusive 'kiosk-mode' to prevent manipulation or fraud attempts using e.g. a chat.

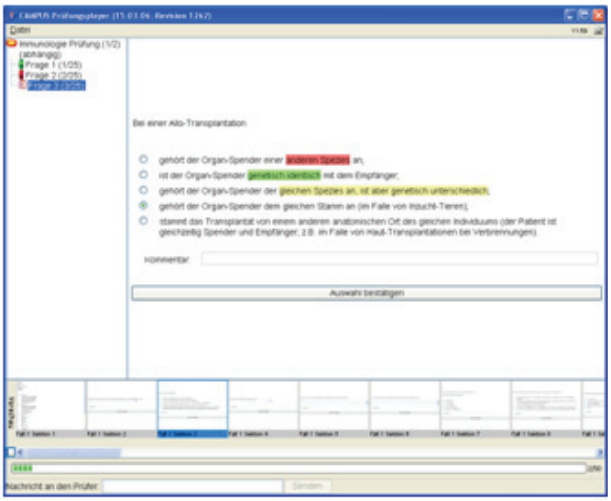

Figure 2 - The client software

Log files are created at every layer so that the test can be reconstructed even in case of a complete and permanent server failure. With this technology a breakdown of the server or a network failure is transparent to the client software – the test can be continued and the data can be synchronized later.

To ensure certainty of law, a screenshot, showing the unprocessed raw data of the examination, is taken each time a student commits an answer. Those screenshots are combined into a video which can be used to validate the result of the test afterwards.

To increase the confidence of the students in the results the video can be sent to a student's e-mail address after the test. This video is protected by a student's and an examiner's password so that both sides can prove its authenticity.

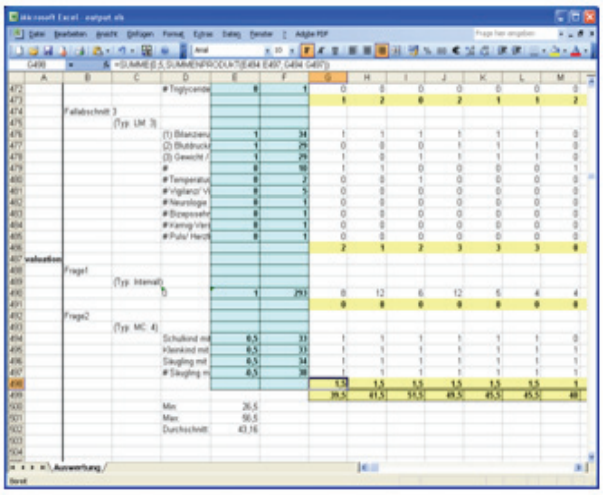

Figure 3 - Test results with adaptive formulas

The test result can be made available as HTML pages and a Microsoft Excel sheet with adaptive formulas (see Figure 3) where the examiner can modify the rating and sees the altered overall result just in time.

Results

The software has been used at the *Heidelberg University Hospital* successfully since 2004 with hundreds of students (up to 120 students at the same time). Although problems had occurred (for instance database problems), the videos and log files helped to reconstruct the corrupted or missing data completely.

The software has successfully addressed two of the main problems of computer-based assessment:

1. Prevention of having to abort an exam because of a network or server failure
2. Certainty of law for computer-based assessment by using unprocessed data shown as a video

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Creating MP3 Audio Files from Scientific Articles

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Abstract

Reviewing scientific literature is an important part of research and education. In the University of Utah Department of Biomedical Informatics published articles are assigned as required reading. As an alternative to reading these articles, students were given the opportunity to listen to audio reproductions of the articles. To create audio files from Portable Document Format (PDF) files took several steps and an average of two hours per article. Articles were converted from PDF files to plain text, reviewed for layout and text conversion errors, reviewed for pronunciation and word usage mistakes, adjusted for pace, and saved as Moving Picture Experts Group Audio Layer-3 (MP3) audio files. This process was used for converting weekly required reading articles for a fifteen week informatics course.

Keywords:

speech synthesizer, computer-assisted instruction, education

Introduction

In the course of training in the University of Utah Department of Biomedical Informatics scientific articles are referenced and given as required reading. In a fifteen week informatics course, an option was given to students to listen to the required reading articles as an alternative to reading them. Speech synthesis was used to convert Portable Document Format (PDF) files to Moving Picture Experts Group Audio Layer-3 (MP3) files.

Speech synthesis has been studied mostly in the realm of communication aids for the disabled.[1-3] Research has shown that non-technical, fictional literature is best understood by listeners.[3] Creating audio files from published literature will allow the Department to investigate the comprehension of technical concepts in a graduate school environment.

Methods

Scientific articles were acquired from journals as PDF files using the University of Utah institutional license. A commercial text-to-speech engine was used for converting PDF files into plain text. Special formatting, figures and tables, and peripheral page text caused the conversion to include artifacts or misinterpret page flow. Each article had to be reviewed for layout and text conversion errors. As expected, many medical and technical words were not in the text-to-speech application's dictionary and were pronounced incorrectly and needed to be spelled out phonetically. In addition, the pronunciation of heteronyms like "read" and "record" were determined automatically (sometimes unsuccessfully) from surrounding words. Human review was needed to ensure correct word usage. The text-to-speech engine had difficulty reading the complex, protracted sentences found in scientific literature. To correct issues with pace, sentences were divided up in to smaller parts and pauses were inserted. Article sections were individually converted into audio files as tracks for easier navigation. The commercial text-to-speech engine included the ability to save audio in the MP3 format. Tracks for each article were bundled in a compressed folder for distribution.

Results

Fifteen scientific papers were successfully converted from PDF files to MP3 audio files using the workflow described above. Each conversion took approximately two hours and resulted in a compressed folder of audio files.

Discussion

Scientific articles given in audio format was seen as a convenience and a time-saver for graduate students. The process of creating the audio files proved time consuming. While commercial products claim to enable conversion, layout and text conversion errors, pronunciation and word usage mistakes, and pace issues occurred.

Acknowledgments

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Information Needs Associated with Hazard and Near Miss Reporting

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Abstract

The purpose of this study was to understand the information needs of APN students related to hazards and near misses in order to expand a reporting system to provide Just-in-Time learning.

Keywords:

information needs, patient safety, adverse event

Introduction

As part of a patient safety curriculum for Advanced Practice Nurse (APN) students, a Hazard and Near Miss Reporting System (HNMRS) was developed for reporting of information on hazard (dangerous situations) and near misses (close calls) that occurred during students' clinical shifts. HNMRS includes 13 types of hazards and near misses: Accident (non-fall), Environment Hazard/Safety, Equipment/Device, Fall, Food/Nutrition, Infection, Laboratory, Medication, Patient Disappearance, Procedure/ Treatment, Restraint, Transfusion, and Other. We plan to extend the functionality of HNMRS beyond reporting to Just-in-Time learning by providing context-specific links to internal and external knowledge sources related to the type of hazard or near miss reported. Context-specific links have demonstrated utility in meeting information needs at the point of care. [1, 2] The purpose of this study was to understand the information needs of APN students related to hazards and near misses.

Methods

A focus group was conducted with four APN students in the baccalaureate year of a BS/MS curriculum. Students were asked to provide information about the hazards and near misses they had reported and their information needs related to particular types of hazards and near misses. Students were asked to express their information needs as questions. They were then analyzed and organized into the thirteen categories. Questions were classified into three information types: (S) subject-specific (i.e., patient-related data), (D) domain-specific, or (I) institution-specific.[3]

Results

The information needs were classified into the hazard and near miss categories and by type of information need (Table. 1). Information needs related to patient-specific data are not included because they would typically be answered by consulting an electronic health record, not through context-specific links to knowledge sources.

Conclusion

APN students experienced information needs related to hazards and near misses. Context-specific links to knowledge sources may help to prevent adverse events through Just-in-Time learning when a hazard or near miss occurs.

Table 1 - Information needs

Equipment/Device	Type
• How do I use the device?	D
• Who do I contact for replacement? (e.g., broken)	I
• How long should the device be in? Any protocol?	D
• Is there an institutional protocol for this device?	I
• How do I know if it placed correctly?	D
• What are normal and abnormal signs of function? (e.g., NG tube)	D
Fall	
• How do I prevent patient falls?	D
• Who do I contact for incident report?	I
Food/Nutrition	
• How can I get a meal for my patient?	I
• How can I get a menu in another language?	I
Medication	
• What do I do if a medication error occurs?	I
Patient Disappearance	
• What is the procedure for reporting elopement?	I
Procedure/Treatment	
• How do I do the procedure?	D
• Is there any manual I can follow?	I
• Does the procedure need patient consent?	I
• How do I educate the patient about the procedure?	D
Transfusion	
• What is the official protocol related to transfusion?	I

Acknowledgement

This study was supported by grants from the Health Services Resources Administration and the National Institutes of Health (P20 NR007799).

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Information Needs Associated with Hazard and Near Miss Reporting

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COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Abstract

- The purpose of this study was to understand the information needs of APN students related to hazards and near misses in order to expand a reporting system to provide Just-in-Time learning.

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Introduction

- As part of a patient safety curriculum for Advanced Practice Nurse (APN) students, a Hazard and Near Miss Reporting System (HNMRS) was developed for reporting of information on hazard (dangerous situations) and near misses (close calls) that occurred during students' clinical shifts. HNMRS includes 13 types of hazards and near misses: Accident (non-fall), Environment Hazard/Safety, Equipment/Device, Fall, Food/Nutrition, Infection, Laboratory, Medication, Patient Disappearance, Procedure/Treatment, Restraint, Transfusion, and Other.

Introduction (cont.)

- We plan to extend the functionality of HNMRS beyond reporting to Just-in-Time learning by providing context-specific links to internal and external knowledge sources related to the type of hazard or near miss reported. Context-specific links have demonstrated utility in meeting information needs at the point of care. [1, 2] The purpose of this study was to understand the information needs of APN students related to hazards and near misses.

Hazard and Near Miss Reporting System

Welcome Po-Yin Yen to the Hazard and Near Miss Reporting System!

Date of Shift:

Month | Day | Year

Question 1:
On your shift today, were there any "dangerous situations" that could cause a future event?

- ○ Yes, Please check all that apply:
- ☐ **Accident (non-fall)** [Info]
- ☐ **Environmental Hazard/Safety** [Info]
- ☐ **Equipment/Device** [Info]
- ☐ **Fall** [Info]
- ☐ **Food/Nutrition** [Info]
- ☐ **Infection** [Info]
- ☐ **Laboratory** [Info]
- ☐ **Medication** [Info]
- ☐ **Patient Disappearance** [Info]
- ☐ **Procedure/Treatment** [Info]
- ☐ **Restraint** [Info]
- ☐ **Transfusion** [Info]
- ☐ **Other** [Info]

No: ○

Methods

- A focus group was conducted with four APN students in the baccalaureate year of a BS/MS curriculum. Students were asked to provide information about the hazards and near misses they had reported and their information needs related to particular types of hazards and near misses. Students were asked to express their information needs as questions. They were then analyzed and organized into the thirteen categories. Questions were classified into three information types: (S) subject-specific (i.e., patient-related data), (D) domain-specific, or (I) institution-specific.[3]

Results

- The information needs were classified into the hazard and near miss categories and by type of information need (Table. 1). Information needs related to patient-specific data are not included because they would typically be answered by consulting an electronic health record, not through context-specific links to knowledge sources

Table 1. Information needs

Equipment/Device	
•How do I use the device?	D
•Who do I contact for replacement? (e.g., broken)	I
•How long should the device be in? Any protocol?	D
•Is there an institutional protocol for this device?	I
•How do I know if it placed correctly?	D
•What are normal and abnormal signs of function? (e.g., NG tube)	D
Fall	
•How do I prevent patient falls?	D
•Who do I contact for incident report?	I
Food/Nutrition	
•How can I get a meal for my patient?	I
•How can I get a menu in another language?	I

Table 1. Information needs (cont.)

Medication	
•What do I do if a medication error occurs?	I
Patient Disappearance	
•What is the procedure for reporting elopement?	I
Procedure/Treatment	
•How do I do the procedure?	D
•Is there any manual I can follow?	I
•Does the procedure need patient consent?	I
•How do I educate the patient about the procedure?	D
Transfusion	
•What is the official protocol related to transfusion?	I

Conclusion

- APN students experienced information needs related to hazards and near misses. Context-specific links to knowledge sources may help to prevent adverse events through Just-in-Time learning when a hazard or near miss occurs.

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1. Cimino JJ. Use, Usability, Usefulness, and Impact of An Infobutton Manager. AMIA Annual Symposium Proceedings/AMIA Symposium. 2006.
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3. Currie LM, Mellino LV, Cimino JJ, Bakken S. Development and representation of a fall-injury risk assessment instrument in a clinical information system. Medinfo. 2004;11(Pt 1):721-5.

Acknowledgement

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Evaluation of Competency-Based Online Learning Modules for Nurses in Emergency Planning and Response

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Abstract and objective

Several grants have been received to develop an online curriculum for nurses in emergency preparedness using the competencies developed by the International Nursing Coalition for Mass Casualty Education (INCMCE). Another unique aspect of the development of these modules is that they reflect the "How People Learn Cycle" (HPL). This presentation will provide data to determine the effectiveness of learning programs designed to educate nurses volunteering for service in the US.

Educational informatics provides a model for learning that is based on resources that augment what the learner already knows. Using this more customized approach, learners can then integrate new knowledge within the context of their practice. The long term objective of this study is to provide quality educational materials for volunteer nurses.

Content validity was determined and design principles upheld for HPL. 953 learners were drawn from 33 Medical Reserve Units and from six states hosting volunteer nursing Registries. Data were collected after the third module was completed in the online series. Paired t-tests of pre-course and post-course total confidence scale scores indicated a significant increase in mean ratings, with the first 10 items being significant ($p < .05$). Overall mean scores for technology integration demonstrated a positive experience using the online approach.

Keywords:

disaster response, emergency preparedness

Introduction

A survey of US nursing schools validated the fact that the curriculum was lacking in content related to emergency planning and response [1]. In addition, faculty were not prepared to teach this content One of the highest rated requests was for the development of an online curriculum that would meet the competencies as developed by the INCMCE. Beginning development efforts were the result of a think tank of nursing experts in emergency planning and response.

Methods

The modules were developed in conjunction with the multimedia developers from Little Planet Learning, Inc. based in Nashville, TN. Data were not collected until the third case (which was a biological case) was completed. 953 learners were drawn from 33 Medical Reserve units and from six states hosting volunteer nursing registries. The study was a pre and post-test design allowing for data collection in the areas of self-rated confidence of skills (based on defined competencies) and assessment of technology use in delivery of the content (assessed via use of the Flashlight evaluation tool). Demographic data from the users was also collected. During module development, content validity was determined along with an assessment by experts that the design had upheld the principles of "How People Learn" (HPL).

Results

Paired t-tests of pre-course and post-course total confidence scale scores indicated a significant increase in mean ratings ($p < .01$). The first ten items indicated a significant increase in confidence scores ($p < .01$), with the remaining items showing no or limited increases. Given that the total set of modules were not completed by the subjects, these findings are not surprising. The first 10 items are basic competencies, while the remaining 6 are considered more intermediate level skills that require additional content in order to be met After the learning experience, subjects completed a survey that was designed from items using the Flashlight Evaluation Tool comparing this online experience with other non-online experiences. Ratings were based on a five point Likert scale from 1-5 with 5 responses being considered positive. Overall mean scores for the 10 item questionnaire were 4.2, falling between agree and strongly agree.

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Evaluation of Competency-Based Online Learning Modules for Nurses in Emergency Planning and Response

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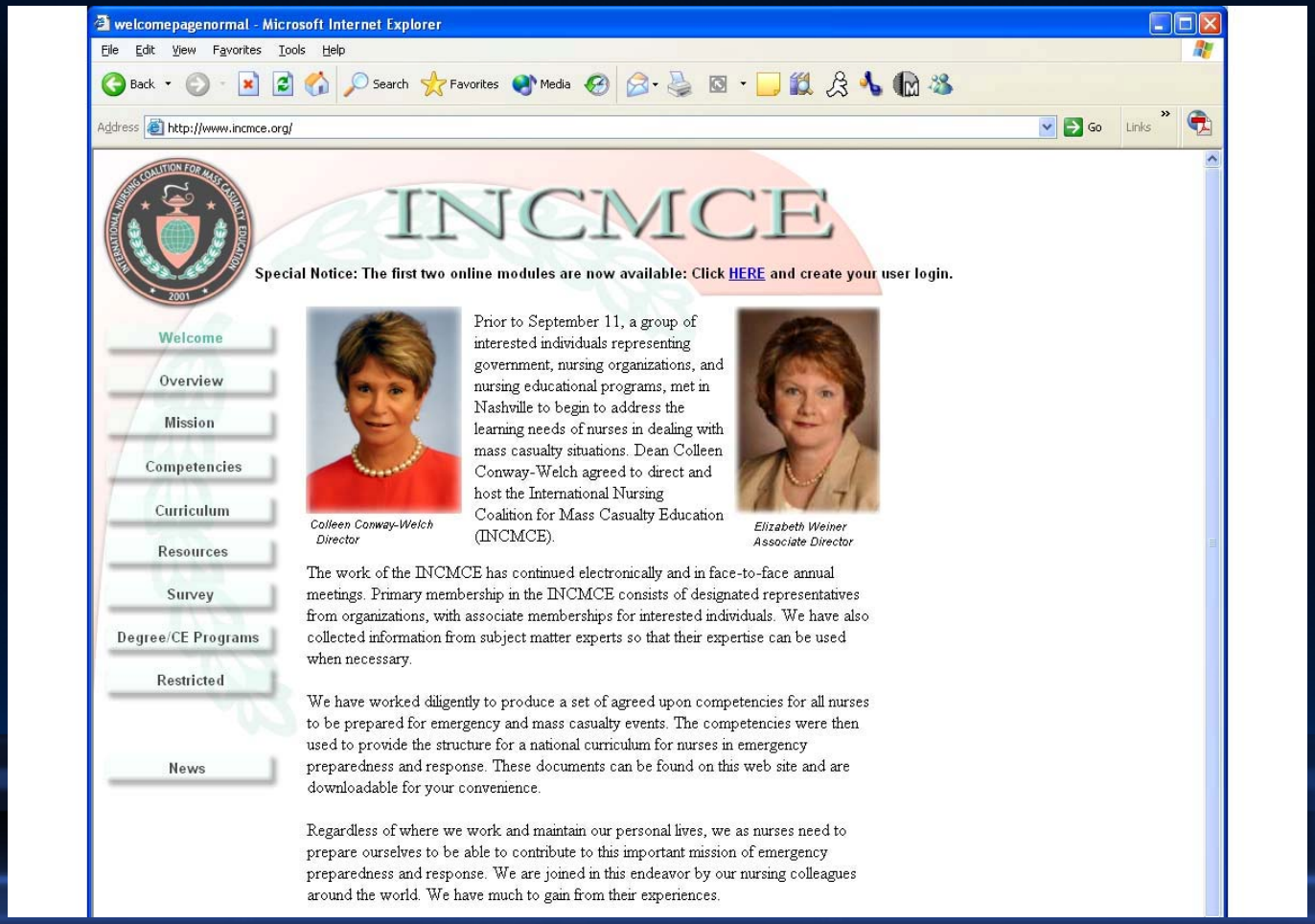
www.incmce.org
International Nursing Coalition for Mass Casualty Education



Name Change in April 2007

- From International Nursing Coalition for Mass Casualty Education (INCMCE)

- To Nursing Emergency Preparedness Education Coalition (NEPEC)

…committed to emergency preparedness and disaster response education of nurses

www.nepec.net

Mission

- To provide a platform for nurse educators, practice and professional organizations, governmental agencies and others to pool expertise, make recommendations and disseminate best practices about emergency preparedness and disaster response education in the US and worldwide

Specific Aims

- Bring together the best of international expertise to inform the mission
- Identify core competencies
- Create sound curricula
- Develop improved methods of disseminating information
- Strengthen networking
- Inform policy-makers

First Activities

- Agree on Competencies for all nurses in emergency planning and response

- Survey US nursing programs about content taught prior to and post 9/11/2000 that related to emergency planning and response

Online Modules

- Funded by US Agency for Healthcare Research and Quality and US Health Resources and Services Administration Bioterrorism Curriculum and Development Grant
- Designed to meet nursing competencies
- Reflective of national “How People Learn”

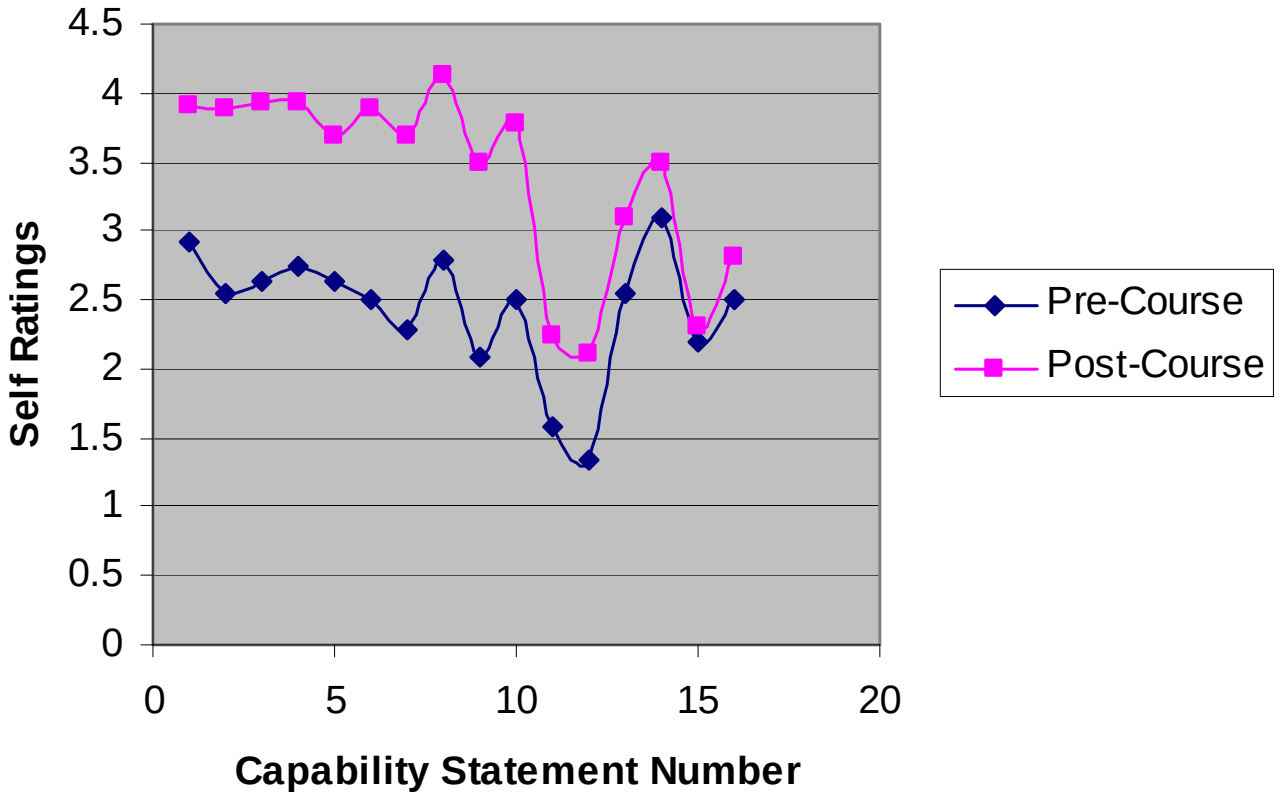
Methods

- 953 nurse learners from 33 Medical Reserve units and 6 states hosting volunteer nursing registries completed first 3 modules
- Pre and post-test design to assess self-rated confidence of skills and assessment of technology use in delivery of the content
- Demographic data and validation of content also completed

Results

- Paired t-tests of pre-course and post-course total confidence scale scores indicated a significant increase in mean ratings ($p<.01$)
- First ten items (basic competencies) accounted for significance

Mean Participant Ratings from Pre-Course and Post-Course Self Evaluations of 16 Capability Statements



Assessment of Technology Use

- Using Flashlight Survey Tool (Teaching, Learning, and Technology Group)
- 5 point Likert scale with 5 being most positive
- Overall mean scores for the 10 item questionnaire were 4.2, falling between agree and strongly agree

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Evaluation of Breast Cancer Risk Calculators as Learning Tools

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Abstract

Many tools are available to teach women about breast cancer risk factors. Breast cancer risk calculators are tools that are available via the Internet to provide information to woman about their breast cancer risk. Women age 35 and older were recruited to participate in a study using online breast cancer risk calculators as learning tools. A total of 45 women participated in the study. A one group pretest post test survey questionnaire design was used to evaluate the impact of the risk calculator websites on women's knowledge and attitudes. The results indicate women identified more breast cancer risk factors after using the calculator, decreased their concern/worry about breast cancer and indicated they would do something with the information to help themselves.

Keywords:

patient education, health status indicators, risk assessment

Introduction

Methods to learn about breast cancer risk factors and risk take on many forms. Leaflets, brochures, TV, magazines, friends, family, personal counseling, group counseling and the Internet all provide information to woman about breast cancer risk factors. Breast cancer risk calculator websites are being used to give women an estimate of their risk for developing breast cancer by asking them questions related to some of the risk factors associated with the disease. The purpose of this study is to assess the learning of risk factors and risk levels using a breast cancer risk calculator, to evaluate changes in perception of risk, and explore behavior modification intent.

Methods

A convenience sample of women age 35 and older was recruited for participation in the study through e-mail invitations and flyers posted in the greater Houston, Texas area. Participants were directed via the e-mail to the informed consent website. If the participant agreed to participate they were directed to an online pretest survey. Once completed, the participant was directed to a public online breast cancer risk calculator. After completing the breast cancer risk calculator the participants clicked on the post test survey link from the e-mail and completed the post test survey. Questions on the surveys consisted of knowledge of risk factors, level of concern about developing breast cancer, and the intended use of the information they received.

Results

Fifty-two women who were aged 35 years old or older responded to the invitation. Of that group 35 completed the study. All of the women in the study indicated they had heard about breast cancer risk factors. The majority of women were Caucasian (86%) between the ages of 41-55 (60%) and had graduated from college (69%). A comparison of the pretest and post test knowledge of 17 breast cancer risk factors[1] showed that participants improved their identification of 9 of them. Interestingly, although 35 percent of the participants were surprised that their risk was higher than they thought, as a whole the participants worry or concern decreased (51%-17% respectively). Based on the information the participants received 80 percent indicated they were going to make changes to the risk factors they could affect. In addition the women indicated they would continue with their current breast cancer screening regimen (71%), begin a screening program (20%), find more information about breast cancer (29%) and talk to their physician (26%). Areas of confusion were the number of risk factors (26%), risk measurements and what they mean (29%), and their risk level in relation to the general population (23%).

Conclusion

The online breast cancer risk calculator appears to be a method that can promote knowledge about breast cancer risk factors and disease risk. However, the topic of risk and how it is communicated via the breast cancer risk calculator needs further investigation to assess ways the information can be presented and understood.

[1]http://www.cancer.org/docroot/CRI/content/CRI_2_2_2X_What_causes_breast_cancer_5.asp?sitearea

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The Practice in Health Information Systems Training

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Abstract

The health information system implementation is mostly seen as technical project and little research is done evaluating outcomes of organisational learning. There seems to be a gap between teaching new function management and systematically evaluate information system implementation and its effect in healthcare practice. Modern technology like Health Information Systems with computers and new application are implemented. However the training uses traditional educational methods and upholds old-fashioned ways of learning. The pervasiveness of new educational technology has not yet emerged in health information system training

Keywords:

health information system, training, education

Introduction

In Central Finland Health Care district implementation of electronic patient record took place during September 2005 to May 2006. The Health Care district employs approximately 2600 officials: consisting of 282 doctors, 1489 members of nursing personnel, 919 persons in other positions like secretaries and assistants. In this hospital there are approximately 2100 end-users for patient record consisting of doctors, nurses, other healthcare professionals and administrative personnel. Arrangements for implementation included in-house training for users' minimum 3-4 hours. This means 2100 *3 hours that is 6300 hours, which is 777 working days spent in training sessions. For time being there is some knowledge about the influence of training in usage of patient information system.

Training of health information systems

The current awareness in systematic reviews and evidence-informed education within policy and research circles is a part of a general progress towards establishing policies and professional practice on the basis of sound evidence of efficiency. The best practice concept covers those processes, practices or systems, identified in public and private organisations that execute exceptionally well, which are widely recognised as improving an organisation's performance and efficiency in specific areas. Systematic reviews on education can help to collate a range of research types so as to investigate what works and what does not, how things work or why they do not; or to study existing practices, trends, needs or promising areas for development. [1, 2, 3]

Based on a review when instructing health information system previous computer skills or competence were neither explicitly defined nor measured. Even tough in several studies the participants presumably had computer know-how because the system itself presented advanced technology. The learning environment was in most cases the participant's own work surroundings. The knowledge or know-how attained from the training, or the educational impact on information system usage were seldom explored or measured. The review revealed that competence in any level of health informatics contributes to the learning process. The learning environment was seldom created for the educational purpose only. The system training was mainly a part of an introduction course to a new function or changes in the organisation. Teaching methods were interestingly often traditional, including written material and lectures. The innovations in virtual learning are nonetheless proliferating. Different teaching methods were widely used and pedagogical approaches varied from behaviouristic to cognitive and constructive approaches. [1]

Challenges in educational practice

Health information system teaching and learning is going to influence attitudes and future working practices. [4] The health system is expanding its use of information technology to complete evermore demanding tasks within health system. To manage these changes, staff education, personnel attitudes and the management of changes knowledge is required. [5] As main goal for implementing health information system is to manage information so that everyone has right of entry to the information they require to do their jobs effectively and make available better, more competent care.[4] Many healthcare professionals realise they need skills in finding and using information, and in assessing information systems. Yet today's health professionals generally have no formal training in health informatics. [6,7]

It is challenging to asses the impact of training and education on clinical utilisation of health information systems. Objectives for implementation consists of knowing how well do the system work. Then new function management should improve patient care.[1] The goals for training reveal did the training succeed and how clinical utilisation of information system is going on. Evaluation needs to be done in two dimensions taking into consideration both individual and organisational level of learning. Modern technology like Health Information Systems with computers and new application are implemented. However the implementation training uses traditional educational methods, classrooms and supports old-fashioned ways of learning.

The pervasiveness of new educational technology has not yet emerged in health information system training.[1, 6, 7] Learning spaces need to sustain multiple ways of learning. Learning designs should be created around people and learning principles. Learning is more important than the use of technology only, but technology can impede learning. New technology can progress and assist learning in various ways. [8, 9] Best practices in education rise from research, consensus models and benchmarking. Good practice has contact and collaboration, using active learning strategies and respects diverse talent and ways of learning.[2, 10] Within in health care deployment of pedagogies that support high-context, multidimensional, emergent approach and uses asynchronous tools should be apparent.

Discussion

Health information system implementation has effects in learning, both individual and organisational level. Prior to training one should assess competence of trainees. Evaluation of new function management and system usage, training achievements and assessment should be carried out systematically. Publishing findings profits information that is basic for creating Best practice.

The health information system implementation is often seen as technical project and some research is done evaluating outcomes of organisational learning. Hence, there seems to be a gap between teaching new function management and systematically evaluate information system implementation and its effect in healthcare practice.[1]

Learning is enhanced when it is more like a team effort that a private competition. Good learning, like excellent employment, is collaborative and social, not competitive and remote. Functioning with others repeatedly increases contribution in learning. Reflecting, sharing one's own ideas and responding to others' reactions creates meaningful interaction and deepens process oriented learning activity within health care.[9]

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Virtual Aging Class for College Students Using Multimedia Simulations and Activities

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Abstract and objective

The purpose of this study was to develop and apply a virtual class for healthy aging education for college students. A class for healthy aging and health management was established based on Network Based Instructional System Design(NBISD), using the following five process: 1) Analysis stage 2) Planning stage 3) Content Framing and development stage 4) Program application stage 5) Evaluation stage. The class homepage consisted of lecture room, discussion, assignment, activities, reference room, question & answer, bulletin board, and announcem

ent. In the application of virtual class, HTML, Javascript, multimedia (image, audio & video, simulation, and game) were utilized. Content and technical validity tests were done by experts. The completed program was applied to college students and showed the positive responses from the target students. Virtual class with multimedia such as simulation and games could be an effective teaching media of aging education for college students in the information age.

Keywords:

virtual, education, aging, multimedia

Introduction

The need to include aging education in curricular for college students has been acknowledged and recommended recently [1]. Rapid increase of old population has prompted an interest in preparing the young generation to better lead the future aged society. Healthy aging education is one method of sensitizing the young generation to the need of aging society [2]. Aging education for college student is one area that could benefit from the use of multimedia interactive virtual class to attract the users who are used to web based teaching environment [3].

Virtual class is one method that can be used to supplement or replace the traditional class room education [4]. Interactive virtual class allows the user to control the computer program, so they may learn at their own pace, provide an interactive learning environment in which materials can be targeted or tailored, and provide a variety of multimedia formats including graphics, video and audio, games, and simulations [5].

The purposes of this study were to develop and apply virtual class of healthy aging education for college students using multimedia simulations and activities.

The specific aims are as follows:

1) to analyze the learning need of the target students, learners' learning and computer related characteristics, and technical and environmental need.
2) to design the information, interaction, motivation, and evaluation mechanisms.
3) to develop the content using multimedia such as graphics, animation, video & audio, games, and simulation.
4) to operate the developed program
5) to evaluate the program

Methods

Virtual aging class was developed in the following five steps. 1) The learning needs of the target students, the learners' general learning and computer related characteristics, and technical and environmental needs were analyzed. 2) The education contents, interaction and motivation method, and evaluation mechanisms were designed using the results from the analysis. 3) The content using multimedia such as graphics, animation, video & audio, games, and simulations were developed. 4) The developed program was demonstrated to the experts and the sample group of students and revised according to their comments. 5) The program was uploaded on the web and operated for 16 weeks. 6) The evaluation was done with the users about learning function, display structure, and system function.

Results

In analysis stage, the topics of virtual class were developed based on a survey about the college students' knowledge and attitudes of aging and literature review. According to the target students' needs for aging education, the following list of contents were determined for aging education: 1) Theory of aging, 2) Aging process, 3) Genetic and environmental effects on aging, 4) Physical and Psychosocial aging, 5) Issues related to the elderly such as elderly abuse, sexuality, alcohol and substance abuse, 6) Successful aging, 7) Nutrition and exercise for

aging, 8) Internet information related to aging and longevity, 9) Social welfare system in Korea and other country, 10) Long-term care system for the elderly. The topics selected were validated with the experts in aging and gerontological area. The education information (cyber lecture, reference room), interface between learner and contents, learner and instructor, learner and learner (question & answer, bulletin board, e-mail, discussion), motivation (game, simulation, video & audio), and evaluation (quiz, test, assignment) were designed with the detailed functions. In development stage, contents frames were constructed based on the order of contents, technical stability, and user interface. Forty five cyber classes, 10 videos, 104 images, 4 simulations, and 4 games based teaching materials were included in the program. Simulations were designed for visual, mobility, and other functional changes during the aging process (Figure 4). Games were designed for brain, family tree, lifeline for student, and lifeline for the elderly (Figure 5). The instructor can check the students' participation using the administrator mode and provide the feedback for each student.

The final program was operated and over 100 students were registered in the aging class as an elective course. The evaluation was done about users' satisfaction of learning function, system function, and screen construction on the web and showed the positive responses from the users using 5 point Likert scale. The students responded that the class helped them to be concentrated and interested in the contents. Also, they gave the high scores on attractive graphics and variety of multimedia. Convenience and speed of the system were scored least and need more improvement. The majority of students reported that this class was very useful and made them feel sympathy for the elderly.

Table 1 - Evaluation of user satisfaction

Category	*Item*	*Mean*
Learning Function	Easy to understand	4.00
	Convenient	3.80
	Satisfied	4.10
	Interested	4.50
	Accurate	4.00
	Concentrated	4.20
Display Construction	Appropriate letter size	4.30
	Logical construction	4.10
	Attractive graphic	4.40
System Function	Variety of multimedia	4.30
	Exact learning guide	4.00
	Fast up & download	3.50
	Appropriate interface	4.00

Discussion

This project aims at developing and applying virtual aging class for college students using multimedia simulation and activities. The study results reveal that the virtual aging class with multimedia interaction is an effective learning tool for college students. Students learned the topic more interestingly using the multimedia learning materials. In addition, the class develops positive attitudes about aging.

A majority of subjects indicated a preference for the multimedia instruction of aging. The study results demonstrate that virtual class with multimedia such as games and simulation can be an effective tool for improving comprehension and eliciting interest in the lessons.

Consistent with previous reports[6], the present investigation found that experience with virtual class and multimedia activities was interesting and holding attention of the students in the information age. Multimedia interaction such as video, audio, games, and simulation can clarify instruction by allowing students to visualize and experience the complex and dynamic process of aging.

Conclusion

Based on the findings of this study, further investigation is required to evaluate the effect of the virtual aging class in more detail. Remaining questions to address include the following:

· What aspects of aging process can be effectively simulated for teaching?

· How would virtual only aging class compare with blending virtual and traditional offline learning experience?

· What are the best strategies for incorporating multimedia into aging education?

The ultimate objective of this line of research will be to determine how best to prepare the multimedia such as simulations and games on aging education for successful aging and health promotion for the different age group such as middle age or old age group.

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Virtual Aging Class for College Students Using Multimedia Simulations and Activities

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Introduction

Aging Society ⇨ Aged Society

Rapid increase of Elderly Population in Korea

Aging Education

Preparing young generation for future aged society

Aging Education for College Student

Successful aging & Healthy aging education

Virtual Class with Multimedia

Web-based instruction for Digital age

Graphics, Video, Audio, Simulation, Game:

Virtual experience of Aging Process

Purpose of the Study

I. to analyze the learning need of the target students, learners' general and computer related characteristics, and technical and environmental need.

II. to design the information, interaction, motivation, and evaluation mechanisms.

III. to develop the contents using multimedia such as graphics, animation, video & audio, and simulation.

IV. to operate the developed program

V. to evaluate the program

Research Procedure

Analysis Stage

Need Analysis
Content Analysis
Leader Analysis
Technical Environment Analysis

- Education Need Analysis
- Literature Review/ Course Objectives
- Learner's Usability of Computer
- Validity Test in Content/ Technology

Designing Stage

Information Designing
Interaction Designing
Motivation Designing
Evaluation Designing

- Contents
- Learner & Content & Instructor Interaction
- Motivation
- Evaluation

Producing Stage

Contents Framing
Media Production
Integration
Formative Evaluation

- Contents
- Motion, Image, Pictures, Illustration
- Program development & Loading on the web
- Pilot test

Operation Stage

- Open to the target students

Evaluation Stage

- Contents & System Evaluation

Analysis Stage

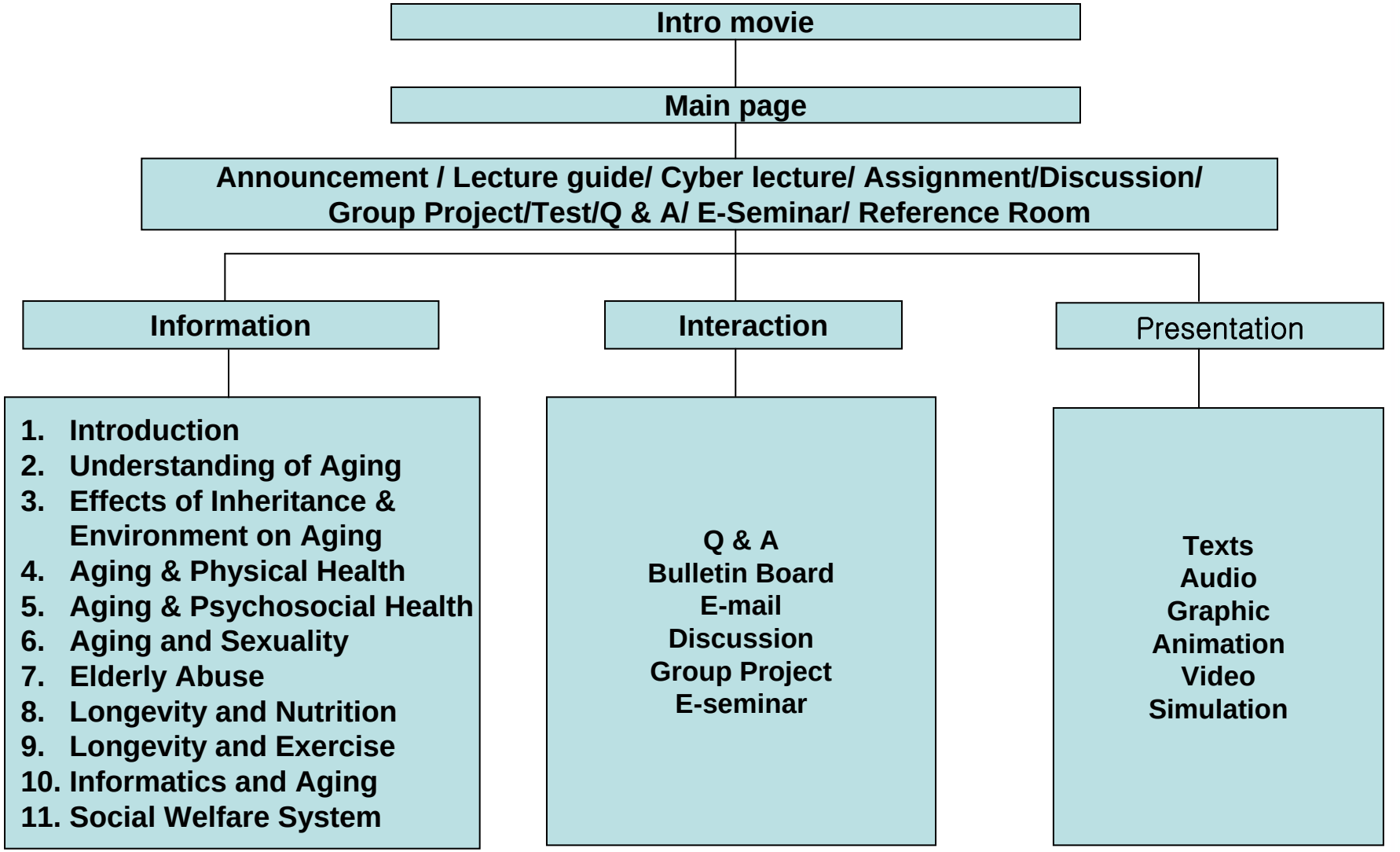
- **Topics of education program were developed based on a survey about the college students' knowledge and attitudes of aging and literature review**

- **According to the target students' needs for aging education, the topics were selected and validated with the experts in aging and gerontological area**

Designing, Producing, & Operating

- Designing
  - Education information: cyber lecture, reference room
  - Interface between learner and contents, learner and instructor, learner and learner : Q & A, bulletin board, e-mail, discussion, group project, e-seminar
  - Motivation : game, simulation, video & audio
  - Evaluation : quiz, test, assignment
- Producing
  - 45 cyber classes, 10 videos, 104 images, 8 simulations, and 10 text based teaching material
- Operating
  - The final program was uploaded on the cyber class homepage of K University

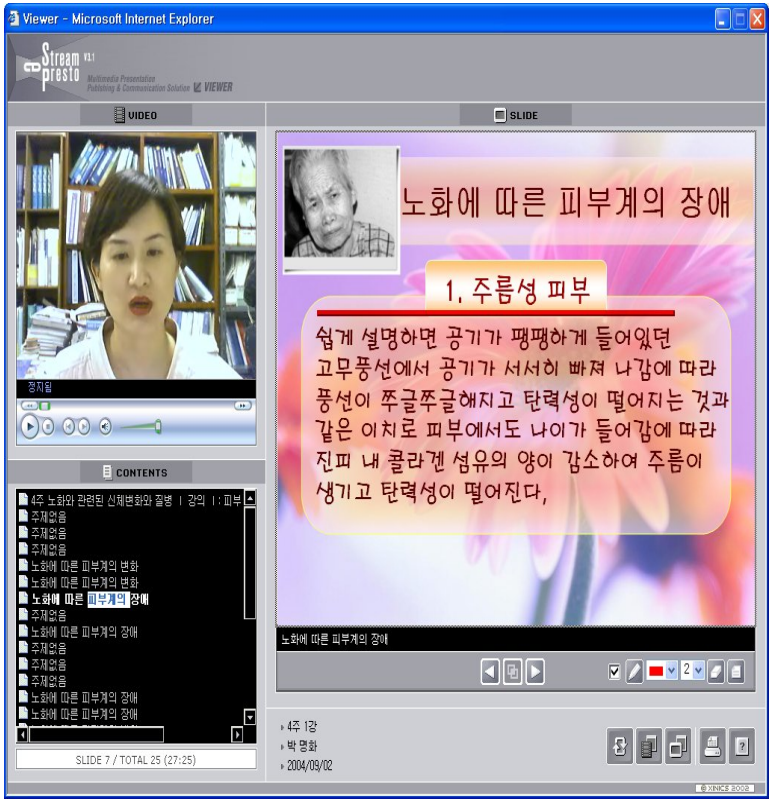
Structure of the System



Class Websites

Main Page

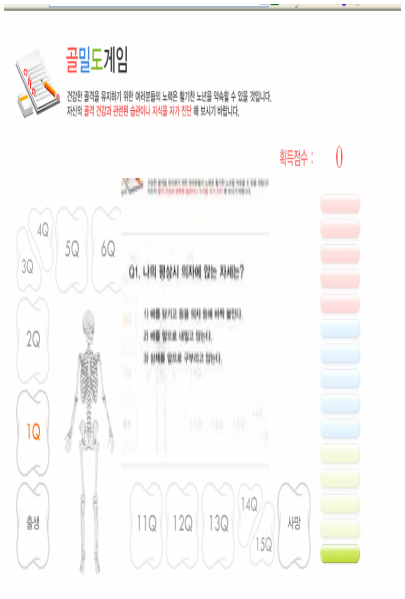
Cyber Lecture



Simulation & Game

Simulation of Visual Aging

Game of Bone Health



Evaluation

Category	Item	Mean
Instruction function	**Easy to understand**	**4.00**
	Convenient	**3.80**
	Satisfied	**4.10**
	Interested	**4.50**
	Accurate	**4.00**
	Concentrated	**4.20**
Screen Construction	**Appropriate letter size**	**4.30**
	Logical construction	**4.10**
	Attractive graphic	**4.40**
System Function	**Variety of multimedia**	**4.30**
	Exact learning guide	**4.00**
	Fast upload & download	**3.50**
	Quick and appropriate interface	**4.00**

Conclusion

- Virtual Multimedia class on aging education is an effective learning tool for the college students.
- Virtual class with multimedia such as video, audio, and simulation can clarify instruction by allowing students to visualize complex and dynamic process of aging.
- The ultimate objective of this line of research will be to determine how best to prepare the multimedia such as simulations and games on aging education for successful aging and health promotion for the different age group such as middle age or old age group.

Information

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Problem-Based Learning Approach for the On-line Public Health Courses

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Abstract

In order to develop an online problem-based learning (PBL) method which will fit best into the International Cyber University for Health (ICUH) programs and meet all the learning needs of students in the field of public health, we have first considered the characteristics and nature of each course. Therefore, a modified PBL discussion method was adopted to attain the maximum efficiency for students to learn better from the subjects in the course contents. Although it is still in its initiation stage, the evaluations showed a successful implementation of PBL method with high satisfaction of students. In this article, we will examine the general PBL method, suggest our modification of PBL method for the courses, and finally analyze student's evaluation on PBL method.

Keywords:

problem-based learning (PBL), online education, cyber, discussion approach, public health

Introduction

At the entrance of the 21st century, cyber education offers an environment that enables instruction and learning to become independent of time and space. It opens up learning opportunities to people with physical or other limitations, thus unable to participate in conventional classroom education. The excitement and chance to learn are not limited to a single country, region or group, but extends to global community.

The conventional long distance courses are usually based upon the mere presentation of the didactic materials with an interaction, which is usually limited to question and answer type quizzes. Web conferences and net meetings are not integrated in a comprehensive model of teaching and learning [1]. It was as assumed that one of the main obstacles to meaningful learning is the discipline oriented approach to most of the educational curricula and courses. This is the fundamental reason why many authors claim that problem based learning (PBL) is the most useful way for engaging the students in a learning process based upon realistic situations whereby knowledge from different disciplines are integrated [2].

As a part of the project named, "Development of PBL (Problem-Based Learning) & CDL (Competency-Directed Learning) E-Learning Module for Asia-Pacific Area's Health Professionals," the International Cyber University for Health (ICUH) is currently introducing the public health oriented PBL discussion method into its on-line courses.

The goal of PBL is to motivate students to develop self-learning skills in a small group [3]. The PBL environment is student-centered, students-directed, fosters intrinsic motivation, promotes active learning, encourages peer teaching, involves timely feedback, and inculcate student self- and peer assessment [4]. The students are encouraged to use self-directed learning skills to analyze a given scenario to identify the problem, formulate key-learning objectives and collect whatever additional information required to address those objective [5].

PBL differs from traditional lecture-based curriculums in that it relies on the use of real or simulated problems to develop critical thinking skills. PBL provides a stimulus and a framework for applying problem solving skills, as well as the opportunity to acquire the information needed to understand the mechanisms and solution behind the problem [6].

In order to encourage the student to develop an appreciation for the interrelated nature of the physical, biological, and behavioral mechanisms that must be considered with each health problem, we plan to introduce PBL approach to web-based classes for ICUH.

The purpose of this study was to develop and evaluate the PBL method for graduate students in public health in order to assess the feasibility of an online approach as a PBL modality. In order to develop an online PBL method which will fit best into the ICUH programs and meet all the needs of students in the field of public health, we have first considered the characteristics and nature of each course. Subsequently, a modified PBL discussion method was adopted and implemented to draw the maximum efficiency for students to learn better from the subjects in the course contents. In addition, we also analyzed the student's evaluation on the PBL method employed.

Materials and methods

We introduced PBL discussion learning method to our three courses 2006 Fall semester of the ICUH: Introduction to Health Informatics, Comparative Health Law Seminar, Leadership in Crisis and Communication in Disasters & Health Care.

The students of each course were clustered into small groups of 8-10 students. Through the creation of an online environment, students working in small groups accessed information resources that had been prepared for them in advance. The communications are based on web conferencing, access to web pages, personal contacts, and group meetings.

PBL discussion process

We modified a PBL discussion process to maximize the teaching and learning efficiency for both professors and students. We have considered two factors: (1) characteristics and nature of public health courses and (2) web-based approach.

Three courses (Comparative Health Law Seminar, Leadership in Crisis Communication in Disasters & Health Care and Introduction to Health Informatics) have shown different characteristics and nature in education compared to other similar fields, such asmedicine and nursing. The public health courses often deal with health policy and administration which combines problem-solving with consensus-building and policy-making process. In addition, since this approach is introduced to cyber courses, the whole process should be carried out online, which may require some changes in communication, technology and methodology. After thorough consideration, we have developed the followingPBL process for the public health courses to magnify the learning efficiency for students who participate in online discussions

Table 1 - The modified PBL processof public health

PBL Process	Description
Pre-Discussion Activities – Blackboard Function	
Case (Scenario) Presentation	A case or scenario is posted on the blackboard of online classroom one week prior to the PBL discussion session. The related questions for self-study are also presented.
Private Student Research	Students read the case and begin to find resource materials and other references related to the case.
Intra-Discussion Activities (3~4 groups) – Meeting Room Function	
Case Recitation	A Tutor recites the case to be discussed and confirm if students understand the case correctly.
Fact Finding	A tutor leads students to source the facts, which may become debatable or significant in discussion.
Student Presentation	Each student makes a presentation on the answers for the questions and go on to the crossover discussions amongst the group.
Possible Solution Finding	Students argue and discuss on possible solutions for the posted case study
Consensus Building	Voting process will be carried out to build consensus among students on important matters. (Voting Function)
Decision Making	Students can develop a policy through decision-making process after consensus building.
Post-Discussion Activities – Board Function	
Class Discussion	Using the board function in the online classroom, the discussion results from each discussion group are presented and further discussed among all the students in the class.
Report & Evaluation	Each student submit a separate report as well as an evaluation for each PBL session (Report Function)

Evaluation of the effectiveness of PBL approach

After each PBL session, students evaluated the PBL discussion class for the feedback. We developed a simple 15-question evaluation form with 5-point scale which requires students to write both advantages and disadvantages of online PBL discussion approach. The questionnaire consisted of five sections, learning process, cases & problems, tutor's role, student's role, and learning effectiveness.

We analyzed the relationship among learning process, cases & problem, tutor's role, student's role for the learning effectiveness (Figure 1). This study compared the relative effects of each variable for learning effectiveness in the multivariate model.

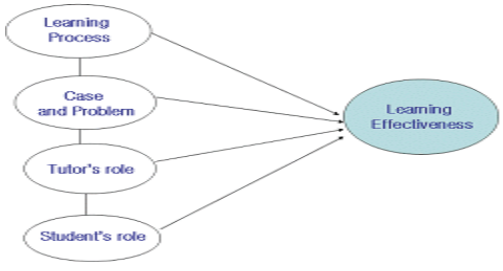

Figure 1 – Framework of the analysis

Kruskal-Wallis test was carried out to examine the statistical significance on the scores among three courses [8]. The

scores of each student were measured by two factors (Agree/ Disagree), and Chi-Square test was used to analyze the association between each factor and learning effectiveness. In addition, Multiple regression analysis was used to analyze the relationship between a single dependent variable and several independent variables.

Results

Students evaluation on online PBL discussion session

The results showed comparatively high scores in most parts. The students enjoyed much freedom to participate in discussions since they were not afraid of making mistakes online compared to traditional classroom environment. Some students pointed out the technical or systematic difficulties in the usage of meeting room function since computer or web access was running as smoothly. The Kruskal-Wallis test showed that the difference in the scores among three courses was statistically significant in learning process (chi-square value = 10.14, p-value = 0.006) and case and problem (chi-square value = 6.73, p-value= 0.034). The detailed results are shown in Table 3.

Association between learning effectiveness and factors type

The changes in learning effectiveness were measured according to the response factors (Agree/Disagree) of each variable. The results show that most variables in learning process, case & problem, tutor's role and student's role except for two variables, Organization of PBL Discussion and Appropriateness of PBL Questions were statistically significant, suggesting the high association between learning effectiveness and factors type as shown in Table 2.

The effect of learning process, case, tutor's and student's role factors on learning effectiveness

The effects of the independent variables to learning effectiveness were tested. Table 4 summarizes the coefficients, t-value, adjusted R2, and significance level of the regression model. In the regression model, the overall model was significant ($F=6.22$, $p<0.001$) and 76 percent of the variance of LDL cholesterol level is explained by independent variables ($R2=0.7567$). The learning process factor had significant influence on learning effectiveness in two variables, organization of PBL discussion and easiness of opinion presentation. The case factor also had significant influence on learning effectiveness in one variable, relevance of PBL case. In addition, the result shows that the case factor was significantly related to learning effectiveness (beta= 0.55622, t-value= 3.21, $p<0.0038$).

Discussion and conclusion

Although it is still in the initiation stage, the evaluations portrayed a successful implementation of PBL method with high satisfaction response from the students. The PBL approach enables students to understand the relevance of underlying knowledge and principles in health care practice [9].

For the PBL process, the web is used as a repository of multimedia documents that can be accessed by the students of the virtual classroom, a source of valuable structured information, and a synchronous communication channel with the capability of recording and marking the sequence of interventions. The use of web-based method appears to be a potentially feasible problem-based learning modality for the graduate public health course. Web-based PBL approach provides a unique opportunity for students worldwide to experience health education challenges that originate in a variety of distinctly different culture. Without any distance constraint, students can collaborate in a common work setting as they pursue solutions to health problems.

Another common setback is staffing time. Efficient PBL learning environment is highly dependent on the function and the participant group. This requires a tutor cum moderator to be well-versed in facilitating the PBL discussion environment, more than simply to be a subject matter expert. Feedbacks provided by students will be used to produce an enhanced PBL approach that will be evaluated further to determine its educational potential as compared to the traditionally assigned reality-based education. The student evaluations provide rich material to be reflected upon in terms of instructional and learning strategy for PBL. The results of the study will be also used to make future design and technology modications to the tutorials as part of an ongoing development process. In our PBL approach, students were given ill-structured problems through which they develop critical thinking and problem-solving skill. The obvious change to a more student-centered focus resulted in students reporting that they were more motivated to learn and that they maximized learning opportunities and became much more focused on their learning needs and responsibilities in the learning process.

Table 2 - Association between Learning Effectiveness and Factors Type

			Learning Effectiveness			
			Agree	**Disagree**	**Chi-Square Value**	**p-Value**
Learning Process	Organization of PBL Discussion	Agree	17(62.96%)	10(37.04%)	0.23	0.630
		Disagree	6(54.55%)	5(45.45%)		
	Easiness of Opinion Presentation	Agree	14(82.35%)	3(17.56%)	6.13	0.013
		Disagree	9(42.86%)	12(57.14%)		
	Helpfulness of Student Presentations	Agree	16(76.18%)	5(23.81%)	4.82	0.028
		Disagree	7(41.18%)	10(58.82%)		
Case & Problem	Relevance of PBL Case	Agree	15(93.75%)	1(6.25%)	13.75	<0.001
		Disagree	7(33.33%)	14(66.67%)		
	Hardness of Resource Search	Agree	23(71.88%)	9(23.13%)	10.92	<0.001
		Disagree	0(0.00%)	6(100.00%)		
	Appropriateness of PBL Questions	Agree	15(65.22%)	8(34.78%)	0.53	0.463
		Disagree	8(53.33%)	7(46.46%)		
Tutor's Role	Inducement of Student Participation	Agree	17(77.27%)	5(22.73%)	6.13	0.013
		Disagree	6(37.50%)	10(62.50%)		
	Positive Feedbacks	Agree	14(87.50%)	2(12.50%)	8.41	0.003
		Disagree	9(40.91%)	13(59.09%)		
	Appropriate Intervention	Agree	15(78.95%)	4(21.05%)	5.39	0.020
		Disagree	8(42.11%)	11(57.89%)		
Student's Role	Activeness of Participation	Agree	18(78.26%)	5(21.74%)	7.67	0.005
		Disagree	5(33.33%)	11(66.67%)		
	Sufficient Preparation	Agree	20(74.07%)	7(25.93%)	7.16	0.007
		Disagree	3(27.27%)	8(72.73%)		
	Understanding of Student Presentations	Agree	20(71.43%)	8(28.57%)	5.29	0.021
		Disagree	3(30.00%)	7(70.00%)		

Table 3 - Determinant of Learning Effectiveness by Multiple Regression Analysis

		Beta-Coefficient	**t-Value**	**p-Value**
Learning Process	Organization of PBL Discussion	-0.27092	-1.85	0.0767
	Easiness of Opinion Presentation	0.22872	1.78	0.0874
	Helpfulness of Student Presentations	0.09444	0.63	0.5331
Case and Problem	Relevance of PBL Case	0.55622	3.21	0.0038
	Hardness of Resource Search	0.06482	0.56	0.5808
	Appropriateness of PBL Questions	0.13569	0.99	0.3313
Tutor's Role	Inducement of Student Participation	0.0892	0.51	0.6116
	Positive Feedbacks	0.16278	1.16	0.2587
	Appropriate Intervention	-0.27616	-1.47	0.1556
Student's Role	Activeness of Participation	-0.18422	-1.13	0.268
	Sufficient Preparation	0.10595	0.72	0.4761
	Understanding of Student Presentations	0.36701	2.28	0.0318
Model Fitness	F statistic	6.22		
	P-value	<0.0001		
	R square	0.7567		

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Online Problem-Based Learning Approach for Public Health Courses

Presenter: Young Moon Chae

Young Moon Chae, Seung Hee Ho, Soo Jin Yoon, Byung Wha Lee, Seon Kui Lee, Min Kyung Kim, Bernard C. M. Tan,Jee Hee Kim

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Introduction

- *International Cyber University for Health* (ICUH)

  - collaborative effort with *Asia Pacific Academic Consortium for Public Health* (APACPH)

  - To provide high quality online public health education in the Asia-Pacific region

  - One of the vision is to offer an environment that enables instruction and learning to become independent of space and time.

  - Since its official inauguration on May 3 2004, ICUH has evolved rapidly to offer PBL based courses, translation services and concurrently run a credit exchange program.

Materials and Methods

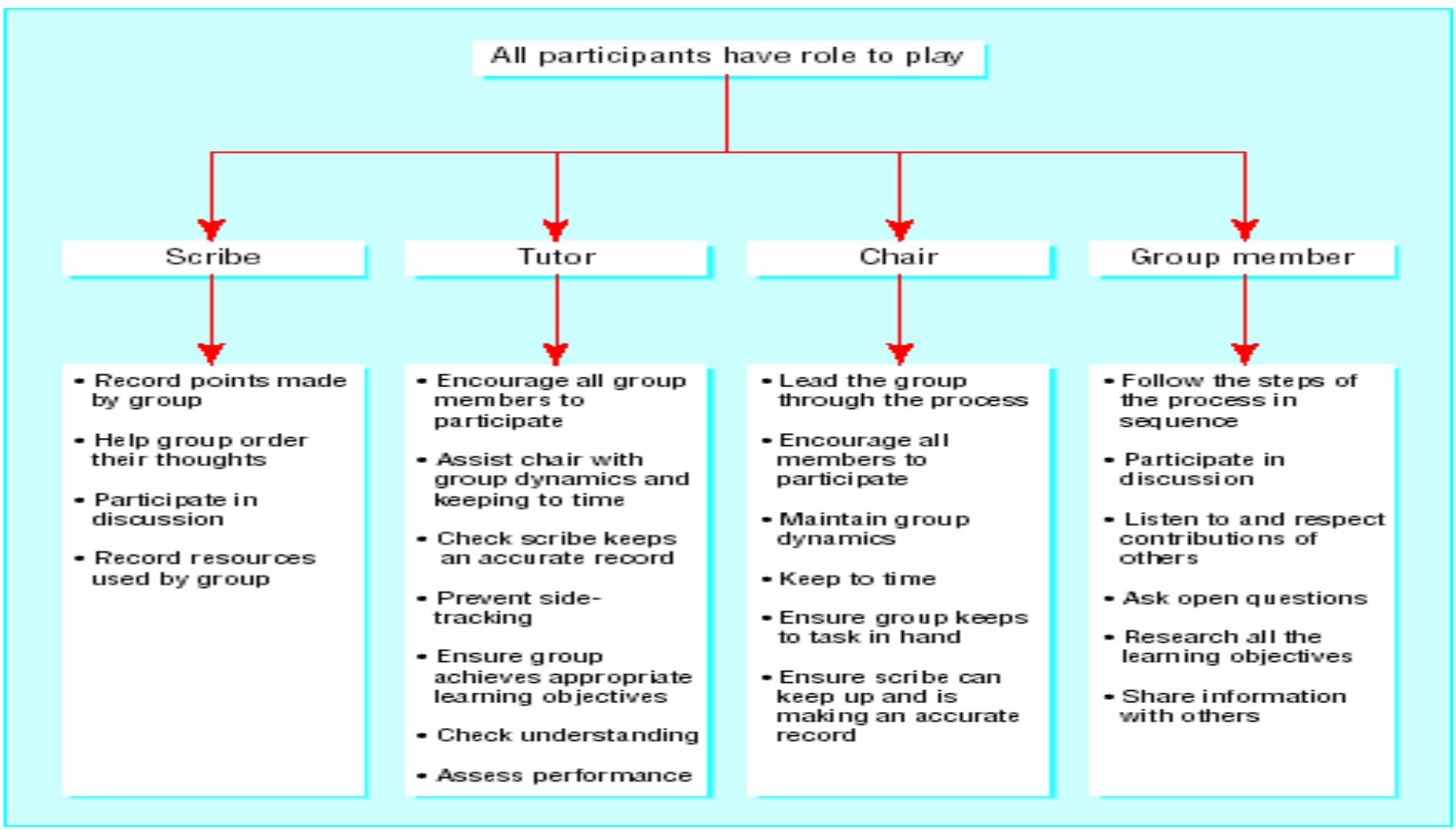
- PBL sessions were implemented in the following courses:
  - 2006 Fall semester：*Introduction to Health Informatics*, *Comparative Health Law Seminar, Leadership in Crisis and Communication in Disasters and Health Care*.
  - 2007 spring semester : *International Child Health, Systems Analysis and Design in Healthcare*

- Small Group discussion (8-10 students)
- Information resources prepared prior to the online discussion sessions
- Communications - Web conferencing, bulletin board

PBL Discussion Process

PBL Process	Description
Pre-Discussion Activities – Blackboard Function	
Case (Scenario) Presentation	A case or scenario is posted on the blackboard of online classroom one week prior to the PBL discussion session. The related questions for self-study are also presented.
Private Student Research	Students read the case and begin to find resource materials and other reference related to the case.
Intra-Discussion Activities (3~4 groups) – Meeting Room Function	
Case Recitation	A Tutor recites the case to be discussed and confirm if students understand the case correctly.
Fact Finding	A tutor leads students to source the facts, which may become debatable or significant in discussion.
Student Presentation	Each student makes a presentation on the answers for the questions and go on to the cross-over discussions amongst the group.
Possible Solution Finding	Students argue and discuss on possible solutions for the posted case study
Consensus Building	Voting process will be carried out to build consensus among students on important matters. (Voting Function)
Decision Making	Students can develop a policy through decision-making process after consensus building.
Post-Discussion Activities – Board Function	
Class Discussion	Using the board function in the online classroom, the discussion results from each discussion group are presented and further discussed among all the students in the class.
Report & Evaluation	Each student submit a separate report as well as an evaluation for each PBL session (Report Function)

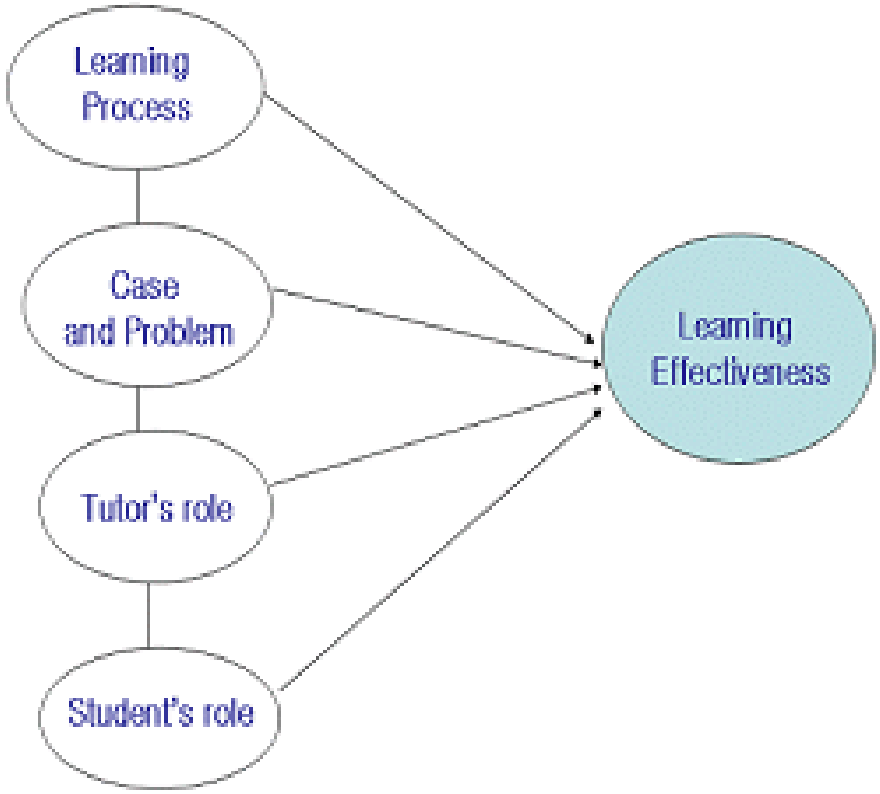
Roles of participants in a PBL tutorial



Evaluation of the effectiveness of PBL Approach

- 15 Question evaluation with a 5 point scale

- Questionnaire consisted of five sections - *Learning process, Cases & Problems, Tutor's role, Student's role, and Learning effectiveness.*



Framework of the Analysis

Results – fall, 2006

			Learning Effectiveness			
			Agree	Disagree	Chi-Square	p-Value
Learning Process	Organization of PBL Discussion	Agree	17(62.96%)	10(37.04%)	0.23	0.63
		Disagree	6(54.55%)	5(45.45%)		
	Easiness of Opinion Presentation	Agree	14(82.35%)	3(17.56%)	6.13	0.013
		Disagree	9(42.86%)	12(57.14%)		
	Helpfulness of Student Presentations	Agree	16(76.18%)	5(23.81%)	4.82	0.028
		Disagree	7(41.18%)	10(58.82%)		
Case & Problem	Relevance of PBL Case	Agree	15(93.75%)	1(6.25%)	13.75	<0.001
		Disagree	7(33.33%)	14(66.67%)		
	Hardness of Resource Search	Agree	23(71.88%)	9(23.13%)	10.92	<0.001
		Disagree	0(0.00%)	6(100.00%)		
	Appropriateness of PBL Questions	Agree	15(65.22%)	8(34.78%)	0.53	0.463
		Disagree	8(53.33%)	7(46.46%)		
Tutor's Role	Inducement of Student Participation	Agree	17(77.27%)	5(22.73%)	6.13	0.013
		Disagree	6(37.50%)	10(62.50%)		
	Positive Feedbacks	Agree	14(87.50%)	2(12.50%)	8.41	0.003
		Disagree	9(40.91%)	13(59.09%)		
	Appropriate Intervention	Agree	15(78.95%)	4(21.05%)	5.39	0.02
		Disagree	8(42.11%)	11(57.89%)		
Student's Role	Activeness of Participation	Agree	18(78.26%)	5(21.74%)	7.67	0.005
		Disagree	5(33.33%)	11(66.67%)		
	Sufficient Preparation	Agree	20(74.07%)	7(25.93%)	7.16	0.007
		Disagree	3(27.27%)	8(72.73%)		
	Understanding of Student Presentations	Agree	20(71.43%)	8(28.57%)	5.29	0.021
		Disagree	3(30.00%)	7(70.00%)		

Results - Determinant of Learning Effectiveness by Multiple Regression Analysis

		Beta-Coefficient	t	p-Value
Learning Process	Organization of PBL Discussion	-0.27092	-1.85	0.0767
	Easiness of Opinion Presentation	0.22872	1.78	0.0874
	Helpfulness of Student Presentations	0.09444	0.63	0.5331
Case and Problem	Relevance of PBL Case	0.55622	3.21	0.0038
	Hardness of Resource Search	0.06482	0.56	0.5808
	Appropriateness of PBL Questions	0.13569	0.99	0.3313
Tutor's Role	Inducement of Student Participation	0.0892	0.51	0.6116
	Positive Feedbacks	0.16278	1.16	0.2587
	Appropriate Intervention	-0.27616	-1.47	0.1556
Student's Role	Activeness of Participation	-0.18422	-1.13	0.268
	Sufficient Preparation	0.10595	0.72	0.4761
	Understanding of Student Presentations	0.36701	2.28	0.0318
Model Fitness	F statistic			6.22
	P-value			<0.0001
	R square			0.7567

Results – spring, 2007

			Learning Effectiveness			
			Agree	Disagree	Chi-Square	p-Value
Learning Process	Organization of PBL Discussion	Agree	6(75.00%)	2(25.00%)	2.65	0.102
		Disagree	5(58.33%)	8(41.67%)		
	Easiness of Opinion Presentation	Agree	6(60.00%)	4(40.00%)	0.44	0.275
		Disagree	5(45.45%)	6(54.55%)		
	Helpfulness of Student Presentations	Agree	4(80.00%)	1(20.00%)	2.0	0.001
		Disagree	7(43.75%)	9(56.25%)		
Case & Problem	Relevance of PBL Case	Agree	8(80.00%)	2(20.00%)	5.83	0.021
		Disagree	3(72.73%)	8(27.27%)		
	Hardness of Resource Search	Agree	3(100.00%)	0(00.00%)	3.18	0.124
		Disagree	8(44.44%)	10(55.56%)		
	Appropriateness of PBL Questions	Agree	4(80.00%)	1(20.00%)	2.0	0.162
		Disagree	7(43.75%)	9(56.25%)		
Tutor's Role	Inducement of Student Participation	Agree	8(80.00%)	2(20.00%)	5.83	0.021
		Disagree	3(27.27%)	872.73%)		
	Positive Feedbacks	Agree	9(69.23%)	4(30.77%)	3.88	0.056
		Disagree	2(25.00%)	6(75.00%)		
	Appropriate Intervention	Agree	6(66.67%)	3(33.33%)	1.28	0.188
		Disagree	5(41.67%)	7(58.33%)		
Student's Role	Activeness of Participation	Agree	8(57.14%)	6(42.86%)	0.38	0.298
		Disagree	3(42.68%)	4(57.14%)		
	Sufficient Preparation	Agree	9(60.00%)	6(40.00%)	1.22	0.212
		Disagree	2(33.33%)	4(66.67%)		
	Understanding of Student Presentations	Agree	2(50.00%)	2(50.00%)	0.01	0.413
		Disagree	9(52.94%)	8(47.06%)		

Results - Determinant of Learning Effectiveness by Multiple Regression Analysis

		Beta-Coefficient	t-Value	**p-Value**
Learning Process	Organization of PBL Discussion	0.57127	1.65	0.1372
	Easiness of Opinion Presentation	-0.78203	1.78	0.0874
	Helpfulness of Student Presentations	0.48189	2.24	0.055
Case and Problem	Relevance of PBL Case	-0.05527	-0.16	0.8772
	Hardness of Resource Search	0.09136	0.38	0.7173
	Appropriateness of PBL Questions	0.05885	0.29	0.7823
Tutor's Role	Inducement of Student Participation	0.52365	1.86	0.1003
	Positive Feedbacks	0.25371	0.97	0.3583
	Appropriate Intervention	-0.08361	-0.43	0.6807
Student's Role	Activeness of Participation	-0.36739	-0.90	0.3948
	Sufficient Preparation	0.77727	2.14	0.0644
	Understanding of Student Presentations	-0.09173	-0.32	0.7571
Model Fitness	F statistic			5.78
	P-value			0.0094
	R square			0.8967

Discussion & Conclusion

- Evaluations portrayed successful implementation of PBL method with high satisfaction response from students.
- The use of web-based method appears to be a potentially feasible problem-based learning modality for the graduate public health course.
- Efficient PBL learning environment is highly dependent on the function and the participant group. The presence of a tutor well versed in facilitating a PBL discussion group than being a subject matter expert is vital.
- The results of the study will be used to make future design and technology medications to the tutorials as part of an ongoing development process.

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The Quality Indicators of Delivering E-learning for Dementia Care to Nurses

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Abstract

The inadequate supply of trained professionals to provide quality care for people with dementia is a big problem. E-learning could provide an effective solution to this challenge. Although e-learning is not a new teaching method, a quality framework is lack that can be used to judge the quality of e-learning delivery for working nurses. This gap thus should be overcomed. Therefore, the primary aim of this study is to identify the quality indicator for effective e-learning delivery. Based on these indicators, a quality framework of e-learning packages that teach nurses to deliver dementia care is constructed. The approach taken is systematic literature review. The literature in the fields of e-learning for adult education and nursing continuing education were reviewed. Based on critical analysis of published literature, our quality framework was constructed. It consists of seven components, namely, learner, facilitator, content, delivery mode, technology, service and outcome. Each component covers various issues that need to be further investigated.

Keywords:

e-learning, web-based learning, distance learning, continuing nursing education, e-learning framework, dementia care, adult learner, quality assurance

Introduction

The world's population is aging. Associated with an aging population is a prevalence of dementia. Governments and healthcare consumers are concerned about the inadequate supply of trained professionals to provide quality care for people with dementia. The nurses are the major health care workers that provide quality care to dementia patients. Thus, there is an urgent need to provide training to nurses to ensure that they are qualified and use best practices to provide high quality care to patients with dementia [1]. Nowadays, the advances in Information and Communication Technology (ICT) have made it possible to deliver dementia care information via networked computers. Although a lot of work has been conducted in using e-learning method to deliver health care education to nurses, there is little study about using e-learning method for delivering dementia care education to nurses. To ensure that this e-learning course is effective and efficient, a quality framework should be established as a guideline for its development.

Methods

The approach taken is systematic literature review. Two fields of literature were searched: e-learning for adults and nurse continuing education. The following databases were searched for the literature in the field of e-learning for adults: CINAHL, Medline, ERIC, SpringerLink, the ACM digital library, ScienceDirect, ProQuest 5000, Synergy, A+ Education and IEEE. The keywords used for database search were "nurs*", "e-learning", "online learning", "web-based learning", "adult education", "quality framework", "quality assurance", and "e-learning model". The database searched on the second field include CINAHL, Medline, ScienceDirect and ProQuest 5000. The keywords used for the search were "nurse continuing education", "nurse computer literacy", "nurse information literacy", and "dementia care".

Results

In order to construct an e-learning quality framework, three basic themes need to be considered: learner, teacher, and content. Firstly, the targeted learners are nurses. In order to keep pace with the development in the medical field, technology and policy, they are increasingly engaged in continuous education [2]. The nature of learning and the driving forces for nurses to learn should be considered. Secondly, the teacher's role should always be considered. As both teaching and learning are not happening face-to-face in e-learning environment, 'facilitator' is used to replace the term 'teacher'. Facilitators facilitate the students' learning rather than a dispenser of information, as is sometimes practiced in a traditional learning course. In addition, content are the information to be delivered to satisfy nurses' need for practical dementia care, thus should be carefully designed.

In the online environment, three other themes are worth to be considered, too. They are technology, delivery mode and service. It is obvious that technology is important for the successful delivery of e-learning. Students must be online to learn via computers in Web-based learning delivery. It is critical that learners could interact with other learners, with facilitators, and with content [3]. Moreover, high quality service is the pre-requisite to guarantee the success of an e-learning project, such as, the firewall software problem [4] and password confusion issues have to be solved [5]. In addition, the pedagogical theories which are

suitable to design and deliver knowledge in online learning environment are important for the success of the delivery.

Discussion

A proposed quality framework for an e-learning package that teaches nurses to deliver dementia care is shown in Figure 1. It consists of seven constructs, namely, learner, facilitator, content, delivery mode, technology, service and outcome.

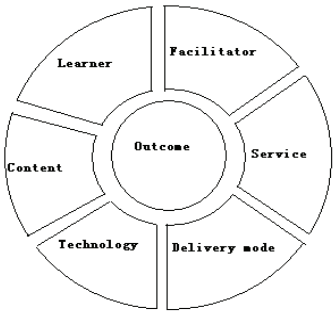

Figure 1 – A proposed quality framework for an e-learning package that teaches nurses to deliver dementia care

1. Learner

Learners of the e-learning course are working dementia care nurses, who have diverse backgrounds and levels of experience. Three issues were emphasized about nurse learners in literature: time limitations, nurses' computer literacy and familiarity with internet technology. It is obvious that lack of time to complete the course is one of the main barriers for nurses to gain a successful e-learning experience [5]. The learners' computer literacy and their familiarity with internet technology are varied. Thus the e-learning designers should understand nurses' levels of computer and information literacy before customizing effective e-learning courses for them.

2. Facilitator

There are two kinds of facilitators that are considered in our framework: knowledge facilitator (online teacher) and technical support facilitator. The knowledge facilitators should create a positive learning experience for each learner and be empathic to individual learner's needs [6]. Technical support is vital to help learners use and access the systems and the learning environment. Both knowledge facilitator and technical support facilitator should be qualified, accessible and responsive [6].

3. Content

The content of e-learning for dementia care package should be interesting, logically organized and flow well [7], comprehensive and authentic [5]. It should be directly relevant to learners' work needs and easy to understand. As the learners are working nurses who already have certain knowledge, what they want to learn via e-learning is new approaches and techniques. The previous researchers [5] suggested that improving understanding about how people suffering with dementia see the world should be an important learning objective; information on the various stages of dementia should be included. The same useful information is about the dementia patient's medications.

4. Delivery mode

In order to achieve high-quality delivery, pedagogical strategies should emphasize the following three issues: *(1)Knowledge base* - learners have different levels of previous knowledge and engagement with dementia. Therefore a variety of levels of information should be included [8]. *(2)Learning pace* - Being able to control their own pace of learning is important for nurse learners. *(3)Delivery format* - a variety of media and communication tools should be used to accommodate different learning styles. It should offer a combination of text, graphics, video and audio.

5 Technology

Technology factors to be considered include usability of website and interactivity. The previous researchers said that usability of Website is comprised of "Format (hyperlinks/buttons for ease of search-ability) and Flexibility (multimedia or plain text of material presentation indicating the utilization of web potential)"[9]. The interface for e-learning material should be carefully designed to ensure usability, which includes ease of navigation, clarity of instructions and so on.

6 Service

Service is defined as accessibility. Access to the entire website should be straightforward. Unconstrained access to services such as libraries, bookstores, and an extensive range of other learning resources should be provided via web links [6]. The course content should be available 24 hours per day, 7 days per week to ensure that the learners could access the course any time, anywhere [7]. It should also provide the learners with the download and printout right from the beginning.

7 Outcome

The outcome in the quality framework is measured by enhancing nurses' competence in two broad aspects, clinical aspect and IT aspect. The e-learning program should facilitate the learners to acquire new and relevant dementia care skills and knowledge. Besides improving nursing knowledge about dementia care, after completing the e-learning course, learners should have better computer skills and be more familiar with Internet technology.

Conclusion

This paper proposed a quality framework of e-learning delivery to teach working nurses dementia care. This framework was build upon the researchers' studies in the fields of e-learning and adult learning. The reliability and validity of this framework is yet to be tested through empirical field studies, which is the direction of our further study.

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A Quality Indicators of Delivering E-learning for Dementia Care to Nurses

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The background

- A big problem: there are not adequate supple of trained professionals to provide quality care for people with dementia.
- E-learning could provide an effective solution to this challenge.
- The aim of this study is to identify indicators of effective e-learning delivery and based on them, to construct a quality framework of e-learning packages that teach nurses to deliver dementia care.

Methods: systematic database search in two fields

- How to deliver e-learning to adults
  - Databases:

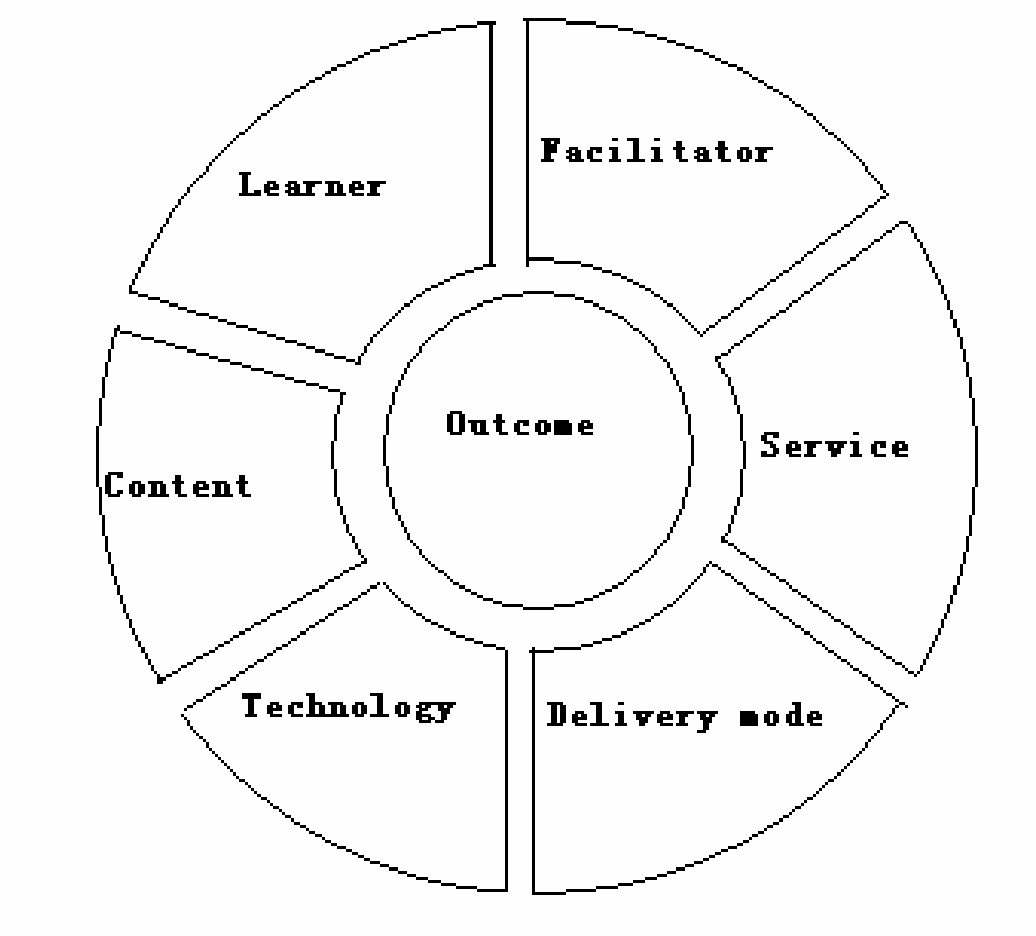
    CINAHL, Medline, ERIC, SpringerLink, the ACM digital library, ScienceDirect, ProQuest 5000, Synergy, A+Education and IEEE.
  - Keywords:

    “nurs*”, “e-learning”, “online learning”, “web-based learning”, “adult education”, “quality framework”, “quality assurance”, and “e-learning model”.
- Nurse continuing education
  - Databases:

    CINAHL, Medline, ScienceDirect, ProQuest 5000
  - Keywords:

    “nurse continuing education”, “nurse computer literacy”, “nurse information literacy”, and “dementia care”.

A proposed quality framework for an e-learning package that teaches nurses to deliver dementia care



Learner

- Learners of the e-learning course are working dementia care nurses, who have diverse backgrounds and levels of experience.
- Two main issues that affected successfully complete the course
  - Nurses' computer literacy and familiarity with Internet technology
  - Time limitations

Facilitator (online teacher)

- Facilitators facilitate the students' learning rather than a dispenser of information, as is sometimes practiced in a traditional learning course.
- The facilitators should create a positive learning experience for each learner and be empathic to individual learner needs[1]
- The facilitators should be
  - Easy to reach
  - Qualified and experienced
  - Responsive

Content

- Features
  - Relevant to clinical practice[1]
  - Logically organized and flow well[2]
  - Interesting and meaningful to learners
  - Comprehensive and authentic[3]
  - Easy to understand
- Useful information on dementia care education suggested by MacDonald and Stodel[3]
  - How people suffering with dementia see the world
  - Information on the various stages of dementia
  - The resident’ medications.

Delivery mode

- In order to achieve the high-quality delivery, pedagogical theories are important. And constructivism seems to be a suitable theory for designing and delivering e-learning course[4,5,6].
- Other issues needed considered:
  - **Knowledge base**: a variety of levels of information should be included to suit different levels of previous knowledge of learners
  - **Learning pace**: self-paced learning
  - **Delivery format**: a variety of media and communication tools should to used to accommodate different learning styles. And it should offer a combination of text, graphics, video and audio, which learner could easily access.

Technology

- Technology includes usability of website, and interactivity.
  - Usability of website comprising ”Format (hyperlinks/buttons for ease of search-ability) and Flexibility (multimedia or plain text of material presentation indication the utilization of web potential”[7].
  - The design of interface should ensure usability, which includes:
    - user friendly
    - ease of navigation
    - clarity of instructions.

Service

- Service is defined as accessibility.
- Access to the entire website should be straightforward.
- Available 24 hours per day, 7 days per week.
- Provide the learners with download and printout right.
- Two issues needed considered: the bandwidth limitations and the time zone issues.

Outcome

- The outcome component in the quality framework means enhancing nurses' competence in two broad aspects:
  - **Clinical aspect**: acquire new and relevant dementia care skills and knowledge
  - **IT aspect**: better computer skills and more familiar with Internet technology

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Construction and Evaluation of e-Learning System for Medical Treatment Safety Measures

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Abstract

To consider effective medical treatment safety measures, various factors that lead to the malpractice should be understood and be analyzed objectively. In The University of Tokushima hospital, the incident report system was constructed. The safety management room is set up in the university hospital. Its system collects information and analyzes many submitted incidents to contribute safe medical treatment. However, there was no mechanism effectively educating though the system that reported on these results to the staff was able to be prepared. Because it is difficult to teach to about 1000 all staff by the set education. Moreover, it is a current state in the staff in the university hospital that in very busy, there is not even so much educated time. Then, it reports in this research because the e-Learning system is developed to do the medical treatment safety education effectively, and it evaluated it to the learners who are staffs in hospital.

Keywords:

e-Learning, medical safety management

Materials and methods

A necessary educational teaching material was made based on the statistical data having been extracted by the incident report system. The composition data of an educational teaching material is the following.

1.Video data used by lecturing on medical treatment safety management. 2.Power Point data made in safety management measure room. 3.Voice data for narration. 4.Test data

System configuration
The system configuration is: Server's OS is FedoraCore3 which is distribution of Linux, Web server is Apache2.0, SMTP server is sendmail8.12.10 , Database engine is PostgreSQL7.4.3 and program language is PHP4.3.4. The flash was used to compose the educated screen that the learner saw easily. When all contents are built in by using the Flash technology, the data capacity downloaded to the client is large. Then, educational Viewer made in the flash, and constructed the function that only contents were able to be downloaded. Thanks to this function, The volume of data that the client downloads is a little. The client downloads only necessary data from the server. Therefore, this system can be used even with the cellular phone whose cost is generated for the amount of the communication of the packet.

Evaluation experiment It experimented for about 50 nurses this time.

Contents Laws to protect personal information took effect on April 1, 2005, banning the public and private sectors from using information on a person other than for its intended purpose and from providing it to a third party without permission. The hospital is not an exception. We made contents for protection of personal information.

Results and conclusion

The nurse's record is made electronic in The University of Tokushima hospital. Then e-Learning was able to be used smoothly in this trial.

Evaluation by nurses Because the nurse was able to access the system from anywhere, it was very convenient. 50 percent of them inspected it outside work. The person who received the lecture was able also to study repeatedly. They could learn repeatedly where they could not understand. They were surprised at the place in which it was able to test by the cellular phone. But move data were not good.

Evaluation by safety management room By the use of only the WWW browser, Safety management person can easily input contents data into the database. With the nurses' usage log of the system, teachers would find their weak points and blind spots at an easier rate than before. The grasp of learner's progress report became possible through the system. Those would be reflected to e-teaching and actual lectures. It encourages interactive education. Once a data is registered, the Safety management person can easily retrieve the slides stored in the database at any time they should give a lecture. In the future, people who work at the university hospital can educate through the system.

This time, the trial was done for 50 nurses. As a result of the trial, it can be said that e-Learning concerning the safety control is a success. There was hardly a convenience of the system. It received high acclaim from the nurses

who was the learner. However, when the number of system users increases, it is necessary to solve the problem on a lot of operation sides like the registration problem etc. of ID. The mechanism of the ASP type is composed of the university hospital and it will expand it to a general hospital in the future.

Construction and evaluation of E-Learning system for medical treatment safety measures

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The Tokushima University Hospital
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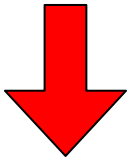
徳島大学病院
Tokushima University Hospital

Background

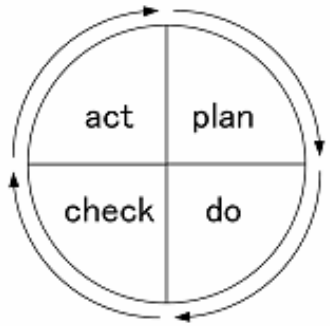
- Health care environment
  - Health care continues to experience dramatic change
  - The rapid explosion of the medical knowledge
  - The medical accidents have happened frequently



- Organization
  - Safety management room

Organization

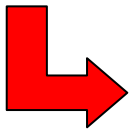
- The Tokushima University Hospital took four measures
  1. Safety management room
  2. Make medical information electronically available
  3. ISO 9001 for quality management
  4. ISO 14001 for environment management



Plan → Do → Check → Action

Safety management room

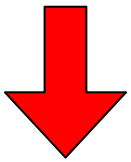
- Submitting: The incident report is submitted through system
- Investigation: The submitted incident is investigated
- Analysis: whether an incident report leads to the malpractice
- Measures: So as not to generate the incident, measures are done.



Education for medical personnel

Purpose

- Face to Face Education: It is the most important method. But all about 3000 staff cannot gather at the same time.
- The educating content is abundant.
- The education effect cannot be measured.



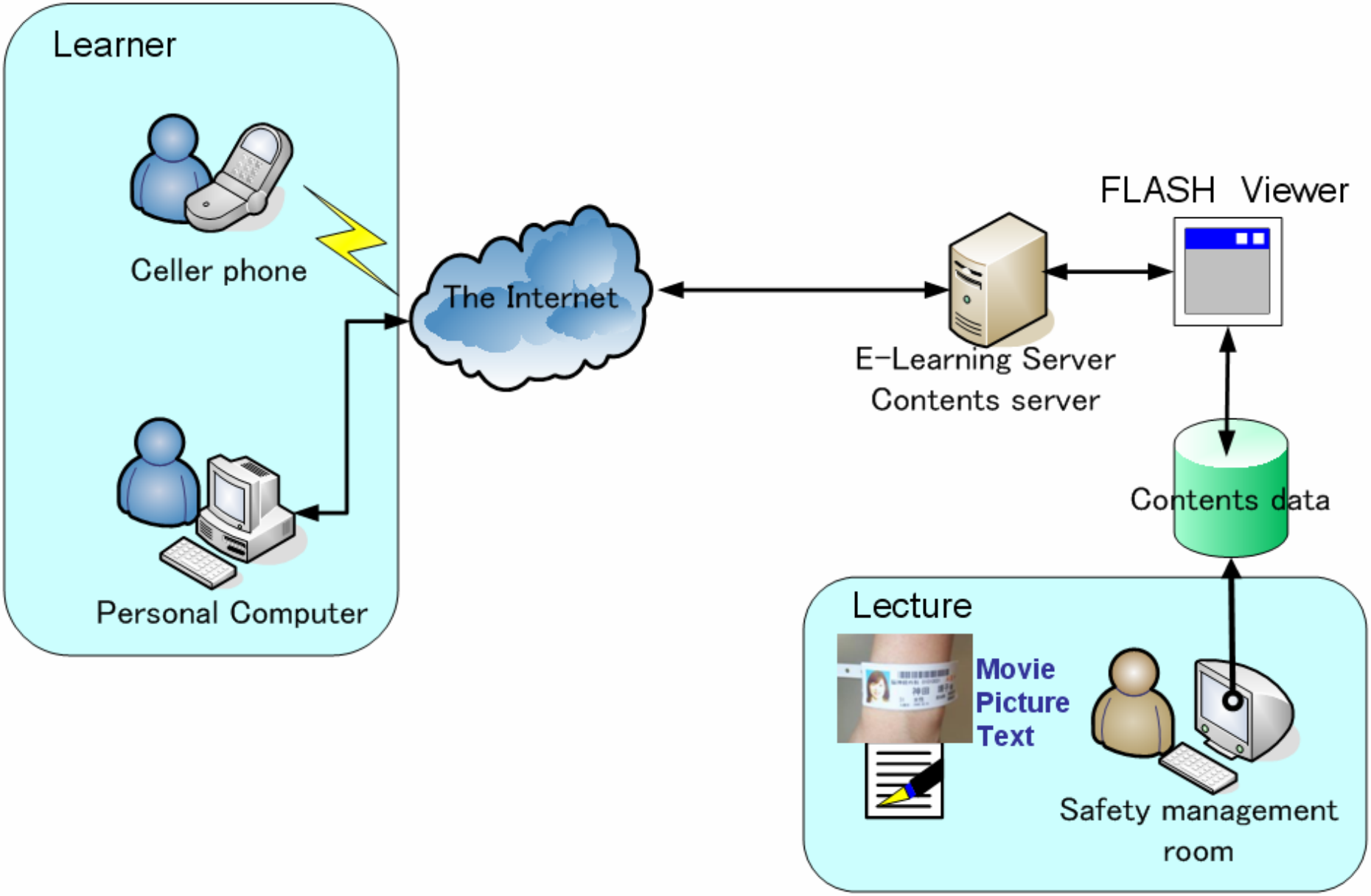
- We constructed E-Learning system for medical treatment safety measures.
  - E-Learning is a tool that supplements Face to Face education.

Method contents

- The necessary educational teaching material was based on the statistical data extracted from the incident report system. The educational teaching material is composed of the following:

1. Video data used for lecturing on medical treatment safety management
2. Power Point data made in safety management room
3. Voice data for narration
4. Test data

Method E-Learning system



VIDEO

ITEM

undefined

POWER POINT
Image data
(jpg, gif and so on)

高血圧人口について

Title

日本人男性の高血圧の人口の割合が、過半数を超えるのは何歳以上か？次のA～Dの中から選びなさい。

Question

- A) 30歳～39歳
- B) 40歳～49歳
- C) 50歳～59歳
- D) 60歳～69歳

Answer

次へ

Next

送信

Submit

Trial Use & Results

- Trial
  - This experiment involved about 400 nurses.
  - Contents: nursing education programs.
- Evaluation by nurses
  - Because the nurse was able to access the system from anywhere, it was very convenient.
  - 50 percent of them accessed it from outside work.
  - The person who received the lecture was also able to review the information repeatedly.
  - They were surprised at the place in which it was able to test by the cellular phone. But move data were not good.

Trial Use and Results

- Evaluation by safety management room
  - Because the nurses E-learning results are recorded, instructors could find their weak points and blind spots at an easier rate than before.
  - Tracking a learner's progress report became possible through this system.
  - It encourages interactive education.
  - Once data is registered, Safety management personnel can easily retrieve the slides stored in the database at any time they should give a lecture.
  - High appraisal was received as shown above.

Discussion

- Management: In doing the PDCA cycle to a safe medical treatment, the education and the measurement of the education effect are very important.
- Contents: The image and the video data are very important for the medical treatment contents.
- Near future program: The mechanism of the ASP type is now used in the university hospital and will expand to general hospitals in the future.

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E-Learning in Ophthalmology: An Approach with High Learner Acceptance

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Abstract

For many clinical departments the assessment of technical and financial implications of e-learning is difficult due to lacking knowledge about effective methods in e-learning.

Here, an approach on the basis of pre-existing lecture material is presented: E-learning contents are generated through extending existing lecture presentations with clinical cases and systematic knowledge as well as further interactive elements. In the summer semester 2006 a series of 13 lecture related e-learning modules was made available for training in the University Eye Hospital Freiburg. In the subsequent evaluation students attested a very high acceptance and contentment regarding the given e-learning modules.

Keywords:

e-learning; ophthalmology; evaluation; multimedia

Introduction

E-learning has a variety of properties leading to an steadily increasing demand for its usage in medical education, e.g. the embedding of high quality multimedia or the re-usage of available learning modules Additionally, several studies have shown that learning outcomes of e-learning are at least at equal with traditional methods [1-3]. Despite these considerable needs for e-learning by students and evident successes in education with it, many clinical departments still hesitate to develop or use e-learning for their training. Possible reasons for this include the difficult assessment of both its technical as well as its financial implications for the medical teachers.

Recently, on-the-fly systems for lecture recording and authoring are available to rapidly generate electronically accessible material with comparable low technical and financial barriers [4, 5]. A problem with this approach in the medical field is the frequent presentations of patients in medical lectures. The need to provide protection of the patients' personal rights can only be met by elaborate post-processing (i.e. "cutting") of the recorded lectures.

Here, an approach is presented which is based on pre-existing lecture materials and which allows for the rapid implementation of e-learning modules by clinical departments with low personal and technical resources. Further, medical learners' requirements for an effective training of extensive contents are met by an easy graphical user interface and the avoidance of unnecessary complexity [6].

Figure 2 – Graphical user interface of the e-learning module Glaukom (in German). Learners are encouraged to interactivly participate in a clinical question-answer dialogue. Source materials are Microsoft PowerPoint presentations which are converted to Adobe Flash Format.

Methods

The e-learning modules were introduced for the first time during the summer semester 2006 accompanying the ophthalmology course at the University Hospital Freiburg. The e-learning modules were aimed for the supplementation and deepening of actual lecture and seminar contents as well as the self-assessment of learners.

The didactic concept involved the presentation of multimedia clinical views on signs, symptoms and diseases in combination with systematic ophthalmologic knowledge. Active participation of students in the learning process was achieved by interactive elements. Therefore, existing high qualitative lecture presentations (Microsoft PowerPoint) were enriched with contents on systematic background knowledge, multimedia clinical cases and interactive ele-

ments like questions and exercises. The learners remember cases they know from their lectures by interactively participating in a clinical question-answer-dialogue.

For security and technical reasons the modules were converted to the Adobe Flash Format (ShockWave Flash) by the Articulate Presenter application. This tool generates a hierarchical navigation tree, thumbnails for previewing and a full text index. Multimedia files in the Adobe Flash Media Format can be inserted in the e-learning modules as well. Distribution with personalized access was served by the Learning Management Systems (LMS) of the University Freiburg (CLIX).

Results and discussion

In the summer semester 2006 a series of 13 ophthalmologic lecture related e-learning modules was made available for a total of 167 medical students. The evaluation was performed at the time of the examination of those students with a return rate of 92% (n=153). 85% percent of the students processed all modules; about 66% of the students worked 30 minutes and longer on each module. An interactive approach to the material was chosen by 68% vs. 32% of the learners who preferred a linear script processing mode. The rting (always on a 4-point Lickert Scale) of texts concerning content was in 100% "rather good" and better. The usability was evaluated in over 82% as being "rather good" and better. Concerning the learning benefits of the e-learning modules, 38% of students found them to be "rather beneficial" and even 56% to be "very beneficial". Over 95% of the students attested to be better prepared for the examination through the e-learning. 92% of learners wanted the e-learning to be further expanded. Of the 153 students in their 2nd or 3rd clinical term, 72% had their first contact with e-learning. The interest in ophthalmology changed from about 64% percent "rather low" and worse to about 90% "rather high" and better during the ophthalmologic education (this effect cannot only be asserted to the e-learning). About 87% percent of students had "rather much fun" or "very much fun" in electronic learning.

The acceptance of the e-learning modules on this large scale was not expected when they were introduced. The clinical curriculum demands a high rate of presence learning after the reformation of medical training in Germany. An average of 8 hour occupation with the e-learning modules is thus a good indicator for the students' very positive attitude towards the e-learning offer.

Medical training is characterized by a high input of systematic and case-based knowledge. Many complex and high interactive e-learning systems are not very well suited to effectively provide high amounts of knowledge. Possibly, the high acceptance by learners is due to the very effective provision of a substantial amount of knowledge necessary to pass the examination. The technical concept and interactive modalities of this e-learning approach are limited compared to some other e-learning systems [7]. However, the learners who are compelled to master large amounts of contents are highly satisfied with this easy and familiar way of learning.

To summarize, a very positive result in students' response to this straightforward and very effective e-learning approach in ophthalmology could be detected. The requirements of medical students for electronic training can be met in many cases with both relatively limited technical and financial resources.

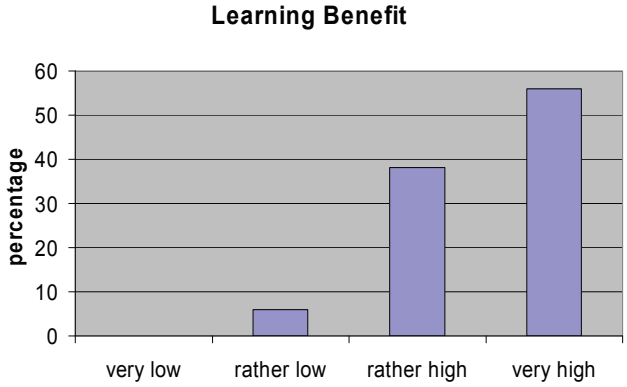

Figure 2 – Self-assessment of the learning benefit due to e-learning (n=152). The overall evaluation results of the e-learning modules were very positive.

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E-Learning in Ophthalmology: An Approach with High Learner Acceptance

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objectives

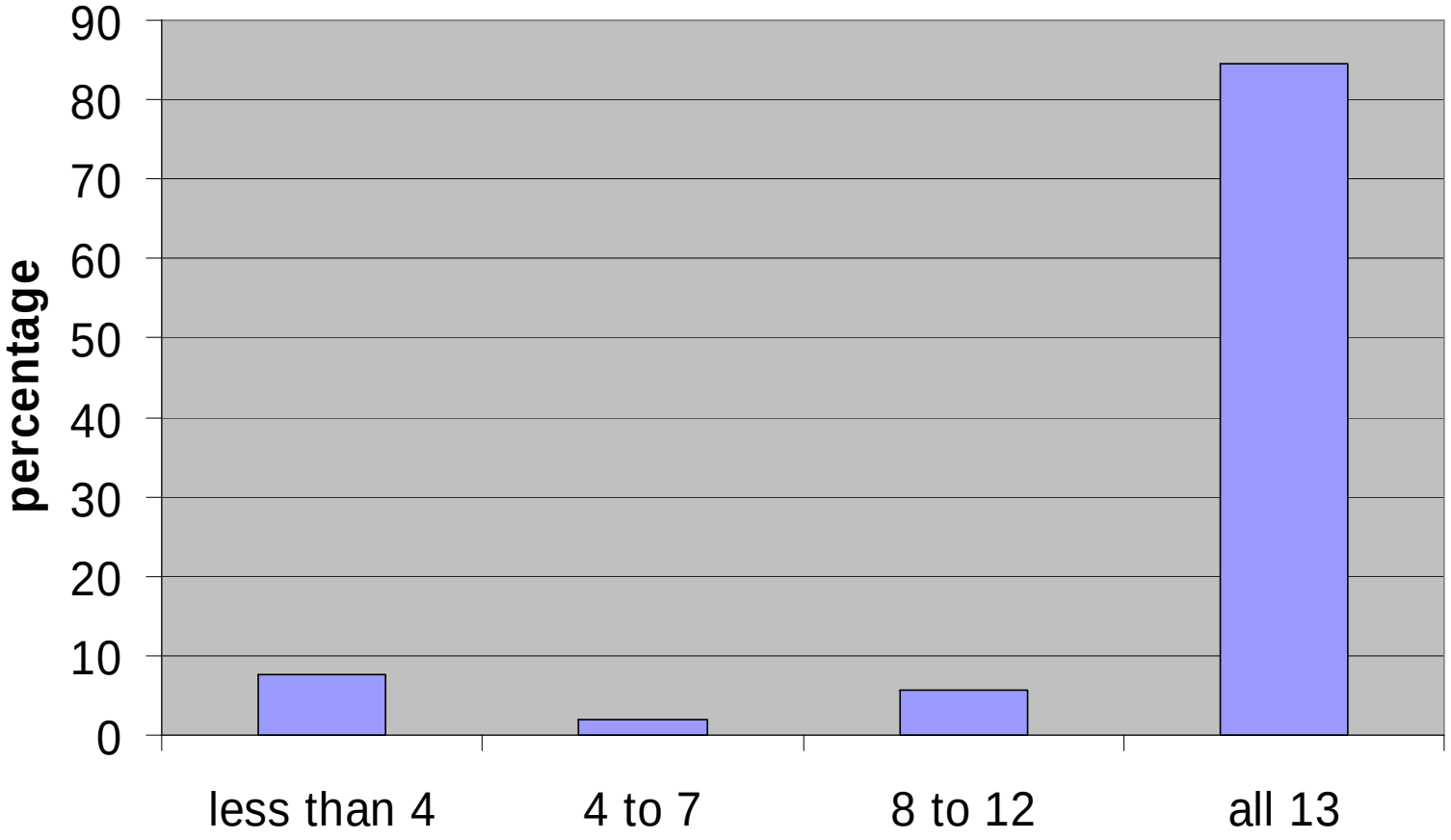
- E-learning modules in Ophthalmology
  - Rapid development
  - Small ressources
  - Based on extensive lecture material
- Web-based presentation with „protected“ access
- Evaluation in the summer semester 2006

didactic approach

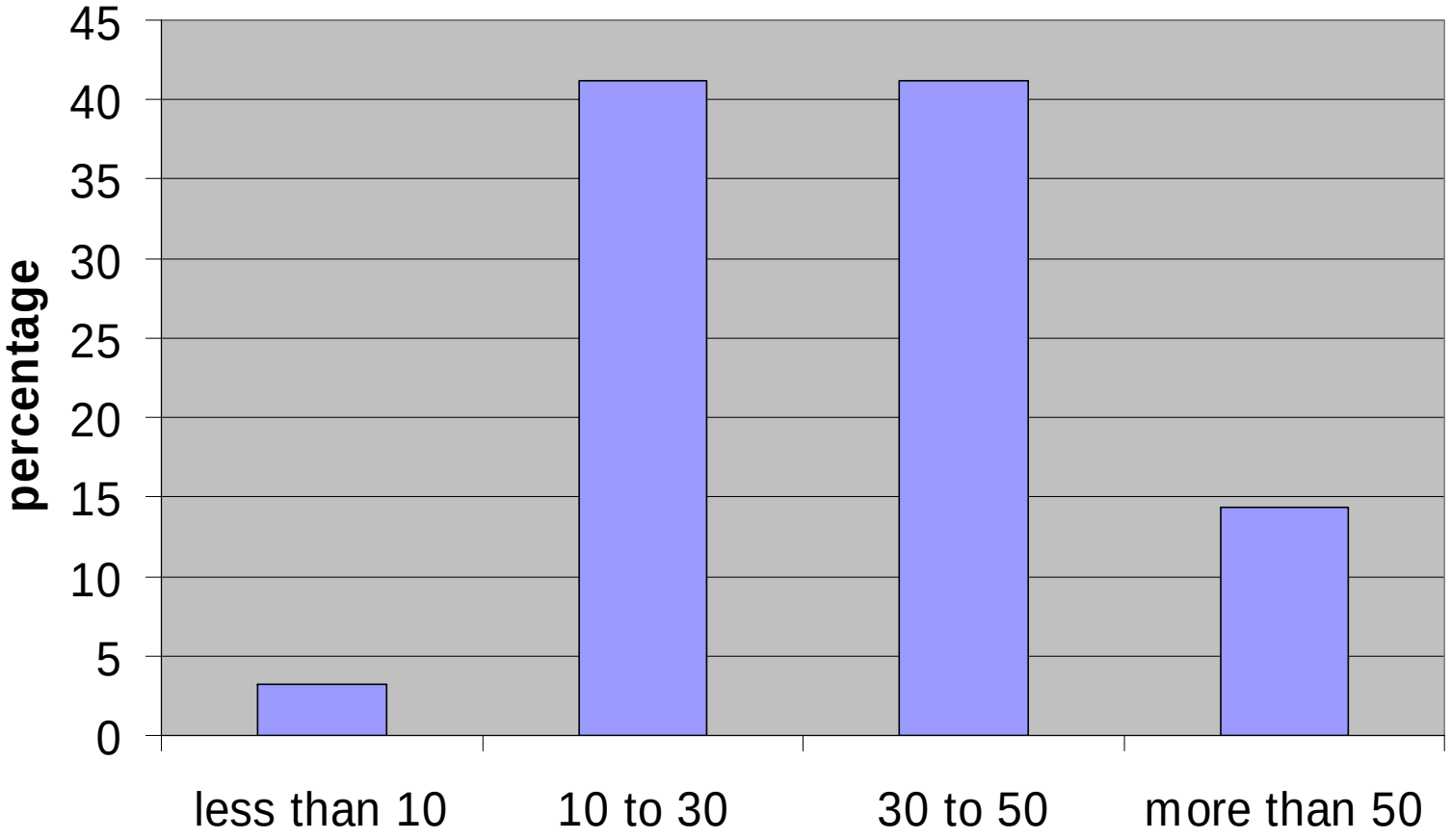
- Enhanced lecture material
  - Patient cases
  - Systematic knowledge
  - Interaction: Questions and Exercises
- Time- and space-independent learning and repetition of lectures
- Integration of multmedia-based material

Graphical user interface

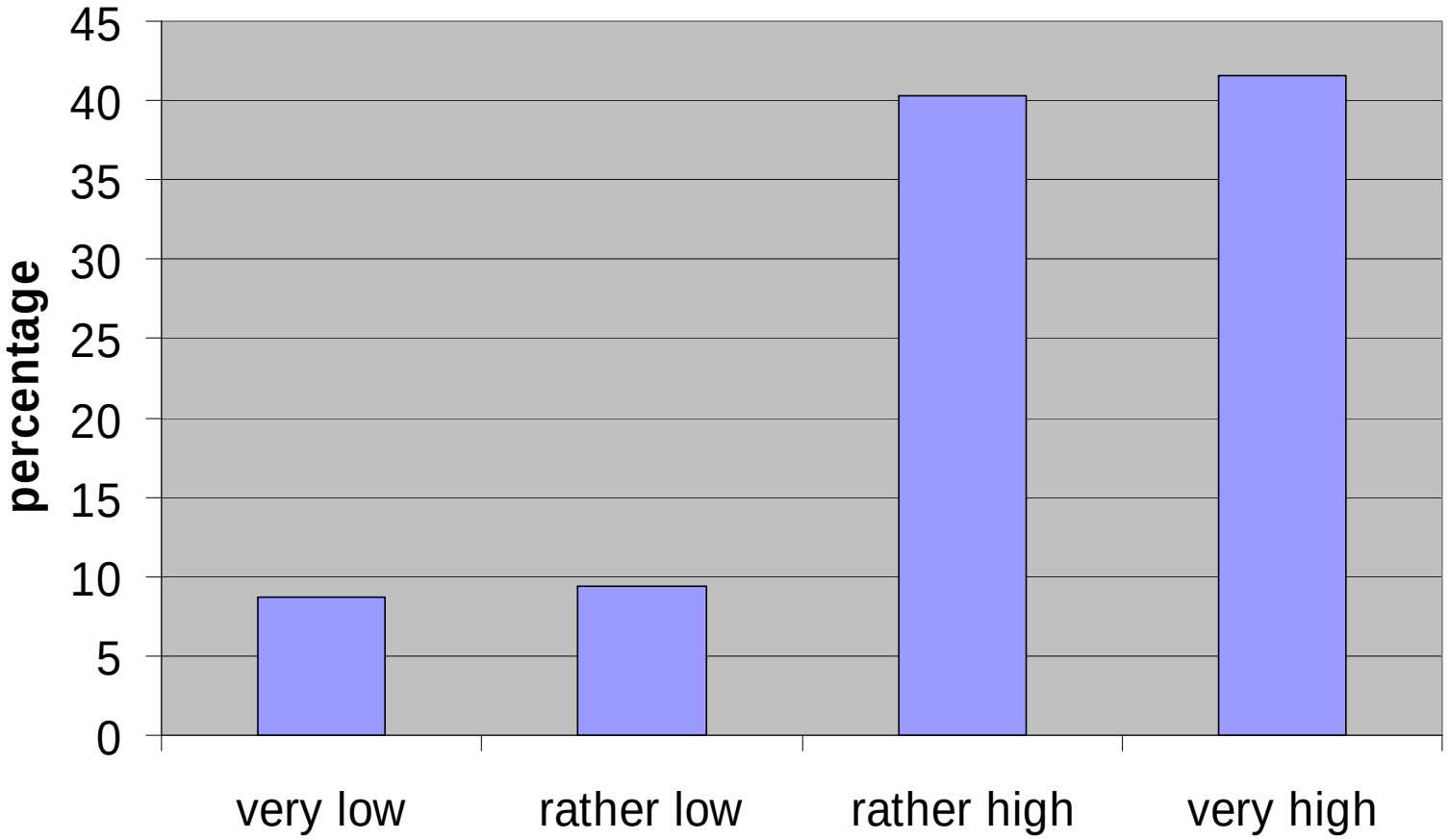
attended e-learning modules (n=156)



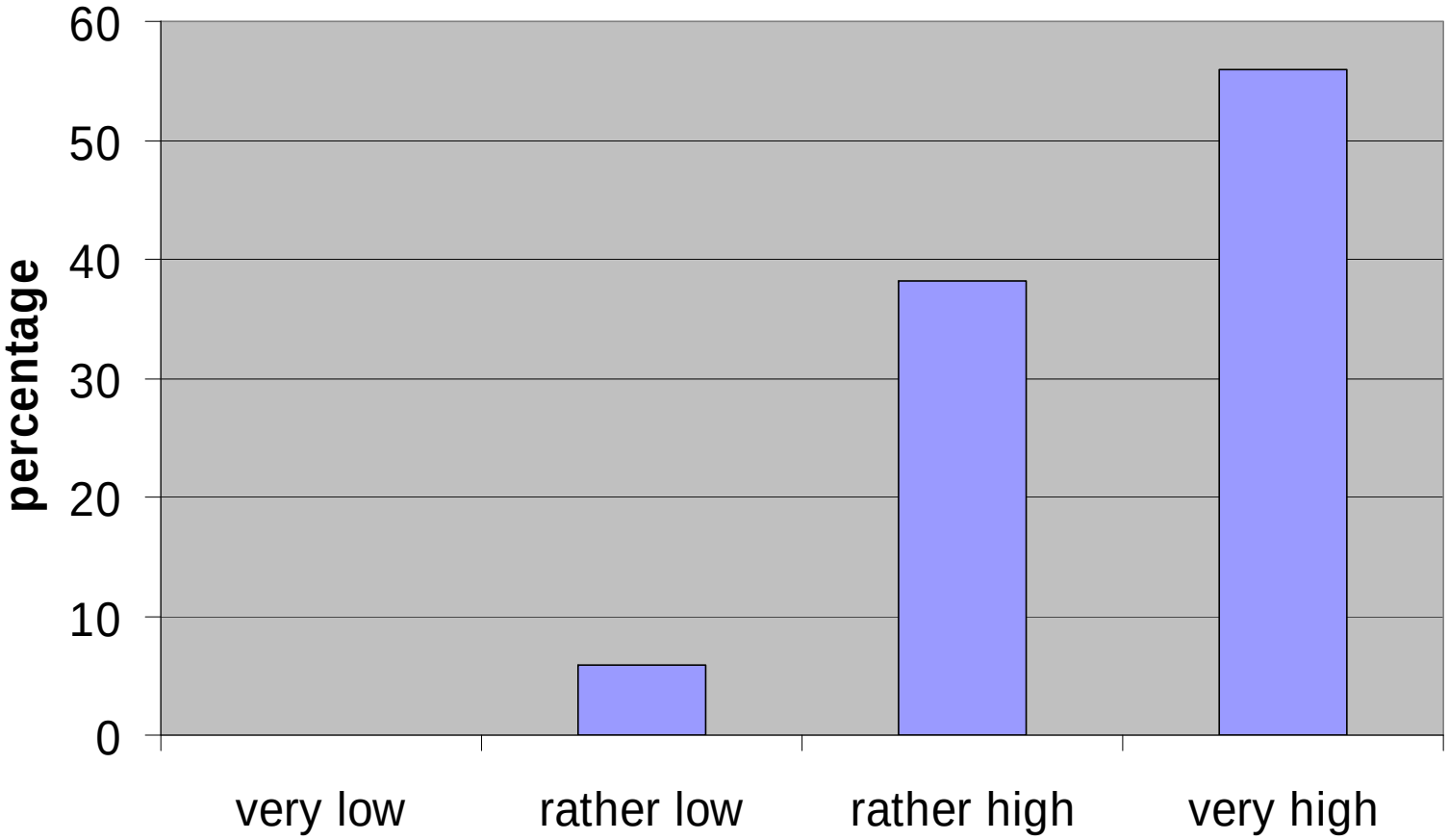
time per e-learning module [min] (n=153)



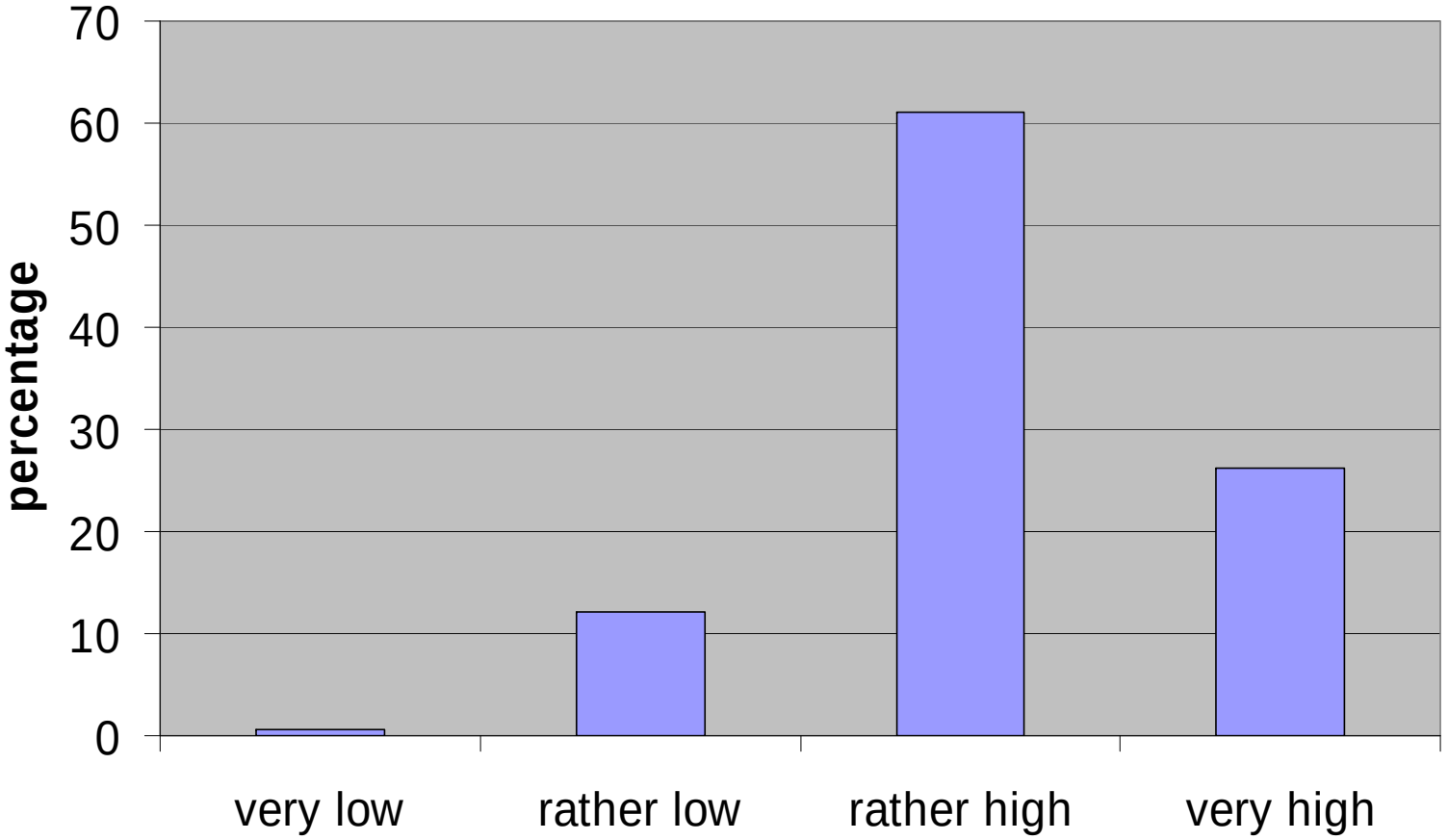
usability (n=149)



learning benefit (n=152)

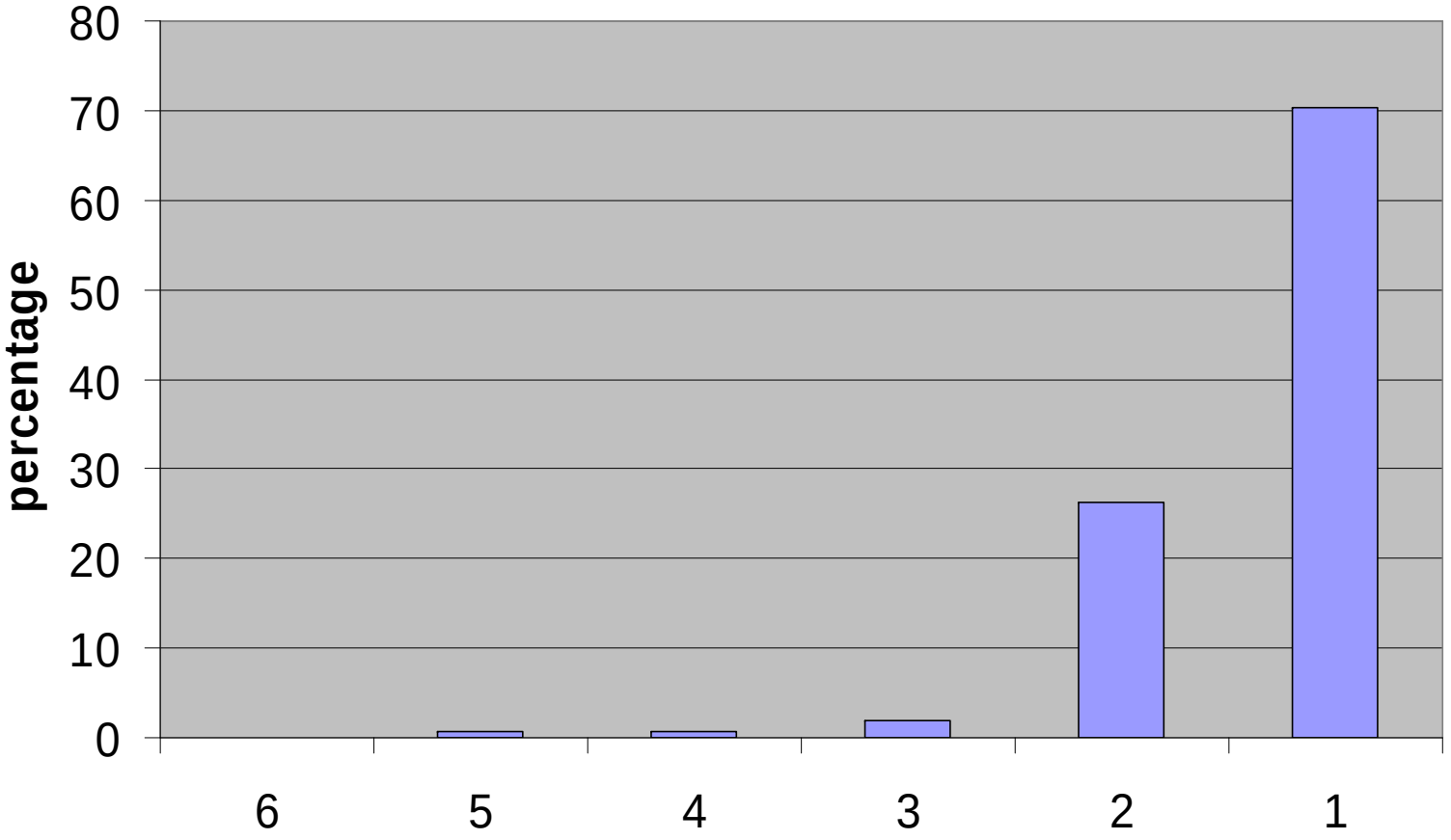


fun while e-learning (n=149)



E-learning global assessment (n=152)

[degree 6: worst – degree 1: best]



conclusion

- Successful rapid implementation of e-learning modules in Ophthalmology
  - Based on existing lecture material
  - Enhanced by patient cases and systematic knowledge
  - Enhanced by mulimedia-based material
- Positive evaluation results
  - High acceptance and contentment
- Effective approach to improve medical teaching with e-learning modules

references and contact

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Combined Interactive Presentation of Patient Cases and Linear Contents: An Application in Oral and Maxillofacial Surgery.

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Abstract

Many case-based learning systems are characterized by both time-consuming authoring processes as well as a rigid scheme of interaction with the provided cases. In this paper, an XML-driven e-learning framework is presented which can be generically applied in various medical disciplines. It focuses on the effective development and multimedia-based presentation of patient cases, linear contents and questions. Contents related to each other can be linked and displayed together.

In the Division of Oral and Maxillofacial Surgery at the University Hospital Freiburg this framework was introduced and evaluated through an e-learning system providing a presentation of 41 authentic cases in combination with two standard textbooks. An evaluation showed that learning with the e-learning application resulted in similar learning outcomes than conventional paper based method.

Keywords:

e-learning; oral surgery; maxillofacial surgery; case-based learning; multimedia; XML presentation framework

Introduction

In electronic medical education the interactive multimedia-based presentation of authentic patient cases in combination with systematic background information has shown to be of great value for the acquisition of clinical knowledge. Many sophisticated case-based learning systems with complex user interfaces are available which focus on a problem-oriented learning paradigm [1-4]. They usually require high levels of authoring resources and are sometimes rigid and time intensive in the presentation of material to the learners [5]. Also, learners in today's crowded medical curricula require time-effective methods to learn on authentic case-based materials without the need to follow a certain didactic concept. Furthemore, it is important to support the learners in acquiring, refreshing and combining their systematic knowledge. This is further supported via directly connecting this knowledge to specific cases without the need for any complex search.

In the following, a platform is presented that focuses on both the easy and effective authoring as well as presentation of patient cases and linear contents by employing standard XML tools. The contents can be combined through linking and presenting them together to provide the learner with a unified view on the medical subject of interest.

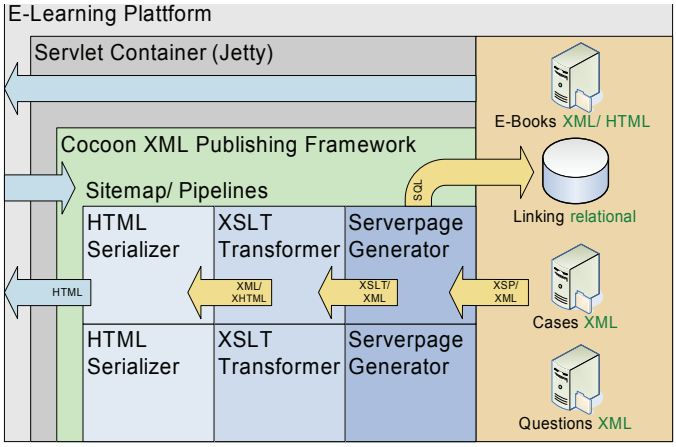

Figure 1 – Generic architecture of the e-learning platform based on the Apache Cocoon XML publishing framework. Cocoons concept of highly modularized "pipelines" enables the rapid development of extensible and reusable software

Methods

A schema driven e-learning platform for the effective presentation of cases and sequential systematic knowledge has been developed, technically based on the Apache Cocoon framework (Figure 1). It can give access to large quantities of cases and linear content with simple hierarchical navigation and search. The sustainable usage of the platform in various medical disciplines is guaranteed by application of extensible schemas and standards.

The case structure is geared towards clinical practice and expressed in a generic RelaxNG XML schema extendible according to specific clinical implementations. The effective authoring and learning has been given special

emphasis by reducing the complexity of the cases to a level that allows for easy access to the cases but is still detailed enough to clarify specific clinical processes.

Linear contents are expressed in the well established DocBook XML standard [6]. Transformation of the DocBook-conformant contents is performed with open-source tools permitting a high flexibility in output design and format. The linkage of patient cases, corresponding background knowledge and associated questions is implemented with common relational database techniques.

Figure 2 – Graphical user interface (in German).On the top-left the main menu appears above a full text search dialogue box. The patient case navigation is shown as a hierarchical tree structure enabling the learners to quickly access the parts of interest. Below the case header a listof links to the relevant systematic contents is opened fordirect access to the associated e-book.

Results and discussion

In the Division of Oral and Maxillofacial Surgery at the University Hospital Freiburg an e-learning system has been developed and evaluated based on the introduced platform providing 41 multimedia-enhanced authentic patient cases and two extensive standard textbooks covering oral and maxillofacial surgery [7, 8]. Navigation between the cases and their corresponding background knowledge has been made possible via two-sided links that are easy to follow from either the case or the e-book.

A controlled cross-over evaluation in the winter semester 2006/07 (n=42) showed e-learning and conventional (paper based) learning to have similar learning outcomes (9.4 vs. 9.5 from a total of 20 point). The assessment of the direct benefits in medical education associated with the particular learning methods is significantly different between e-learning and conventional learning: 4.2 vs. 3.6 on a 5 point Lickert scale (p=0.005). The “fun-factor” while working on the cases differed also significantly: 4.1 vs. 3.2 on a 5 point Lickert scale (p=0.005). In principal, the usability of the e-learning application was evaluated as being good.

The evaluation results further suggest that learners are satisfied with a comparably simple e-learning system which gives them direct access to patient cases and linear contents without the need for any complex interaction. It is highly important for the sustained success of such an e-learning application with only loose user guidance to be integrated in the curriculum in a blended learning approach: medical teachers use e-learning side-by-side with other more conventional means to enrich their lectures.

Further development is directed towards enhanced presentation and navigation of cases and linear contents as well as the extension of the current system to other medical subjects (e.g. general surgery).

An extensible and flexible medical e-learning platform based on XML technologies has been presented enabling the development and presentation of case-based and linear contents. The platform was successfully introduced and evaluated in the field of oral and maxillofacial surgery and is now subject to further extension to general surgery.

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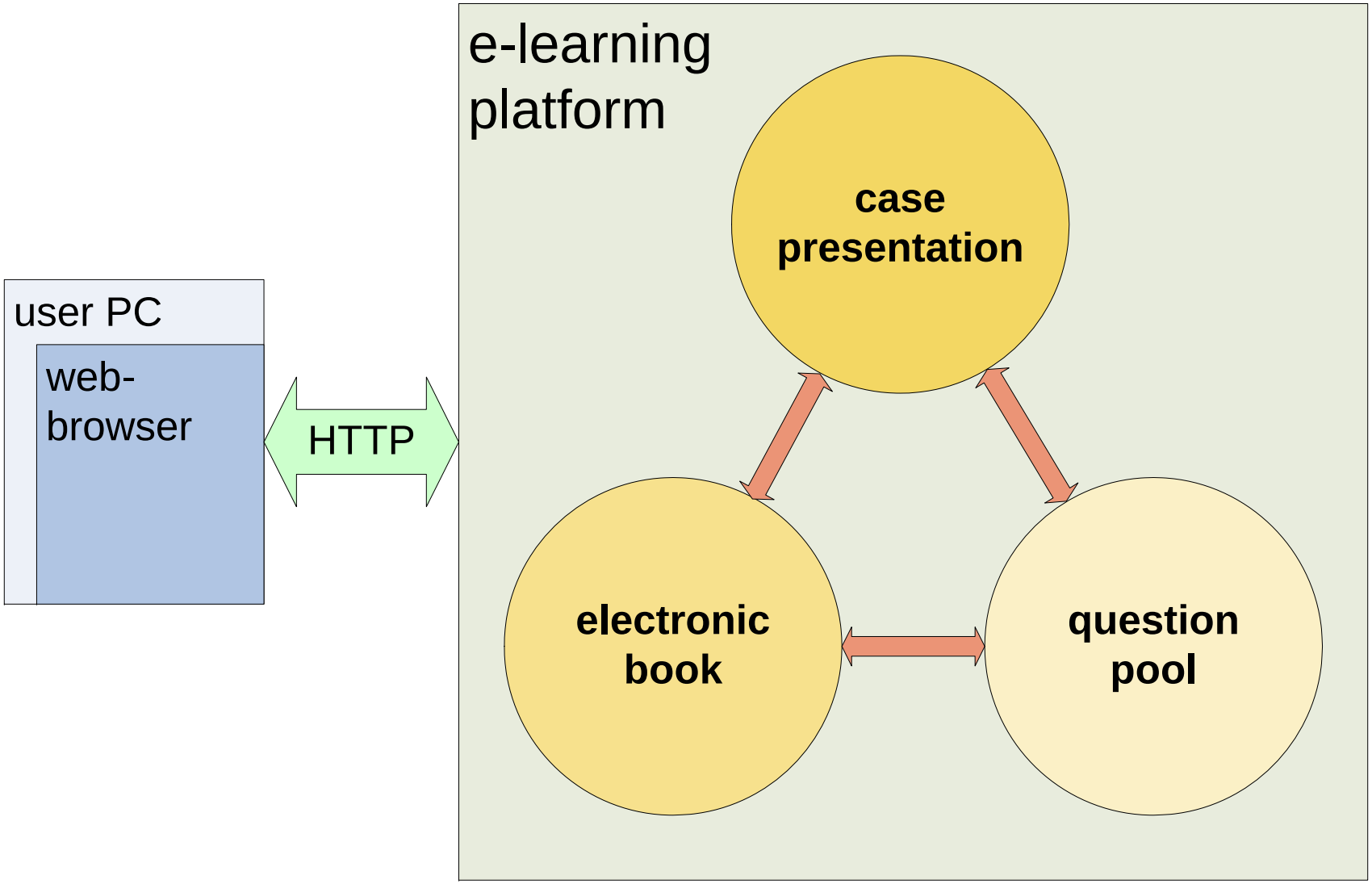
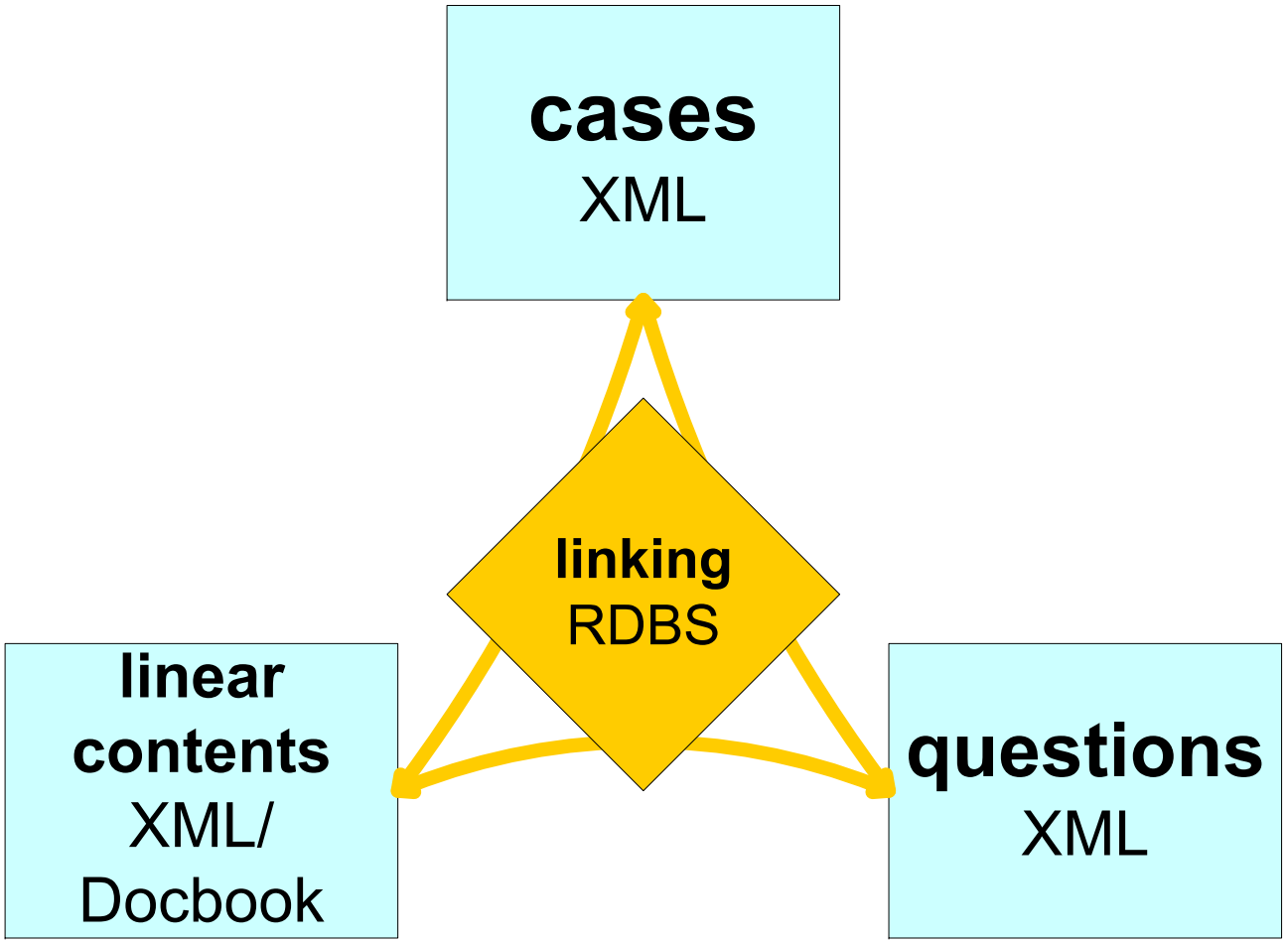
objectives

- Framework for the web-based presentation of
  - Patient cases
  - Linear contents
  - Questions
  - Linking of contents
- Implementation in Oral- & Maxillofacial Surgery
- Evaluation

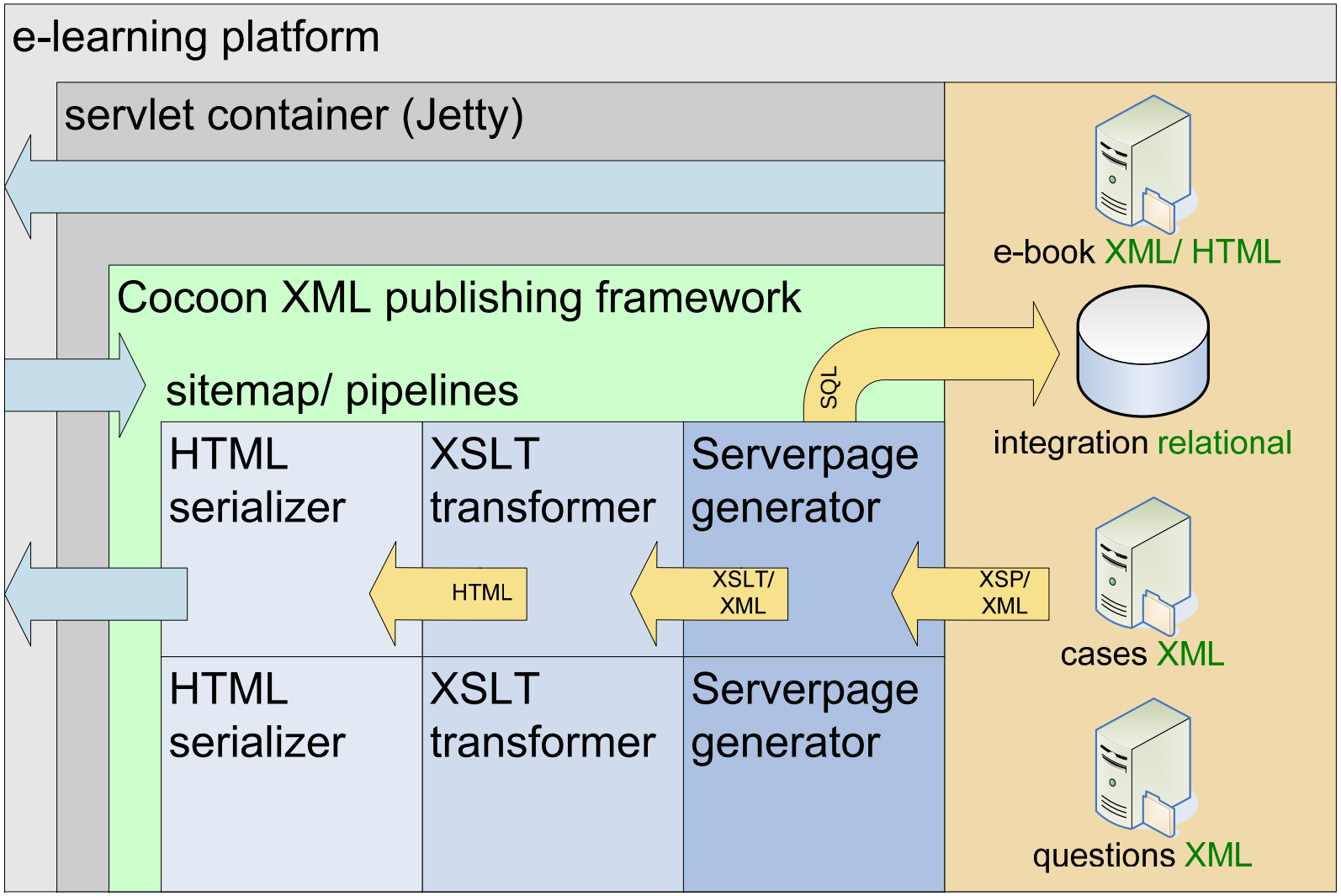
conceptual view



components

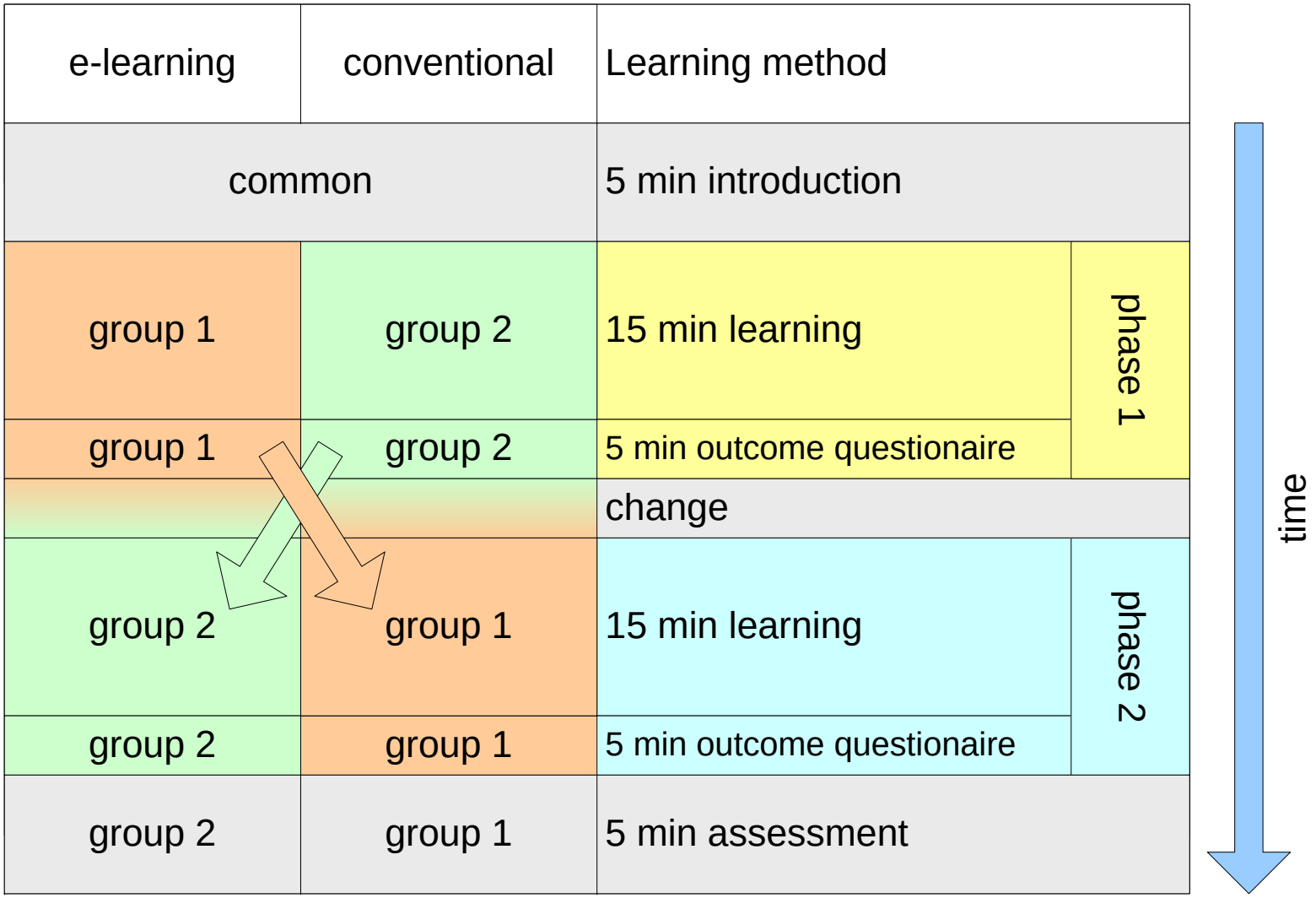

cases
XML
linking
RDBS
linear contents
XML/
Docbook
questions
XML

architecture



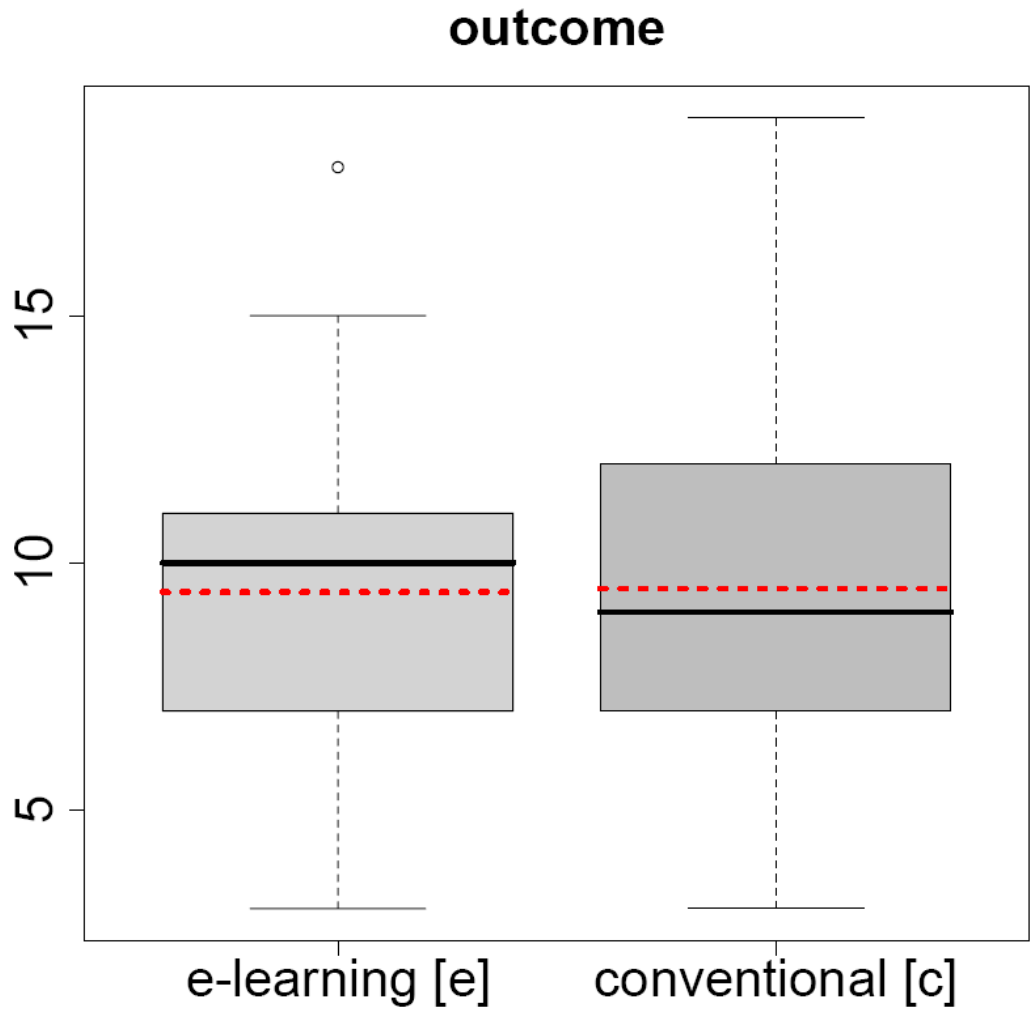
graphical user interface

evaluation design



evaluation results I

- n=42
- max. 20 points
- n.s.



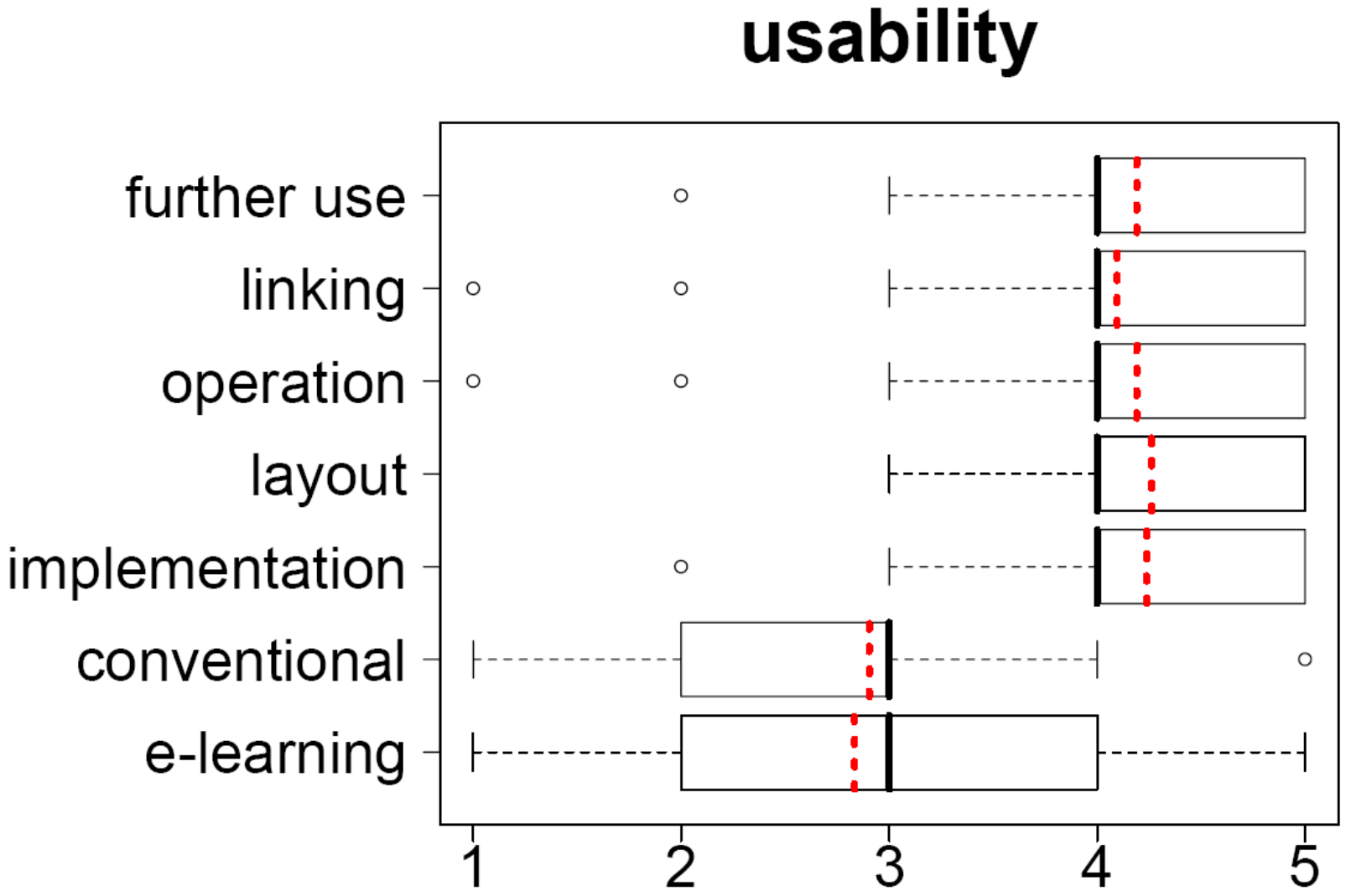
evaluation results II

	outcome	**benefit**	**relevance**	**fun**
scale	*[0,20]*	*[1,5]*	*[1,5]*	*[1,5]*
e-learning	9,4	4,2	3,9	4,1
conventional	9,5	3,6	3,8	3,2
significance	n.s.	0,005	n.s.	0,0001

comparison of learning methods (mean, n=42)

- outcome
- benefit in medical education
- relevance for the later profession
- Fun-factor while learning

evaluation results III



summary

- Successful development of an e-learning presentation framework based on open-source tools
- Implementation of an e-learning application in Oral- & Maxillofacial Surgery
  - 41 patient cases and 2 electronic books
- Evaluation in crossover design (n=42)
  - Similar outcomes of e-learning vs. conventional learing
  - Significant higher assessment of benefit for medical education of e-learning vs. conventional learning
  - Significant more fun during case processing in e-learning vs. conventional learning
  - Good overall usability
- Further development
  - Enhancement of presentation features
  - Extension to other medical subjects

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E-learning for Occupational Medicine Through an Interactive Guidelines Tool

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Abstract and objective

We are developing an E-learning system for allowing the occupational medicine physicians to be updated on the most recent guidelines (GLs) in his/her area. The system will be particularly focused on GLs developed within a joint initiative between the "Fondazione Maugeri Clinica del Lavoro e della Riabilitazione IRCCS", involved into occupational medicine since its birth, and the Italian Society of Occupational Medicine and Industrial Hygiene. These guidelines are currently available in textual format (booklets) and, within the project, they will be computerized and used in interactive modality for educational purposes.

Keywords:

e-learning; guidelines; occupational medicine

Introduction

As a consequence of the continuous technological and organizational changes of industrial production activities, occupational medicine increasingly needs a systematic and timely enlarging/updating of its scientific basis and intervention methods. In the near future, occupational medicine physicians will be given supplementary tasks, with respect to the traditional, clinical ones: in addition to medical encounters and healthcare surveillance, they will have the role of consultant for risk evaluation and management, information and education of workers, and the management of burocratic and legal issues.

Within the project "e-learning for the quality of life and the safety in occupational environment", funded by the Ministry of Health, an activity for the continuous education via e-learning has been designed. As first step, an analysis on the educational needs of 300 occupational medicine professionals has been performed through an ad hoc built questionnaire, in order to identify the topics of the learning activities according to the real needs of the potential users. The results, not yet published, pointed out interest as to communication skills, models and strategies for the prevention and control of risks, prevention and surveillance for specific expositions.

Guidelines (GLs) are one of the matters to be administered through the E-learning platform (A-Tutor). In the following sections we explain how GLs may be taught in an interactive way, that we consider more attractive, efficient and effective.

The GL interactive tutorial will be tested on:

- a set of guidelines already available as textbooks, among which: prevention of occupational dermatitis; health surveillance of workers exposed to inorganic lead and other inorganic substances; health surveillance of workers exposed to pesticides; health surveillance of workers exposed to styrene
- a set of rules to implement the risk evaluation and control plan [1]

Methods

The goal of the work is to create a GL repository, that can be browsed and interactively used with real or simulated cases through a portal, that will be the final user interface. Thus, the first step is to represent GLs with a homogeneous computational formalism. GUIDE, a tool developed within our department, will be used to this aim [2].

GUIDE components are organized in a distributed architecture: an editor to formalize guidelines, a repository to store them, an inference engine to implement guidelines instances in a multi-user web environment, and a reporting system storing the guidelines logs in order to be able to completely trace any individual physician guideline-based decision process.

While most traditional systems are limited to display GLs as hypertexts through a web portal, in the proposed architecture, GL-embedded knowledge is represented also as an hyper-flowchart, which allows to:

- represent GL in a synthetic way, as a sequence of tasks and decisional points;
- represent different detail levels without loosing the general view of the GL;
- link to specific sessions of the original GL text, to obtain explanations on a given task;

- suggest the GL-compliant behaviour both in real and simulated cases;
- query the user on cases generated by the system itself (simulated cases) and critically evaluate user's answers

Moreover, if different versions of the GL exist for different users (physician/ nurse/ worker/ etc.), the user will find on the portal the appropriate version according to his role.

Whenever, during a GL running, a user's answer is not GL-compliant, the user is asked for a motivation: may be that answer is due to lack of knowledge, but also it might be due to a reasonable different opinion.

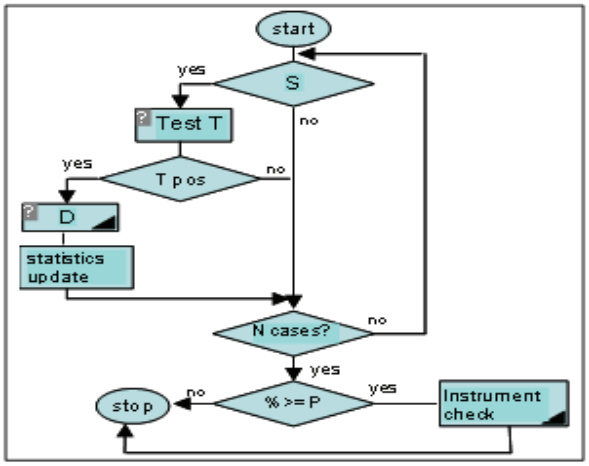

Figure 1 - Formalization of a generic guideline as an hyper-flow chart

Results

To clarify the expected results by a simple example, let suppose to have this GL:

" If the worker is exposed to the potentially dangerous substance S, then he must undergo test T regularly (each 6 months). The test has sensibility equal to k% and specificity equal to h%. If the test result is positive, the individual must be treated with drug D (recommendation supported by scientific evidence reported in L). Administration modality of the drug is the following: begin therapy with a dose d for three days,then shift to dosage d2 for two weeks, then decrease gradually and stop in three months. After having tested N workers, in case the percentage of positive results is above a predefined threshold P%, instrumentation S, present in the farm must be carefully controlled (quality check).The protocol for the quality check is the following: ..."

Its formalization is shown in Figure 1, representing the most general GL level:

Tasks "D" and "Instrument check" show a triangle in their bottom right, meaning these tasks are expandable into more detailed flow diagrams. For example, D task will be expanded in a diagram explaining the drug administration protocol.

Tasks "Test T"and "D" show a question mark in their top left, meaning that it is possible to access an explanation about that recommendation. About test T, the user can see studies on its sensibility, specificity, positive and negative predictive value and accuracy in different testing conditions. From task D, scientific publications about the drug effectiveness, cost and side effects can be found.

System-user interaction

The steps for using the portal are the following:**1.**The user, that must be previously registered, logs-on, allowing the system to retrieve his/her profile (including role)

2. he can browse the GL repository, searching GLs by keywords: for example he can retrieve all the GLs related to the effect of noise in the working environment
3. after choosing the GL, he can simply "study" it, using the hypertext modality
4. then, he can focus the major issues by means of the hyper-flowchart modality, that is more synthetic, modular, and easily allow both general and particular views
5. Then the user may check his performance by two modalities:
    a. "learning by examples": the user provides data for a particular case study and the system show the *solution*, that is the path(s) of the flowchart that represents the GL recommendations for that case
    b. "learning by critiquing": the system generates data of a hypothetical case (simulated case) , the user proposes, step by step, a sequence of actions, and the system advises him if the user-proposed process is not compliant with the GL

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Elearning: a comparative study about knowledge acquisition by nurses

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Phd Professor at São Paulo University - USP

INTROTUCTION

Organizations have developed several educational strategies to qualify their employees. They have been using eLearning as a tool to disseminate information [1].

São Luiz Hospital and Maternity has been investing in the intellectual capital through the adoption of eLearning in their personnel training process.

The Program, named “Quality Tools”, was implemented on March 1st, 2005, consisting of three steps:

- Introduction and further explanation on the program and definition of the concepts of quality;
- Structure and principles of Quality Enhancing Program and exercises;
- Quality tools: process model, activity flowchart, check-list, brainstorming and exercises.

The objective of this study was to compare the knowledge acquired by each group of nurses – those using eLearning and those receiving face-to-face training.

MATERIAL AND METHODS

The quantitative research methodology followed the experimental method leading to comparison of face-to-face with online training given to the night shift nurses. The control group was formed by nurses attending face-to-face training, while the experimental group comprised the eLearning program trainees.

The population in this study amounted to 60 nurses. Eleven nurses were excluded for different reasons, and the 49 remaining, out of their own free will agreed to participate in the research. The trainees were distributed in each group at random, with restriction and matched treatment populations.

The data collection tools of this study consisted of two questionnaires: one for characterizing the population and the other, called the Pre/Post Test, provided by the eLearning methodology team, consisting of professionals from different areas guided by a pedagogy master. The latter test was applied to the experimental and to the control groups, both before and after the training program, in order to evaluate the trainees´ input.

RESULTS AND DISCUSSIONS

The study population consisted of 49 nurses:

- 46 (94%) were female
- 40 (82%) had been working there for more than three years.
- 23 (47%) were 30 to 39 years
- 18 (37%) were 40 to 49 years
- 41 (84%) had over six years time since graduation
- 44 (90%) had post-graduate degree
- 47 (96%) had some notions for informatics
- 28 (57%) had taken e-learning courses
- 41 (84%) had participated in the first phase of the online course offered by São Luiz Hospital and Maternity.

It can be verified that the group is young and post-graduated, two aspects favoring an early contact with computer science [2].

RESULTS AND DISCUSSIONS

The data have been analyzed with descriptive measures (mean, median, standard deviation, maximum value and minimum value).

The average grades in the different groups and moments of assessment have been compared, and a new model of analysis of variance (ANOVA) has been used, with two factors: assessment moment (pre-course and post-course) and group (face-to-face or Internet): redundant measures were considered in the assessment moment factor.

The data obtained in this research show that, both the face-to-face and the online groups gave a larger number of right answers in the post-course than in the pre-course test.

Table 1 shows the descriptive measures of the grades awarded to the face-to-face and the eLearning groups, at the moment of assessment.

RESULTS AND DISCUSSIONS

Table 1 – Total number of right answers by the face-to-face group population (N=25) and eLearning group population (N=24) in the pre-course and post-course tests - São Paulo, 2006.

Assessement	Face-to-face		E-learning	
	Pre	Post	Pre	Pos
Mean	16.4	17.8	17.8	19.4
Median	19.0	19.0	19.0	20.0
Standard Deviation	4.5	3.2	3.1	1.7
Min.	6.0	11.0	9.0	16.0
Max.	23.0	22.0	21	22

RESULTS AND DISCUSSIONS

The data show that the average grades obtained by both groups are almost equivalent, values being a little higher in the group trained online. This shows that online training is as effective a learning tool as face-to-face training.

The statistical analysis has not shown significant differences between the mean grades of the face-to-face and the online groups. Also there was evidence of an increase in the mean grade after the individuals had undergone training, which means a significant effect of the assessment moment. It has been thus concluded that the mean grade of individuals was significantly higher in the post-course test than in the pre-course test.

RESULTS AND DISCUSSIONS

The comparative results of the two modes of training show that both face-to-face and online learning were efficacious, as the mean grade of trainees was higher in both cases, which indicates acquisition of the contents presented.

Online courses provide an opportunity for instructors or teachers to give better lessons, enabling them to use a series of, not only technical but also pedagogical training tools, instead of the old one-to-many pattern of presentation [3].

Elearning is a strategy adopted by organizations in order to train and qualify professionals and add value to the intellectual assets of the company through knowledge management.

CONCLUSION

The study verifies that the mean number of right answers increased after the training for both groups:

- In the face-to-face group it increased from 16.4 to 17.8
- In the eLearning group it increased from 17.7 to 19.4

These results show acquisition of knowledge by both groups of nurses in an equivalent proportion, thus confirming the efficacy of both methods employed. The research data show that knowledge is acquired, no matter what strategy was used in training – whether it is face-to-face or online.

CONCLUSION

Elearning is an efficacious and efficient method, as it adds several advantages regarding flexibility as well as time and cost saving, which cannot be attained by face-to-face training because of the limitations of the latter.

Elearning, therefore, provides a more customized study, which can be adapted to each trainee's rhythm, overcoming geographical barriers with time flexibility, as the student can choose when and where to undergo his/her training.

In nursing, eLearning provides time optimization and flexibility in training, and it highlights the importance of adopting new teaching tools to suit each individual's learning dynamics; it is a fast and efficient model of professional qualification and training.

CONCLUSION

The implementation of computer science technology in the health sector will equip nurses with an additional instrument to improve the quality of the assistance they render and the knowledge they impart. It will give them the opportunity of being reintegrated in their true functions and enhance their performance in the technical and human care of their patients.

It can be concluded that eLearning permits to change educational behavior and paradigms, and introduces a new learning culture, incorporating technological advances in the formation of nurses.

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E-Learning: A Comparative study out Knowledge Acquisition by Nurses

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Abstract

Organizations have been using strategies to enhance human resources, such as computer training. The aim of this study is to compare the knowledge acquired by nurses groups who used computer training and those who had traditional classroom training. The quantitative research methodology follows the experimental method. This study was held at São Luiz Hospital and Maternity. The study population consisted of 60 nurses, divided into two groups. One of them had traditional classroom training, and the other one had computer-assisted training. Participants were evaluated both before and after training. The results show that an equal amount of knowledge was acquired by each group, and the conclusion was that both methods are efficient.

Key words:

distance education - continuing education – comparative study – eLearning

Introduction

Organizations have developed several educational strategies, and among the new technologies developed, those applied to teaching have encouraged the distance learning process [(1)].

To attain a unique position in the market, São Luiz Hospital and Maternity has been investing in the intellectual capital and developing human skills through the adoption of eLearning in their personnel training process.

After a successful initial assessment of eLearning as a teaching tool, the hospital proceeded to invest on the Quality-Oriented Education Program, named "Quality Tools", with three steps: 1.Introduction on the program and definition of the concepts of quality; 2.Structure and principles of Quality Enhancing Program; 3.Quality tools and exercises. At that point, this would be the right moment for this research. The objective of this study was to compare the knowledge acquired by nurses using eLearning and nurses receiving face-to-face training.

Materials and methods

The quantitative research methodology followed the experimental method leading to comparison of face-to-face with online training given to the night shift nurses. The control group was formed by nurses attending face-to-face training, while the experimental group comprised the eLearning program trainees.

The population in this study amounted to 60 nurses. Eleven nurses were excluded for different reasons, and the 49 remaining, out of their own free will agreed to participate in the research. The trainees were distributed in each group at random, with restriction and matched treatment populations.

Face-to face training was given by the researcher in 2 hours through the Power Point software in the hospital training rooms, providing the same content as eLearning. ELearning was given in about 40 minutes in the hospital intranet.

The data collection tools of this study consisted of two questionnaires, one of which was given by the researcher for characterizing the population and the other, called the Pre/Post Test, was provided by the eLearning methodology team consisting of professionals from different areas guided by a pedagogy master. The latter test was applied to both groups, before and after the training program, in order to evaluate the trainee's input.

Results and Discussion

The results and eventual discussions here concern the comparison between both groups of nurses.

The study population consisted of 49 nurses: 46 (94%) were female, 40 (82%) had been employed for over three years, 23 (84%) were 30 to 49 years old, 44 (90%) were post-graduated, 47 (96%) had notions of informatics, 28 (57%) had taken e-learning courses, 41 individuals (84%) had participated in the first phase of the course on line offered by the hospital.

It can be verified that the group is young and post-graduated, two aspects favoring an early contact with computer science.

The computer science is part of the contemporary social context, and drives people to adapt themselves and make use of new technologies in their personal and professional life [(2)].

The data were analyzed with descriptive measures (mean, median, standard deviation, maximum and minimum value).

The average grades in the different groups and moments of assessment were compared, analysis of variance (ANOVA) was used, with two factors: assessment moment (pre-course and post-course) and group (face-to-face or Internet): redundant measures were considered in the assessment moment factor.

The possibility of an interaction effect between factors was assessed. When the interaction effect is not significant, the main effects may be assessed directly, otherwise the behavior of a factor should be assessed according to the levels of the other factor [3].

The data obtained in this research showed that trainees of both methods had a better grade in the post-course test at the moment of assessment (Table 1).

Table 1 – Total number of right answers by the face-to-face group population (N=25) and eLearnning group population (N=4) in pre-course and post-course tests - São Paulo, 2006.

Assessment	Face-to-face		Elearning	
	Pre	Post	Pre	Pos
Mean	16.4	17.8	17.8	19.4
Median	19.0	19.0	19.0	20.0
Standard deviation	4.5	3.2	3.1	1.7
Min.	6.0	11.0	9.0	16.0
Max.	23.0	22.0	21	22

The data showed that as a rule the lowest grades were those of the face-to-face group, not only in the pre-course but also in the post-course tests.

The mean increase obtained in the tests made by e-learning trainees is not significantly different from those attending face-to-face training. The statistical analysis shows that no group effect was verified.

The comparative results of the two modes of training show that both were efficacious, as the mean grade of trainees were higher in both cases, which indicate acquisition of the contents presented.

Online courses provide an opportunity for teachers to give better lessons, enabling them to use a series of, not only technical but also pedagogical training tools, instead of the old one-to-many pattern of presentation[4].

Conclusion

This study has reached its objective, as its results compare the amount of knowledge acquired by both groups.

The study verified that knowledge was acquired, no matter what strategy was used in training. It can be inferred that e-learning is an efficacious and efficient method, as it adds several advantages regarding flexibility as well as time and cost saving, which cannot be attained by face-to-face training because of the limitations of the latter.

E-learning, therefore, provides a more customized study, which can be adapted to each trainee's rhythm, overcoming geographical barriers with time flexibility, as the student can choose when and where to undergo his/her training.

In nursing, the eLearning provides time optimization and flexibility in training, highlighting the importance of adoption of new teaching tools to suit each individual's learning dynamics; it is a fast and efficient model of professional qualification and training,

It can be stated that eLearning allows changes in educational behavior and paradigms, introduces a new learning culture, incorporating technology in the formation of nurses.

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Medical Software Usage In a Primary Care Training Program - Are We Training Our Future Doctors To Use the EMR?

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Abstract

The electronic medical record (EMR) is playing an increasingly important role in primary care. This study investigates the current training provided by a primary care training program in the EMR, barriers to training, and an examination of both supervisor and trainee views on technology and training provision. The results indicate acceptance of the EMR in primary care and appropriate basic EMR skills. However, both trainees and supervisors state that there is a lack of formal training. A concern raised through this study was the divergent views between program organisations and supervisors on who should provide this training.

Keywords:

electronic medical record, training, primary care, medical software

Introduction

The usage of computers in Australian primary care has gathered pace over the last decade. Associated with this uptake of computers is the evolution of the electronic medical record (EMR) (1). Given the penetrance of EMR usage in Australian general practice, a number of barriers still exist in Australia for a fully integrated EMR. Liaw et al suggests issues of standards, business costs and training as barriers to usage of medical software (2). This is supported by research that reports that four main areas need to be addressed: environmental, organisational, personal and technical. (3) (4).

John Seely Brown, in his article, "Growing up Digital," suggests two important traits which are present "iPod" generation – their ability to multi-task, and their like for instant information (5). This generation will be the first truly digital generation, with the capacity to use electronic-based work processes such as the EMR. The question lies now in whether we are adequately training our next generation of doctors to succeed in a computerised work setting. As training is important to successful uptake of the EMR, primary care trainees are in the ideal situation to learn, develop and refine their EMR skills (6).

Aims

This study had three goals:

1. To investigate current perceived skills in using computers and EMR functions
2. To investigate what training is currently provided
3. To investigate the views and attitudes of trainees and their supervisors on technology, the EMR, and training provision

Methods

This descriptive study surveyed all GP supervisors (n=74) and community-based trainees (n=273) undertaking a three-year fellowship in an Australian primary care training program. First year trainees were excluded as they were hospital-based, not community-based. Surveys captured quantitative data but also allowed for qualitative descriptive comments. Survey data was entered into a specifically designed Access Database, analysed using frequencies, and a comparison between supervisors and trainees was made using Odds Ratios and Logistical Regression. The qualitative data was independently analysed by three investigators to explore emergent themes, which were subsequently discussed and consensus achieved. This project was reviewed and approved by The University of Melbourne Human Research Ethics Committee.

Results

The survey response rate was 44% from primary care trainees (n=120), and 77% from GP supervisors (n=57) who provide the majority of day to day supervision to the trainee. Seventy-four percent of trainees were female whilst seventy-seven percent of supervisors were male. Mean age of trainees was 32 years old whilst supervisors mean age was 47 years old. Over 90% of trainees and supervisors were trained in Australian universities.

Trainees and supervisors were questioned about their views, knowledge and current skills in medical software. The results are listed in Table 1. On comparison with the two groups studied, skills in using basic EMR processes were equal between groups, with supervisors having superior skills in advanced tasks such as the 75 year-old health assessment (OR 0.31 [0.15-0.62]) and Chronic Disease Management plan (OR 0.20 [0.09-0.47]).

Training issues – trainee views

The majority of trainees had no prior training in the EMR, with only 27% indicating previous training. EMR education in the program for the vast majority of trainees was done on-site with supervisors (78%) in an ad hoc fashion, mainly learn-as-you-go or passively while observing consultations. 58% of trainees reported EMR training that lasted between 30-120 minutes, whilst only a third (35%) received more than 3 hours, and some trainees had none at all.

Trainees were asked about whether they would like further training and if so, when and where training should be undertaken. 53% indicated a desire for formal training with 28% stating no further training was required. There was overwhelming support for formal training to be undertaken before entering community based placements and in particular advanced skills development (81%).

Trainees were asked to describe barriers to the usage of EMR medical software. Common themes emerged regarding lack of time and lack of specific EMR knowledge and are similar to the themes listed in the supervisor views.

Training issues – supervisor views

Over half (53%) of GP supervisors indicated that they had been previously trained in the use of EMR software. However a third (37%) of supervisors indicated a need for further EMR training with a similar number unsure about the need for further training. Supervisors indicated strongly that training for trainees should be undertaken before or at the commencement of their practice based terms (82%).

The supervisors were asked to identify barriers to medical software training in their practices. The responses could be divided into five themes:

1. Generational issues – an assumption that trainees were more IT-savvy and thus no training was required
2. Knowledge – supervisors' lack of medical software skills and knowledge
3. Time – emphasis on pre-placement training
4. Priorities – limited time with clinical issues taking priority
5. Place of training – there were divergent views on the ideal venue for training, between in-house supervisor-run training versus training from dedicated training providers

Discussion

Both trainees and supervisors were positive about the role of medical software, were not intimidated by technology and stated their preference for computers in delivering medical care. Other skills were similar between the two groups.

The results of this study suggest that medical software is not being utilised effectively in the trainee group, yet the trainees are confident in their computer skills. It suggests basic skills are naturally learnt and practised by trainees but higher level functions such as care plans and health assessments are not being utilised for patient care by trainees. This would indicate that training particular in advanced skills is lacking and that direction is required by training supervisors and organisations.

Descriptive comments made by both trainees and supervisors indicating low levels of formal training and previous training in usage of medical software. The comments made by trainees about in-house training are a concern given that the EMR is a legal document and must accurately reflect the patient status. The common assumption that the new generation of doctors will already know how to use EMR software is not only incorrect, but poses a significant barrier towards ensuring that the next generation of general practitioners will be fully proficient in the computerised work environment.

Many barriers listed by the two groups are similar to barriers identified in other published articles. A new barrier to emerge from this study is the divergent viewpoints about which party is responsible for the training. Stakeholders including supervisors, training program organisations and government bodies must provide a consensus agreement in the areas of resources, formal training requirements and competency level evaluations as part of the trainee's learning program.

Conclusion

Primary care training programs will have a crucial role in developing skills in the area medical software usage. Training should be a shared responsibility between both the supervisor and training provider to ensure skill competencies. The future of primary care requires a more computer-literate doctor. Doctors with these attributes will need to be assisted in drawing these skills together.

Table 1 – Training views, knowledge and skills in Medical Software (MS = medical software)

Trainee View (n=120) / Supervisor View (n=57) – listed in combination. Numbers described as %					
Background View	**SA**	**A**	**N**	**D**	**SDA**
MS is useful for patient care	64/60	33/30	3/10	0/0	0/0
MS is a hindrance to patient care	3/2	4/9	9/11	52/24	32/54
I am using MS optimally	12/12	46/44	18/18	22/19	2/7
I am fearful of MS	1/0	4/7	10/11	47/42	38/40
I am fearful of technology	1/0	7/9	11/16	40/35	41/40

I prefer handwritten notes	1/4	4/12	13/7	35/37	47/40
I am confident in my computer skills	21/21	53/40	18/35	8/10	0/4
SA = Strongly Agree A = Agree N = Neutral D= Disagree SDA = Strongly Disagree					

Skills/Ability to use computers in various tasks (Numbers as %)		
	Trainees	Supervisors
Writing scripts	97	100
Writing referrals	97	92
Ordering tests	95	96
Performing a patient reminder	91	89
75 year old assessment	47	74
Chronic Disease Management plan	56	86
Past History record update	88	93

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1. Western MC, Dwan KM, Western JS, Makkai T, Del Mar C. Computerisation in Australian general practice. Aust Fam Physician 2003;32(3):180-5.
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Medical software usage in a primary care training program. Are we training our future doctors to use the EMR?

Dr. Justin Tse, Dr. Carolyn O'Shea, Mr. Josh Szental & Ms. Denise Ho

Royal Melbourne Hospital Clinical School
The University of Melbourne

Background:

- Increasing usage of computers in primary care (1)
- Barriers against effective usage: standards, financial costs and training (2,3)
- Digital generation/natives – the “now” generation has the capacity to utilise the EMR for health care (4)
- Primary care trainees are in the ideal situation to learn skills in usage of the EMR (5)

Objectives:

1. To investigate current perceived skills in using computers and EMR functions
2. To investigate what training is currently provided
3. To investigate the views and attitudes of trainees and their supervisors on technology, the EMR, and training provision

Methods:

- Descriptive study of GP supervisors (n=74) and GP trainees (n=273)
- Quantitative and qualitative arm
- Data analysed using frequencies, odds-ratios and logistical regression
- Qualitative study undertaken to complement quantitative data collected

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Results:

Demographics:

- Trainee response rate – 44%, mean age 32 years old, 74% female
- Supervisor response date – 77%, mean age 47 years old, 77% male

(Male : Female % representative of Australian training cohort)

Training level:

- Trainees – 44% 2nd year/ 56% 3rd year
- Supervisors – 72% 2nd year/ 5% 3rd year/ 13% both 2nd/3rd year training
- >90% trainees and supervisors undertook medical school training in Australia

Trainee views in Electronic Medical Record

Royal Melbourne Hospital Clinical School
The University of Melbourne

Trainee View (n=120) / Supervisor View (n=57) – listed in combination. (Numbers described as %)					
Background View	**SA**	**A**	**N**	**D**	**SDA**
MS is useful for patient care	64/60	33/30	3/10	0/0	0/0
MS is a hindrance to patient care	3/2	4/9	9/11	52/24	32/54
I am using MS optimally	12/12	46/44	18/18	22/19	2/7
I am fearful of MS	1/0	4/7	10/11	47/42	38/40
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I prefer handwritten notes	1/4	4/12	13/7	35/37	47/40
I am confident in my computer skills	21/21	53/40	18/35	8/10	0/4
SA = Strongly Agree A = Agree N = Neutral D= Disagree SDA = Strongly Disagree					

Skills to use computers in various tasks

Royal Melbourne Hospital Clinical School
The University of Melbourne

Skills/Ability to use computers in various tasks (Numbers as %)		
	Trainees	Supervisors
Writing scripts	97	100
Writing referrals	97	92
Ordering tests	95	96
Performing a patient reminder	91	89
75 year old assessment	47	74
Chronic Disease Management plan	56	86
Past History record update	88	93

Comparisons between trainees and supervisors indicated equal skills except for advanced skills: 75 year old assessments (OR 0.31 [0.15-0.62]) and chronic disease plans where supervisors had better skills (OR 0.20 [0.09-0.47])

Trainee views

- Over 70% had no prior training
- 17% had formal training with their current training provider
- General EMR education was done via GP supervisor (78%) – usually in ad-hoc, in-formal encounters
- Supervisor training – 58% - 30-120 minutes
- 53% would like formal training with most indicating training before commencement of placements
  - Skill areas for training – early survival phase in primary care to advanced EMR skills

Supervisor views

- Nearly 50% had no prior training
- 2% had formal training with their current training provider
- 37% would like up-skilling in usage of EMR
- Supervisors – 82% indicated a need for trainees to have formal training before the start of clinical placements

Results:

Barriers: Five themes

1. Generational issues – an assumption that trainees were more IT-savvy and thus no training was required
2. Knowledge – supervisors' lack of medical software skills and knowledge
3. Time – emphasis on pre-placement training
4. Priorities – limited time with clinical issues taking priority
5. Place of training – there were divergent views on the ideal venue for training, between in-house supervisor-run training versus training from dedicated GP training program providers

Discussion

- Perception that medical software is a useful tool and general confidence in skill levels
- Advanced software functions not utilised by GP trainees which may indicate lack of formal training in these skills – this is confirmed in results which indicate low levels of formal training in supervisors and trainees and that EMR education is ad-hoc, informal and low in training time
- Both trainees and supervisors would like formal training particular before clinical placements however there is discourse on who should provide training; supervisor or GP training organisation
  - This conflict needs to be appropriately addressed for improved EMR software usage
- Barriers to usage are similar to previous studies

Conclusion

- Primary care supervisors and primary care training providers have a key role to play in up-skilling GPs in the usage of the EMR
- Training should be a shared responsibility
- Appropriate use of the EMR by our future primary care doctors will ensure improved patient outcomes

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3. Tse J, Liaw S. CONDUIT: computerized research networks, implementation and capacity building issues. Health Informatics Society of Australia DEST Conference Publication 2003.
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Academic Data Warehouses: Tool for Medical Student Education in Medical Informatics and Population Health

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Abstract

Academic data warehouses are increasingly being used to support health services research and quality assessment initiatives. A less common use of such systems is in support of medical education. As new requirements for health professional competence in medical informatics emerge, data warehouses are a potentially powerful teaching tool for introducing and reinforcing these concepts. The 2nd report of the AAMC Medical Student Objectives Project describes several learning objectives related to medical informatics and population health. At the University of Virginia, we have a decade of experience with a custom-built academic data warehouse; over the past five years we have explored the educational potential of our system. In this abstract, we describe our vision for how data warehouses like our own might be useful for training in these important areas.

Keywords:

database management systems, academic medical centers, medical informatics, medical education

Academic Data Warehouses and the AAMC Medical School Objectives Project Report II

Academic data warehouses typically include a wide variety of clinical, administrative, and financial patient data. Most commonly, data is integrated within a single healthcare organization, though this is not always the case. These systems often include custom-developed user interfaces allowing users to directly query the database. While curricular demands have broadened to include medical informatics and population health, the information infrastructure to support these requirements has lagged. Data warehouses offer students the ability to gain hands-on experience in interacting with clinical databases, potentially serving as a useful tool in handling these new educational requirements.

In 1998, the American Association of Medical Colleges (AAMC) Medical School Objectives Project (MSOP) Report II focused exclusively on medical informatics and population health, outlining a series of learning objectives for medical students organized into five different roles: Life-Long Learner, Clinician, Educator/Communicator, Researcher, and Manager.

Data warehouses and medical education

Like many of the roles described in the MSOP II, the Life-Long Learner role includes several learning objectives that might be readily addressed by hands-on experience with an academic data warehouse. While this role focuses primarily on accessing knowledge sources, the core areas (including information retrieval skills and the ability to filter, evaluate, and reconcile information) could be appropriately addressed by queries into an academic data warehouse. Using such a system would also potentially allow exploration of medical terminologies and coding systems such as ICD9-CM, SNOMED, and LOINC. The learning objectives associated with the role of Researcher, defined broadly to include a range of skills related to data acquisition, management, and analysis, is perfectly suited to the functionality of a an academic data warehouse. Secondary datasets are key resources for clinical investigators, and students can use data warehouses to learn about their strengths and limitations for this purpose. Finally, learning objectives in the Manager role, with their focus on quality assessment and health care service planning, could be addressed by optimizing these tasks in an academic data warehouse, allowing students to look at benchmarking / performance data for practice groups and discuss the myriad issues related to using existing data for this purpose. Specific details for these examples will be included in the poster presentation.

Conclusion

Information systems in academic medical centers have not been optimized to support new competency requirements in undergraduate medical education. Organizations with data warehouses should strongly consider introducing them into the curriculum as potentially invaluable tools for introducing and reinforcing key concepts related to medical informatics and population health. Many of the key learning objects in the AAMC MSOP II could be very productively addressed by access to these systems.

Evaluation of certifying examination of healthcare information technologists

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Japan Association of Medical Informatics (**JAMI**)

History and Purpose

History

- In 2001, JAMI started the task force to foster healthcare information technologist (HIT), who can understand both information technology and healthcare. And from the year 2003, the certifying examination for HIT have started.
- Tests about **information technology**, **health care**, and **health information system** form the certifying exam. The number of questions of these tests are 40, 40, and 60, respectively.
- From the beginning of this exam many persons applied, and by the end of 2006, 5129 persons have been qualified as the primary HIT.

Number of Applicants each year					Number of Persons Certificated as HIT			
Year	**2003**	**2004**	**2005**	**2006**	**2003**	**2004**	**2005**	**2006**
Male	**2623**	**3036**	**3532**	**2949**	**856**	**1055**	**1391**	**1041**
Female	**898**	**767**	**844**	**786**	**123**	**162**	**257**	**244**
Total	**3521**	**3803**	**4376**	**3735**	**979**	**1217**	**1648**	**1285**

Purpose of this paper

- Evaluate the certifying exam by elucidating whether the desired characteristics has been certified by the exam.

The Desired Characteristics of HIT, seen in the general instructive objectives (GIO) of "Information Technology"

- Basic Knowledge about Computer
  - History, Hardware, Software, Programming, ..
- Network Technology
  - OSI model, Basic knowledge about networking, ..
- Database Technology
  - Architecture, Relational DB, SQL, Transaction, Access control, ..
- System Development
  - Design and System Development, DFD, UML, ..
- Operation and Management
  - Recovery and maintenance, Risk management, ..
- Information Security
  - Security Technology, Secure Operation, ..

The Desired Characteristics of HIT seen in GIO of "Health Care"

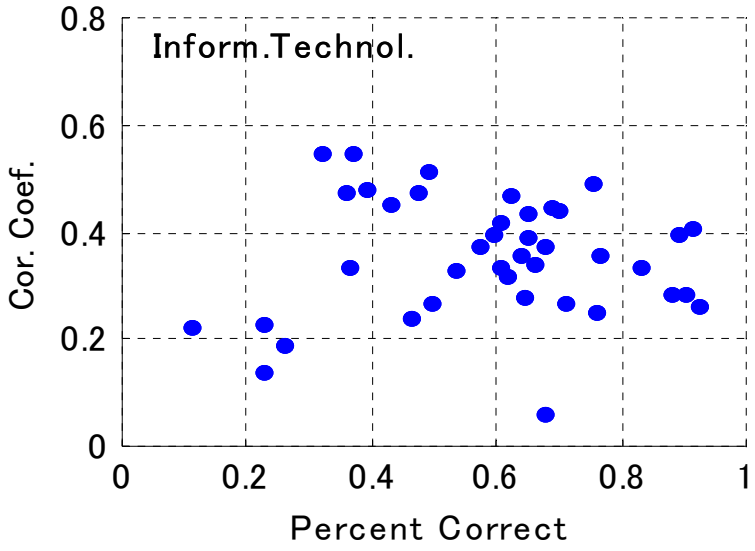
- General Remarks
  - Code of ethics, Informed consent, QOL, ...
- Social System in Medicine
  - Payment system, Insurance, Regulations, ...
- Hospital Management
  - Role of each clinical department, Patient flow, Team medicine, ...
- Social Medicine
  - Systems in public health, ...
- Clinical Medicine
  - Introduction to clinical medicine
- Medical Record
  - POMR, EHR, ...
- Nursing System
  - Nursing chart, ...
- Clinical Examination
  - Blood test, Biochemical test, Blood transfusion, Genetic test, ...
- Safety Management
  - Clinical pass, ...
- Topics
  - Genetic medicine, VR, ..

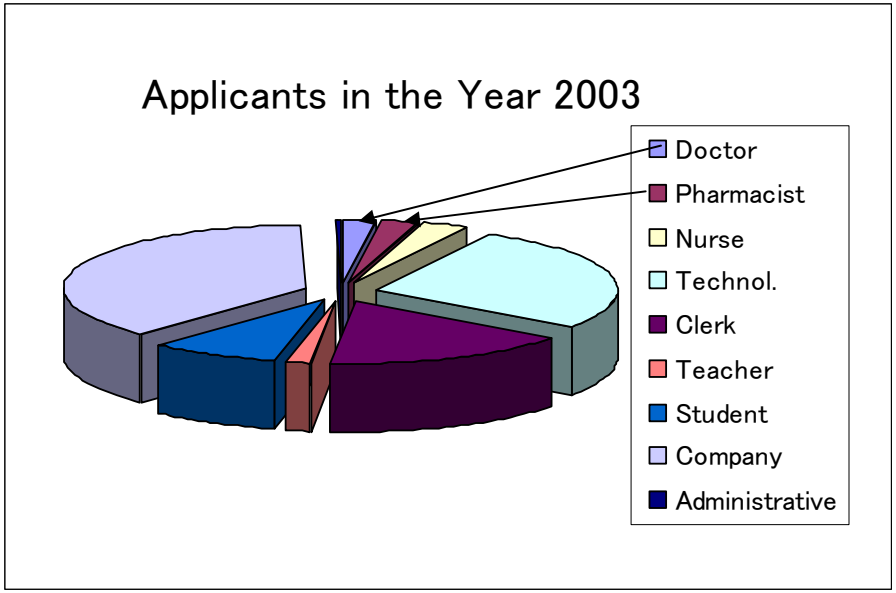
The Desired Characteristics of HIT seen in GIO of "Health Information System"

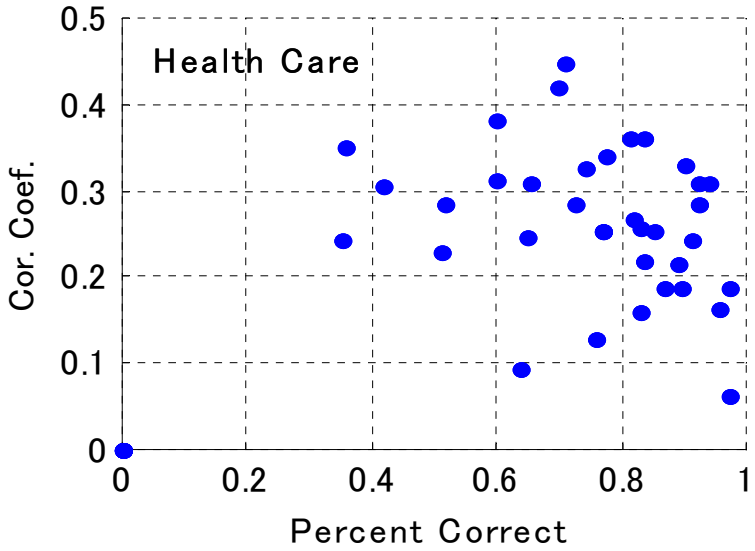
- Characteristics of Health-related Data and System
  - Requirements for health information system, ...
- Issues related to Hospital Information System
  - Explanation of subsystems, ...
  - Design, Development, Install, in practice
  - Practical way in operation, Education, ...
- Wide-area Network in Healthcare
  - Health and welfare system, ...
- Communication, Coordination, Collaboration
  - Role of HIT at the time of system designing, development, negotiation, teaching, daily operations, ...
- Standardization
  - IHE, Security and standardization, ..
- Electronic Health Record
  - Issues related to EHR
- Ethics
  - Code of Ethics, Privacy, ..
- Evaluation of Clinical Data
  - Data mining, Statistics, ...

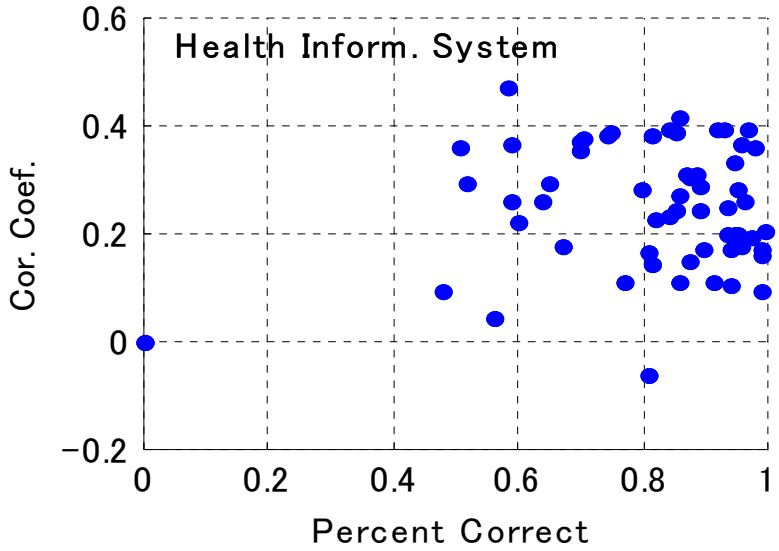
Results of the first certifying exam

As the scores of percent correct of many questions exceed 0.8, it was known that we can ask more to HIT, here Cor. Coef. is the correlation coefficient between the score of each question and the total score of that exam.

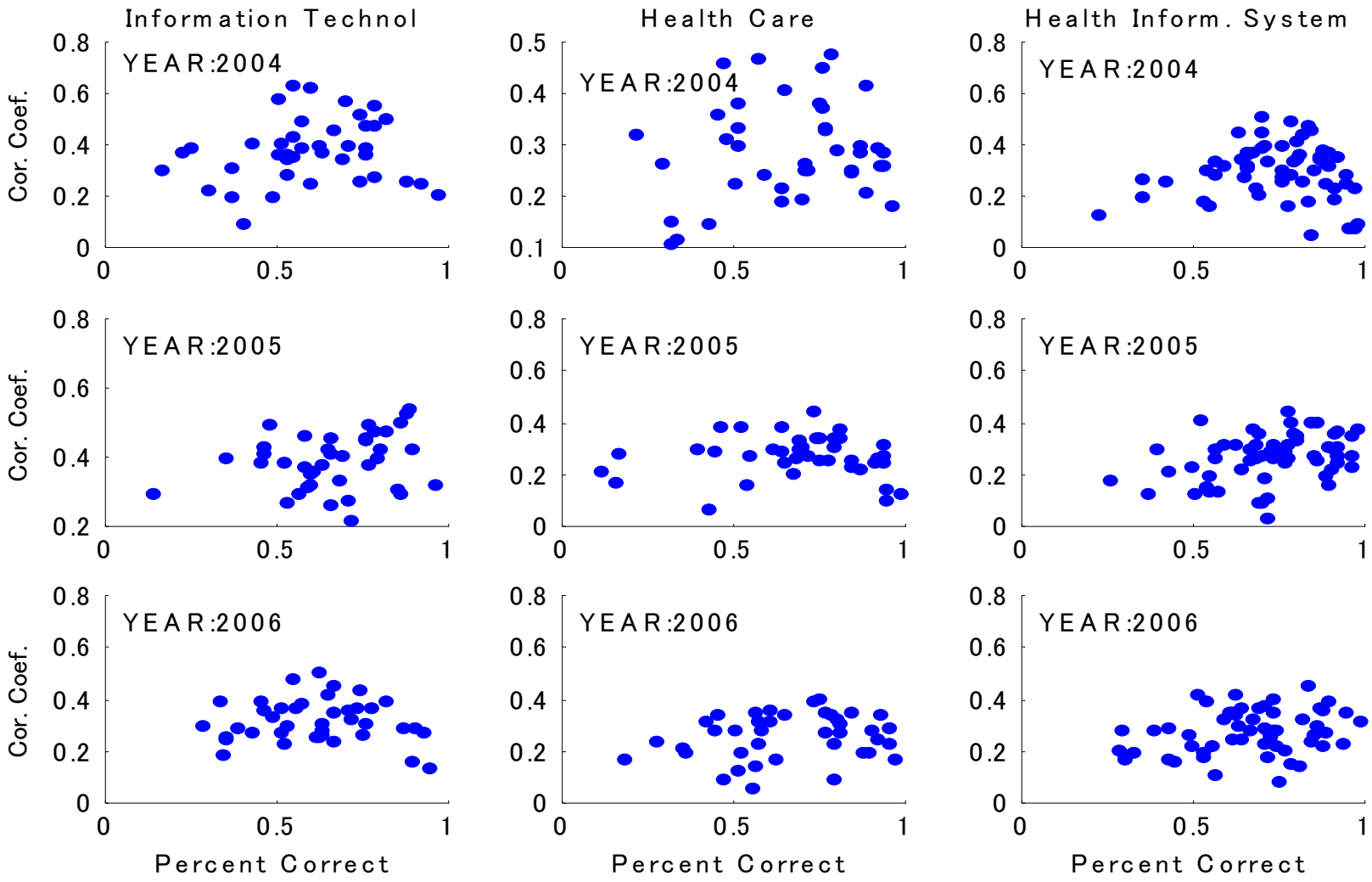








Correlation Coefficient vs. Score of Percent Correct for new Applicants each year



Method and the Categories used in the evaluation

Method

Under GIO, the specific behavioral objectives (SBO) were made. According to SBO, questions were created to measure abilities that HIT should have. As each question always treats one theme, we can categorize the objectives of each question. Seven categories were chosen as listed in the right, and questions were selected in accordance with these categories.

As this is the exam for primary HIT, a few questions are categorized into 5,6 or 7. To avoid distortions caused by the different number of questions we selected at most 3 questions to each category in each test. The selection of these 3 questions is done by the difficulty measure, i.e., average score of each question normalized to the allotted score.

Using the data of the new applicants who first apply the exam, average score of percent correct to each category in each test was evaluated, which are then used to know what category contributes most to the certification of HIT.

Categories

1: **Ability to follow logic**
- **Flow Chart, Binary Mathematics, ...**

2: **Computer Literacy (Knowledge)**
- **Terminology**

3: **Medical Knowledge**
- **Common sense about clinical medicine, ...**

4: **Knowledge about hospital management**
- **Insurance, formulas used in hospital management, …**

5: **Decision with Ethical Mind**
- **Privacy, Security, Code of Ethics, …**

6: **Behavior at the Time of Emergency**
- **Ask best choice or priorities in the time of troubles**

7: **Ability to evaluate/understand Clinical Data**
- **Understand figures or tables describing some clinical status, introductory knowledge about medical statistics**

Results

The percentage of the number of applicants who passed or failed the exam are listed in the "Passed" or "Failed" cell. These percentages were taken to the total number of applicants with the same range of average score.

1:Ability to follow logic

Score	Cases	Passed	Failed
0.00–0.25	3396	14.22	85.78
0.25–0.75	5816	30.38	69.62
0.75–1.00	557	52.06	47.94

2: Computer Literacy (Knowledge)

Score	Cases	Passed	Failed
0.00–0.25	2298	7.57	92.43
0.25–0.75	6135	26.21	73.79
0.75–1.00	1336	56.74	43.26

3:Medical Knowledge

Score	Cases	Passed	Failed
0.00–0.25	1578	16.60	83.40
0.25–0.75	5102	29.18	70.82
0.75–1.00	814	46.93	53.07

4:Knowledge about hospital management

Score	Cases	Passed	Failed
0.00–0.25	2080	14.57	85.43
0.25–0.75	6672	27.01	72.99
0.75–1.00	2612	47.47	52.53

Results (continued)

- 5:Decision with Ethical Mind

Score	Cases	Passed	Failed
0.00–0.25	142	4.23	95.77
0.25–0.75	5122	19.37	80.63
0.75–1.00	6100	38.48	61.52

- 6:Behavior at the Time of Emergency

Score	Cases	Passed	Failed
0.00–0.25	34	0.00	100.00
0.25–0.75	4381	16.91	83.09
0.75–1.00	6935	37.55	62.45

- 7:Ability to evaluate / understand Clinical Data

Score	Cases	Passed	Failed
0.00–0.25	852	10.33	89.67
0.25–0.75	8745	27.11	72.89
0.75–1.00	1767	50.14	49.86

Category	Average	Median	Mode
1	0.32	0.33	0.33
2	0.45	0.39	0.33
3	0.44	0.39	0.33
4	0.55	0.56	0.50
5	0.76	0.80	1.00
6	0.79	0.83	1.00
7	0.58	0.58	0.75

Results (continued) and Discussions

- Logistic regression analysis (dependent variable is the result of exam)

Category	Coef. B ±SE	Wald statistic	estimated odds ratio		
			exp(B)	95% confidence interval	
1	1.48±0.143	107.6	4.40	3.32	5.82
2	2.44±0.148	272.4	11.47	8.58	15.32
3	1.54±0.150	105.5	4.69	3.49	6.30
4	4.58±0.212	465.2	97.75	64.46	148.24
5	3.96±0.261	230.8	52.57	31.53	87.65
6	3.46±0.250	191.4	31.78	19.47	51.87
7	2.59±0.218	141.6	13.36	8.72	20.47

- Discussions
  - The results of logistic regression analysis would mean that the certifying exam will be very sensitive to select persons who have good knowledge about hospital management, having ethical mind, and conduct well at the time of emergency. But the knowledge about clinical medicine may not be so important. All of these characteristics are those we have expected to primary HIT.

Contact Detail

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- Contact Detail

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Evaluation of Certifying Examination of Healthcare Information Technologists

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Abstract and objective

To improve the healthcare literacy in both of healthcare providers and system vendors, the Japan Association of Medical Informatics started the task force to foster the Healthcare Information Technologists (HIT) in 2001. After two years of preparation, the annual certifying exam for the primary HIT has started. The purpose of this paper is to report the evaluation of this exam by using four year of experiences. It was found that the exam will be sensitive to select persons who have good knowledge about hospital management, having ethical mind, and conduct well at the time of emergency.

Keywords:

healthcare information technologist, certifying examination, education

Introduction

As is stated by Prof. Evelyn J.S. Hovenga, the chair of MEDINFO2007, improvement of health literacy and development of a sound e-health environment that enables us to improve health conditions of individuals by active and effective use of health information among health care team and the individuals will be the keys to reduce the national medical expenditure. To create such the e-health environment, however, the computer system should meet the demands both of users and of the society, i.e., it should support the care process substantially to realize better patient care, it should be cost effective, and all information should be treated in secure and authorized ways. However, the computer systems used in healthcare sectors now in Japan are far behind of these demands. We have not yet succeeded even to prove the value of the computer systems. Moreover, the introduced systems sometimes mismatch the practical patient care, since few computer technologists working at system vendors know the practical health care process. All of these will come from the deficiency of persons who knows both of the health care processes and the computer technology. To solve this problem, the Japan Association of Medical Informatics has launched a project to foster Healthcare Information Technologists (HIT). To grasp the real requirements for HIT and to decide what to certify, 40 specialists gathered in the year 2001. In that assembly we made the general instructional objectives (GIO) and the specific behavioral objectives (SBO) to foster HIT. According to GIO/SBO, we published a series of textbooks. These textbooks have been widely used in schools and companies, and become the first standard textbooks in this area.

From the year 2003, the annual certifying exam for the primary HIT has started. The certifying exam consists of three tests about information technology, health care, and health information system, comprising 40, 40, and 60 questions, respectively. We have created these questions every year in accordance to SBO to measure abilities that HIT should have.

Until 2006, exemption rule existed for the tests of information technology and health care. Applicants having other specified licenses exempted from the test assigned to each license.

From the start of exam, unexpectedly large number of persons applied. Indeed, about 3800 persons have applied the exam each year. By the year 2006, it reaches 15435 persons in total, and 5129 persons have been qualified as the primary HIT.

The persons from system vendors are continuously increasing from 38% to 61% in these 4 years, and the percentages of them who passed the exam improved from 29% to reach 38%. Though the exam is rather difficult for students and for nurses who have little chances either to use healthcare information systems or to see computer programs, the percentage that pass the exam has remarkably improved from 7 to 15% for students, and 7 to 26% for nurses during these 4 years.

There remains a question, however, what characteristics the exam certifies. This paper devotes to answer this question.

Materials and method

In these 4 years, 4037 persons applied the exam more than twice. The percentage to pass the exam after applying it more than twice is 44.1 %, while it is 29.4% to pass the exam at their first challenge. This somewhat large difference may indicate that it will be better to use only the data at the first challenge of each applicant. In this paper, we used the data of the first challenge of the 11398 applicants.

As each question always treats one theme, we can categorize the objectives of each question. As the typical requirements for HIT, we chose seven categories and selected questions in accordance with these categories. The seven categories are: (1) Ability to follow logic. The questions about flowchart, binary mathematics, etc., are in this category. (2) Computer

literacy. Questions of the level of terminology are here. (3) Medical knowledge. Here, the common sense about clinical medicine was asked. (4) Knowledge about hospital management. Questions about formulas used in hospital management, insurance system, etc., are in this category. (5) Ethical mind. Questions about the code of ethics at practical settings are in this category. (6) Behavior at the time of emergency. The questions asking best choice or priorities in the time of troubles are in this category. (7) Ability to evaluate clinical data. Any questions to ask understanding figures or tables describing some clinical status, or introductory knowledge about medical statistics are in this category.

As this is the exam for primary HIT, a few questions are categorized into 5, 6 or 7. To avoid distortions caused by the different number of questions we selected at most 3 questions to each category in each test. The selection of these 3 questions is done by the difficulty measure, i.e., the average score of each question normalized to the allotted score.

After selected the questions, we calculated the averages of the scores of percent correct of questions in each category of each applicant, and performed a logistic regression analysis to know what category contributes most to the certification of HIT. Since some categories, e.g., categories 1 and 2, are taken only from the test results of information technology, values of these categories are missed for such applicants who does not take the information technology test. The number of complete cases was 6028, in which no missing values exist.

Results

To grasp the sensitibity of each category to certification, we first show the distribution of scores in table 1. In this table, percentages of the number of applicants who passed or failed the exam are listed in the "Passed" or "Failed" cell. These percentages were taken to the total number of applicants with the same range of average score.

1: Ability to follow Logic			
Score	Cases	Passed (%)	Failed (%)
0.00-0.25	3396	14.22	85.78
0.25-0.75	5816	30.38	69.62
0.75-1.00	557	52.06	47.94
2: Computer Literacy			
0.00-0.25	2298	7.57	92.43
0.25-0.75	6135	26.21	73.79
0.75-1.00	1336	56.74	43.26
3: Medical Knowledge			
0.00-0.25	1578	16.60	83.40
0.25-0.75	5102	29.18	70.82
0.75-1.00	814	46.93	53.07
4: Knowledge about Hospital Management			
0.00-0.25	2080	14.57	85.43
0.25-0.75	6672	27.01	72.99
0.75-1.00	2612	47.47	52.53
5: Ethical Mind			
0.00-0.25	142	4.23	95.77
0.25-0.75	5122	19.37	80.63
0.75-1.00	6100	38.48	61.52
6: Behavior at the time of emergency			
0.00-0.25	34	0.00	100.00
0.25-0.75	4381	16.91	83.09
0.75-1.00	6935	37.55	62.45
7: Ability to evaluate/understand clinical data			
Score	Cases	Passed (%)	Failed (%)
0.00-0.25	852	10.33	89.67
0.25-0.75	8745	27.11	72.89
0.75-1.00	1767	50.14	49.96

Table 1 - Distribution of Scores

Table 2 shows the simple statistics of each category.

Table 2 - Simple statistics of 7 categories

Category	Average	Median	Mode
1	0.32	0.33	0.33
2	0.45	0.39	0.33
3	0.44	0.39	0.33
4	0.55	0.56	0.50
5	0.76	0.80	1.00
6	0.79	0.83	1.00
7	0.58	0.58	0.75

Table 3 shows the result of logistic regression analysis. The dependent variable is a dichotomous status of the exam.

Table 3 - Result of the logistic regression analysis

Cate-gory	Coef.B ±SE	Wald statistic	estimated odds ratio		
			exp(B)	95% conf. interval	
1	1.48±0.143	107.6	4.40	3.32	5.82
2	2.44±0.148	272.4	11.47	8.58	15.32
3	1.54±0.150	105.5	4.69	3.49	6.30
4	4.58±0.212	465.2	97.75	64.46	148.24
5	3.96±0.261	230.8	52.57	31.53	87.65
6	3.46±0.250	191.4	31.78	19.47	51.87
7	2.59±0.218	141.6	13.36	8.72	20.47

Discussions and concluding remarks

From tables 1 and 2 some characteristics of the exam can be seen. For example, making appropriate decision at the time of emergency is easy for many applicants, but, it is very difficult to pass the exam if one fails to make such decision. The result of logistic regresion analysis would mean that the certifying exam will be very sensitive to select persons who have a good knowledge about hospital management, having ethical mind, and conduct well at the time of emergency. But the knowledge about clinical medicine may not be so important. All of these characteristics are those which we have expected to primary HIT, and this will prove the adequacy of the exam.

To improve the quality of exam, the performance of each question has been evaluated each year, based on the item response theory. GIO/SBO and the textbooks are updated so as to cope with the rapidly changing environment. Training schools are also held annually. Through these activities of JHIFT, HIT has accepted in Japanese society, and the workplaces for HIT have been gradually spreading.

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The Convergence of Bioinformatics and Medical Informatics : Bibliometric analysis of health informatics research, 1991-2005

Chang-Hung Lin[a], Kee-Wong Phay[b], Yi-Hsin Elsa Hsu[b], Po-Lun Chang[c]

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Keywords:

bibliometric, SCI, bioinformatics, medical informatics, biomedical informatics

Introduction

The field of biomedical informatics sits at the crossroads of biology science, medical science, computer science, information science, and cognitive science. The convergence of bioinformatics and medical informatics to biomedical informatics will provide a much broader view of the composition of health information soon became the mainstream in these domains. Shortliffe and Cimino pointed the evolution in the field of biomedical informatics in 2006. Our purpose was to study the biomedical informatics research performance based on 7830 documents published in Science Citation Index (SCI)-indexed periodicals between 1991 and 2005. These documents were analyzed and evaluated according to publication distribution and were used to determine the quantitative characteristics of the research.

Methods

Documents used in this study were based on the databases of the *SCI* which was accessed from the ISI *Web of Science*, 'bioinformatics', 'medical informatics' and 'biomedical informatics' were used as keywords to search titles, abstracts, and keywords. Parameters analyzed included type of document, page count, authorship, journal, author keywords and country of publication.

Results

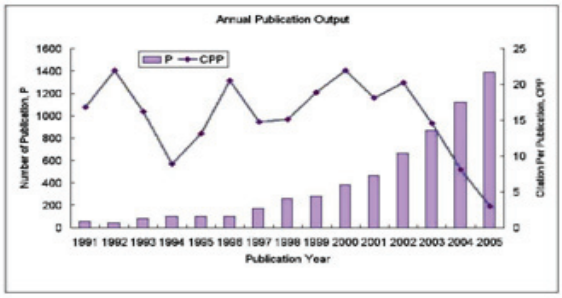

Figure 1 - Annual publication output

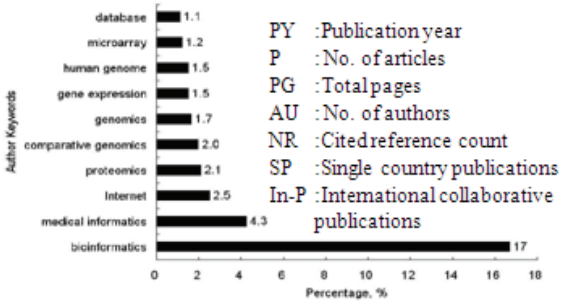

Figure 2 - Ten most used author keywords

Table 1 - Major characteristics of the research

PY	P	PG	PG/P	AU	AU/P	NR	NR/P
1991	56	441	7.9	178	3.2	842	15
1992	47	376	8.0	156	3.3	934	20
1993	80	591	7.4	223	2.8	1128	14
1994	100	771	7.7	324	3.2	1324	13
1995	99	786	7.9	301	3.0	1848	19
1996	99	780	7.9	321	3.2	1966	20
1997	171	1316	7.7	570	3.3	3799	22
1998	259	2165	8.4	834	3.2	5539	21
1999	282	2218	7.9	938	3.3	6669	24
2000	384	3093	8.1	1540	4.0	9477	25
2001	463	3856	8.3	1932	4.2	12127	26
2002	662	5625	8.5	2829	4.3	19853	30
2003	866	7978	9.2	4384	5.1	27022	31
2004	1122	10539	9.4	5711	5.1	36452	32
2005	1392	13111	9.4	6732	4.8	46078	33

Table 2 - Publication activity of top ten countries

Country	SP	SP%	CP	CP%	TP	TP%
U.S.A.	2063	41	579	59	2642	43
U.K.	489	9.8	239	24	728	12
Germany	312	6.3	197	20	509	8.4
Japan	287	5.8	56	5.7	343	5.6
France	200	4.0	110	11	310	5.1
Canada	172	3.5	137	14	309	5.1
Peoples R China	200	4.0	69	7.0	269	4.4
Australia	105	2.1	79	8.1	184	3.0
Italy	111	2.2	69	7.0	180	3.0

Sweden	90	1.8	37	3.8	127	2.1

Conclusions

- The results show an increasing number of articles since 1997 and author numbers, article pages and cited reference count numbers indicate a continuous growth of biomedical informatics community.
- The five most author used keywords were bioinformatics, medical informatics, internet, proteomics and comparative genomics.
- Fifteen document types were found in the total of 7830 documents. 78 percent of all documents are articles.
- The USA was the leader and dominated the most publications followed by UK, Germany, Japan, France ,Canada.
- The production came from many countries, denoted the devotion to this research in different area around the world.

The Convergence of Bioinformatics and Medical Informatics : Bibliometric analysis of health informatics research, 1991-2005

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[b] *Graduate Institute of Health Care Administration, Taipei Medical University, Taiwan*

[c] *Institute of Health Informatics, National Yang-Ming University, Taiwan*

Objective

- The convergence of biomedical informatics will provide a much broader view of the composition of health information soon became the mainstream in these domains.
- Search and analysis the publication of biomedical informatics.

Method

- Database:
  Web of Science from THOMSON ISI
- Document based on:
  - Science Citation Index (SCI)
  - Published from 1991 to 2005
- Keyword:
  ‘bioinformatics’, ‘medical informatics’ and ‘biomedical informatics
- Bibliometrics analysis

Results

- Major characteristics of the research include bibliometric analysis of publication year, page count, number of author, and number of reference
- Percentage by language
- Bibliometrics analysis by document Type
- Ten most used author keywords
- Publication activity of top ten countries
- Total publication papers are about 7,830.
- Total citations are about 93,709
- The publications were published in 1,684 journals.

Major characteristics of the research

PY	P	PG	PG/P	AU	AU/P	NR	NR/P
1991	56	441	7.9	178	3.2	842	15
1992	47	376	8.0	156	3.3	934	20
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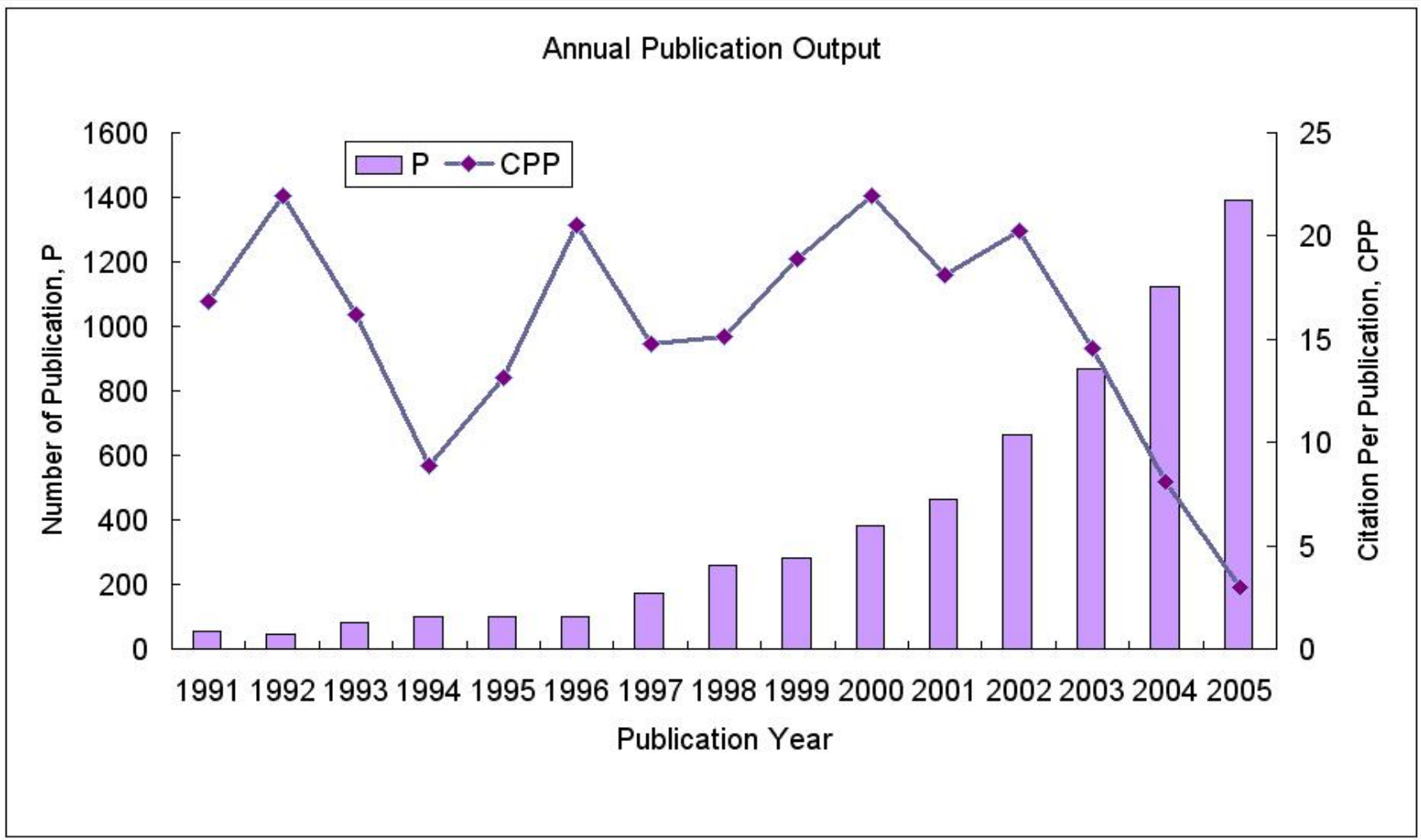
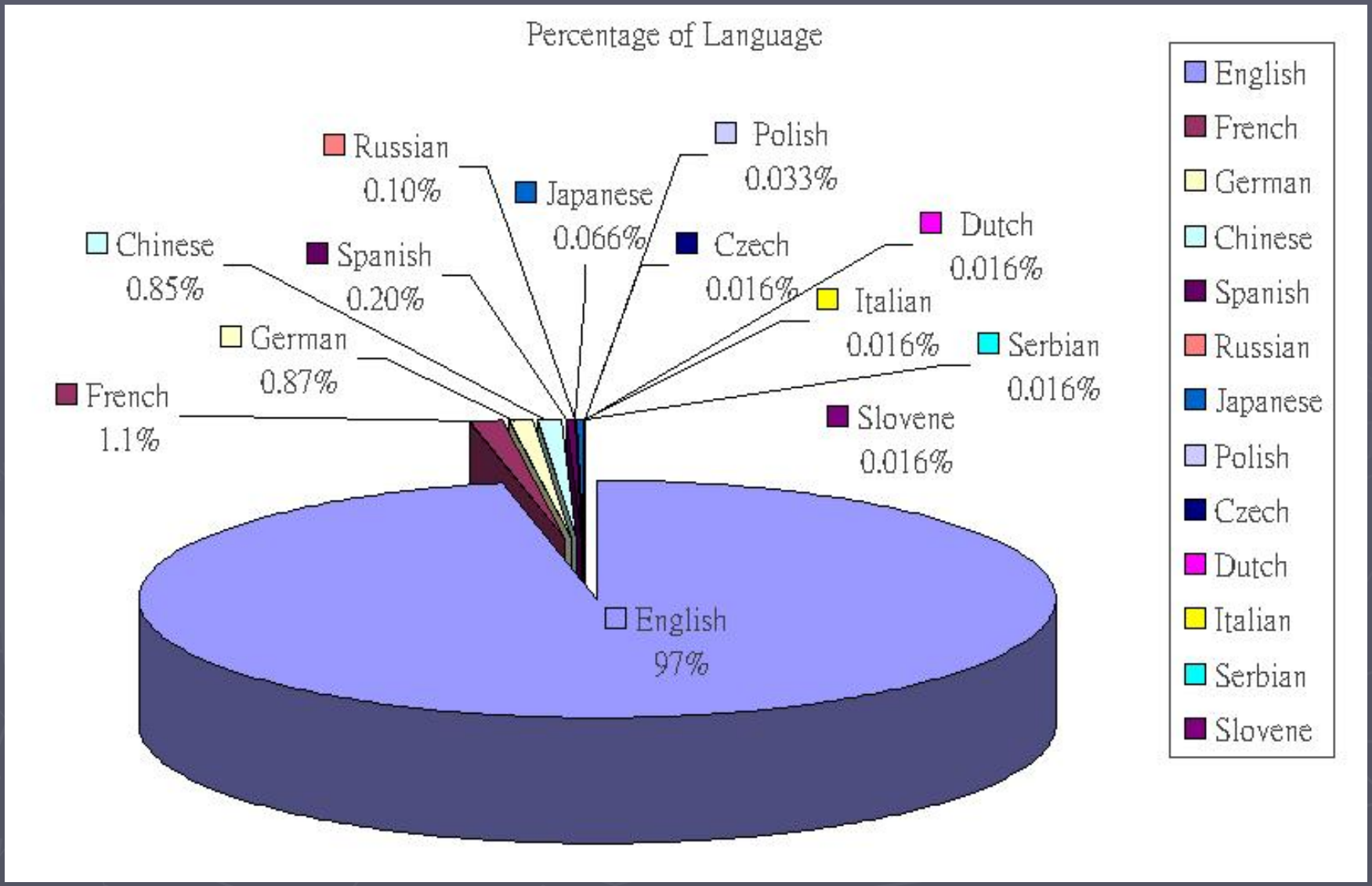
PY: Publication year, P: No. of articles, PG: Total pages, AU: No. of authors, NR: Cited reference count

Publication and Citation Per Publication by Publication Year



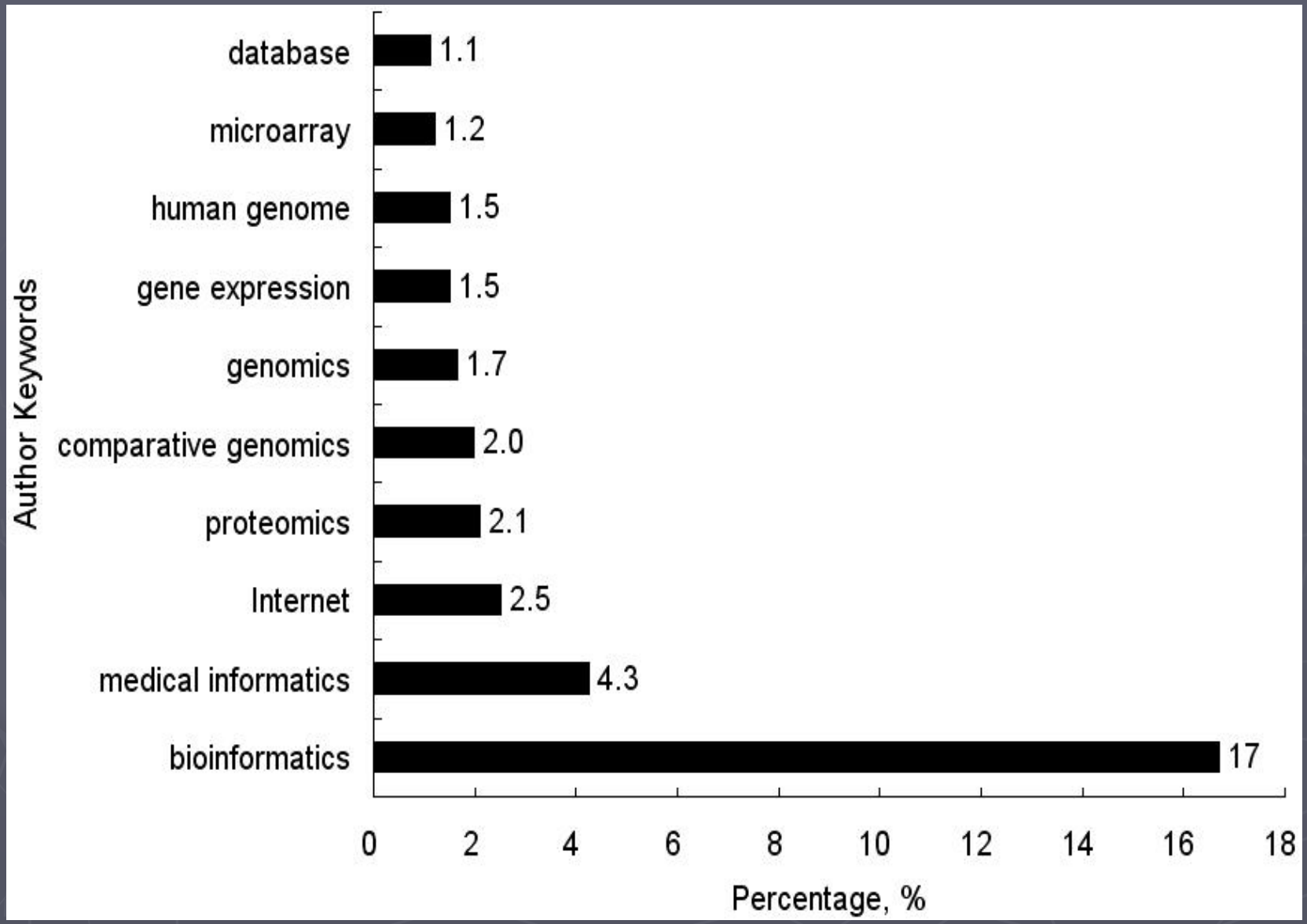
Percentage by Language



Document Type

DT	P	%	C	%	CPP
Article	6082	78	75299	80	12
Review	827	11	15355	16	19
Editorial Material	443	5.7	2551	2.7	5.8
Meeting Abstract	290	3.7	10	0.011	0.034
Letter	71	0.91	199	0.21	2.8
News Item	64	0.82	51	0.054	0.80
Correction	13	0.17	2	0.0021	0.15
Note	9	0.11	171	0.18	19
Book Review	8	0.10	0	0.0	0.0
Reprint	8	0.10	8	0.0085	1.0
Software Review	8	0.10	11	0.012	1.4
Biographical-Item	2	0.026	1	0.0011	0.50
Database Review	2	0.026	45	0.048	23
Discussion	2	0.026	6	0.0064	3.0
Correction, Addition	1	0.013	0	0	0.0

Ten most used author keywords



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Italy	111	2.2	69	7.0	180	3.0
Sweden	90	1.8	37	3.8	127	2.1

SP: Single country publications, CP: Collaborative publications

Conclusion (1/2)

- The results show an increasing number of articles since 1997 and author numbers, article pages and cited reference count numbers indicate a continuous growth of biomedical informatics community.
- The five most author used keywords were bioinformatics, medical informatics, internet, proteomics and comparative genomics.
- Fifteen document types were found in the total of 7830 documents. Seventy-eight percent of all documents are articles.

Conclusion (2/2)

- The production came from many countries, denoted the devotion to this research in different area around the world.
- A step farther….
  - Based on our concurrent leading status, Taiwan can devote more to this new field.
  - The keywords analysis provide us a hint for the future research.

The survey of computer literacy among students of Mazandaran University of Medical Sciences 2005-2006

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Babaee, Heidar, Medical record student at Mazandaran University of Medical Sciences, Iran
Naderi Rad, Esmaeel, Medical record student at Mazandaran University of Medical Sciences, Iran

Abstract

Information technology (IT) has radically changed the way that many people work and think. Computers are integral to medical practice, education, and research. As computer literacy has given way to information literacy, knowing how to manage and utilize the information that technology brings is essential for students of the future Computers are becoming ubiquitous in health and education, and it is expected that nurses from undergraduate nursing programs are computer literate when they enter the workforce. The call for medical students to become literate in the uses of information technology has become a familiar refrain. Every student needs a basic understanding of information processing. It is not necessary that every student be a programmer. Students should develop and demonstrate proficiency in the use of computers, learning to use applications such as word processing, spreadsheets, database management programs, electronic mail, and packages and applications specific to their field of study. The purpose of this study was to examine the level of computer literacy among Mazandaran University of Medical Sciences in Iran. This article describes a cross-sectional survey research study. This study has done among students of Mazandaran university of Medical sciences include 45% male and 55% female. Data collection was semi- structured and standard questionnaire contains 34 closed questions and 4 open questions that are classified in three divisions include using of the computer, basic knowledge of computer and IT skills. More than 50% of students had a sufficient knowledge about IT. Most of them reported that they learn IT by themselves and got more knowledge and skill in the university. We studied the relationship between the special computer course passing and IT skills in 108 students includes 54 passed and 54 hadn't this unit. 36 persons with special computer course were familiar to IT skills but 18 persons of them were not. Versus them in the persons who hadn't the special unit (computer course) 24 persons were familiar to IT and 30 persons were not.

Why teach computer security to medical students?

Ana Ferreira, Ricardo Cruz-Correia,
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CENTER FOR RESEARCH IN HEALTH INFORMATION
SYSTEMS AND TECHNOLOGIES

Introduction

- Electronic Medical Records
  - integrate heterogeneous patient information
  - support healthcare practice

- Barriers
  - information security

Need for young doctors to better understand and use security

Objective

- To investigate attitudes and awareness of 1st year Medical students towards EPR security

- Do medical informatics' lectures help?
- Do they influence their attitudes?
- How can they be improved?

Methods

- Anonym questionnaire applied before and after the lectures in the academic year of 2003/2004
- The questionnaires introduced security scenarios for the students to comment
- 4 questions were answered

Results (1)

The first scenario described a breach of patient privacy to an EPR by one of the students' colleagues

Q1.A – Is the described scenario a security breach?

	Before the lectures % (n)	After the lectures % (n)
Answered questionnaires	***(238)***	***(222)***
Valid answers	*98 (232)*	*98 (217)*
Yes	**100 (232)**	**100 (217)**

Results (2)

Q1.B – What would you do if you found out about this security breach?

	Before the lectures % (n)	After the lectures % (n)
Valid answers	*61 (144)*	*60 (132)*
Reason with the colleague	**54 (77)**	**44 (58)**
Inform responsible authorities	**40 (58)**	**50 (66)**
Others	**6 (9)**	**6 (8)**

Results (3)

Q2 – Would you change your attitude if you found out that the colleague shared his password with a friend and that friend breached patient confidentiality?

	Before the lectures % (n)	After the lectures % (n)
Valid answers	*62 (148)*	*62 (138)*
No	**74 (109)**	**83 (115)**
Yes	**26 (39)**	**17 (23)**

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Results (4)

Q3 – Do you think that more sensitive information (HIV, Cancer) requires stronger security measures than other types of information?

	Before the lectures % (n)	After the lectures % (n)
Valid answers	*43 (103)*	*91 (204)*
No	**44 (91)**	**38 (77)**
Yes	**55 (112)**	**52 (127)**

Discussion

- After Security and Ethics' lectures, students:
  - feel more conscientious to report privacy breaches to responsible parties (Q1.B)
  - understand better what computer security is and how to behave in order to protect confidentiality of electronic information
  - consider indirect disclosure of sensitive information, such as with another person's password, a serious fault (Q2)
  - become more aware for the need of different protection levels of security depending on how sensitive information can be (Q3)

Conclusion

- We believe that the introduction of Information Security and Ethics early in the degree of the Medical course influences the awareness and attitudes of first year medical students towards computer security and EMR

- This can greatly influence the success of EMR integration whilst improving and fastening healthcare treatment

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Why Teach Computer Security to Medical Students?

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Abstract

The introduction of Electronic Medical Records (EMR) within the healthcare practice can be beneficial in order to integrate and centralize heterogeneous patient information. However, there are still some problems that hinder the successful use of EMR. The concern for patient privacy is one of them. The aim of this paper is to present the results of a study that assesses attitudes of 1st year medical students towards computer security and the EMR. An anonym questionnaire was given to the students at the beginning and at the end of the academic year of 2003/ 2004 for them to comment on several security related scenarios. 238 questionnaires were answered at the beginning of the year whilst 222 were answered at the end of the year. The students feel, at the end of the year, that they understand better what computer security is and how to protect patient privacy information. This shows that teaching computer security to medical students, the future users of EMR, can greatly influence the success of EMR integration and therefore improve and fasten healthcare treatment.

Keywords:

computer security; education, medical, undergraduate

Introduction

The introduction of Electronic Medical Records (EMR) within the healthcare practice allows for the integration of heterogeneous information that are usually scattered over different locations [1] [2]. However, there are some barriers that impede its successful integration in most healthcare practices [3] [4].

One specific barrier relates with the privacy and security of patient information [5]. The use of new information systems within healthcare stresses the need for young doctors to comprehend them from their conception so that they can be used in a beneficial way and support their future daily work. As such, all the feedback provided during their training into the medical profession is essential for the enhancement of those systems [6], moreover in terms of computer security.

The Biostatistics and Medical Informatics Department of Porto Faculty of Medicine teaches Ethics and Medical Informatics to 1st year medical students [7]. The later subject includes theoretical and practical lectures about Electronic Medical Records (EMR) and computer security.

This study aims to assess the opinions, attitudes and awareness of 1st year medical students towards computer security issues relating to EMR, and how these can affect the successful integration of EMR within the healthcare practice.

Methods

An anonym questionnaire was given to the students both at the beginning and again at the end of the academic year of 2003/2004. It was applied two times so that we could compare their attitudes before and after they had attended the Ethics and Medical Informatics' subjects.

The questionnaires introduced 3 scenarios for the students to comment. The first scenario described a breach of patient privacy to an EMR by one of their colleagues. There were two questions relating with this scenario:

- Q1.A – Is the described scenario a security breach?
- Q1.B – What would you do if you found out about this breach?
- The second scenario included additional information to the first scenario. It explained that the colleague in question had shared his password with a friend and that friend was the one to access patient private information, without him knowing it. The question related with this scenario was:
- Q2 – Would you change your attitude if you found out this new piece of information?

The third scenario introduced the issue of more sensitive information (e.g. HIV, Cancer results or even VIP related) and how this information must be protected. The question presented within the questionnaire was the following:

- Q3 – Do you think this kind of information requires stronger security measures than other types of information?

The answers to these questions were inserted into SPSS® and analysed separately.

Results

A total of 460 questionnaires were filled by the students. 52% (238) were answered before the lectures started whilst 48% (222) after the lectures finished. Table 1 shows the results obtained from the applied questionnaires.

Table 1 – Results obtained from the questionnaires

		Before the lectures % (n)	After the lectures % (n)
Answered questionnaires		*(238)*	*(222)*
Q1.A	*Valid answers*	*98 (232)*	*98 (217)*
	Yes	100 (232)	100 (217)
Q1.B	*Valid answers*	*61 (144)*	*60 (132)*
	Reason with	54 (77)	44 (58)
	Inform	40 (58)	50 (66)
	Others	6 (9)	6 (8)
Q2	*Valid answers*	*62 (148)*	*62 (138)*
	No	74 (109)	83 (115)
	Yes	26 (39)	17 (23)
Q3	*Valid answers*	*43 (103)*	*91 (204)*
	No	44 (91)	38 (77)
	Yes	55 (112)	62 (127)

For Q3, the main reason given by the students that felt no extra security measures were needed to access more sensitive information is that all security measures must be effective for all cases, independently of the patient or healthcare performed. The majority of the students that thought extra security measures were necessary agreed that this would provide for the protection of certain social groups from discrimination.

Conclusion

According to this study's results, after Medical Informatics and Ethics' lectures, students feel more conscientious to report privacy breaches to responsible parties (Q1.B). They understand better what computer security is and how to behave in order to protect confidentiality of electronic information. They consider indirect disclosure of sensitive information, such as with another person's password, a serious fault (Q2). Further, at the end of the year, students become more aware for the need of different protection levels of security depending on how sensitive information can be (Q3).

We believe that the introduction of Medical Informatics and Ethics early in the degree of the Medical course has an influence in the awareness and attitudes of first year medical students towards computer security and EMR. This can greatly influence the success of EMR integration whilst improving and fastening healthcare treatment.

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An e-Learning Experience in a Biomedical Research and Public Health Institute

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Medical Bioinformatics Department, Institute of Health "Carlos III"

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This paper evaluates the current state of educational activities in biomedical informatics, bioinformatics and convergent technologies from the Department of Medical Bioinformatics of the National Institute of Health "Carlos III". It raises the possibility of designing several didactic virtual activities. It establishes the key elements that define the structure and educational methodology necessary for the success of a virtual course. They highlight the importance of collaborative work, the need of the implementation of new methods of communication and the design of new learning activities and new evaluation criteria. It also establishes the need of an e-learning platform for distance on-line learning. The implementation of e-learning in the Institute of Health "Carlos III" has opened the possibility of adapting diverse courses traditionally taught face-to-face to be taught on line. Also new courses have been designed. Health management, research methodology, biosecurity, studies of epidemiological outbreaks, bioinformatics or biomedical informatics are some examples of the wide range of topics offered.

Keywords:

education, e-Learning, medical bioinformatics

Introduction

The Area of Biomedical Informatics (BIOTIC) was founded in 1998, as an answer to the increasing need of the Institute of Health Carlos III (ISCIII) to establish an expert team, with the mission of developing and researching new informatics tools to facilitate the use and understanding of new approaches to genomic based medicine. The ISCIII is a National Public Research Institution that provides scientific support to all the National Health System of Spain. One of its appointed tasks is to promote research in biomedicine and health sciences, being its main goal to develop and provide scientific and technical services to the National Health System and to society in general. In this respect, the BIOTIC team which is composed of biologists, chemists, pharmacists, informatics experts, statisticians and experts in education and e-learning is entrusted with the research and development of informatics tools that aid in the understanding and use of new approaches to genomics based medicine[1]. This multidisciplinary group also facilitates the knowledge of new technologies such as Nanotechnologies, Biotechnologies, Information Technologies and Cognitive Sciences (NBIC) and their convergence for the treatment of biomedical information and their application in research, clinical practice and public health [2].

The relevant role that BIOTIC plays in the research areas mentioned above has made it possible to develop and carry out an important educational and training activity. These programs address the training needs of different collectives such as personnel in hospitals, public health schools, research centers, scientific societies, universities, associations of health professionals, technological centers and national centers. Some of this activity is done through BIOTIC's participation in the Education Node of the National Institute of Bioinformatics (INB). This initiative funded by Genoma España, has as its main objective the training of bioinformaticians for their integration in genomics and proteomics research groups.

Methods

Researchers in the area of BIOTIC regularly attend courses and congresses related with bioinformatics, microarrays, genomics and health, biomedical informatics and convergent technologies to be up to date on their areas of specialty.

Courses developed by BIOTIC have been traditionally taught face-to-face. The teaching methodology implemented focuses on the analysis of the learning needs and the profile of the students and it depends on the characteristics of the program to be taught. Once the needs have been identified, the next steps are to design the learning contents and to define the criteria for performance as well as to prepare and/or adapt available resources (technical, human and material) to adequately carry out the specific educational program.

The instructional methods are mainly of two types: exposition of the information and exercises or practical activities with feedback. Practical activities apply theoretical concepts, which are determined by the learning objectives of the education program. The area of BIOTIC bases its work in three main axes:

- Technology and innovation: the new technologies are revolutionizing the research and education fields.
- Sustainability: trying to make new technologies to become part of the student's everyday work.
- Promote an enterprising scientific nature.

The key elements that define the teaching methodology carried out are based on the transfer of knowledge through [3]:

- Planning and design of the teaching program based on curricular models validated through scientific research.
- Evaluation of the students' previous knowledge and their expectations about the course.
- Use of the didactic methods that are most adequate for the objectives of each program.
- Application, through the available materials and tools, of the knowledge and skills obtained.
- Evaluation activities are carried out to see if the students have learnt the concepts.
- Evaluation of the teachers and the quality of the course.

In general, the lack of specialists and experts that can lead these processes, together with the lack of an economic, didactic, technical and management plan, can drive any program to its failure. With the objective of implementing this educational model, the ISCIII acquired a tele-educational platform (WebCT). At the same time the National School of Public Health of the Institute created the e-learning commission, of which BIOTIC is a member.[4]

The tele-education platform WebCT (Web Course Tools) has all the basic characteristics required for distance learning systems through networks. The WebCT enables knowledge management directed towards teaching online through the Internet and requires some minimum technical requirements, basically the same that are needed to connect to the Internet. The WebCT permits to establish interaction spaces through the communication tools that it offers (e-mail, chat, forum, shared blackboard, etc...). It also permits to define different roles and functions to the participants (teacher, student, technical administrator, etc.), the publication of learning contents, building of glossaries, evaluation tests or exams, design of individual and group activities, links to databases and digital libraries, among other resources.

Implementing virtual education demands previous training of the future on-line teachers both at the technological and didactic level. In response to this increasing interest, the area of Biomedical Informatics suggested and developed and now teaches a course for training online teachers. This is an alternative educational solution that also meets the strict scientific and academic requirements necessary to respond to the training needs of the professionals of the ISCIII. It was thought that it was important that the whole course be taught through the WebCT platform so that students (future online teachers) would experience themselves the advantages and disadvantages of e-learning. This way they could get the skills and abilities specifically needed for teaching online which include technological, didactic and curricular training. It was essential for the students to apply the acquired knowledge by designing an online course in their professional field based on a curricular perspective.

The teaching in virtual environments has to be established under pedagogical models that promote education processes through the implementation of communication techniques, creating spaces that make possible active, creative and critical participation of the agents involved.

Results

The results of the evaluation of the courses taught by the Area have been highly positive. The circle of centers and universities in which the researchers in BIOTIC teach is getting wider and some of these courses have been awarded with a "Mention of Quality".

One of the main achievements of the course recently taught by the Area of Biomedical Informatics about online training for the professionals of the ISCIII is the development of several courses or Masters related to the professional specialty of the students [5]. Most of the students worked in groups of 2 or 4 members.

Discussion and conclusion

It is important to approach e-learning education with an open mind for virtual environments and not with a face to face teaching mentality. Online teachers have to be familiar with both Information and Communication Technologies (ICT) and pedagogic strategies for virtual environments. They should be aware of the possibilities and limitations of these technologies in virtual environments. They should have knowledge of group work techniques adapted to the virtual environment and knowledge of the different learning theories applicable to virtual surroundings. It is important not to confuse means with the ends: the technology should be at the service of education and not the other way around.

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Instituto de Salud Carlos III

MINISTERIO DE SANIDAD Y CONSUMO

An e-Learning Experience in a Biomedical Research and Public Health Institute

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An e-Learning Experience in a Biomedical Research an Public Health Institute

Introduction

- The National Institute of Health Carlos III (ISCIII) provides scientific support to all the National Health System of Spain.
- The Area of Biomedical Informatics (BIOTIC) aims to develop new computational approaches for facilitating genomic based medicine.
- Research lines are: Biomedical Informatics, Bioinformatics and Microarrays and Convergent Technologies (NBIC) in health applications.
- BIOTIC carries out an intense teaching activity in its areas of specialization and it is involved in the e-learning program of the National School of Public Health of Spain.
- BIOTIC has developed and it is now teaching a virtual course on methodological and technological aspects of e-learning (the scientists of the BIOTIC Department had previously taken this course).
- They develop and teach virtual courses in their field of knowledge and specialization both at the national and the international level.

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Materials and Methods

- BIOTIC participates in educational programs of several national and international institutions, both public and private.
- The area is involved in the National Institute of Bioinformatics (INB), funded by "Genome Spain Foundation" through the Horizontal Training Node".
- The main objective of the INB is to contribute and to apply bioinformatics solutions to the development of projects in the fields of genomics and proteomics.
- BIOTIC has developed several courses to disseminate and train health professionals in Bioinformatics and other applications of Information Technologies in the Biomedical field (Figure 1). Traditionally these courses were taught "face to face".
- Nowadays BIOTIC is a member of the e-learning commission of the ISCIII.

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Materials and Methods

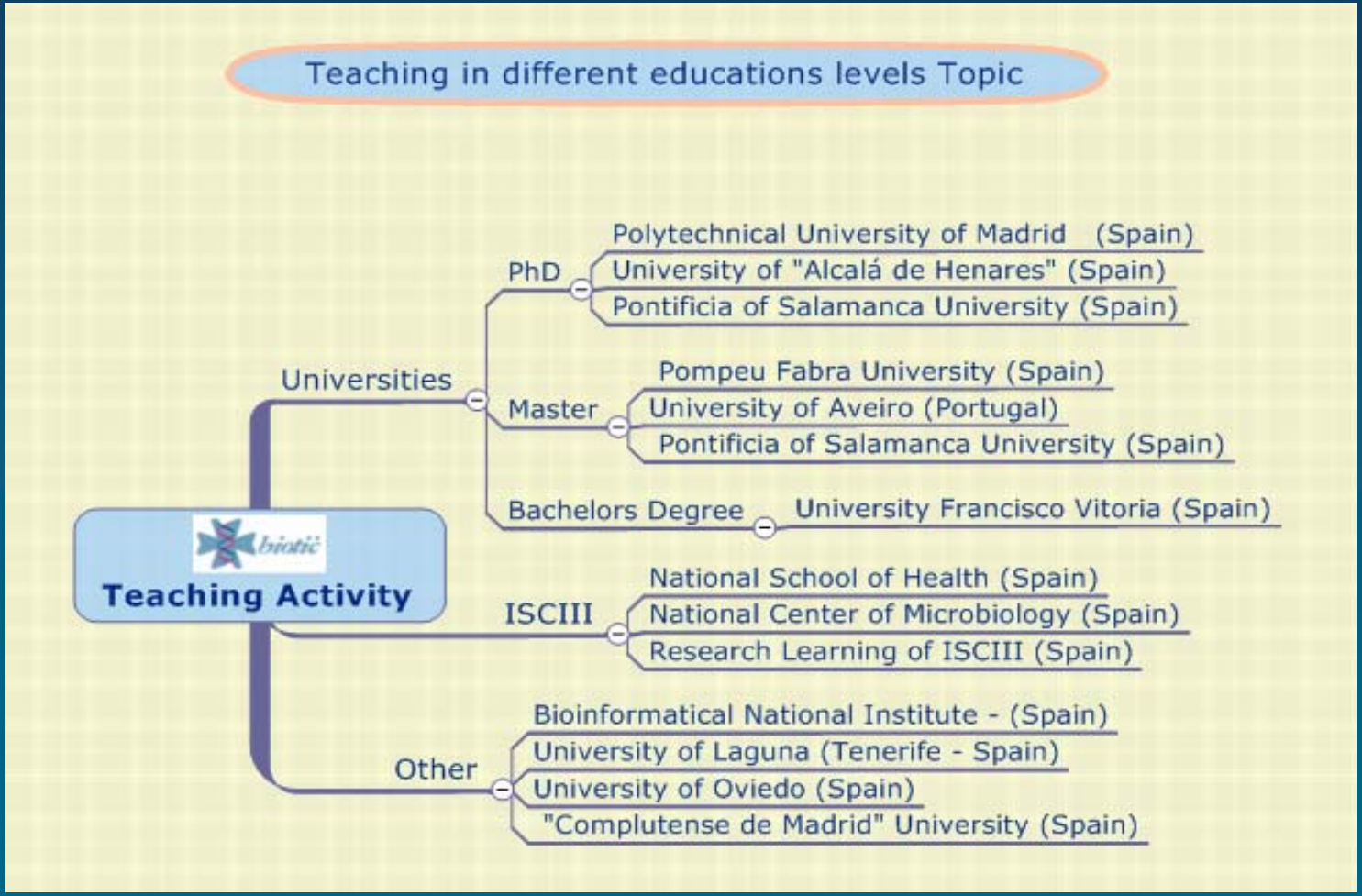

Figure 1

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Materials and Methods: Teaching Methodology

- The teaching methodology implemented has several steps:
  - analysis of the learning needs and the profile of the students,
  - design of the contents and definition of the evaluation criteria
  - preparation and/or adaptation of the available resources (technical, human and material).
- After careful assessment of pros and cons the ISCIII acquired a tele-educational platform (WebCT). There is a need to train future online teachers both at the technological, didactic and curricular level.
- BIOTIC developed a virtual course for training online teachers through the WebCT platform. The objectives were:
  - experience themselves the advantages and disadvantages of e-learning
  - learn how to use the WebCT tool
  - development of abilities, knowledge, an attitudes that online teachers should have
  - Application of the acquired knowledge by designing an online course in their professional field based on a curricular perspective (Figure 2).

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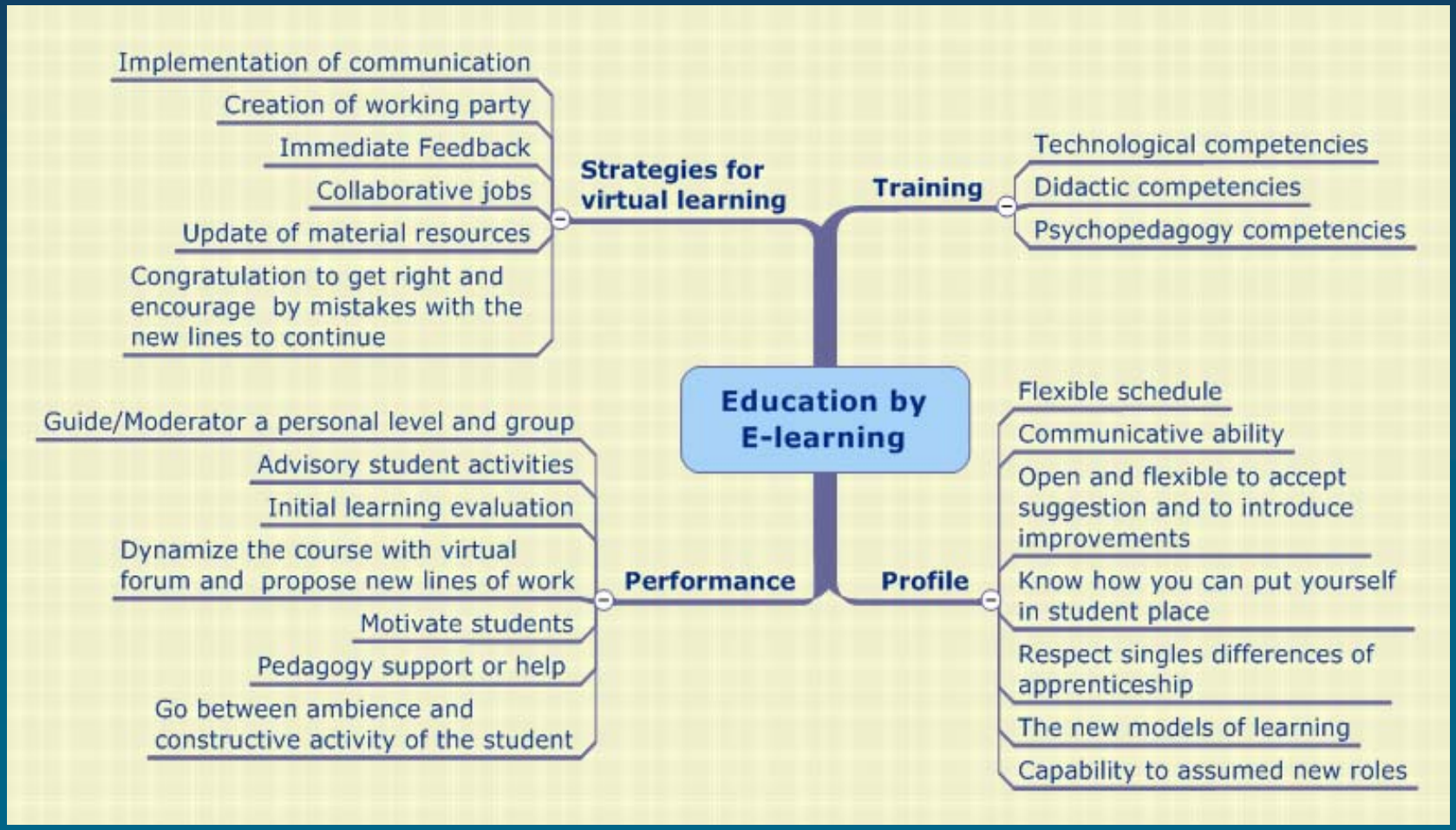
Materials and Methods: Knowledge in e-learning education



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Materials and Methods: Teaching Methodology

◇ Elements that define the teaching methodology online:

- The teaching experience of the teachers, as well as their knowledge of the subject they teach.
- Models validated through scientific research: analysis of the educational needs in the field of knowledge, the instructional resources and the method of teaching (face-to-face, virtual or mixed).
- The evaluation of the students' previous knowledge and their expectations about the course.
- Activities that encourage students to actively participate should be designed with the conviction that the student is the first agent of its own learning.
- Continuous update of the learning contents.

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Materials and Methods: Teaching Methodology

◇ Elements that define the teaching methodology online (cont):

- The practical activities are carried out through computers connected in a network.
- In some cases students go the microarray laboratory to acquire their knowledge "in situ".
- Evaluation activities such as exams and/or practical exercises are carried out to check that the students have learnt the concepts.
- Evaluation of the teachers and in general of the quality of the course

An e-Learning Experience in a Biomedical Research an Public Health Institute

Results

- The results of the evaluation of the courses taught by BIOTIC have been highly positive
- The circle of centers and universities in which researchers at BIOTIC teach is getting wider and some of these courses have been awarded with a "Mention of Quality"
- One of the achievements of the course online taught by BIOTIC is the development and or adaptation to the WebCT platform of several courses or Masters´ modules related to the professional specialty of the students :
  - Master in Health Administration (MASe) (semi-online)
  - Expert in Health Research Methodology (online)
  - Operation of the Level 3 (P3) Biosecurity Installations in the National Center for Microbiology (semi-online)
  - Field Epidemiology: Study of outbreaks (online)

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Results

◇ Researchers in BIOTIC have designed the following courses:

- Integration of Protein Classical Biochemistry with New Technologies (online)
- Introduction to Bioinformatics and Proteins and Nucleic Acids Sequence Analysis (online)
- Introduction to Biostatistics in Biomedical Informatics (online)

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Conclusions

- It is important to approach e-learning with an open mind
- Online teachers have to be familiar with both Information and Communication Technologies (ICT) and pedagogic strategies for virtual environments
- Be aware of the possibilities and limitations of virtual environments
- Knowledge of the different learning theories
- Knowledge of group work technique adapted to the virtual environment
- Its important not to confuse means with the ends. Technology should be at the service of education

An e-Learning Experience in a Biomedical Research an Public Health Institute

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Reorganization of Japanese Textbooks for Nursing Informatics

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Abstract

In order to reorganize Japanese textbooks for nursing informatics, we compared the contents in three recent Japanese textbooks for students of nursing, nurse managers and healthcare information technologists with those in the latest American textbook. The American textbook had twenty or seventy times as many items as corresponding contents to the Japanese textbooks. The results indicated the necessity of a considerable improvement in Japanese textbooks of nursing informatics for nursing managers.

Keywords:

nursing informatics, textbook, education

Introduction

The Japanese government expects that national healthcare costs will rise dramatically in the future. New strategy in 2006 recommended that maximizing IT structural reform capabilities will be essential in resolving these issues. The Ministry of Health, Labour and Welfare actively promoted comprehensive and effective computerization throughout the medical, healthcare, nursing and social welfare fields. There was no certification program for informatics nurses in Japan. However reorganization of Japanese textbooks for nursing informatics is necessary to train Japanese nurse informatists as soon as possible.

Methods

We used three Japanese textbooks published in 2004 for this comparison.

The first one was the fourth edition of an introduction to nursing informatics for students (TBI).

The second one dealt with health information management for nurse managers (TBM).

The third one showed the way to implement and update clinical information systems for healthcare ITs (TBH).

Some nurses applied to take the certification examination for healthcare information technologists, and our previous

study proved that the certification requirements for healthcare ITs were similar to those for informatics nurses.

We regarded the American textbook, Saba's fourth edition[1] (TBS), as the latest standard work, because it was revised in 2006. We compared the index of each textbook with that of the American textbook.

Results

All Japanese textbooks had an English index. TBS had over 2000 items in the index. However, the Japanese textbook had few English items. In the Japanese index, a total of 492 items were found in TBI, and 347 in TBM. There were 662 items in TBH (Figure 1). All Japanese textbooks were found to have fewer contents.

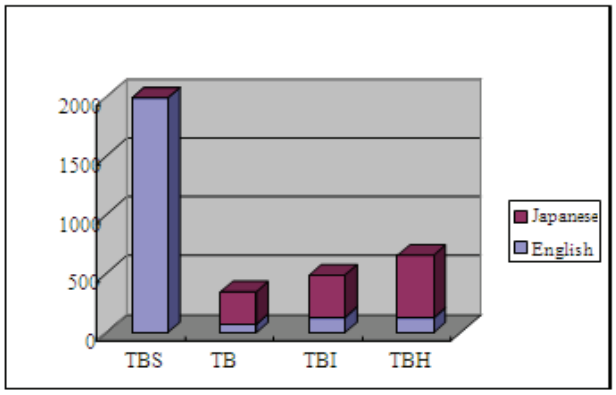

Figure 1- Total items in index

113 items in TBM were the same as those in TBS, while TBI had thirty four corresponding items and TBH had twenty nine items (Figure 2). TBM had more corresponding items than the other Japanese textbook surveyed

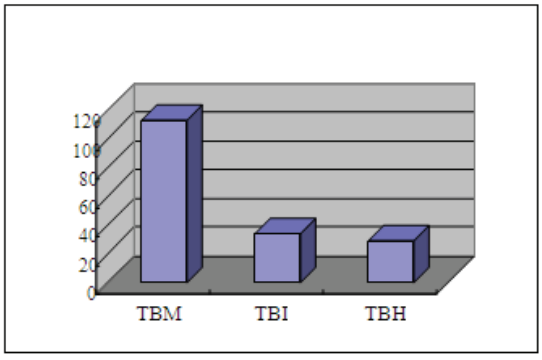

Figure 2- Items corresponding with TBS

Fifty two items in TBI and in TBH were the same as those in TBM (Figure 3). TBM had more corresponding items with other Japanese textbooks than TBS.

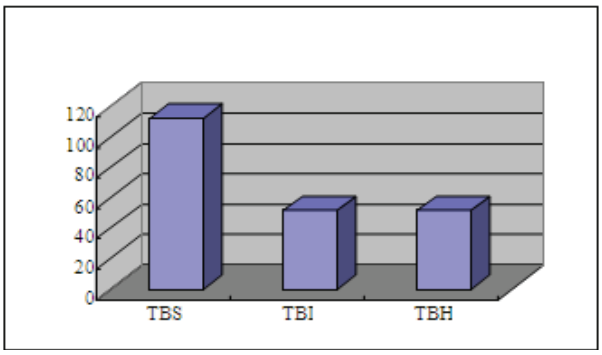

Figure 3- Items corresponding with TBM

Items found in only one textbook were prominent. Sixty seven items were found in only two textbooks, and thirty items were found in only three textbooks.

Only 16 items were common to all Japanese textbooks, and could be classified into two groups: 9 items were related to data sharing and standardization, and 7 items were related to electronic health records (Table 1).

Table 1- Items found in all Japanese textbooks

Group 1
Data sharing, ICNP, ICN, HL7, ISO, NIC, SNOMED, EBM, Standard Privacy Policies
Group 2
EHR, Nursing record, Specifications, Informed consent, Information, Security, Data warehouse

Discussion

Japanese textbooks were not standardized. Each textbook had many independent items.

Using Saba's textbook as a reference, all Japanese textbooks were found to have fewer corresponding contents. Most of the contents in Japanese textbook did not correspond with those in the American certification examination for informatics nurses.

The Ministry of Health, Labour and Welfare is promoting the implementation of electronic health recode in every hospital. However no educational program for nursing informatics specialists existed in Japan. Many nursing managers are confronted with issues related to the effective use of electronic health records. The finding that TBM had more corresponding items with TBS than with the other Japanese textbooks surveyed illustrated the need for increased information and knowledge in nursing informatics among Japanese nursing managers.

Conclusion

Japanese textbooks should be standardized and the content for nursing managers should be improved.

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Reorganization of Japanese Textbooks for Nursing Informatics

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Introduction

The Japanese government expects that national healthcare costs will rise dramatically in the future. New strategy in 2006 recommended that maximizing IT structural reform capabilities will be essential in resolving these issues. The Ministry of Health, Labour and Welfare actively promoted comprehensive and effective computerization throughout the medical, healthcare, nursing and social welfare fields. There was no certification program for informatics nurses in Japan. However reorganization of Japanese textbooks for nursing informatics (NI) is necessary to train Japanese nurse informatists as soon as possible.

New IT Reform Strategy in Japan

Priority Policy Program 2006

July 26, 2006

IT Strategic Headquarters

1. The Pursuit of IT Structural Reform Capabilities

1.1 Structural reform of healthcare through IT
— Full online processing of all medical insurance claims and lifetime self healthcare management —

<Basic Aspects>

Since the adoption of the e-Japan Strategy II, priority measures have been taken for the computerization of healthcare as one of seven leading areas, but computerization remains at low levels. With estimations showing the rapid increase in national healthcare expenditure resulting from our aging society in the future and so on, it is with urgency that we must: prevent illnesses, improve medical quality and increase medical efficiency, streamline healthcare costs and rectify healthcare disparity by utilizing IT's structural reform capabilities to its fullest.

First, we must effectively utilize the health information collected and accumulated from medical records, health check results, and medical insurance claim data, etc. with computerization, to prevent illnesses and raise the quality and efficiency of medical care. Possible policies would be lifetime self healthcare management, nationwide statistical and epidemiological analysis with personal information protection such as ensuring anonymity of health information, and medical cooperation among institutions by utilizing IT. We must actively work toward realizing these measures by developing a standard for computerization, reducing costs to implement medical information systems, and creating incentives to encourage medical cooperation using IT.

Secondly, there is a need to streamline healthcare costs, by cutting healthcare insurance administration costs through promoting medical computerization. For example, complex medical fee calculations and processing of medical insurance claims mostly on paper lead to higher costs for healthcare insurance administration. Therefore, we have paved the way, in principle, to oblige online processing of medical insurance claims from medical institutions to

http://www.kantei.go.jp/foreign/policy/it/Program2006.pdf

Old style teaching items in Japanese nursing schools

Item on IT training courses	Rate of schools teaching each item (%)	
	Nakano's research	Ishigaki's research
How to operate a computer	83.5	57.4
Word processor	65.8	47.2
Spreadsheets	64.6	47.2
Computer components	64.2	—

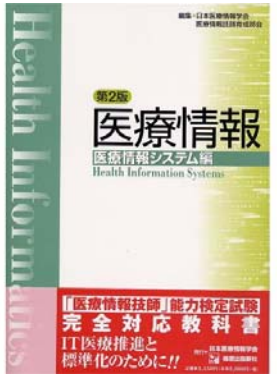
1) Nakano et al.: Current State and Problems of Nursing Informatics Education in Japanese Nursing School, Japanese Journal of Nursing Education 39(1): 61-67, 1998.
2) Ishigaki et al.: Education of Nursing Informatics – the Present state and future, 18th JCMI Proceedings, 76, 1998.

Methods

New Japanese textbooks for NI

1. The textbook (fourth edition) of an introduction to nursing informatics for students (TBI).

2. The textbook for health information management for nurse managers (TBM).



3. The textbook for a way to implement and update clinical information systems for healthcare ITs (TBH).

We compared the index of each textbook with that of the fourth edition Saba's textbook (TBS).

Sample index of Japanese Textbook

索 引

用語・人名

アルファベット

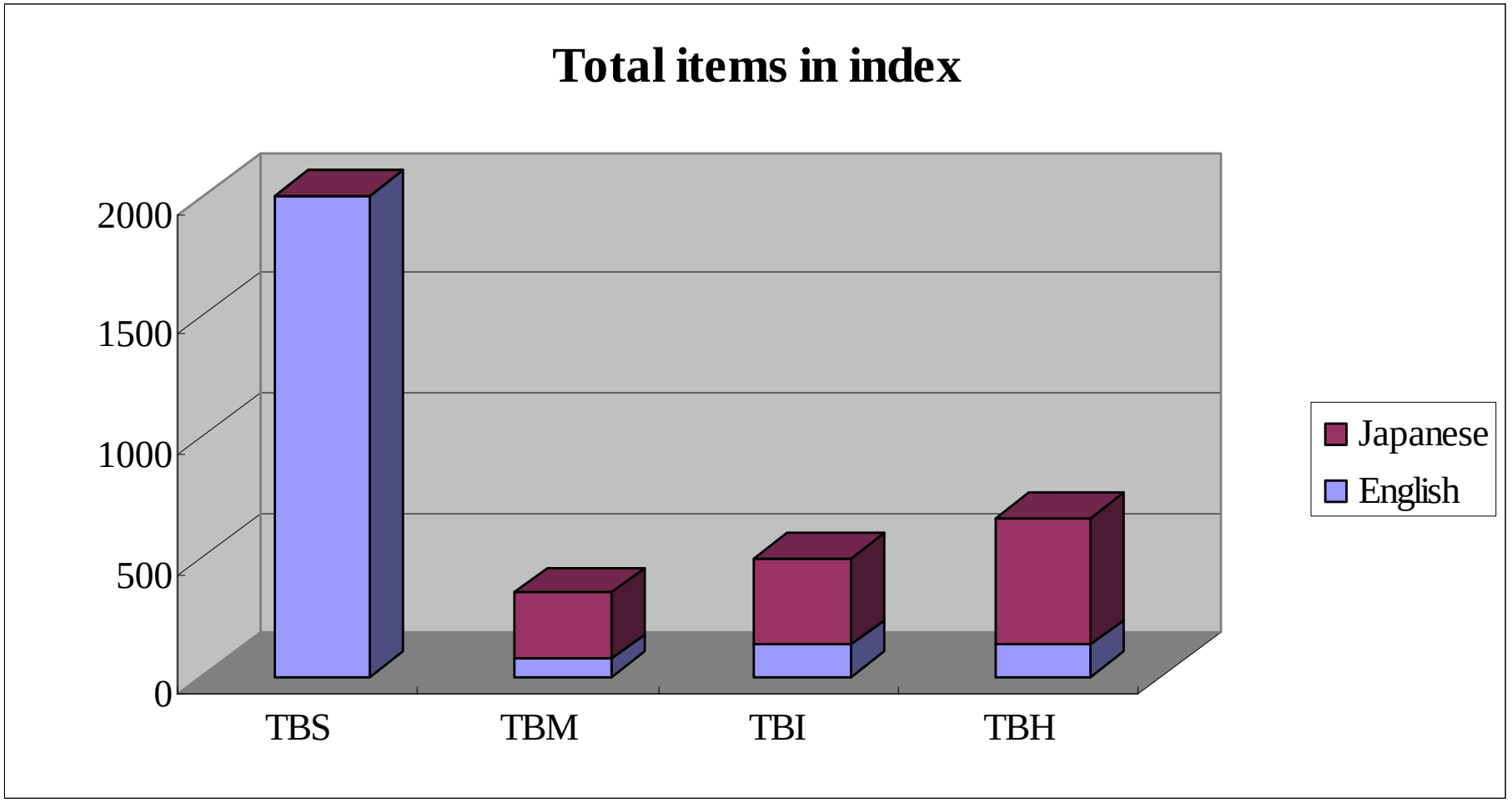
あ 行

か 行

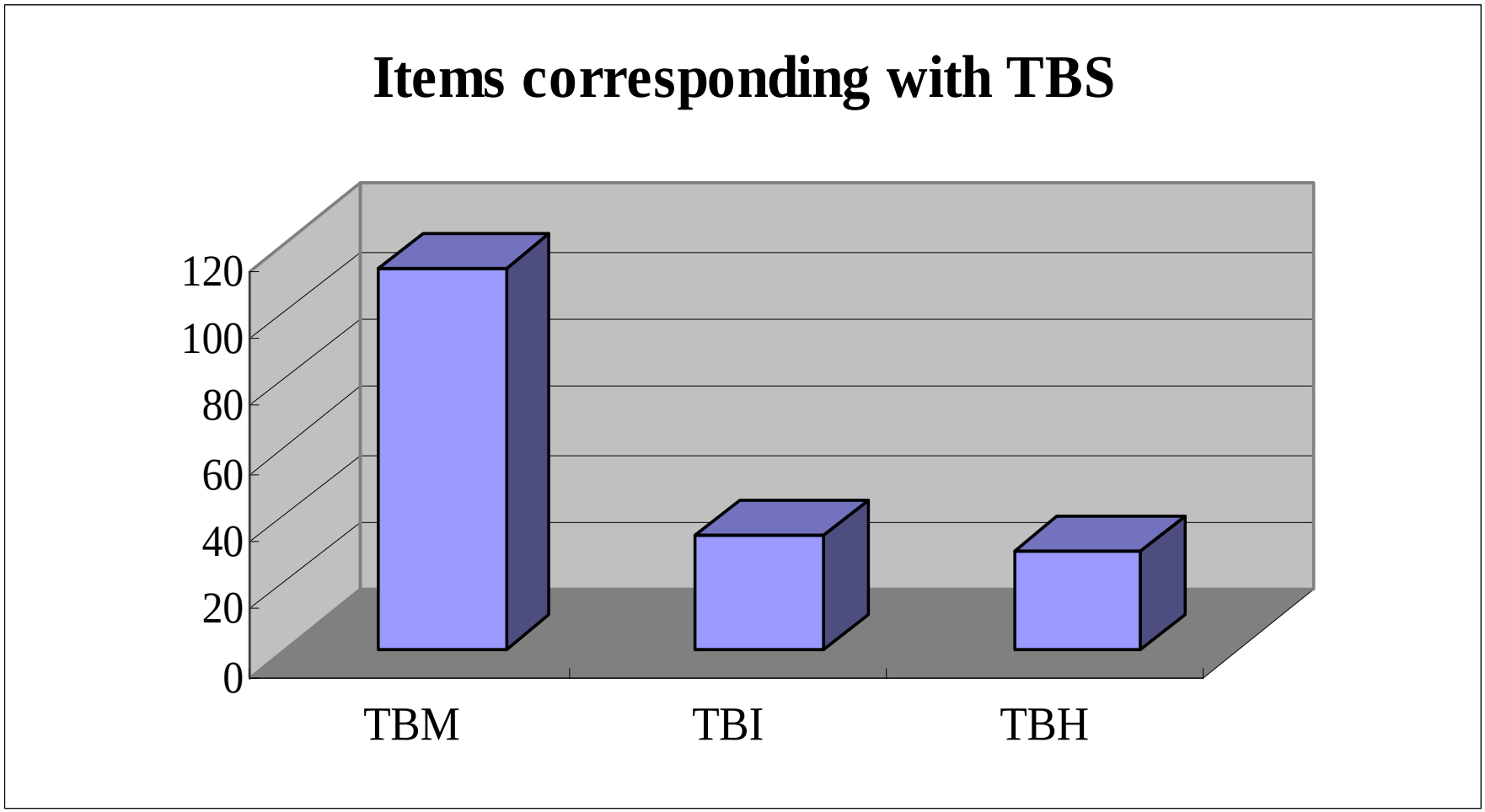
さ 行

た 行

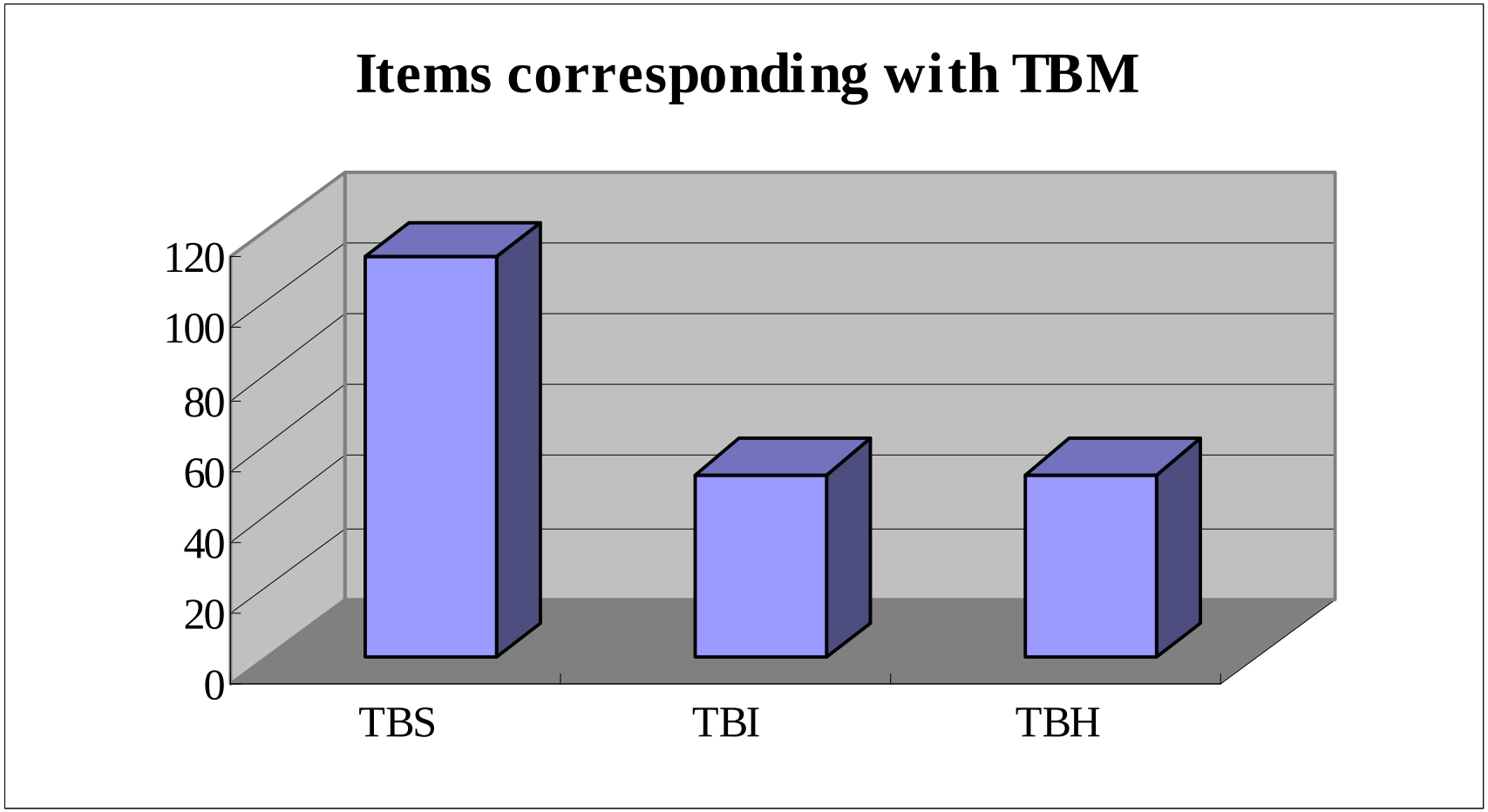
Results 1


Total items in index
2000
1500
1000
500
0
TBS
TBM
TBI
TBH
Japanese
English

Result 2



Result 3



Result 4

Corresponding items in each textbook

All textbook	16 items
Only 3 textbooks	30 items
Only 2 textbooks	67 items

Result 5

Items found in all Japanese textbook

Group 1

Data sharing, ICNP, ICN, HL7, ISO, NIC, SNOMED, EBM, Standard Privacy Policies

Group 2

EHR, Nursing record, Specifications , Informed consent, Information, Security, Data warehouse

Discussion and Conclusion

Using Saba's textbook as a reference, all Japanese textbooks were found to have fewer corresponding contents. Most of the contents in Japanese textbooks did not correspond with those in the American certification examination for informatics nurses

Many nursing managers are confronted with issues related to the effective use of electronic health records. The finding that TBM had more corresponding items with TBS than with the other Japanese textbooks surveyed illustrated the need for increased information and knowledge in nursing informatics among Japanese nursing managers.

Japanese textbooks should be standardized and the content for nursing managers should be improved.

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Building Health Informatics Capacity - Educating the Workforce

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Abstract

The master program in health informatics at Aalborg University in Denmark has existed in more than 10 years and more than 140 students have graduated from the program at the time of the survey. A questionnaire survey was conducted to get an overview of the student's motives for entering the program, and get their opinion about being a student in the program, and what subjects they felt contributed to their further career. The survey also formed a basis for drawing job profiles. The majority of the graduates changed job once or more after graduation, but they stayed within health informatics. The survey has contributed substantially to the revision of the curriculum.

Keywords:

medical informatics, education, employment, career mobility

Introduction

The health informatics master's program at Aalborg University was started in 1994 and the first masters earned their degree in 1998. The main goal of the program is to enable the students to bridge the gap between health professionals and IT professionals.

To be admitted in the program the student must hold a masters degree or a B.Sc. in a health science and after three years of study the student has earned 90 ECTS points and will receive a Master's Degree in Health Informatics. The program consist of 26 ECTS of traditional course work and 64 ECTS of problem-based project work. The subjects in the courses are organized in four tracks: 1. Database theory, network theory and decision support. 2. System and context, demand/system specifications, user interaction. 3. Project management, assessment/ evaluation, and organizational change. 4. Methodologies for data acquisition, quantitative/qualitative analysis. The students gather four times a year at weekend workshops for intensive lectures, laboratory exercises and oral discussions. The rest of the time the backbone of communication is a conference system which runs on a server at the university [1,2].

In order to evaluate how the students contribute to the health informatics capacity, and to monitor how the program is able to prepare the students for their future job we have investigated the student's job situation after graduation. The survey was done in 2004 where 147 students had graduated from the program.

Method

A cover letter pointing to a web-based questionnaire containing 45 questions was sent to the 147 students who had graduated from the program. The questionnaires were analyzed anonymously. Descriptive statistics were applied to the standardized answers. There were very few free text answers which were summarized by the authors.

Results

The response rate was 69%. 80% of the students had more than 10 years of work experience when they entered the program. 70% of the students indicated that one of the reasons for entering the program was a desire for personal development. 58 % further indicated that they wanted to achieve a new job profile and 38% saw an opportunity to advance their career. 51% also indicated that they wanted to gain insight in the use of IT systems. Only 17% indicated that higher salary was a driving factor for entering the program.

Table 1 - Employment before and after graduation

Employment	Before	After	Migration
Hospital - clinic/laboratory	36	16	-20
Nursing school	11	11	0
Regional institution/administration	5	10	5
Hospital - administration	11	9	-2
University or research institution	3	8	5
Hardware/software industry	3	8	5
Hospital IT-department	10	7	-3
Other	7	6	-1
Ministry or government institution	1	4	3
Municipal institution	3	4	1
Other public institution	2	3	1
Other health informatics industry	0	2	2
Consultancy	1	2	1
Homecare	4	1	-3
Pharmaceutical industry	0	1	1
Own company	1	0	-1
Missing	3	9	6
total	101	101	

The students were also asked where they were employed before they entered the program and where they were

employed three month or more after graduation. The result is shown in table 1.

They were asked to describe their current work function on which they spend more than 10% of their time, and the result is shown in table 2. Each could choose one or more function.

Table 2 - Work function after graduation

57	Implementation of it-systems	13	Decision support
47	Education	13	Multimedia, internet, intranet
45	Project management	12	* for municipality health care/administration
40	Quality assurance	10	Telemedicin
35	Consultancy	8	Research and development
33	* for hospitals	7	* for education
29	Management/organisation	4	Medical imageanalysis
20	General administrative tasks	3	* for public health
13	* for primary care	3	Pervasive computing

* = Development/purchase of systems for ….

All the masters were employed or had set up their own business at the time of the survey. The raise in income after the job they had during their studies was significant.

At the question: "If you were in the situation to day when you entered the program would you then choose to study health informatics in this program again?" 77% responded yes, 7% says no and 16% were not quite settled in their view.

Discussion

Much has been written about various university graduate programs in health informatics, but only little has been written about the outcomes for the graduates of the programs. [3-6].

The dominant motivation for entering the program was the desire to achieve personal development. It is naturally very difficult to evaluate such an outcome, but comparing the very high satisfaction with the program in general, we assume that this goal has been achieved by the graduates. The second most common motivation was to achieve a new job profile. 58% of the graduates indicated this, and as 50 % had changed job one, two or three times since they graduated it is very likely that they achieved new job profiles. This is supported by the results regarding job migration.

In the contrary to the programs at Heidelberg University and University of Utah the majority (76%) of the graduates from Aalborg University work with health informatics after graduation and 92% remain within the health care sector. An immediate explanation is that nearly all the students at the point of entering the program already have a job in health care.

At Heidelberg University more than half of the graduates worked outside of medical informatics, which in their opinion underlined the quality of the informatics oriented part of education, because the medical informatics graduate can compete with those from general computer science. We find it rather supporting for the quality of our program that the graduates are able to find jobs within health informatics – the area in which they are specialized to function in and that they can contribute with high level knowledge about very complex problems.

Conclusion

The majority of the graduates from the master program in health informatics at Aalborg University participated in the survey of their background and motivation for entering the program, and which activities had contributed to their further career.

The majority of the students enter the program with a Bachelor degree in Nursing or Medical Laboratory Technology. They change their job once or more after graduation they migrate from employment in clinical settings to job in the administration, universities or research institutions and industry. None are unemployed, and they stay within health informatics working with implementation of it-systems, education, and project management. They were practically all very satisfied or very satisfied with their education, and they would choose the same program if they were in that situation to day.

The survey has been essential to the revision of the curriculum.

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AALBORG UNIVERSITY

Building health informatics capacity - educating the workforce

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Virtual Centre for Health Informatics
Aalborg University
Denmark

Master programme in Health Informatics at Aalborg University

- Started in 1994
- 3 year programme – 30 ECTS / year (part time study)
- 243 masters have earned their degree
- 35 students admitted every year
- Drop out < 20% mainly during 1. year
- 100 active students at any time
- 53% Nurses, 13% Lab techn., 11% MD, 23% other Bachelor degrees
- Age of the students 28 – 50 years
- Recruiting from all Scandinavia

4 key characteristics of the program

- Problem based
  (interdisciplinary)
- Project organised
  50% project work
  50% course work
- Team work
- Distance and
  face to face learning

Problem-based project work

Each year focus on health informatics from different perspectives:

1. year: an analytical perspective
2. year: a design perspective
3. year: a scientific research perspective

The project work can be divided into 4 phases

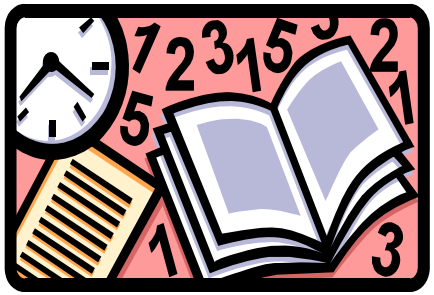
1. Formulation of the problem
2. Investigation research
3. Production writing/editing process
4. Evaluation process

Students bring their own problems – faculty does not suggest problems

Coursework

A course is a systematic representation of a discipline

The purpose is to provide the student with sufficient disciplinary knowledge to cope with interdisciplinary problems



Courses are introduced at the weekend seminars and the students guided on a conference system (FirstClass)

Organization of the courses

The courses are organized in four tracks, and within each track there is a learning progression through the three years

	From data to decision	System and context	Technology change	Methods for data collection and analysis
3.Yr	Systems for decision support	User interaction with health information systems	Technical and organizational change	Quantitative and qualitative analytical methods
2.Yr	Advanced health information management	Health information system modeling	Technology assessment and evaluation of	Descriptive quantitative and qualitative methods
1.Yr	Basic data collection, -transport, -storage and decision making	Health information system's requirements	Organizations and project management	Methodology for project work and basic literature search

Evaluating the capacity build

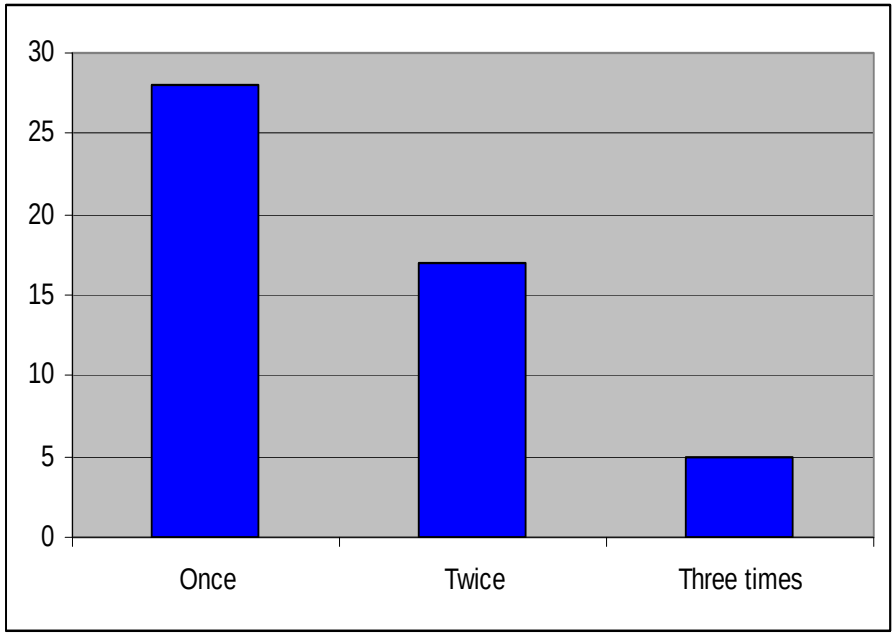
In order to evaluate how the students contribute to the health informatics capacity, and to monitor how the program is able to prepare the students for their future job we have investigated the student's job situation after graduation. The survey was done in 2004.

A cover letter pointing to a web-based questionnaire containing 45 questions was sent to the 147 students who had graduated from the program. 69% responded. The questionnaires were analyzed anonymously. Descriptive statistics were applied to the standardized answers.

Results: Change of jobs

76% of the graduates are working within health informatics. 8% are working with IT outside the health area, mainly IT- or pharmaceutical industry. 15% do not work with IT at all, the majority is either working in clinical positions (nurse or physician) or in managerial positions within the hospital.

Half of the students change job after graduation. The figure shows how many students have changed their job once, twice or three times since they graduated.



Results: Employment before and after graduation

The students were asked where they were employed before they entered the program and where they were employed three month or more after graduation.

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Hospital - administration	11	9	-2
University or research institution	3	8	5
Hardware/software industry	3	8	5
Hospital IT-department	10	7	-3
Other	7	6	-1
Ministry or government institution	1	4	3
Municipal institution	3	4	1
Other public institution	2	3	1
Other health informatics industry	0	2	2
Consultancy	1	2	1
Homecare	4	1	-3
Pharmaceutical industry	0	1	1
Own company	1	0	-1
Missing	3	9	6
total	101	101	

Results: Work function

Work function	
Implementation of it-systems	57
Education	47
Project management	45
Quality assurance	40
Consultancy	35
* for hospitals	33
Management/organisation	29
General administrative tasks	20
* for primary care	13
Decision support	13
Multimedia, internet, intranet	13
* for municipality health care/administration	12
Telemedicin	10
Research and development	8
* for education	7
Medical image analysis	4
* for public health	3
Pervasive computing	3

There are many different work tasks fulfilled by the masters, and the majority fulfills more than one task in their job. The masters were asked to check as many as necessary to describe their current work function on which they spend more than 10% of their time, and the result is shown in the table.

* = Development/purchase of systems for ….

Discussion

In the contrary to the programs at Heidelberg University [3] and University of Utah [5] the majority (76%) of the graduates from Aalborg University work with health informatics after graduation and 92% remain within the health care sector. An immediate explanation is that nearly all the students at the point of entering the program already have a job in health care.

At Heidelberg University more than half of the graduates worked outside of medical informatics, which in their opinion underlined the quality of the informatics oriented part of education, because the medical informatics graduate can compete with those from general computer science [3]. We find it rather supporting for the quality of our program that the graduates are able to find jobs within health informatics – the area in which they are specialized to function in and that they can contribute with high level knowledge about very complex problems.

The survey has been essential to further development of the curriculum.

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[1] IMIA Working Group on Health and Medical Informatics Education. IMIA Database on Health and Medical Infor-matics Education Institutions, Programs and Courses. Internet Web Page . 26-11-2006. 26-11-2006.

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Readiness and Necessity for Self-directed Learning Among Nursing Students in Japan

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Abstract and objective

In nursing education, self-directed learning is important for both nursing students and nurses [1]. The objective of this study was to understand information-related learning behaviors in order to establish a self-directed learning curriculum for nurses. In addition, the information-use environment for clinical nurses was also considered. Nursing students were surveyed using a questionnaire, and a clinical nurse was interviewed. More than half of the nursing students were dissatisfied with regard to document retrieval. Difficulties between the conformability of the search terms and the search results were a concern. Regarding the information-use environment and information-seeking behaviors, many students requested that the library service be attended. Some suggested that training for performing scholarly information searches specializing in the nursing field and for evaluating search results would be useful.

Keywords:

students, nursing; education, nursing; education, professional; curriculum; information storage and retrieval

Methods

Survey for nursing students

Forty-nine students completed a questionnaire survey regarding information retrieval and the information needs of nursing students.

Interview with a clinical nurse

We interviewed a nurse with more than 20 years of clinical nursing experience. The interview included questions regarding her information needs and the information-use environment in clinical settings. The results were analyzed using a qualitative method.

Results

Survey for nursing students

More than half of the nursing students were dissatisfied with the information-use environment and the information retrieval process. Specifically, they found the selection of keywords for document retrieval to be difficult and the system to be unadaptable.

Interview with a clinical nurse

Information-use environment

The nurse used Internet search engines, e-mail, and the university library at her office and at home and was proactive with regard to seeking information. However, she reported that her colleagues had various difficulties.

Information needs in clinical settings

Information regarding medicine was the most frequent topic of her information searches. Original documents were the most difficult items to obtain.

Conclusion

Nursing students and clinical nurses are rather uncertain with regard to how they should seek needed information. Their difficulties were exacerbated by the diversity of their information needs, time restrictions, and the information-use environment. We think that the creation of a self-directed learning curriculum for nursing students is needed in Japan.

Reference

[1] E,O'Shea. Self-directed learning in nurse education: a review of the literature. Journal of Advanced in Nursing 2003:43(1):62-70.

Readiness and Necessity for Self-directed Learning among Nursing Student in Japan

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Backgound

- In nursing education, self-directed learning is important for both nursing students and nurses [1].

Objective

- The objective of this study was to understand information-related learning behaviors in order to establish a self-directed learning curriculum for nurses.
- In addition, the information-use environment for clinical nurses was also considered.

Method(1)

- Survey for nursing students
  - Forty-nine students completed a questionnaire survey regarding information retrieval and the information needs of nursing students.

Method(2)

- Interview with a clinical nurse
  - We interviewed a nurse with more than 20 years of clinical nursing experience.
  - The interview included questions regarding her information needs and the information-use environment in clinical settings.
  - The results were analyzed using a qualitative method.

Result(1)

- Survey for nursing students
  - More than half of the nursing students were dissatisfied with the information-use environment and the information retrieval process.
  - Specifically, they found the selection of keywords for document retrieval to be difficult and the system to be unadaptable.

Result(2-1)

- Interview with a clinical nurse
  - Information-use environment
    - The nurse used Internet search engines, e-mail, and the university library at her office and at home and was proactive with regard to seeking information.
    - However, she reported that her colleagues had various difficulties.

Result(2-2)

- Interview with a clinical nurse
  - Information needs in clinical settings
    - Information regarding medicine was the most frequent topic of her information searches.
    - Original documents were the most difficult items to obtain.

Conclusion(1)

- Nursing students and clinical nurses are rather uncertain with regard to how they should seek needed information.
- Their difficulties were exacerbated by the diversity of their information needs, time restrictions, and the information-use environment.

Conclusion(2)

- We think that the creation of a self-directed learning curriculum for nursing students is needed in Japan.

References

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Thank you !

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A Web-based Data Management System for Ubiquitous Bio-signal Data Monitoring

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Abstract

For the successful ubiquitous healthcare, the biological signal data should be easily assessed and properly maintained. This paper describes a system for the web-based data management. It consists of a device interface, an HL7 gateway, a data upload control, a central repository, and a web server. We use MFER standard for encoding medical waveforms and HL7 for transferring data. For the easy assessment and management of data, the user-specific web services were designed.

Keywords:

computer systems, system integration, internet, MFER

Introduction

Recent advances in the ubiquitous computing technology make it possible to measure bio-signal data anywhere, anytime. For the early diagnosis, treatment, and prevention, the measured data should be easily accessed and properly maintained. This paper demonstrates a web-based data management system which encodes the bio-signal data using MFER standard, wraps them in HL7 messages, transfer the messages, and stores them in the central database.

The Ubiquitous House (U-house) Project is a long-term project funded by Korean Science and Engineering Foundation. The goal of the project is to develop ubiquitous telemonitoring systems, bio-sensors, and a central database system. All of the bio–signals such as EKG and EEG are supposed to be monitored unconsciously during the daily life in the U-house. In order to collect the measured data from the U-house regardless of various monitoring devices, we have developed a web-based data management system.

Methods

Currently six types of biological signal data (ECG, blood pressure, glucose, temperature, weight) are monitored and collected from the U-house. The web-based data management system consists of the five components.

Device interface: For the communication of the waveform data (ECG, EEG etc.), we use the MFER[1] (Medical waveform description Format Encoding Rule) standard specialized in encoding medical waveforms. We developed MFER DLLs to support fast and easy implement for other developers.

HL7 gateway: After receiving waveform data, the HL7 gateway automatically generates HL7 (Health Level 7) messages. An HL7 message contains the patient information and the metadata for the waveform. HL7 gateway sends the messages to the central repository.

Data upload control: The role of the web-based data upload control is to provide a robust method for uploading waveform data. We designed a client-side ActiveX control which consists of the three key components: an MFER parser, a file compressor, and a transfer module. The MFER parser gets the header information of the encoded files. Then it hands over the information to the file compressor and the transfer module. Files are compressed by the file compressor. Finally the transfer module uploads files to the repository.

Central repository: The central repository contains the integrated biological signal data. For MFER files, we only stored header information (e.g., the number of channels, sampling rate, etc) and file pointers in the database.

Web server: Three kinds of web services were designed for three different user groups (doctors, patients, and system administrators). Doctors can review all of the measured data of his/her patients. Patients (subjects) can review their own bio-signal data and add new data. System administrators can check file transfer errors and establish new connections between the new devices and the waveform device interface.

Results and discussion

The first generation of the data management system was developed in 2003. For the second generation of the data management system, we have designed a more robust data upload module. We used Microsoft Internet Information Server 5.0 as a web server, and Active Server Page (ASP) and scripting languages. Microsoft SQL Server 2000 is used as the database management system of the central repository.

1 Available at: http://ecg.heart.or.jp/Jp/Index.htm

We expect that the proposed system can be a promising model for the ubiquitous health care environment.

Acknowledgments

This work was supported in part by the Advanced Biomedical Research Center (ABRC) funded by KOSEF, and in part by the MIC (Ministry of Information and Communication), Korea, under the ITRC (Information Technology Research Center) support program supervised by the IITA (Institute of Information Technology Advancement) (IITA-2006-(C1090-0620-0002)).

A Web-based Data Management System for Ubiquitous Bio-signal Data Monitoring

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Department of Biomedical Engineering,
College of Medicine, Seoul National University,
South Korea

Research Purpose

- **Development of ubiquitous bio-signal telemonitoring system**
  - **Using standard exchange format**
  - **Using efficient web technologies**

Motivations

- Necessity of medical information standardization
  - To reduce medical error
- Convenient practical use of medical information
  - Dynamic manufacturing and administration of patient information and measuring information of medical devices
- Application and development of standardization technology
  - HL7 : A standard for the exchange of electronic data used in medical environments
  - MFER : A JAHIS (Japanese Association Health Information System Industry) standard for waveform data

Overall Scenario

Home Monitoring Devices

Data

Ubiquitous Home Server

Standard (HL7, MFER)

BIRD
(Biometric Integrated Repository Database)

Internet

XML,HTML,XHTML

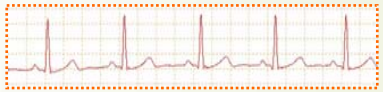
Web based
Medical Information Sharing

Data Exchange Through Gateway

ABRC

u-House

Data exchange



Bio signal measuring devices

Home Server

U-House Home Server

MFER Encoded File

Interface Module

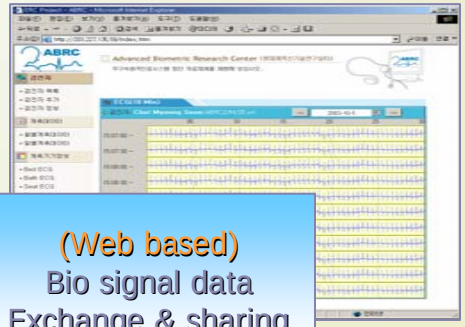
MFER Analyzer

HL7 Generator

Common interface gateway

Effective presentation

Mobile Service



(Web based)
Bio signal data
Exchange & sharing

XML, XSLT

XML, HTML, XHTML

HL7 Message

Data integration

HL7 Archiver

BIRD

(Biometric Integrated Repository Database)

Central Repository & Web Server

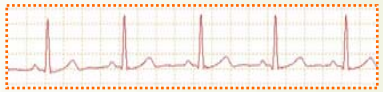
Web Service

Service

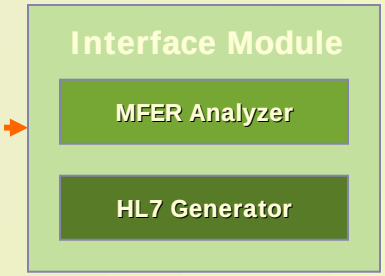
Device Interface

u-House

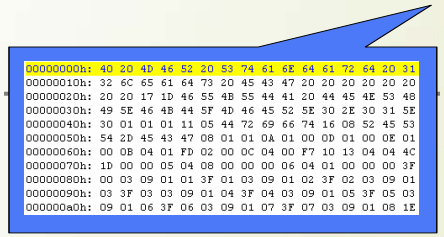
Data exchange

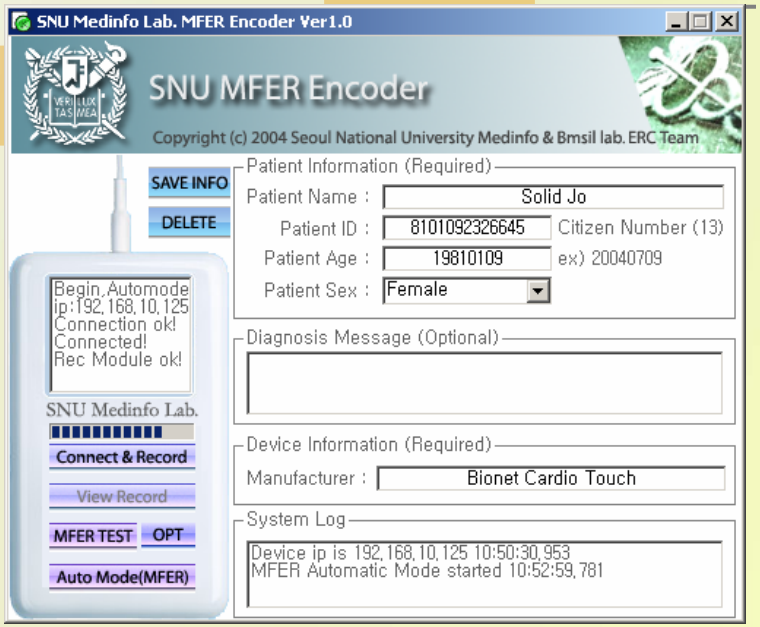


MFER Encoded File



Common interface gateway

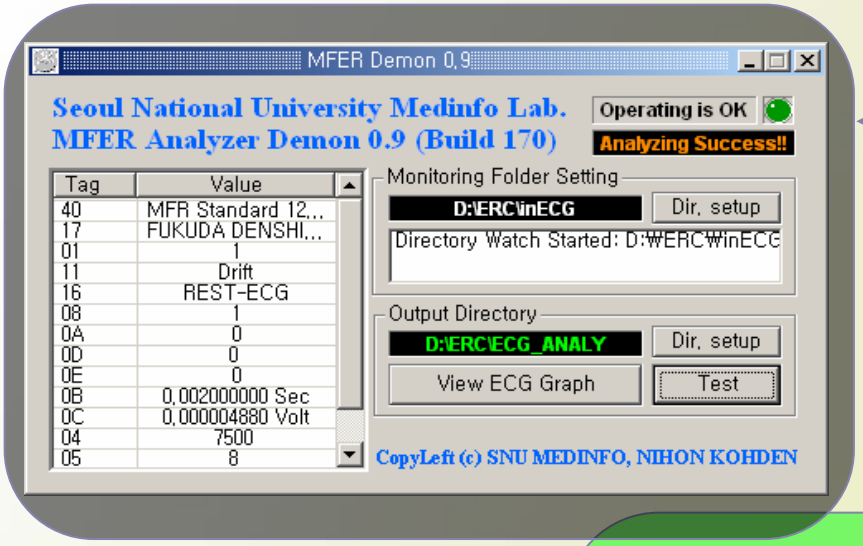




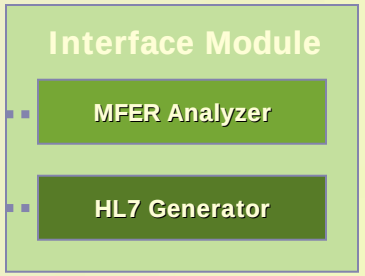
MFER Encoder

For device interface, we developed MFER Encoder that encodes waveform data into the MFER standard format.

Gateway

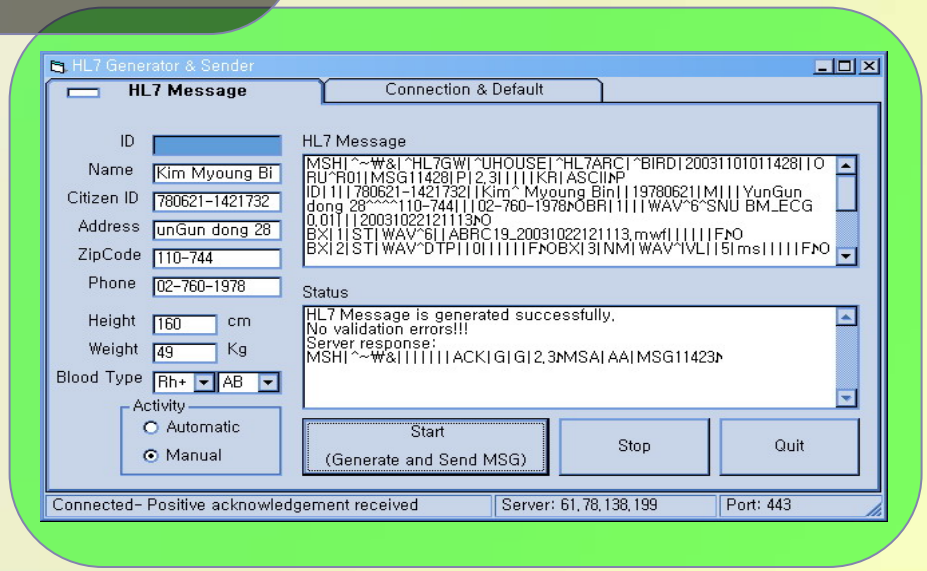


MFER Analyzer



Common interface gateway

HL7 Generator



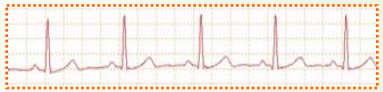
Gateway sends the patient information and the metadata for the measured waveform data into the HL7 standard format.

Data Exchange Through Web

ABRC

u-House

Data exchange



Bio signal measuring devices

Home Server

U-House Home Server

MFER Encoded File

Web Upload Module

- MFER Parser
- File Compressor
- File Transfer

Data Upload Control

Compressed MFER

Data integration

Web Server

BIRD

(Biometric Integrated Repository Database)

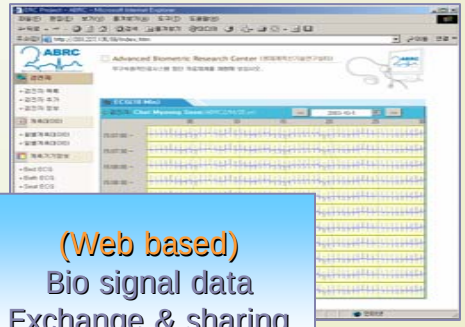
Central Repository & Web Server

Effective presentation

Mobile Service

XML, XSLT

XML, HTML, XHTML



(Web based)
Bio signal data
Exchange & sharing

Web Service

Service

Web-based Data Upload

- The Web-based data upload is our enhanced mechanism for transferring waveform data
- We designed it as a client-side ActiveX control
- Waveform data is transferred into the compressed MFER form
  - To speed up large file upload

Web Services

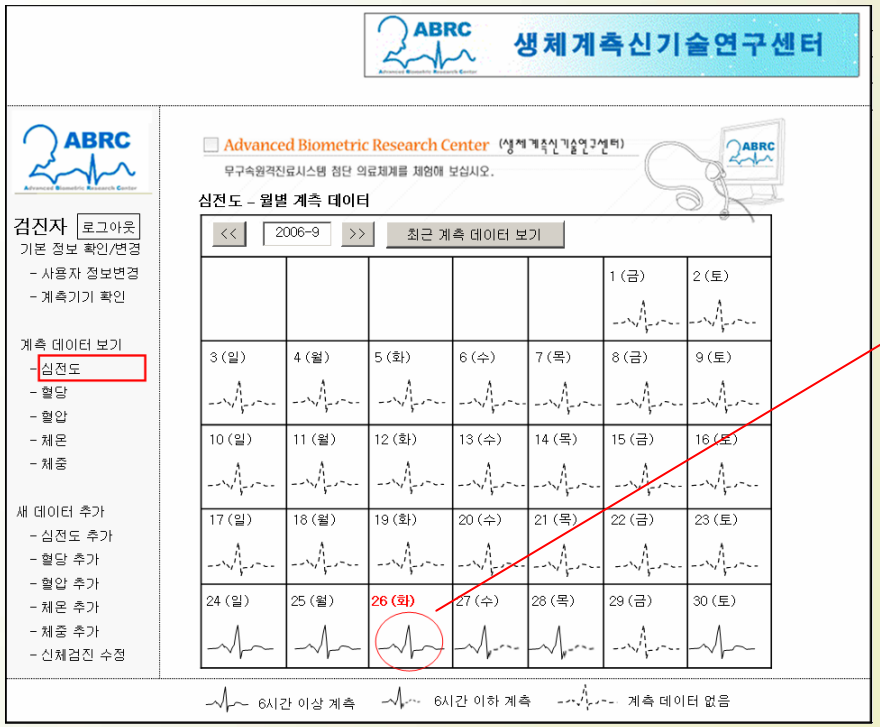
Target Users

- Doctors
  - Review all of the measured data of his/her patients
- Patients
  - Review and maintain their own bio-signal data
- System administrators
  - Register and manage bio-signal devices
  - Manage bio-signal device users

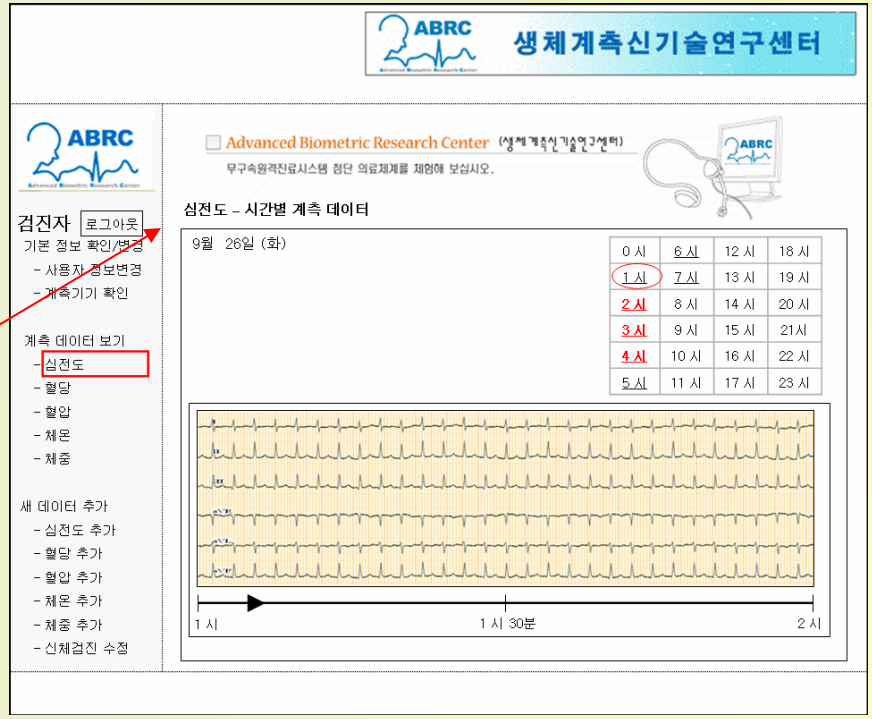
Currently, we are developing our web site using ASP and scripting languages.

Example of Web Services

- Storyboard of ECG retrieval interface



Monthly ECG retrieval storyboard



Hourly ECG view storyboard

Acknowledgments and Contact Details

- This work was supported in part by the Advanced Biomedical Research Cen-ter (ABRC) funded by KOSEF, and in part by the MIC (Ministry of Informa-tion and Communication), Korea, under the ITRC (Information Technology Research Center) support program supervised by the IITA (Institute of Infor-mation Technology Advancement) (IITA-2006-(C1090-0620-0002)).

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Open Source Network Infrastructure for Health Information Systems

Paulo B. Paiva, Rafael V.D. Giusti, Marco A.G. Ribeiro, Meide S. Anção, Daniel Sigulem

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Abstract and objective

This paper describes a network infrastructure based on Open Source software implanted in an academic hospital and medical school at the Federal University of São Paulo (UNIFESP). The UNIFESP network serves more than 3,300 workstations spread in a metropolitan campus. The network was planned in order to connect multi-platform workstations based on the IP protocol, using distributed servers and a decentralized administration. All network services provided by a pool of low-cost central servers and low-end departmental servers, 90% of the peripheral servers are base on free software. Free/Libre/Open-Source Software, or FLOSS, is a term for software that is liberally licensed in order to grant users the right to redistribute, change and improve its original source code. The use of Open-Source Software for the network infrastructure allowed building with scarce resources an always up-to-date system managed by in-house trained staff.

Keywords:

internet, free software, computer networks

Methods

The main concern when building an Open Source network infrastructure was the administration and implementation of network services. The main administrative tasks are facilitated by in-house developed scripts. User administration, network device administration, backups, user directory services, web-page deployment and generation of dynamic web content. Core service administration is performed by a small staff who also train administrators of departmental servers. User accounts are maintained in a central corporative directory based on the Lightweight Directory Access Protocol (LDAP). The use of a centralized directory enables the aggregation of different users rights into a unique structure, facilitating the management of resources available for users.

The network is composed by several class C subnetworks, mainly used for servers and academic workstations, and 4 class B subnetworks, for internal use. Firewalls are implemented using free software at the routers. The policies in the firewalls are based on the denial of all services by default, connections to well known services are allowed selectively. Address translation, which allows workstations with internal addresses to access Internet services is implemented using NAT (Network Address Translation). Segmentation is done by low-end computers, avoiding the propagation of network broadcasts commonly originated by Windows based workstations.

Network management in a large heterogeneous environment presents several pitfalls ranging from the control of new networks and workstations to monitoring traffic. These tasks are performed by the core administrative staff supported by several open source software and in-house developed applications. A device database keeps track of all equipment which is used for network monitoring. Network traffic is monitored using open source software that were tailored to fit specific idiosyncrasies of the university and hospital network. Off-site monitoring, e-mail and pager alerts were implemented.

Results

A network infrastructure based on the IP protocol for heterogeneous workstations of a university and 7 colligated hospitals, was built based upon low-cost servers using Open Source Software for core services. More than 3,300 workstations based on different operating platforms (MS-Windows, Macintosh, SunOS, IRIX , Linux, FreeBSD), and 7,000 users.

Conclusion

A decentralized administration and extensive training of network management staff were of central importance in order to use and maintain the network. Although there are no software license costs, the total cost of ownership (TCO) could be higher than using proprietary software. The network administration was decentralized in order to propagate knowledge between the core administration staff and the rest of the administrative personnel.

Open Source Network Infrastructure for Health Information Systems

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Health Informatics Department,
Federal University of São Paulo, Brazil

UNIFESP

Objective

This paper describes a
network infrastructure based on
Open Source Software implanted in an academic hospital and medical school at the Federal University of São Paulo (UNIFESP), in Brazil

UNIFESP

Free / Libre / Open Source Software - FLOSS

Software whose source code is available under a license that allows users to:

- change
- improve
- redistribute

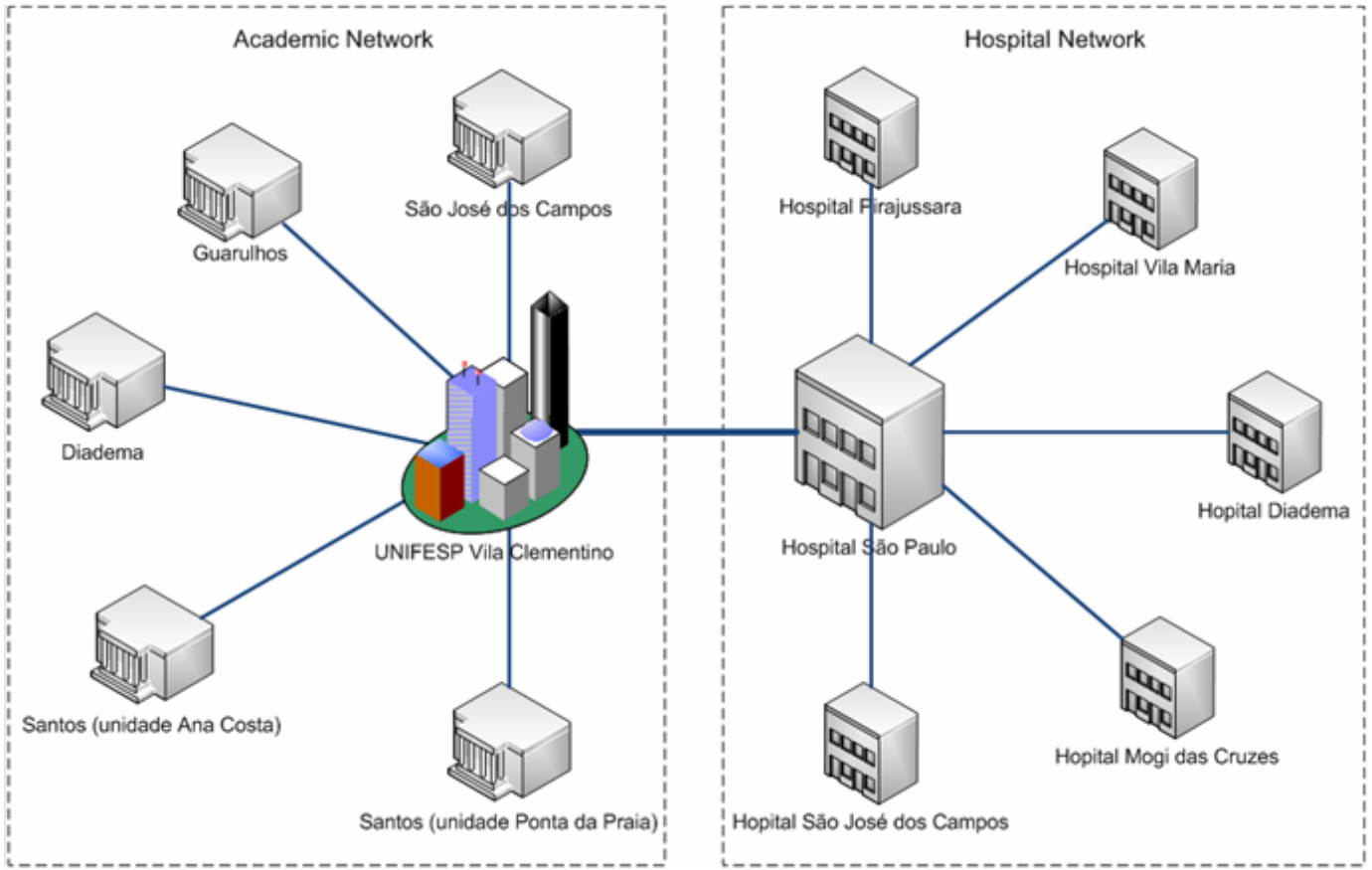
Motivation

Why NOT using proprietary software?

In the context of a public university and academic hospital in Brazil

no provision for
expensive software upgrade and update

Academic & Hospital Networks



200 Servers

4,000 Workstations

7,000 Users

90% OpenSource Based

Multiple end-user platforms
MS-Windows, MacOS, Linux, FreeBSD,
SunOS, IRIX, Tru64

UNIFESP

Network Service Infrastructure Based on FLOSS

- Server Operating Systems
  - Linux
  - FreeBSD
  - NetBSD
  - OpenBSD

Core OS services
Routing and Bridging
NAT - Network Address Translation
Network Packet Filtering

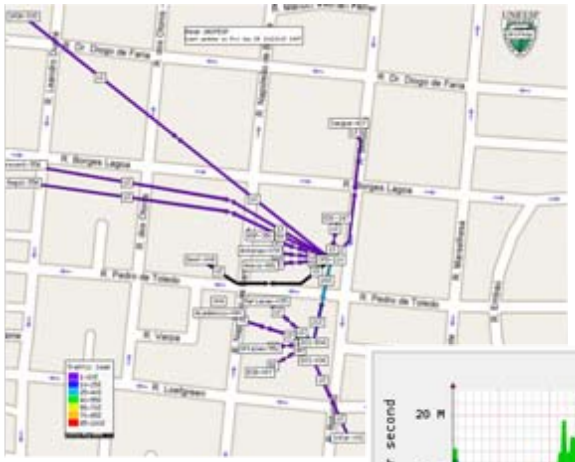
- Basic Network Services
  - DHCP – Workstation Configuration
    - ISO DHCPD
  - DNS – Name Resolution
    - DJB TinyDNS
  - Proxy – Internet Cache
    - Squid
    - SquidGuard
  - Authentication/Authorization
    - FreeRadius
    - OpenLDAP

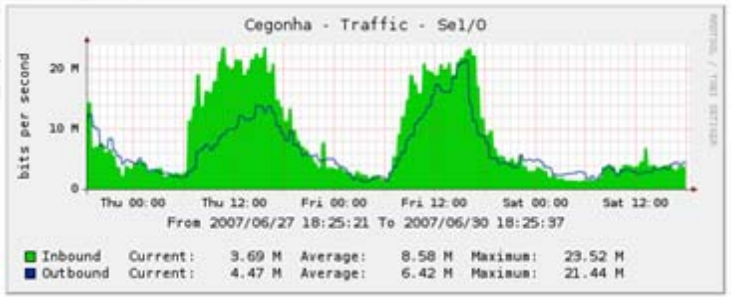
Optimize Bandwidth Usage with cache

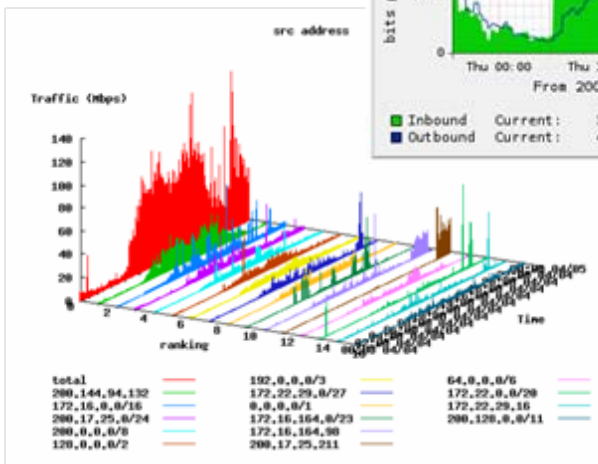
Centralized Directory Based on LDAP

Network Monitoring

- Monitoring
  - MRTG
  - CACTI
  - WeatherMap
  - Nagios
  - Aguri
  - ArpWatch
  - NMAP
  - NTop
  - Bmon
  - Wireshark







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End-User Services

- Voice over IP
  - Asterisk
  - OpenSER
- Web Services
  - Apache
  - OpenSSL
- Remote access
  - OpenSSH
- File and printing
  - Samba
  - CUPS
- Database Management
  - PostgreSQL
  - MySQL

- E-mail
  - Postfix
  - SpamAssassin
  - ClamAV
  - Amavisd
  - MailScanner
  - Postgrey
  - Courier
  - Cyrus
  - MailMan
  - HordeIMP
- Backup
  - Amanda

Conclusion

- No cost and frequent software

  UPGRADES and UPDATES

  - Security fixes
  - Bug corrections
  - New features
- Software customization
  - Staff adds specific functionalities
- Reliability, Security, Performance

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The UNIFESP Core Network Group
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Maria Susan Chern, Silvia Ambiel Diorio,
Renato Alves Lourenço, Rogério Alves Lourenço,
Kleber Mariuço Pedron, Ricardo Alves dos Reis,
Luiz Guilherme Roncati, Rodrigo Santin,
Edda Maria Parente La Selva, Jeferson Marinho de Souza.

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Emergency and Disaster Recovery System Extensions to caBIG™

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[a] *Biomedical Informatics Department, University of Utah, USA*

Abstract and objective

The proposed system, ca!, considers the requirement for medical resource planning as the result of a wide scale disaster. For the purposes of this scenario a Radiological Dispersal Device (RDD) explosion was considered as the event. In order to provide data for planning input for first responders and healthcare workers, combined radiation intensity, type and location (GPS) sensors need to be co-located with such service providers, providing reliable environmental data streams in the potential absence of electrical utility power and Internet, wireless or cellular connectivity. Information should be available in real time for multiple recipient organizations to perform analysis at the local and national level. This proposed low cost solution is comprised of wireless sensors and access points based upon equipment currently provisioned with the emergency services relayed to a caBIG™ style processing node on a grid computing network. Sensors are low power devices designed to run from automotive batteries.

Keywords:

disaster planning, grid computing, caBIG™, explosive agents, radiation, fault tolerant, wireless, RDD

Introduction

Subsequent to the 9/11 terrorist attack on the World Trade Center in New York, there has been an increased public and government awareness for potential terrorist attacks on U.S. soil and overseas assets [1]. Prevention or warning against such acts, are, by their very nature difficult to predict or prevent. Whilst prevention is the most desirable outcome of any counter terrorism activity [2], there has to be the distinct possibility that terrorists, domestic or foreign, will eventually succeed in any case. Therefore, systems designed for monitoring, containment and handling phases of disaster management must be available in a timely and cost effective manner [3]. Monitoring and detection systems are the initial building blocks upon which the containing and handling or treatment phases of intervention are based; the proposed system is a monitoring phase system.

Due to the large potential target list for a Radiological Dispersal Device (RDD) [4], providing an effective monitoring system with adequate geographical coverage in the same manner that one could provide, say, with airport security scanners could be an extremely expensive proposition. Additionally, RDD detonations being only effective for large conventional explosive triggers [5] will likely result in some level of disruption to both power and public wireless or cellular communications infrastructure, complicating existing monitoring device operations [2].

With the first responder, public safety and hospital clinical workers, there is a degree of health risk due to the direct and indirect contamination resulting from a Radiological Dispersal Device [6-8]. By equipping first responder vehicles and medical facility fixed assets (hospitals, morgues and clinics) with sensor devices we can obtain an informed judgment as to the likely levels and nature of exposure for critical health care workers, from both the environment and the triaged patients they come into contact with.

In this project, we propose that by the use of low cost, first responder vehicle mounted, publicly available wireless networking and computing resources, we can provide an effective sensor network for monitoring RDDs. In order to deliver captured sensor data to points of interest in a portable and understandable manner, we propose utilizing the existing caBIG™ Grid network [9-12].

Methods

The initial project is for a laboratory bench simulation providing a proof of concept. The mobile network conjoining all the sensor devices would be simulated using laptop computers, as mounted in law enforcement or first responder vehicles. The initial proof of concept and subsequent simulations will be performed using a cellular based network. Further simulations will be performed using a self-healing mesh network, as the reliability of a cellular network for sensor connectivity or data collection and filtering cannot be guaranteed. Network therefore will consist of wireless sensor devices, collection systems and a network infrastructure built upon ad-hoc wireless networks using laptop computers.

To enable distribution of the data collected by this mesh network, the network will be connected to one or more Grid computing nodes, as part of the caBIG™ computing environment. The use of the caBIG™ Grid computing network allows data to be extracted from the sensor network to a specified vocabulary and with a common data abstraction. Additionally, the data may be accessed from a variety of client nodes, at high speed, in a secure and reliable manner. The data may therefore be viewed both by local and

national government agencies, as well as by regional and distributed cancer centers, allowing for wide area participation in treatment and risk minimization planning.

Results

It is envision that the simulations will show that it is possible to build and operate a low cost, minimally invasive system for monitoring the important environmental concerns regarding a major disaster in an urban environment. Additionally, such a system can be expanded to cover a wider variety of health care relevant indicators to allow for intelligent victim to facility routing and transport. Health care facilities and emergency workers can also provide more effective decontamination site location and secondary radiation sources can be tracked in an automated fashion.

The system will enable improved interpretation of bio-hazard risk for first responders, as well as providing applications to process sensor information in a distributed and tiered manner for clinical and law enforcement purposes. Further analysis by applications developed for regional and federal agencies, especially for the scenario of handling multiple simultaneous events, is a straightforward extension due to the underlying caGRID architecture. Using existing a low cost and proven infrastructure at all application tiers should reduce barriers to entry for public agencies, from both cost and risk perspectives.

Discussion

Our goal is to demonstrate the feasibility of constructing an effective sensor information network for use in public emergencies such as an RDD detonation event. Such a system will be shown to be effective by considering aspects of availability, data coverage, spatial resolution and temporal granularity. For the future, achievement of the specific aims specified here will enable us to work towards delivering a working prototype of the overall system, covering sensor detection, data acquisition and analysis and a hierarchical medically useful set system of analysis applications.

Sensor data as received by an analysis application can be viewed as raw sensor data or aggregated and filtered data, each with a variety of temporal parameters. All sensor data, aggregation and filter services, as well as temporal parameters are represented by metadata within the caBIG™ Cancer Data Standards Repository (caDSR) [13].

Conclusion

Core to the system will be a universal data model allowing for rapid low cost applications software development. In order to provide aggregated sensor data to a distributed set of analysis applications, there must be an abstraction of the acquired sensor data via an agreed protocol and messaging format, tied to a vocabulary. Additionally, provision of a reliable and secure networking framework is assumed, as well as generated application programming interface (API) in order to provide rapid development of low cost analysis application services. The use of the caBIG™ Grid assists in these development goals.

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Emergency and Disaster Recovery System Extensions to caBIG™

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Biomedical Informatics

ca! - The Overall Project

Is it feasible to construct a highly available, low cost, environmental sensor data collection and analysis system for use in emergency situations, by utilizing existing emergency response system infrastructure, for data acquisition, and a distributed computing grid (caBIG™) [3-5] for an applications development and execution environment?

ca! Components

The conceptual model is comprised of three components:

- A sensor data acquisition component
- A sensor data aggregation and storage component
- An applications development and execution environment (caBIG™)

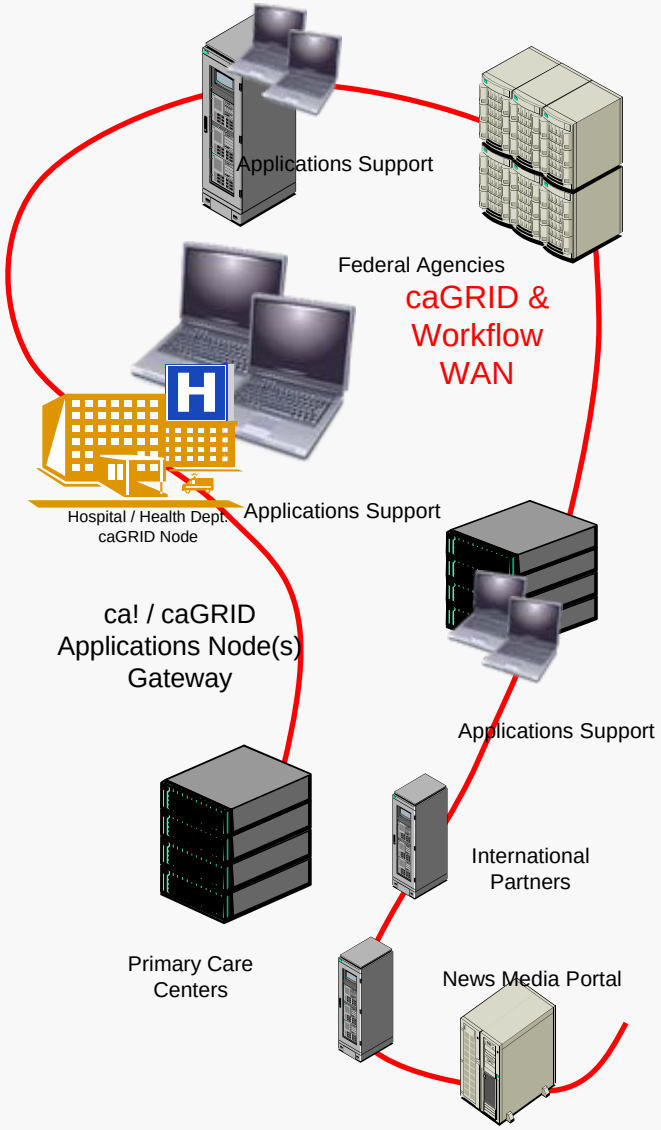
ca! - Sensor Component Criteria

- Sensors operate with no VAC, all 12DC
- Two node types, static and mobile
- Use existing equipment, laptops, in first responder vehicles
- Simple sensors, data recovered using sensor embedded web servers
- Data recovered in raw form, processed at the GRID node I/F
- Very low cost technology, small delta over existing expenditure
- Sensors connected via WI-FI and Peer to Peer networking (reliable network)

caBIG™ Architecture Background

Why Use caBIG™?:

- caBIG™ [3-5], a WAN distributed series of functional cancer research nodes accessible in a manner analogous to plugging into the power *grid* (caGRID [5]) - plug and play…
- Each node may be a single system, a cluster or a parallel system



caBIG™ Functions

- caBIG™ provides a network resource for handling desired cancer research tasks in a standardized manner
- caBIG™ provides the ability to execute tasks in a coarse grained parallel or distributed manner, caGRID / Workflow
- caBIG™ allows for data portability, both at functional and semantic levels, including vocabulary, common data elements, message passing formats and APIs
- Emphasis on cancer research, but extensible

caBIG™ Platform

- caBIG™ uses the Globus Toolkit Version 4 (GT4) [7] for underlying transport
- caBIG™ is a form of GRID computing at the broadest form of the definition, caGRID
- caBIG™ provides an SDK for developers (Cancer Applications) within the caCORE component
- GRID aware applications platform, caGRID
- caGRID provides for security and supports Workflow capabilities

caBIG™ Platform…

- What do we get with caBIG™?
  - Distributed Applications, caGrid
  - Security
  - Service Directory
  - Semantic Services, Vocabulary, Ontology
  - Resource Manager
  - Standard Query Language and Interface
  - Data Integration and Standardization
  - Software Development Environment
  - Standards and Certification

ca! - Sensor Network

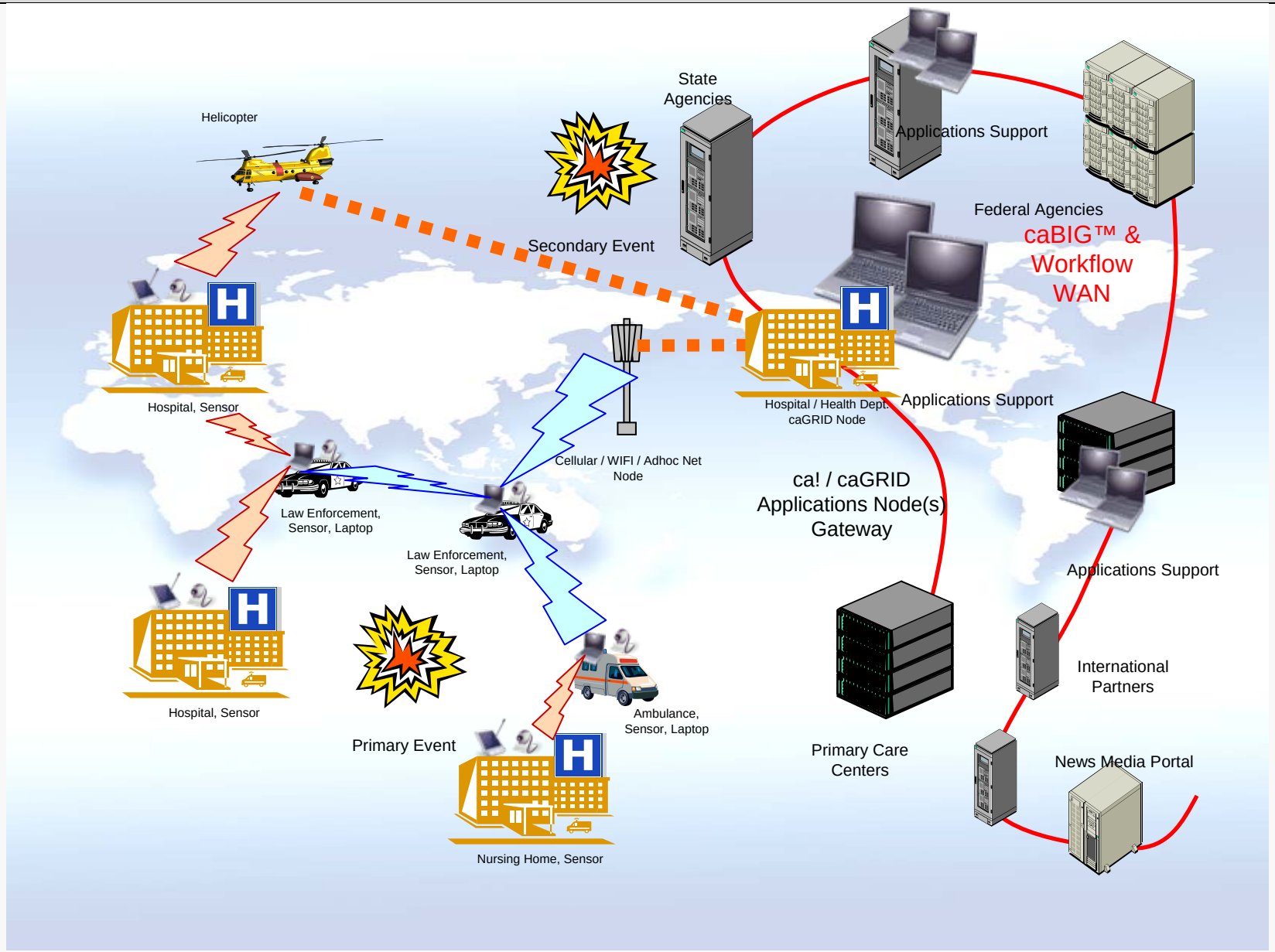
Our Task:

- Extend caBIG™ to support a dynamic mobile sensor network
- Provide a sensor abstraction to the caBIG™ GRID via the Cancer Data Standards Repository (caDSR) [6]
- Allow sensor network and processed sensor data to be visible by any authorized node on GRID
- Accommodate Three Aspects to Sensors:
  - Raw Data
  - Aggregated Data
  - Temporal Parameters

ca! - Applications Layer

- Data is visible to any authorized caBIG™ client on the GRID
- Adheres to caBIG™ standards for vocabulary and data formats, messaging and APIs
- Exploits caBIG™ security controls for sensitive information access
- Allows for remote processing of data
- Distributed data archiving
- Supports layered applications:
  - First Responder
  - State or Area Level
  - Federal or National Level

ca! - Architecture



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Secure Remote Access for Web Based Clinical Information System Using Policy Control of PCs and Healthcare PKI Authentication

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Abstract and objective

This paper describes a robust method of secure remote access for Web based clinical information system using Healthcare PKI authentication. It enables medical staffs to refer the medical data using his own PCs from their home or their mobile phones over the Internet. This system contributes to reduce strain of medical staffs especially in such institutes where intensive care is carried ***uninterruptedly.*** *For this purpose, it must permit the remote access to the hospital information system from PCs in various conditions, it is necessary to establish a secure connection using VPN or SSL, and control the policy of client PCs for the prevention of computer virus effect etc., and at the last, confirm user authentication with strict identification using Healthcare PKI (HPKI).*

Keywords:

Healthcare PKI, Clinical Information System, Secure Remote Access Control, VPN

Introduction

In Japan, healthcare ICT is promoted by Japanese government and in 2006, the government made "New IT Reform Strategy" and "The Action Plan 2006". It emphasizes the reengineering in the healthcare field using ICT. It includes some actual plan such as constructing secure and reliable network for regional and inter-regional cooperation and development of Healthcare PKI (HPKI) which is based on ISO 17090. Actually we started to use HPKI in 2004, as a demonstration experimental system in the University of Tokyo Hospital for secure remote access to the medical data. HPKI was used in this system for authentication purpose, with verification the attributes of the national licenses of healthcare professionals, such as medical doctors, registered nurse, etc. By using this system, a physician can access the medical data of his patients with his own PCs even in his home or his mobile phones.

Methods

In our hospital, medical staffs are able to access to medical records using web based system in addition to special client PCs. The overview of the developed system is shown in Fig.1. Mainly based on the web interface, the following parts were developed.

1. Certification Authority (CA)
For the convenience of user registration operation, All CA function was implemented in a note PC. It is also used for registering HPKI certificate to USB token. The CA function was implemented on a virtual Linux machine in that note PC using OpenSSL library, and the host OS of the PC was Microsoft Windows 2000 with a capability of handling HPKI certificates (i.e. getting a certificate via web interface of the virtual machine, and storing it to the USB token).

2. VPN gateway
The connection between the hospital network and a client PC is established using IPSec. We picked a VPN gateway, Cisco Systems/VPN 3005.

3. Policy Control System
At the establishment of VPN connection, the server side policy is downloaded to the client PC, and during the connection, client PC is under the predefined policy which force PC to evoke only modules essential to brows our server and stop working other unnecessary modules. We picked Check Point (Zone lab)/Integrity.

4. USB Token for HPKI
At the insertion of this USB token, HPKI certificate is copied to the certain repository in Windows, and on the removable of token, the repository is cleared.

5. Reverse Proxy Server
For the verification of the HPKI certificate, especially hcRole attribute, user access is only allowed via this SSL reverse proxy server. At the connection to an internal web server in hospital, the user certificate in client PC is pushed and verified. This proxy server was developed by adding a capability of handling HPKI certificates to Fujitsu Co. Ltd./Interstage Security Director

6. Mobile Access System
For the mobile access over the Internet not using HPKI, we developed CHTML converter gateway. The identification number of each mobile phone is stored at the registration in server side, and the access of unknown device is prohibited. The overview of the system is shown in Fig. 2.

In each case, the user needs to access the SSL gateway first of all, and then log onto the web-based hospital information system using his account (id/password), choose a patient, refer to the patient information.

Results

In this experiment, 30 doctors for the PC client access system and 20 doctors for the mobile phone access system participated and the developed systems are now in use. This system is effective to check the results of emergency laboratory tests, or radiological images on PACS system from remote place.

We also carried out a questionnaire for the participants, and the following points were pointed out.

1. Identity Verification

At the registration, the hospital ID card and the driver's license card with a picture were checked. The participants say it is reasonable enough for the user verification.

2. Client Software

This system requires various client software modules, such as IPSec client software, USB token driver and policy control client, so it is difficult to manage for the user to install or operation.

The software environment of PC clients quite differs from one to another depending on the user's usual system usage or his work. It sometimes caused troubles at the installation or the operation. We had some difficult problems to support users against these various PCs.

3. Connection Environment

For the access from the user's home, the client PC is not always directly connected to the Internet. Especially when the access needs to be established through a NAT router, some users had a difficulty to realize an IPsec VPN connection.

For the mobile-phone access system, no claims were pointed out.

Discussion

Our developed system aims to realize a secure access over the Internet to the web-based clinical information systems in the hospital. Main issues are,

1. Secure Connection

SSL connection over IPsec VPN was used. It is safe enough to protect the clinical information from snooping or other risks for the access over the Internet.

2. Policy Control of client PCs

For the restriction of running dangerous .exe/.dll programs, we need to gather the environment information of various client PCs. It is easy to restrict the access depending on browser type or its version, but it is very difficult to judge whether other installed programs or libraries are safe or not. Our policy control method which allows only essential modules to work is an effective solution in such situation.

3. Authentication using HPKI certificate

In this experimental system, we restricted access to the user whose certificate includes an hcRole attribute of "Medical Doctor". The account itself has the attribute information of the user's job title. The requirement of this feature has lower priority.

We are now discussing for the improvement of this system, taking in recently available technologies such as smart card for the HPKI token, SSL-VPN technology for an easy management of client PCs. Concerning secure data access, it is better to use virtual machine environment on the client PC side working with a SSL-VPN gateway.

Conclusion

Our developed secure remote access system is described. It was implemented based on proxy gateway adding no special reconstruction to our hospital information system. In the experimental results, several improvement factors for the software installation or operation issue were pointed out. For the achievement of higher user-friendliness, it is necessary to apply other easy-to-use methods, such as SSL-VPN with virtual client environment.

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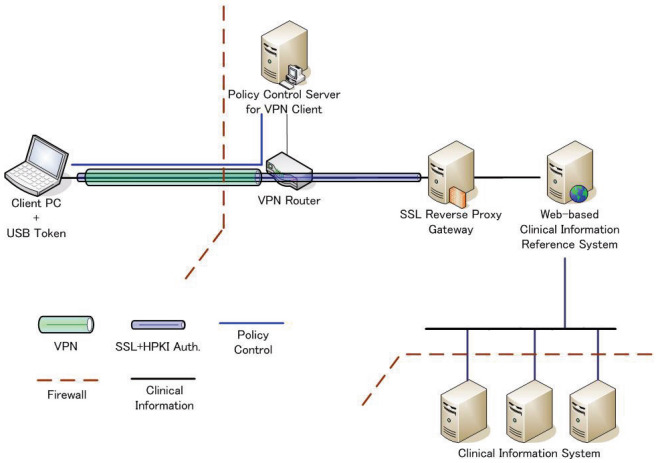

Figure 1 - Overview of developed secure remote access system for PC client

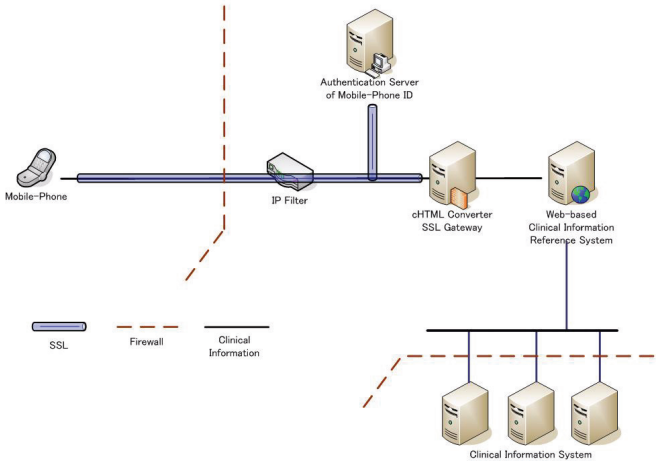

Figure 2 – Overview of developed secure remote access system for mobile phone

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The Web-based Learning Environments Affect the Learning Outcomes: Website Design for the International Journal of Medicine

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Abstract

This project is to describe the development and preliminary evaluation of a website design for the International Journal of Medicine (IJM), and to evaluate if the attitude and learning experience of using information technology would be more positive in the web-based learning environment. The International Journal of Medicine (IJM) is a peer-reviewed, refereed Journal with distribution in more than 200 countries and territories. The journal website was designed to help healthcare professionals and students in their daily practice, lifelong learning and career development. Consequently, there would be a website in a designed learning environment with special learning and communication tools when using the Internet for medical education and practice purposes. Information technology (IT) is there to be used and website and electronic communication provide competitive advantage. Properly planned, designed and implemented website should pay for itself and providing a return on investment. Website provides convenience to the healthcare professionals and students and offers them the ability to communicate more effectively in medical practice and education.

Keywords:

web-based learning, healthcare professionals, medical student, information technology, website design

Introduction

To describe the development and preliminary evaluation of a website design for the International Journal of Medicine (IJM), which can be used by all healthcare professionals and medical students in the field of medical practice and education worldwide to access healthcare information to enhance evidence-based patient care and personal professional development and to evaluate if the attitude and learning experience of using information technology would be more positive in the web-based learning environment, in which the healthcare professionals and medical students could use information technology based learning tools.

Design and methods

The International Journal of Medicine (IJM) is a peer-reviewed, refereed Journal with distribution in more than 200 countries and territories. The journal website was designed to help healthcare professionals and students in their daily practice, lifelong learning and career development. In addition, it seeks to be at the forefront of the international debate on health. The Journal website was designed by the Editor in Chief, Professor Comfort Osonnaya in collaboration of the Editorial and Production Team of the Journal and in collaboration with the various organisations linked to the Journal. These include: the Association of Health Care Professionals (AHCP), the owners of the Journal, the International Medical Publishing Group (IMPG), the publisher of the Journal, the Lowcost Services Group (LSG), the typesetting, production, distribution, administrative and website coordinating Managers of the Journal.

All production, editing, review, commissioning, legal and ethical issues, details of Editorial Board Members and other relevant information and links were included in the website.

Infotex Internet Providers of Sussex, UK were commissioned to host the website and members of the Editorial and Production Team have been working closely with them on the website design.

It was agreed that a complete book, which contains all the information on the website will be published by the Journal Publishers, in order to act as a reference for the production. It was also agreed that the website would have a link to the AHCP, IMPG, PHCJ and other related websites, which are also being updated. The timescale agreed for the IJM and other linked website to go live is between September to December 2006.

The website design team agreed that the initial designed website would be tested and first evaluated by the Editorial and Production Team, together with a small sample of other potential users of the website (healthcare professionals and members of the public). The manuscript of the website book would also be available at the IJM Editorial Board Meeting for further comments from the Editorial

Board Members. The summary of the results of the initial evaluation of the website are stated below.

Results:

The web-based learning environments affect the learning outcomes differently according to the pedagogy (traditional instruction versus constructive), the design of website (linear versus hypertext), and the interaction possibilities provided by the learning platforms (interaction only with the learning materials versus interaction with peer review and the instructor). Consequently, there would be a website in a designed learning environment with special learning and communication tools when using the Internet for medical education and practice purposes. The majority of the respondents indicated that the website met the users' requirements to a very good extent and the website promotes efficient information delivery to the healthcare professionals and students in research, medical practice and education.

Discussion:

The study had a pre-/post-text control group design. The different learning styles for healthcare professionals and medical students can be generated in the following:

- a didactic style where texts and tutorials were offered in a structured way
- a problem-solving style, where the material was presented in the context of the case and the computer asked appropriate questions in a series of multiple-choice tests,
- a free text style, which allowed the user to respond to open-ended questions by typing in natural language responses.

The website environment was designed for healthcare professionals and medical students in two different forms:

- Journal materials offered through conventional www-technology and by engaging in an e-mail discussion with an instructor for a non-interactive web-based learning, and
- Journal materials offered using the web-based learning for self-direct learning as well as interactive forums with an instructor and peer review for a shared learning process.

The advantages of the website include[1-3]:

- being available 24 hours a day, seven days a week
- it is convenient to browse the website and check the information whenever they want
- the website can also allow students and healthcare professionals to collect information and allows them to sign up and order journals and related products and services
- the need for administration is reduced
- an on-line website which is quick, easy and inexpensive to modify
- providing answers to frequently asked questions thus saving staff time
- improved communication by email which is professional and convenient
- it is significantly better than leaving messages on answering machines

Conclusion:

The more interactive computer-learning environment improved learning outcomes. Information technology (IT) is there to be used and website and electronic communication provide competitive advantage. Properly planned, designed and implemented website should pay for itself and providing a return on investment. Website provides convenience to the healthcare professionals and students and offers them the ability to communicate more effectively in medical practice and education.

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THE WEB-BASED LEARNING ENVIRONMENTS AFFET THE LEARNING OUTCOMES: WEBSITE DESIGN FOR THE INTERNATIONAL JOURNAL OF MEDICINE

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Aims and Objectives

- To describe the development and preliminary evaluation of a website design for the International Journal of Medicine (IJM)
- To access healthcare information to enhance evidence-based patient care and personal professional development
- To evaluate if the attitude and learning experience of using information technology would be more positive in the web-based learning environment

Design

- The Journal website was designed by the Editor in Chief, Professor Comfort Osonnaya in collaboration of the Editorial and Production Team of the Journal and in collaboration with the various organisations linked to the Journal.

- All production, editing, review, commissioning, legal and ethical issues, details of Editorial Board Members and other relevant information and links were included in the website

Methods

- The initial designed website would be tested and first evaluated by the Editorial and Production Team, together with a small sample of other potential users of the website (healthcare professionals and members of the public).

- The manuscript of the website book would also be available at the IJM Editorial Board Meeting for further comments from the Editorial Board Members.

Results (1)

- The web-based learning environments affect the learning outcomes differently according to the pedagogy (traditional instruction versus constructive), the design of website (linear versus hypertext), and the interaction possibilities provided by the learning platforms (interaction only with the learning materials versus interaction with peer review and the instructor).

Results (2)

- There would be a website in a designed learning environment with special learning and communication tools when using the Internet for medical education and practice purposes.

- The majority of the respondents indicated that the website met the users' requirements to a very good extent and the website promotes efficient information delivery to the healthcare professionals and students in research, medical practice and education.

Advantages

- being available 24 hours a day, seven days a week
- it is convenient to browse the website and check the information whenever they want [1]
- the website can also allow students and healthcare professionals to collect information and allows them to sign up and order journals and related products and services
- the need for administration is reduced [2]
- an on-line website which is quick, easy and inexpensive to modify [3]
- providing answers to frequently asked questions thus saving staff time
- improved communication by email which is professional and convenient [2]
- it is significantly better than leaving messages on answering machines [1]

Discussion (1)

- The study had a pre-/post-text control group design. The different learning styles for healthcare professionals and medical students can be generated in the following:
  - a didactic style where texts and tutorials were offered in a structured way
  - a problem-solving style, where the material was presented in the context of the case and the computer asked appropriate questions in a series of multiple-choice tests,
  - a free text style, which allowed the user to respond to open-ended questions by typing in natural language responses.

Discussion (2)

- The website environment was designed for healthcare professionals and medical students in two different forms:
  - Journal materials offered through conventional www-technology and by engaging in an e-mail discussion with an instructor for a non-interactive web-based learning, and
  - Journal materials offered using the web-based learning for self-direct learning as well as interactive forums with an instructor and peer review for a shared learning process.

Conclusions

- The more interactive computer-learning environment improved learning outcomes.
- Information technology (IT) is there to be used and website and electronic communication provide competitive advantage.
- Properly planned, designed and implemented website should pay for itself and providing a return on investment. Website provides convenience to the healthcare.

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- Infotex Internet Providers of Sussex,
- Typesetting, production, distribution, administrative and website coordinating Managers of the Journal.

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Utility of Search Strategies Used by Nurses Seeking Internet-Based Health Information

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Abstract

Understanding the search mechanisms associated with using the Internet to locate health information is essential to improve health care information seeking behaviors of both nurses and their patients.

An observational descriptive cross-sectional study design was used to evaluate the strategies nurses use to search for health-related information on the Internet. There was little variability in the sample.

Keywords:

information seeking, internet, health information, nurse

Introduction

The objective of this study was to determine the utility of clinical nurses' search strategies to obtain healthcare information on the Internet. The aim was to establish if there are successful patterns that can be documented and taught to others.

Methods

An observational descriptive cross-sectional study design was used to evaluate the strategies nurses use to search for health-related information on the Internet at one major east coast school of nursing in the Fall of 2005. The convenience sample of 216 subjects searched for data surrounding a specific healthcare related scenario, then reported their satisfaction with the results of their search and answered some disease specific questions using a questionnaire. Data about search strategies used was collected automatically using Spector Corporate Network Edition (Spector CNE) software. Descriptive statistics and linear and logistical regressions were used to examine the hypotheses.

Results

The number of links used by the participants was significantly related to the search time (more time used more links). The group with less effective scored searches tended to use more links than those with effective searches. Low computer experience tended to predict the number of links used.

Discussion

There are many implications for nurses in clinical practice, education, research, and administration.

- Clinical Nurses need to know most efficient and effective ways to search for healthcare information on the www.
- Will access to online information provide a better quality of patient care?
- Do nurses need access to the www whilst at work?
- CE courses should be conducted to enhance information seeking skills.
- Journal clubs can be created to stimulate the integration of Evidence-based practice.
- Learning styles
- Nurses need skills for searching for and judging the quality of online information sources.
- Basic computer skills and computer literacy is needed by all nurses.

Conclusions

More investigation is needed in order to be able to determine the utility of clinical nurses' search strategies to obtain healthcare information on the Internet. The study conclusions offer suggestions for future study.

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The Evaluation of Nursing Cart In Inpatient Medication and Documentations

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Abstract

In the hospital, there are many tools or technology to help the care givers to do their jobs. From the doctor writing orders, to the pharmacist to dispend the drugs, and the nurse give the medication to the patient. Many tools can help them to do these things correct and quickly. The CPOE (Computerized Physician Order Entry) can help the doctors descript the medication, to reduce the wrong spell or it can check the contraindication. The pharmacist can use the robots to fill the prescriptions. They double check the package, and sent the medication to the nurses. On the nursing side, however, they do not have a good tool to help them. Moreover, they need to do much duplicate paper work. It is hard to check the medication by a human brain, and complete the medication in the right time. We also consider the implementation of barcode medication in the feature. Therefore, we want to take a useful tool for nurse to complete their work effective and correct.

Keywords :

nursing cart, cost effective

Methods

In the previous study, we interviewed 98 nurses (about 51% fellows) for what kind of nursing cart they would like. More than 70% nurses accepted to take the mobile tools with the nursing cart together. So, we find out some solutions, such as, Tablet PC, Laptop, PDA, Panel PC and Desktop. With considering the battery life and the screen size, we eliminated the Desktop and the PDA. The Tablet PC, however, is too heavy for a female in Taiwan to take in hand for a long time. At last, we take laptop and panel PC for the final choice for nurses.

We built two kind of nursing cart. One is Panel PC (see Figure 1), and another one is laptop (see Figure 2). In order to make the laptop monitor become touchable. We added a touch screen kit in front of laptop screen.

We take these two nursing cart to the nursing station for 3 weeks. And ask the leader and fellows to use both carts. We designed the questionnaire based on the usability and feasibility. The final vision included 23 five-scale items.

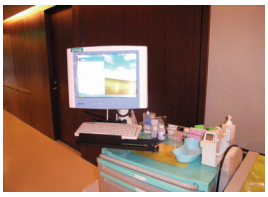


Figure 1- The panel PC

Figure 2 - The laptop

In our information system, there are many buttons, check box, or radio buttons. So, the touchable screen is great useful. We designed an Excel VBA program to simulate our HIS, and asked users to finish one scenario. We supposed that if one take more time to finish a scenario, the tools would be useless. Besides, we also do the qualitative research. We asked them for the advantages, disadvantages and suggestion for both carts.

Results

Of all the 23 items, there are 9items meaning in statistics ($p<0.05$). Most of fellows thought the Panel PC would be more useful than laptop with touch screen. In the time test, the nurses spent more 44 seconds when they use laptop with touch screen averagely to finish a scenario.

The results of qualitative research showed that the work space for nurses was much bigger in the Panel PC. However, the laptop with touchable screen was light and handy.

Conclusion

The result showed that the nursing cart with Panel PC would be better option. But we still need to consider some factors, such as, the price, the maintain cost. In the feature, we want to improve the faults of both nursing carts. Besides, we will bundle the barcode medication and the NIS (Nurse Information System) together. Based on these changes, in the further research we hope we can find out the useful and effective nursing cart for the nurses to do their daily works. With these “smart” nursing carts, we will bring the care givers more time to take care of the patient and do the medication effectively and correctly.

The Evaluation of Nursing Cart In Inpatient Medication And Documentations

Wen-Chih Chen MD	Department of Medical Informatics
Yu-Yin Kuo MD	Department of Medical Informatics
Li-Ping Fang BSN	Nursing Department
Huoy-in Liou BSN	Nursing Department

Medication Process

Prescribing

Transcription

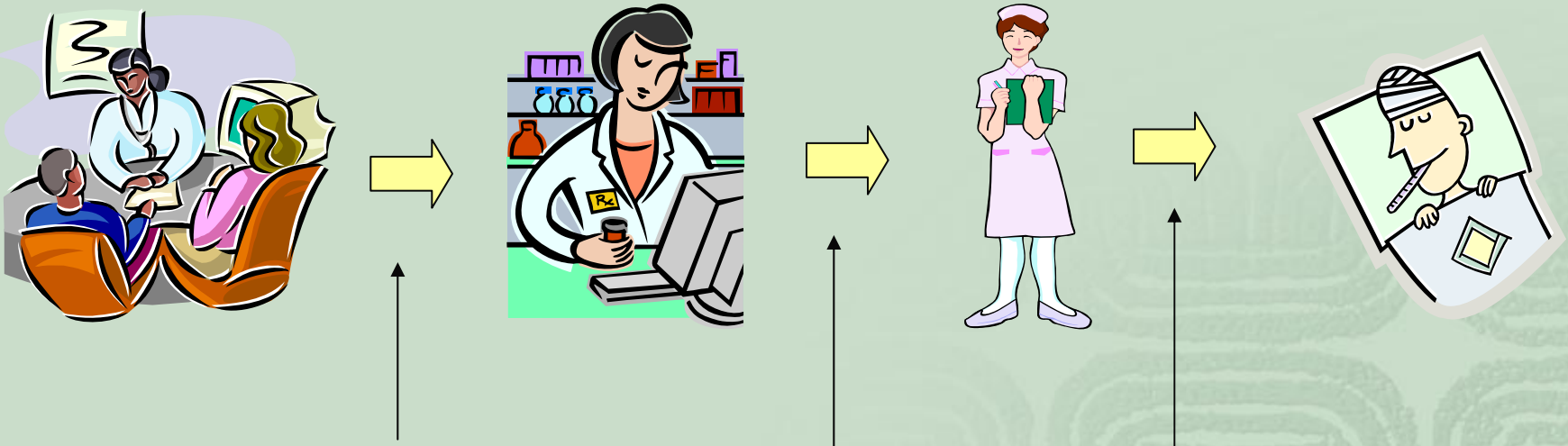
Dispensing

Administration

Medication administration record

Monitoring

Tools for the care givers



CPOE
(*Computerized Physician Order Entry*)

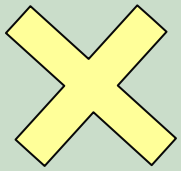
Automatic drug dispensing system

????

The previous study

- 98 nurses (about 51% fellows) were interviewed for what kind of nursing cart they would like.
- More than 70% nurses accepted to take the mobile tools with the nursing cart together.

Mobile tools compare

	Tablet PC	Laptop	PDA	Panel PC	Desktop
battery life	2~4 HR	2~4 HR	1~2 HR	2~4HR	Too short
screen size	10”~12”	12”~15”	Too small	15”~17”	15”~17”
weight	1.5~2.5 Kg [a]	2-3Kg	200 g	5-10 Kg	5-10 Kg
results					

The Tablet PC is too heavy for a female in Taiwan to take in hand for a long time.

The nursing cart We built

Touchable screen

battery

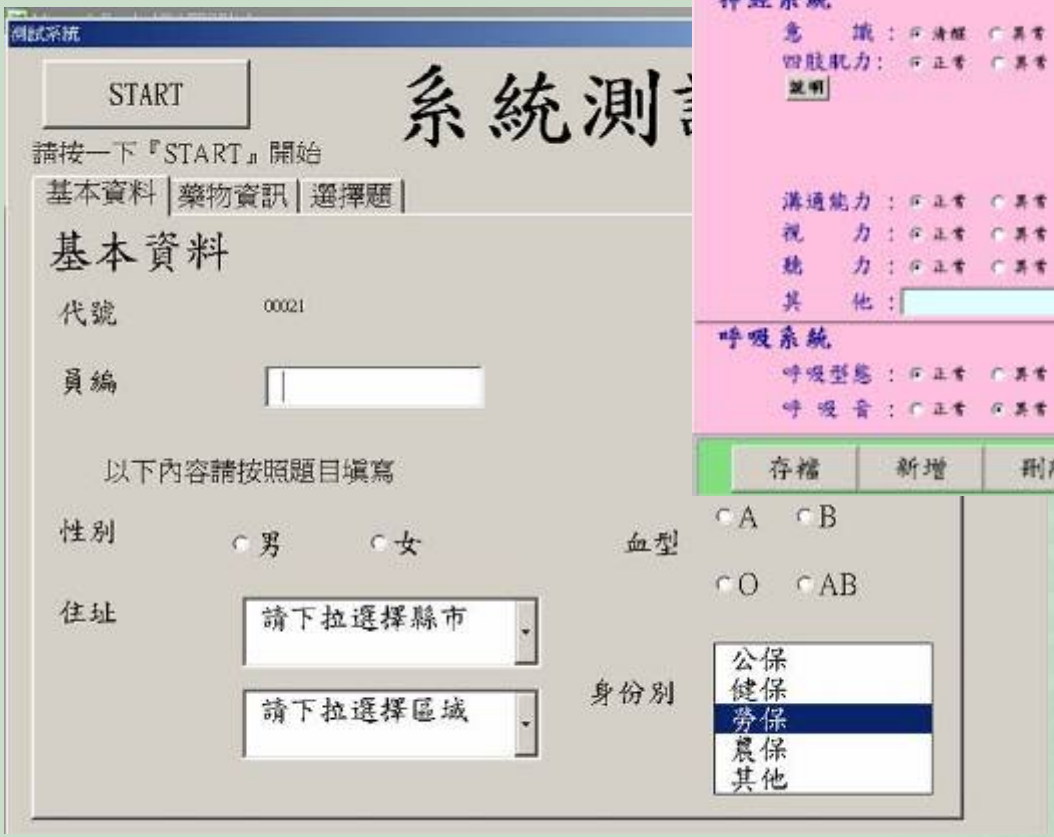
keyboard

The Panel PC

The laptop with a touch screen

HIS and simulate Excel VBA

Excel VBA program

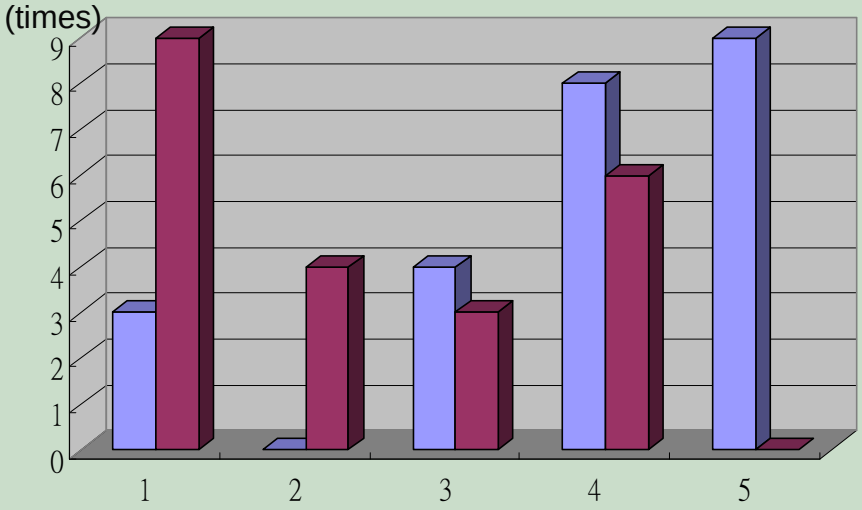


Nursing Information System

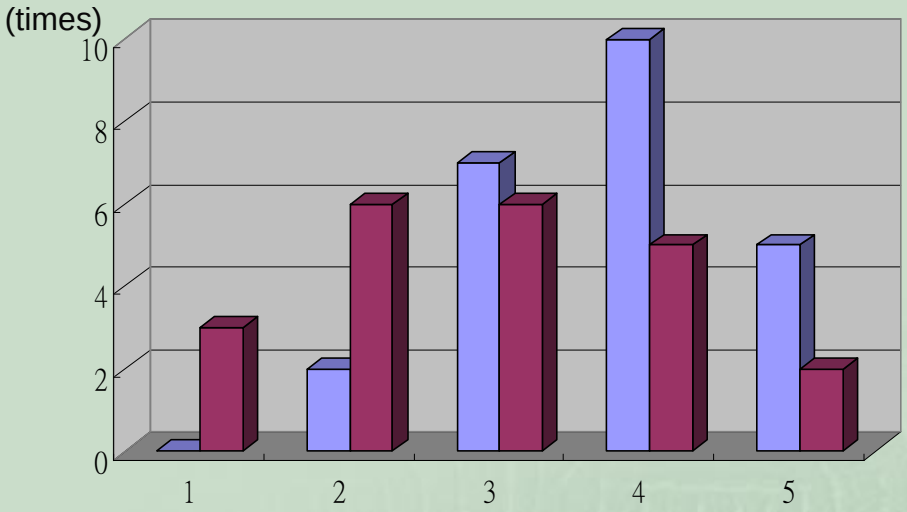
Results

- Of all the 23 items, there are 9 items meaning in statistics ($p<0.05$).
- Most of fellows thought the Panel PC would be more useful than laptop with touch screen.
- In the time test, the nurses spent more 44 seconds when they use laptop with touch screen averagely to finish a scenario.

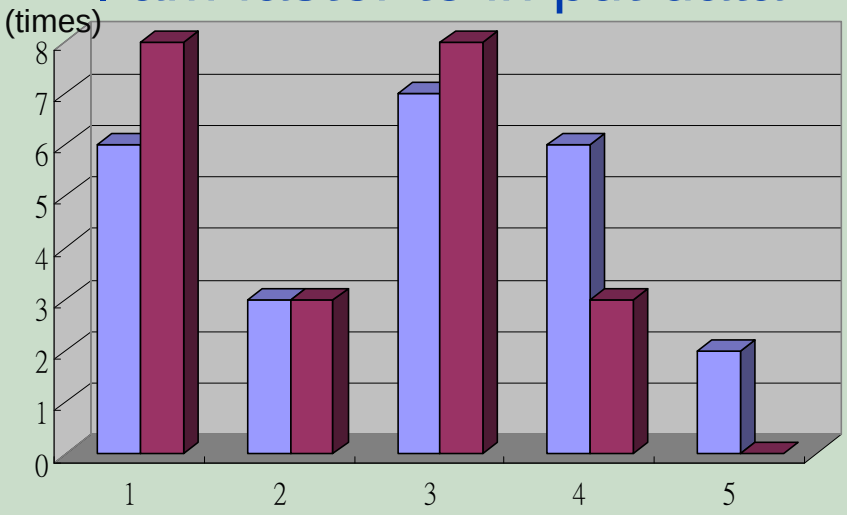
I am easy to use the keyboard



I am easy to get the items I need

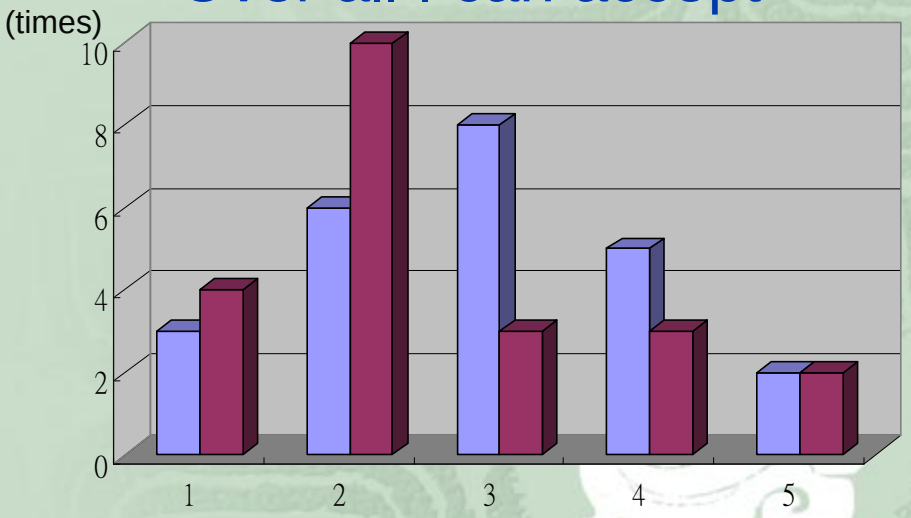


I am faster to in put data



Panel PC The laptop with a touch screen

Over all I can accept



1 scale is the most disagree

5 scale is the most agree

The results of qualitative research

The Panel PC

- The screen is bigger, clear, and bright
- bigger working space
- The touch screen is sensitivity
- More beautiful
- Easy to adjust the touch screen

The laptop with a touch screen

- light and handy
- The wireless is unstable
- Shorter battery life
- The position of keyboard is too high

Conclusion

- The result showed that the nursing cart with Panel PC would be better option
- We still need to consider some factors, such as, the price, the maintain cost.
- in the further research we hope we can find out the useful and effective nursing cart for the nurses to do their daily works.

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The Mobile Phone and Health – Results from a Literature Survey

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Abstract

Due to its ubiquitous availability and rapid technological advancement the mobile phone (MP) has been considered and evaluated for many applications beneficial to health. On the other hand, MP use has raised concerns related to possible adverse health effects like interference with and exposure to electromagnetic fields or distraction during driving. The aim of the present study has been to elucidate and quantify the relationship between research on potentially beneficial and adverse effects of MPs on health by means of a literature survey. Results show that relevant publications increased steadily since the 1990's, initially dealing mostly with potentially adverse effects. Publications on beneficial effects started to increase since the late 1990's and amount to approximately 20% of all publications since 2004. Upcoming technologies and still rapidly increasing numbers of MP users are likely to further increase research within the full spectrum of supposedly beneficial and adverse health effects of MP use.

Keywords:

mobile phone, eHealth, telemedicine, health risk

Introduction

Patient empowerment is one of the top priorities among the many hopes and chances the eHealth era is expected to bring for future healthcare [1]. Placing patients in the center of the healthcare system and providing them with tools and knowledge to manage their health and health related data is considered to be essential in facilitating prevention and improving the outcome of treatment.

Due to its ubiquitous availability and rapid technological advancement the MP is poised to be the universal information and communication toolbox for a steadily increasing portion of the worlds population, both in the developed and the developing parts of the world. MPs have, therefore, the potential to serve as a universal eHealth terminal.

As a consequence, MPs have been used and evaluated for health applications by numerous authors. Likewise, we demonstrated the benefits of MP use for the management of patients with chronic diseases [2] and cardiological teleconsultations [3] together with clinical partners.

On the other hand, MP technologies have also raised concerns related to possible adverse health effects. Initial research occurring during the early 1990's assessed health risks in the following categories:

1. distraction during using and handling MPs, e.g. traffic accidents,
2. the impact of electromagnetic fields on medical devices, i.e. electromagnetic interference (EMI),
3. exposure of humans to electromagnetic fields associated with MPs.

A systematic comparison of both, adverse and beneficial effects of MP technology, however, is lacking. The aim of the present study has been to elucidate and quantify the relationship between research on potentially beneficial and potentially adverse effects of MPs on health by means of a literature survey.

Methods

The impact of MPs with respect to health related issues was assessed by querying the PubMed database [4Eysenbach G. What is e-health? J Med Internet Res 2001: 3(2): e20.with the following search phrase:

"(mobile [ti] OR cellular [ti] OR cell [ti]) AND (phone [ti] OR phones [ti] OR telephone [ti] OR telephones [ti])" so as to find any citation containing at least one of the various expressions for "mobile phone" in the title string.

The received citations were classified based on the title and - if necessary and available - the abstract as belonging to one of the following main categories:

1. **Adverse:** article clearly deals with potentially adverse effects of MPs on health
2. **Beneficial:** article clearly deals with potentially beneficial applications of MPs to improve health
3. **Other:** Undefined (title and abstract are inconclusive), Irrelevant (article not specifically associated with health), and Duplicate (article relates to a preceding article which had already been classified)

Results

A total of 814 citations have been obtained and examined (last PubMed access update on Nov. 28th, 2006).

The evolutions of the frequencies of articles over time are depicted as histograms for citations on adverse and beneficial effects in Figure 1 - Annual numbers of citations

dealing with adverse (lower and light part of the bars) and beneficial effects (upper and dark part of the bars) of MPs on health1.

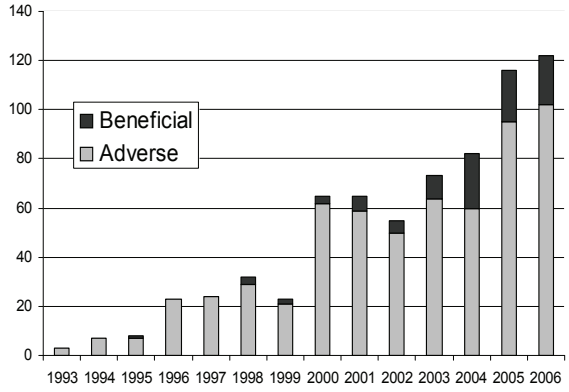

Figure 1 - Annual numbers of citations dealing with adverse (lower and light part of the bars) and beneficial effects (upper and dark part of the bars) of MPs on health

Discussion

Figure 1 - Annual numbers of citations dealing with adverse (lower and light part of the bars) and beneficial effects (upper and dark part of the bars) of MPs on health1 indicates that Publications on the health impact of MPs actually started in the early 1990's and increased in a more or less linear way during the subsequent years. Initially, there were mostly publications on potentially adverse effects. Consistent publication activities on beneficial effects started in the late 1990's, increased until 2003 moderately and leaped to higher levels beginning with 2004. In recent years such publications amount to approximately 20% of all publications considered by this survey.

The presented survey includes only articles listed on PubMed. There are – of course – additional articles dealing with this issue, e.g. articles being associated with the author [3], including articles that would actually have satisfied the search phrase but are not listed on PubMed [5]. Hence, the list is far from being complete and no conclusions can be drawn in terms of absolute numbers.

Since the survey was concluded at the end of November 2006, the numbers for the year 2006 do not yet include December and are therefore underrepresented.

It has to be emphasized that this survey did not attempt to assess details of the outcome of the many articles, neither with respect to adverse nor beneficial effects. Other than a review, this survey did not intend to answer questions like "what is the odds ratio of using MPs with respect to a certain cancer?" or "does MP based home monitoring reduce the frequency of hospital admissions in heart failure patients?". Since for many – in particular older – articles only the title is available on PubMed, a detailed analysis with respect to the outcome would require an additional (probably enormous) effort.

This survey specifically aimed at assessing the interest of the scientific community in all health related effects of MP usage, not only in a particular class or sub-class of effects. To the author's best knowledge such a survey has not yet been performed. This notion is supported by the fact, that in the present sample, no article has been found which covered both, adverse and beneficial aspects of MP use.

Conclusions

Today's MPs provide a large portion of the world's population with an ever more powerful communication tool. With respect to health, MPs were already shown to have both adverse and beneficial aspects – as can be expected from any kind of effective technology. After initial research focused mainly on the risk aspects of MP use, during the last years an increasing number of investigations concentrated on potential benefits.

Upcoming technologies and capabilities and a still rapidly increasing number of MP users will warrant continued and new research within the full spectrum of possible risks and benefits of MP use with respect to health.

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Localization Of Health Agents And Resources By Mobile Devices

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Abstract and objective

This poster reports the research being carried on the following: Initially, some health care situations where low resolution positioning is effectively usable are identified. Despite their limited processing capacity, due to its popularity, mobile devices are a natural choice to implement location awareness. Software can be used to turn regular cell phones and connected PDA's into low resolution positioning devices, without the subscription of expensive Telco's services. Remote computing is used to overcome the processing capacity restraint and improve the performance of the solution. Then, remote Artificial Intelligence techniques are used to improve the geographical resolution and to perform user problem's solution search. Finally, the need of articulated integration with other emerging technologies like Evidence Based Medicine (EBS), Body Area Network (BAN), Portable Patient Record (PPR) is pointed.

Keywords:

telemedicine, health services accessibility, mobile localization, location aware, ubiquitous computing

Introduction

In large cities like Sao Paulo, Brazil, there are several situations when geographical information can affect the health care result. Due to cellular phones and other mobile devices popularity and increasing processing capacity, they are a natural choice to location aware computing implementation. Though their majority don't currently offer built in geo positioning technologies, software solutions can be implemented to supply these capabilities.

Methods

Geographic low resolution health related problems

The importance of geography is intuitive whenever a triggering event, in an unfamiliar place, requires a quick decision of where to go as soon as possible in order to get proper health care. Every connected mobile device knows the fixed antennas they are talking to. Once their coverage area is around 3 km, the worst case resolution is known. Including the low resolution restraint, one possible statement to this rule can be: mobile connected devices software supplied positioning is useful whenever someone has to decide something related to the health care, satisfying geographical restraints with accuracy of at least 3 km. This definition excludes time restraints in order to consider situations as when a patient has to select a specialized doctor which fee can be refunded by his medical insurance system, who has free agenda matching to his schedule and who can be reached inside his 1 hour drive distance geographical area. This is a typical Artificial Intelligence (AI) problem.

Mobile device technologies independence

There are basically 4 technologies to connect mobile devices: Satelite, GSM, CDMA and WIFI and the subgroups and evolutions of these 4. The mathematical solution for positioning in each one of them is different, and the same happens with the resolution. This plurality produces additional complication once the devices often switch from one network to another.

Results

Limited processing capacity

Mobile devices cannot handle AI yet. It demands the transference of the processing is to a remote server. Java technology is used to handle the diversity of mobile device's models. Once it doesn't load the device, additional data processing is used to increase the geographical resolution, offer clues and to build graphical maps to be downloaded into the device.

Conclusion

Integration with other emerging mobile technologies

The presented technology can be easily integrated with EBS, PPR, and BAN mobile solutions through a future platform standard. This can help to supply the location aware part of the ubiquitous computing paradigm in medical informatics.

Low cost solution

Once this approach doesn't use the Telco's positioning expensive services, it can be usable to solve localization problems that require geographical information for a huge number of people that could not afford it otherwise, several years prior to mobile equipment evolution and substitution.

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Informatics Support for Decompression Sickness on Space Missions

Tyler N. Carruth, MPAS-C[a,b], M. Sriram Iyengar[a] PhD[a]

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[b] *Wyle Life Sciences, Houston, TX*

Abstract

Text-based checklists (paper and electronic) together with telecommunications links to Earth-based physicians are currently used to diagnose and treat medical conditions during space travel. GuideView, an application that augments text by presenting clinical guidelines in a structured, interactive, multi-modal format, presents clinical instructions simultaneously in voice, text, pictures video or animations. In this paper we describe a Decompression Sickness (DCS) guideline implemented in GuideView for the diagnosis and treatment during space flight

missions

Keywords:

space flight, decompression sickness, practice guidelines, multimedia

Introduction

During low earth orbit missions aboard the International Space Station (ISS) and the Space Shuttle, text-based clinical guidelines and checklists (paper and electronic) augment the assistance provided by ground-based medical support staff, including flight surgeons, to assist the crew in the diagnosis and treatment of a host of medical conditions. Astronauts can communicate with and be advised by their ground medical support via audio and/or video telecommunications links as well as downlink images for review. Due to possible telecommunication delay or loss of signal during low earth orbit missions, however, this contact with the earth-based medical support can be interrupted or intermittent. This may force the astronauts to rely on the text based procedures to navigate through complex medical tasks to respond to an emergency if one would arise.

Numerous drawbacks and limitations exist with text-based medical checklists, especially for non-physician astronaut users, whose medical experience and knowledge base may be minimal.

Through this project, we present a means of informatics support to create a "procedure assistant" using GuideView to assist in medical event response. In GuideView, procedural steps and information needed by the user to complete a task is externalized; the text is accompanied by video, audio, and images that augment the users ability to perform a task without relying on his or her memory of the system.

Guide view

GuideView technology was originally developed at NASA Johnson Space Center to provide an interactive, electronic means of guiding a user through a series of complex tasks during space exploration missions or in settings where physician availability may be low such as rural areas or remote environments. GuideView consist of two components; the GuideView Author is used to develop the guidelines in the GuideView format, and the GuideView Viewer, used to execute and display these guidelines. Guidelines developed and saved in the GuideView format are called GuideViews.

GuideViews are compatible with multiple platforms including the internet, stand-alone Windows computers, PocketPC-based PDAs, and Windows Mobile cell phones such as T-Mobile SDA and Cingular 3125. This compatibility adds to the versatility of the application in various environments.

Demonstrating GuideView

To showcase the GuideView technology, complex clinical guidelines currently used aboard the International Space Station (ISS) to evaluate Decompression Sickness (DCS) were developed using GuideView. DCS was chosen due to the complexity and number of procedures involved in the required response and treatment.

DCS, otherwise known as "the bends", is a condition astronauts may be susceptible to. In DCS, inert gas present in the bloodstream can come out of solution forming bubbles. These bubbles can embolize various tissues of the body including joints, lungs and brain causing significant pain, musculoskeletal and/or neurological impairment.

Astronauts performing space walks from the ISS may be at increased risk for this injury due to the difference in gas pressure within space suits and the interior of the Space Station[1]. When the human body is exposed to this sudden significant decrease in ambient pressure, or if a suit leak were to occur, DCS may result.

Since DCS can cause substantial impairment, response must expeditious. Because the response to such an event involves many different systems in addition to the medical component, procedures are located in multiple documents including the ISS DCS System Handbook[2,3] and the ISS Medical Checklist.[4]

Creating the DCS GuideView

In the first phase of this project, the procedures related to the recognition and treatment of DCS was reviewed by clinician subject matter advisors. These documents, developed by NASA Flight Surgeons, were used to create structured procedures that could guide an astronaut through the necessary actions of DCS treatment.

The GuideView Author, an authoring program special to this application, enabled the creation of the GuideView interface content through encoding of guideline structure and embedding of text and multi-modal content[4]. Using the GuideView Viewer, the procedural steps are presented using text, voice, still pictures, video, or animation, simultaneously.

Results

Using GuideViews, DCS guidelines were presented through a rich content delivery environment by incorporation of video and images detailing the required tasks to be preformed. Users are able to navigate through the procedure by mouse clicks directing them to the next treatment step based on information from their findings. The development of the DCS GuideView is ongoing and will involve incorporation of additional media and tangential procedures.

Voice command is a feature currently available when GuideView is run on Windows desktops and laptops and allows the user to proceed through the procedure by voice triggers such as “next” and “stop,” and “repeat last” enabling hands-free patient interaction while interacting with GuideView. This feature will be eventually incorporated into the DCS GuideView.

Conclusion

Due to telecommunication delays, real-time earth-based medical support may be difficult during long duration space missions. Text-based medical checklists have significant limitations, especially for non-physician astronauts. Instead, a more informative methodology is needed to provide informatics support such as that provided by the GuideView technology.

Acknowledgements

We thank the following for their support and encouragement. Kathy A. Johnson, PhD, Director, Medical Informatics, NASA Johnson Space Center; John R Svirbely, MD, TriHealth, Cincinnati, OH; Kevin Montgomery, PhD. Tommy Morris, Telemedicine & Advanced Technology Research Center (TATRC). This research was supported in part by Grant number # W81XWH-04-00035, administered by the U.S. Army Medical Research & Materiel Command’s (USAMRMC) Telemedicine & Advanced Technology Research Center (TATRC), (MSI); and NCRR Grant No. 1UL1RR024148 (MSI), and Wyle Life Sciences, Bioastronautics Contract (TC).

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Informatics Support for Decompression Sickness on Space Missions

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[c] *Medical Informatics, NASA Johnson Space Center*

Abstract

- Text-based checklists (paper and electronic) together with telecommunications links to Earth-based physicians are currently used to diagnose and treat medical conditions during space travel.
- GuideView is an application that augments text by presenting clinical guidelines in a structured, interactive, multi-modal format
- GuideViews present clinical instructions simultaneously in voice, text, pictures video or animations
- This project incorporated a Decompression Sickness (DCS) guideline used for the diagnosis and treatment during space flight missions into GuideView.

Background

- For each ISS Expedition, at least one crewmember is designated a Crew Medical Officer (CMO) and tasked with assisting in the health maintenance of his or her fellow crewmembers.
- Although there are a few astronaut physicians, the majority does not have a formal medical background and will have received only limited medical training as part of mission preparation.

Background

Crews aboard the International Space Station rely on telecommunications support to assist them in providing medical care during a mission.

Crews communicate with their ground medical support via audio and/or video telecommunications links as well as downlink images for review.

Text-based clinical guidelines and checklists (paper and electronic) are available too assist the in the diagnosis and treatment of a host of medical conditions.

GuideView

- GuideView technology was originally developed at NASA Johnson Space Center to provide an interactive, electronic means of guiding a user through a series of complex tasks during space exploration missions
- Information and task steps are externalized and presented via text and multimedia
- The cognitive load of the user is decreased.

GuideViews

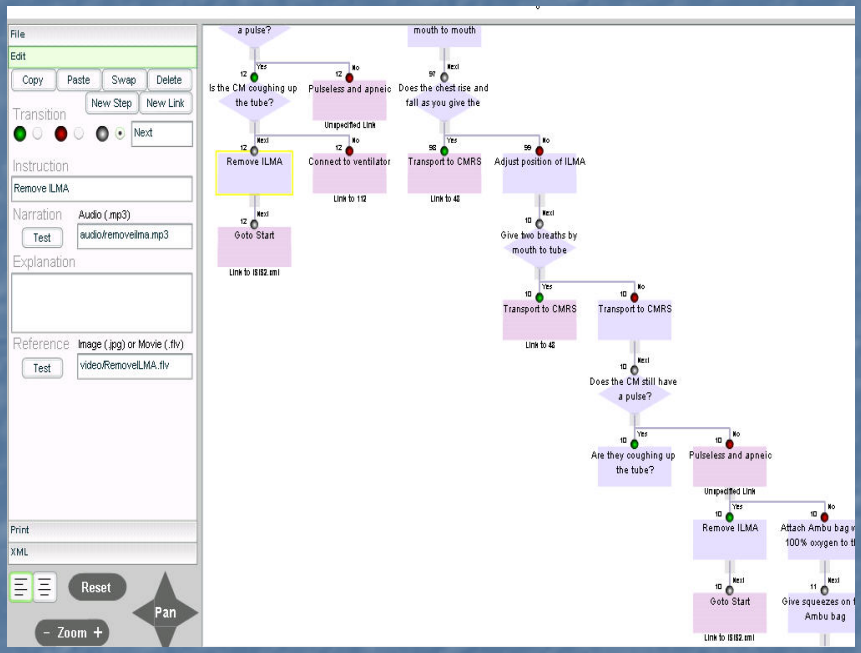
- GuideView consist of two components
  1. GuideView Author - used to develop the guidelines in the GuideView format
  2. GuideView Viewer - used to execute and display these guidelines
- Guidelines developed and saved in the GuideView format are called *GuideViews*.

GuideView Author screen

Enables:

- development of the guidelines in the GuideView format
- insertion of the Visual content (images and/or video)

**The images and video inserted into the program were obtained from NASA archives or produced de novo.*

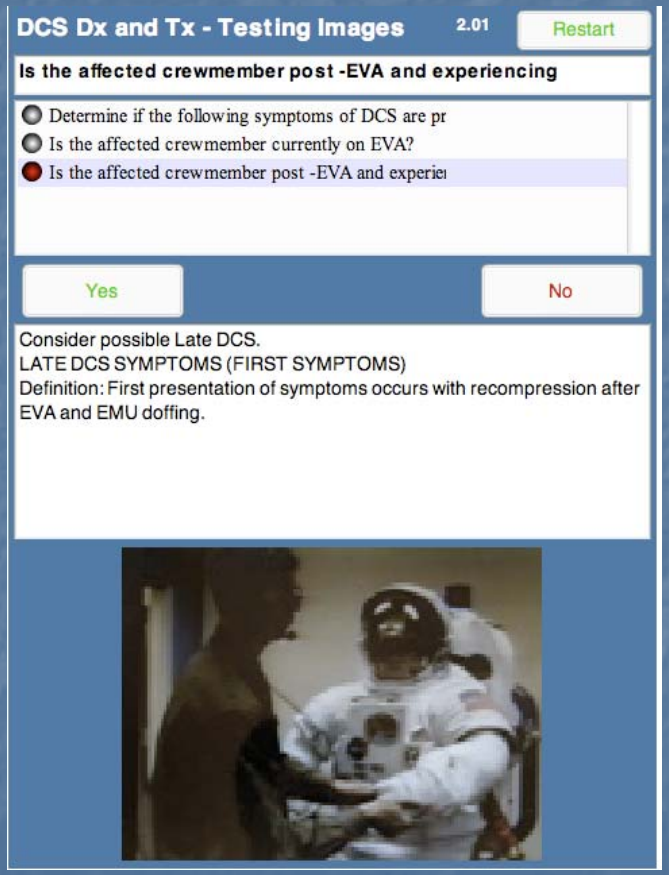


GuideView Author screen

GuideView Viewer

Enables:

- used to execute and display the guidelines in the GuideView format
- Users are able to navigate through the program using mouse clicks



GuideView Viewer screen

Creating the DCS GuideView

- Procedures related to the recognition and treatment of DCS was reviewed by clinician subject matter advisors.
- These documents, developed by NASA Flight Surgeons, were used to create structured procedures that could guide an astronaut through the necessary actions of DCS treatment.
- GuideView Author was used to encode the guideline structure and embedding of text and multi-modal content to create the interface.

GuideView versatility

GuideViews are compatible with multiple platforms including:

- Internet
- stand-alone Windows computers
- PocketPC-based PDAs
- Windows Mobile cell phones
  - T-Mobile SDA and Cingular 3125

This compatibility adds to the versatility of the application in various environments

Conclusion

- Due to telecommunication delays, real-time earth-based medical support may be difficult during long duration space missions.
- Text-based medical checklists have significant limitations, especially for non-physician astronauts.
- A more informative methodology is needed to provide informatics support such as that provided by the GuideView technology.

References and Acknowledgements

Acknowledgements

We thank the following for their support and encouragement. Kathy A. Johnson, PhD, Director, Medical Informatics, NASA Johnson Space Center; John R Svirbely, MD, TriHealth, Cincinnati, OH; Kevin Montgomery, PhD. Tommy Morris, Telemedicine & Advanced Technology Research Center (TATRC). This research was supported in part by Grant number # W81XWH-04-00035, administered by the U.S. Army Medical Research & Materiel Command's (USAMRMC) Telemedicine & Advanced Technology Research Center (TATRC), (MSI); and NCRR Grant No. 1UL1RR024148 (MSI), and Wyle Life Sciences, Bioastronautics Contract (TC).

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Drugs Trading in the Hospital Pharmacies Through a Multi-Agent Electronic Market

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Abstract

Several challenges involved in the reduction of hospital drugs expenditures are difficult to be solved, at least nowadays, but it is important to look for possible ways to undertake or reduce the problem. In this paper we propose an electronic market as a possible solution to reduce costs and time for the hospital pharmacies while increasing flexibility and access to new possibilities of negotiation. This electronic market is based on a Distributed Multi-Agent System which has a multi-criteria negotiation and uses ontology-based services to solve the interoperability problems. The potential solutions obtained through the electronic market interactions will compete with the solutions found by the hospital pharmacy own system. We believe that using our system architecture and services is a step forward in achieving the cooperation between hospital pharmacies and pharmaceutical drug manufacturers around the world. However, we are also aware of challenges and problems that might arise from using this approach.

Keywords:

hospital pharmacy, pharmaceutical medicine manufacturer, electronic market, multi-agent system, negotiation, ontology

Introduction

United States perspectives database were used in a study to evaluate trends in hospital drug expenditures [1]. The study presents these data consisted of drug purchasing information for 5230 hospitals in 2003. The hospital drug expenditures were approximately $23 billion in 2003, representing a 6.3% increase in drug expenditures compared with 2002. Authors identify that some of the factors affecting the trend in hospital drug expenditures included drug prices (2.3%), volume and therapeutic mix (2.1%), and new drugs (1.6%). They projected for 2005 a 10-12% increase in drug expenditures in outpatient settings, a 12-15% increase in clinics, and a 6-9% increase in hospitals. Authors conclude that "Pharmacy managers must remain vigilant in monitoring drug costs in their health system and take a proactive role in pursuing efficient drug utilization" [1]. Several barriers and challenges involved in the reduction of drugs expenditures are difficult to be solved, at least nowadays, but it is important to look for possible ways to undertake or reduce the problem.

One way would be to find the supplier (pharmaceutical drugs manufacturer) with the best price for each one of the needed drugs and also be able to negotiate based on hospital pharmacies (HP) preferences.

Nowadays, most of the HPs around the world buy drugs by contacting each pharmaceutical drugs manufacturer (PDM) that may provide the respective drug. There are several PDMs that may provide the same drug with different commercial names, prices, quality and delivery time. As an example, the HP could need antibiotic drugs, and in this case they could buy "Amoxil" developed by Glaxo-Smithkline, "Novocilin" developed by "Aché", Velamox developed by "Sigma Pharma", just to name a few. The HP could also buy the generic drug (amoxicillin) developed by Abbott, Eurofarma, Sanval, or Medley. It is not an easy task for the hospital pharmacy responsible looks for the best supplier around the world, for each needed drug.

An electronic market (TEM) for trading drugs could reduce costs and time for the HP that needs a specific drug, while increasing flexibility and access to new possibilities of negotiation. Moreover, the PDM would have more chances to sell its drugs.

Electronic marketplaces are enabling new kinds of services and interactions between suppliers and customers [2]. It is an application domain where thousands of heterogeneous companies, acting both as suppliers and customers and using different names to represent the traded products and different currencies to represent the prices, may be involved. Moreover, different companies tend to use knowledge representations (ontologies) that differ significantly either syntactically or semantically. This heterogeneity in the representation of the commercial products is a critical impediment to an efficient business information exchange and to the automation of the business-to-business (B2B) transactions. Furthermore, in a decentralized and distributed approach, companies may negotiate with other companies geographically distributed. The companies negotiate using their own product descriptions as well as their local currency. If each company uses

local currency, and they differ from the ones used by other companies then an interoperability problem occurs. The interoperability problems make the negotiation process more difficult and consequently make hard a final agreement.

We are proposing an EM based on multi-agent system (MAS) paradigm, where each HP and PDM will be represented by an agent. For helping to solve the interoperability problems (problems caused by the use of distinct terminology; and problems generated by the lack of standardization) the ontology-based services [3] are integrated in the EM proposed. In this context, ontologies play an important role since they provide the vocabularies used by the agents. Whereas, in homogeneous MAS, the adoption of a common ontology guarantees the intelligibility of the communication between agents, in open MAS, where the agents are intrinsically heterogeneous and have different private ontologies, the interagent communication is affected by unknown and, thus, incomprehensible terminology, as well as, by the *ad-hoc* use of disparate currencies to represent the price of products.

We believe our proposal is a step forward in achieving the cooperation between hospital pharmacies and pharmaceutical drug manufacturers decreasing time and price, while increasing the number of negotiation with different PDM around the world.

Electronic market solutions

Many electronic markets (EMs) or online pharmacies have been proposed, but they are mainly related with business-to-consumer (B2C) domain, as for example 101Pharmacy[1] and Acme Fresh Market[2]. To the best of our knowledge, this is the first proposal for an EM applied to this specific domain.

The EM proposed here is a permanently open virtual marketplace where registered PDM and HP (represented both by agents) can meet each other through the Web to purchase services according to established norms and rules.

Drugs trading electronic market architecture

Due to the fast growth of B2B e-commerce, the demand for agents is growing because agents are able to, on behalf of their owners, locate and retrieve information and make reasonable decisions based on the owner's profile. Agents negotiate with multiple suppliers, monitor multiple auctions, and use intelligent strategies to find the best deal for the users. Agents can also represent companies/organizations in a B2C and B2B context. This shows not only how agents can collaborate with one another to achieve a common goal, but also how an agent selects the best partners through negotiation [4]. A central point of the agent's paradigm of software development is that communities of agents are much more powerful than any individual agent, which immediately raises the necessity for interoperable agent systems.

In our multi-agent approach we will have at least five types of agents: (i) Facilitator Agent (FAg), (ii) the Customer Agent (CAg), (iii) the Supplier Agent (SAg), (iv) the Ontology-based Services Agent (OSAg), and (v) the External Agent (EAg). The FAg, CAg and SAg are cooperating through a website with the objective of providing or getting drugs, in collaboration, but keeping their own preferences and objectives. The OSAg supports the negotiation process in case the SAg has not understood the content of a message, and it helps in the calculation of prices (that may be necessary when dealing with different currencies).

The agents are deliberative, autonomous, intelligent entities that use different ontologies and apply goal driven reasoning to achieve their objectives. Agents have an inference engine which derives the recommendations from the knowledge base (ontologies) and problem-specific data in instances. In our scenario, the CAg (representing the HP) and the SAg (representing the HP) have the same objective: they want to trade products in the same application domain and still use their own private ontologies (the PDM and HP will not waste time and money converting their drugs catalogues, changing the drug names and involved knowledge). Due to this common objective, we provide an e-commerce ontology that defines an e-commerce vocabulary just for the trading, *i.e.,* a negotiation protocol. This vocabulary contains terms which are used during the negotiation process. Thus, we ensure that all agents will uniformly interpret the negotiation messages exchanged. This does not imply identifying correctly the specific content of the messages, *i.e.*, the requested drugs, since each agent interprets this information based on its own private domain ontology. A user interface allows the interaction between the users and the agents [3].

When a request for a drug is made by some of the registered CAg (HP), the FAg will look for the registered SAg (PDM) that may provide the respective drug. The OSAg enables appropriate conversations and makes possible to reach agreements between agents representing different HP and PDM. In order to avoid the EM indicating a drug that will satisfy the customer needs but will have later some special constraints, the FAg requests to the EAg the validation of the request.

These five types of agents play the following roles:

(i) **FAg** is the entity that matches the right agents and supports the negotiation process.

1 101Pharmacy.org, http://www.101pharmacy.org, November, 2006.

2 Acme Fresh Market, http://www.acmestores.com/pharmacy/pharmacy.html, November, 2006.

(ii) **CAg** represents HP interested in buying drugs. Several suppliers in the world may sell these drugs with different prices and conditions. The user representing the registered HP inserts the information an agent needs in order to ask for a drug and their negotiation preferences. This includes the attributes: drug name, quantity, and currency, with the respective HP negotiation preferences. The currency chosen will be the currency in which the CAg wishes to receive a proposal, *e.g.* Dollar (USD). If the SAg wants to make a proposal, but the drug is priced in another currency, *e.g.* Euro (EUR), the SEAg requests to the OSAg the currency conversion service.

(iii) **SAg** represents pharmaceutical medicine manufacturers interested in providing drugs. Whenever a drug is needed, the FAg conveys this announcement to all registered interested SAg (PDM). The SAg makes an offer if the announced drug is currently in stock and if it understands what the CAg is asking for (the drug name). At least one SAg has to be present in the platform so that communication can be established.

(iv) **OSAg** is responsible for providing the services that support the negotiation among agents. This approach is compliant with the Foundation for Intelligent Physical Agents (FIPA) [5] proposal of creating a specialized Ontology Agent (OA) [6] for open MAS platforms. The idea is to support the interoperability between agents with different individual ontologies by means of a dedicated agent. Our implementation of the ontology agent is named OSAg and follows the FIPA recommendation. It is responsible for providing services to the customer and supplier agents that help solving the interoperability problems. Its task consists of applying different methodologies to detect lexical and semantic similarities between two terms (in this case, between drugs), as well as providing currency conversion services. The OSAg is an autonomous server-side agent that does not require any direct user interaction. The user interface only controls the tasks performed by the OSAg responsible for providing services to other agents to enable them to effectively negotiate together.

(v) **EAg** represents drugs and healthcare products regulatory agencies responsible for enhancing and safeguarding the health of the public by ensuring that drugs and medical devices work and are acceptably safe.

Negotiation Protocol

Java Agent DEvelopment Framework (JADE) [7] is the agent development platform used to build our system. The main reason for choosing JADE lays on the fact that JADE implements the FIPA standards. JADE encloses implementations of the FIPA library of behaviours and interaction protocols. All agents in our platform communicate by exchanging FIPA Agent Communication Language (FIPA-ACL) messages. A FIPA-ACL message contains a set of one or more message parameters, *e.g.*, type of communicative act (performative verb), participants in communication, content of message, description of content, and control of conversation. The communication follows the FIPA Contract Net Interaction Protocol (FIPA-CNP) [8]. The type of communicative act, defined by the performative parameter, is a required parameter of all FIPA-ACL messages. The participants consist of sender and receiver.

The implementation of our negotiation round combines the FIPA-CNP with an additional protocol called ontology interaction protocol (OIP). The former represents the general scenario of agents trading goods or services proposed by FIPA. Alike other interaction protocols, it structures complex tasks as aggregations of simpler ones. The latter implements the message flow necessary for solving the problems of interoperability, including the interaction of customer and supplier agents with the OSAg.

In our context, the CAg plays the role of the initiator while the SAg is the participant during the FIPA-CNP. The initiator wishes to have some task performed and further wants to optimise a function that characterises the task. In this context, the CAg announces in the market the need for a specific drug. For a given task, the participants (SAg) may respond with a proposal or a refusal to negotiate (sell drugs). Negotiations then continue only with the SAg that offered proposals. The CAg (representing the HP) selects, among all proposals received, the best offer based on its own cost-benefit criteria and replies to all SAg (representing the PDM) that made offers with an acceptance or rejection message, depending on the case.

In the former case, once the SAg has completed the task, it sends a message to the CAg in the form of an inform-done performative or, using a more explanatory version, in the form of an inform-result performative. However, if the participant fails to complete the task, a failure message is sent. Three different situations may occur when a SAg receives a CFP (Call-for-Proposal) message: (i) the SAg refuses the CFP, (ii) the SAg accepts the CFP or (iii) the SAg contacts the OSAg because it is unable to fully understand the CFP.

In the first case, the SAg answers with a refuse performative. In the second case, the SAg responds with a propose

performative based on a multi-criteria negotiation (explained later) stating its conditions to sell the drug. The SAg's conditions should be compatible with the conditions originally contained in the CFP. In the last case, after having received a CFP and not being able to interpret the requested item, the SAg sends a message with the performative not-understood to the OSAg, identifying both the sender of the CFP (CAg) and the name of the unknown drug. The OSAg generates and sends a query-ref message to the CAg inquiring about the unknown drug.

- The CEAg analyses the request and answers with an inform performative containing all the information about the required drug. The price is taken from its pricelist.
- After receiving all the information about the item under negotiation the OSAg applies the similarity detection methods [9] trying to find the correspondent drug in the SAg ontology. These similarity detection methods aim at detecting syntactic and semantic similarities between terms. Every candidate term (SAg drug) is compared with the requested term (CAg drug).
- The OSAg informs the SAg of the outcome of the process, *i.e.*, sends the name of the best match or informs that it was unable to find any corresponding item. If necessary, the CAg requests the unit conversion service.
- The SAg is then able to respond to the CAg CFP, either with a proposal (based on the multi-criteria negotiation) or with a refuse performative according to the FIPA-CNP.

Multi-criteria negotiation

The CAg (PH) is responsible for selecting among a set of SAg (PDM) the subset that will provide the needed drugs. As already explained, the CAg negotiates with several SAg to select among them the ones that are the most promising, at the moment, to satisfy its actual need. The negotiation results in a process of multiple rounds.

The negotiation is a kind of decision making where two or more parties jointly search a space of solutions with the goal of reaching a consensus [10]. This search usually is a single dimension process (usually the price) where the different agents, involved in the negotiation process, mutually adapt their price offers in order to reach their goals (to sell or to buy a good). However, this process is inflexible and often unrealistic because more than one single issue has to be negotiated in order to find out an adequate agreement [11]. The first step is to translate the human preferences in attributes that can be analysed, communicated and negotiated by agents.

Each CAg (PH) has some negotiation preferences based on attributes as price, delivery time, or specific PDMs, which have to be taken into consideration during the negotiation round. These preferences mean the PH cost-benefit criteria.

The CAg request describes the needed drug, represented in a private ontology and describes also the CAg preferences, which are codified in the relative order by which attribute are defined in the product structure definition: $Product_x=\{Atb_{x1}, Atb_{x2}, Atb_{x3}\}$ with $Atb_{x1} >_{imp} Atb_{x2} >_{imp} Atb_{x3}$, where $>_{imp}$ means "more important than". In this case it means that Atb_{x1} is more important than Atb_{x2}, and Atb_{x2} is more important than Atb_{x3}. This order is relevant for the negotiation process. Each attribute has also dependencies associated with the different attribute's values (Dep_i). These dependencies may be of three types: time, event and value. $Dep_i=\{\{Dept_i\}, \{Depe_i\}, \{Depv_i\}\}$, where time dependencies constrains the attribute's values in specified time intervals, event dependencies constrains the attribute's values when some specified event happen, and the value dependencies constrains the attribute's values to other attributes' values of other components. During the negotiation process, the SAg formulates proposals in an adaptive way, learning with qualitative feedbacks formulated by the CAg in previous negotiation rounds [12].

The selection of the SAg (PDMs), which will provide the requested drugs, is done through a negotiation algorithm called Q-Negotiation. The Q-Negotiation algorithm uses a reinforcement learning strategy based in Q-learning [Rocha and Oliveira, 2001] for the formulation of new proposals.

In particular, Q-learning enables on-line learning, which is an important capability for B2B negotiations where agents may effectively learn in a continuous way during all the negotiation process, with information extracted from each negotiation round, and not only in the end of the negotiation. The adaptation of the Q-learning algorithm to our scenario, leads to the inclusion of two important features (the reward value calculation and the decrement of the exploration space) detailed in [13].

The distributed dependencies satisfaction algorithm, besides reaching the optimal solution, keeps agent's information as much as possible private. Each agent involved in the distributed dependent problem resolution should know all possible values for its own dependent attributes. Agents will then exchange among them alternative values for the dependent attributes, in order to approach an agreement. As in any iterative negotiation process, agents start the negotiation by proposing its optimal solution and, in the next rounds start trying to reach a consensus. A more detailed description of this algorithm may be found in [13].

Conclusions and future work

An electronic market, including ontology-based services, to solve the trading drugs problem between hospital phar-

macies and pharmaceutical drugs manufacturers has been proposed.

We have implemented a prototype with one agent representing a hospital pharmacy and several agents representing pharmaceutical drugs manufacturers cooperating through a website. To support the negotiation of products, we provide an e-commerce ontology which is shared by all agents and defines a domain-independent business vocabulary. This ontology ensures a meaningful e-commerce communication since all agents will uniformly interpret the intention of the messages exchanged and the generic business terms used. Besides this e-commerce ontology, each agent has its own private drugs domain ontology. Since in a real-world business context, the companies will use different ontologies and adopt diverse ontology representation formalisms, our approach also envisages this possibility: the ontologies may be developed by any ontology development tool and stored in any standard format.

A facilitator agent and an ontology-based services agent were integrated in order to monitor and support the negotiation process. The agents representing the external agencies were not integrated in this phase.

We have implemented a multi-criteria negotiation where CAg may order their preference for using during the selection of the best SAg.

An important requirement in this process, is that information must be kept private to individual companies, since they are competitive by nature and do not want to reveal their market strategy to others. The Q-Negotiation algorithm has the ability to maintain information private and, at the same time, it includes the capability to evaluate multi-attribute proposals, to guide learning during the negotiation process, and to resolve attributes' mutual interdependencies.

Regarding the trading of drugs, things are not so linear, hospital internal rules and country specific rules, just to mention a few, and they have to be taken into account when approach this subject. Our proposed EM already deals with these subjects, in an elementary way, but there is still space to make several improvements. Others issues like communication between different information systems, security, privacy and authorization, are also problems that we will have to address in our proposed EM as well as specific EM subjects like contracts.

We know that it is a hard job but we believe that, after solving all the questions related with the previous mentioned subjects, our proposed EM might be a profitable one for hospitals as well as for pharmaceutical drugs manufacturers that might be created just specialized in supplying solutions to these problems.

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Agent-Based Secure Aggregation of Distributed Health Data

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Abstract

A common problem in the health sector is in balancing the need for patient health information against the risks posed by releasing such private information. The idea of Secure Multi-party Computation (SMC) provides potential ways in which this can be mitigated, by allowing for analysis of data distributed amongst multiple parties to take place without the need to disclose it. This paper presents a two-party SMC protocol which can be used to calculate some basic aggregate functions. In addition, we discuss a rationale for using an agent-based framework to utilize SMC techniques in order to support privacy-preserving access to health information.

Keywords:

data linkage, patient data privacy, data security, secure multi-party computation

Introduction

Consider two separate databases, Diagnoses and Prescription, containing pre-linked patient information about illnesses and drug prescriptions respectively. Suppose that as part of a study into drug adverse effects, a researcher wishes to find a count of people who were diagnosed with cancer less than 3 years after being prescribed with drug X.

Normally, this would require the release of potentially sensitive information – for instance, it would be necessary to release the cancer diagnosis date and drug prescription date in order to be able to perform some meaningful comparison.

This paper presents a two-party SMC protocol for computing a scalar product on *privately selected* elements of private vectors, while ensuring that:

- no party discovers which elements in the vector are used for the aggregation
- no party discovers the values of any individual data, or the partial aggregates at each database

Such a protocol can be used to calculate basic aggregates such as counts and weighted/un-weighted sums. In addition, we discuss how this protocol could be extended towards the calculation of other statistics such as average, standard deviation and covariance in a true (i.e., >2 participants) multi-party scenario.

Finally, we discuss the rationale for an agent-oriented framework to support SMC operations for providing aggregate processing of distributed health information.

Method

The protocol, shown in Algorithm 1, is based on using a series of SMC primitives, whereby the output of each step is fed into the input of the next phase. Standard cryptographic notions of secret-sharing and encryption ensure that while these intermediate values can be used in their successive stages, they do not leak information.

Step 1 of the protocol makes use of general SMC theory, which states that *any* function which can be represented as a combinatorial circuit can be evaluated securely [1]. What prevents the execution of the entire protocol in this manner is that the circuit size is polynomial with respect to input size and complexity. In the case of Step 1, the function is expected to be a relatively simple computation. For the example, it is necessary to reduce the following predicate to circuit form:

(has_cancer == TRUE & uses_drug_x == TRUE & diagnosis_date > prescription_date & (diagnosis_date + 365*3) < prescription_date).

While SMC remains mainly in the theoretical domain, implementations such as Fairplay [2] exist that allow such high level expressions to be compiled and executed.
In Step 2, Alice and Bob engage in a 1-2 Oblivious Transfer protocol using their secret shares obtained in Step 1 for the input. An Oblivious Transfer ensures that Alice cannot determine which message Bob has received. As it is encrypted, Bob is similarly unable to determine which message is received.
The messages are aggregated in Step 3 – By exploiting the properties of a homomorphic public-key cryptosystem, Bob performs a blindfold evaluation of the scalar product in the same manner as used in [3]. Note that, if the predicate P evaluated to 0 (or false), then the value received by Bob, $c_{i,b_i} = E(0,r)$, and Bob is essentially multiplying a zero payload.

Private Input: Databases DbA, DbB owned by Alice and Bob respectively, where DbA_i, DbB_i is the data corresponding to patient i, $|DbA| = |DbB| = N$, and $DbA_i.attr$ refers to the attribute *attr* in DbA.

Public Input: Predicate function $P(DbA_i, DbB_i) \rightarrow \{0,1\}$

Private Outputs: Selective scalar product as secret shares

$$S_A + S_B = \sum_{i=0}^{N} DbA_i.x \cdot DbB_i.y \cdot P(DbA_i, DbB_i)$$

0. Setup. Alice generates a public/private keypair (E, D) for a homomorphic cryptosystem

1. Selection. For each $i \in \{1 \ldots N\}$ Alice and Bob evaluate $P(DataA_i, DataB_i)$ via circuit-based SMC evaluation. Alice obtains $a_i \in \{0,1\}$ and Bob obtains $b_i \in \{0,1\}$ such that $a_i \oplus b_i = P(DbA_i, DbB_i)$

2. Vector Transfer: For each $i \in \{1 \ldots N\}$:

a. Alice sets $c_{i,1-a_i} = E(DbA_i.x, r)$ and $c_{i,a_i} = E(0, r)$ for some random r

b. Alice and Bob execute a 1-2 Oblivious Transfer whereby Alice sends the pair ($c_{i,0}, c_{i,1}$) and Bob selects c_{i,b_i}.

3. Multiplication: Bob sets $w = \prod_{i=1}^{N} c_{i,b_i}^{DbB_i.y}$

Algorithm 1 – Private Selective Scalar Product

Finally, Bob blinds the final product with a random, before returning it to Alice, who can decrypt it. At this stage, both parties hold secret shares of the final output.

In its simplest form, Alice and Bob can set $x, y = 1$ to obtain secret shares of the count of elements.

Extensions

As the output of the protocol is a series of secret shares, it lends itself to a number of natural extensions. Principally, the idea is that the protocol can be run a number of times with x values, and the outputs of each run can then be combined via general SMC circuit evaluation. This has two major implications:

- It can easily be extended to a *true* multi-party scenario with greater than two participants, for instance, in the case where the data is further distributed horizontally (e.g. a scalar product over 3 vectors) or vertically (if a vector is partitioned amongst two parties), or a hybrid mix.
- Based on basic primitives, the protocol can be used to calculate other aggregates such as average (count, sum), standard deviation(sum of squares, average), and covariance (scalar product, average).

An agent-based framework

It is proposed to use software agents – autonomous, proactive, social software entities – towards realising a privacy-preserving framework utilizing SMC techniques on behalf of researchers and database custodians.

The use and execution of SMC protocols is a non-trivial task. They are interactive in nature, requiring databases to become active participants in the information gathering process. Agents are a natural paradigm for an environment involving distributed, complex interactions with multiple points of control [4].

Agents could provide the following functionality:

- Decomposition of researcher queries into SMC primitives
- Dynamic formation of coalitions for query answering, and role fulfillment
- Execution of SMC protocols
- Adapting to intermediate computation results.

Conclusion

Secure multi-party computation protocols, such as the one presented, offer potential ways in which private health data can be analysed without requiring its disclosure. An agent-based framework offers promising ways in which they can be effectively applied. Currently, such a framework is undergoing implementation in the Java Agent Development Framework (JADE) [5].

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GELLO – A Practical Implementation through the Application of Real World Examples

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Abstract and objective

The computing language GELLO has been designed by the HL7 community as a standardized way of expressing complex clinical data queries, yet few implementations exist publicly to explore the practical aspects of such a language and its application towards real clinical information systems. We present a GELLO language implementation and detail the challenges and obstacles encountered without a reference implementation of the language or many suitable real examples of GELLO usage available. The compiler was developed as a component in a GLIF guideline for the treatment of Lymphoma. We conclude that GELLO is a language worthy of use by the medical information community and that effective development of the language through the active implementation of practical examples will allow it to achieve its full potential.

Keywords:
GELLO, GLIF, ARDEN, vEMR, USAM, CDS

Introduction

As part of a project to build advanced decision support and registry reporting tools for the treatment of Lymphoma a decision was made to use GELLO encoded logic. It was originally envisaged that Arden would be the vehicle, however further investigation suggested that GELLO would be a better candidate to evaluate the clinical data to assist relevant decisions, in particular its rich querying facilities. We set about to implement what we believe to be one of the first practical implementations of GELLO worldwide.

Methods

For our compiler tools, we used a standard LALR(1) parser embedded within an existing HL7 V2 framework written in the Delphi programming language. A vEMR (Virtual Electronic Medical Record) interface to the existing data was written as part of the project. The lack of any available implementations of GELLO to refer to required us to work directly from the latest GELLO and HL7 specifications. As GELLO is a work in progress, some changes were required to aspects of the formal grammar. Since GELLO is based on OCLv2 we referred back to the OCLv2 specifications to clarify some of the finer points. We made cosmetic changes to the lexical rules of the grammar, allowing for either " or ' as a string delimiter, and allowing tokens to be case-insensitive. Other changes made comprised of minor syntactic changes to the language. The LET statement and other similar constructs were extended to make the type of the variable optional since in most cases the type of the expression can be inferred. The grammar was reworked to resolve ambiguities in the IF-THEN-ELSE-ENDIF constructs of the original GELLO grammar by introducing a Block construct comprising of a list of Declaratives followed by a final GELLO expression, and also reworking the IF statement to contain a Block rather than a Statement. Other minor extensions included allowing for the final GELLO expression to be optional, and fleshing out several incomplete syntactic structures in the original GELLO specification. We have also progressed with further extensions to the GELLO grammar such as class and type definitions to facilitate building standard GELLO libraries, however these are subject to further research and fall outside the scope of the current GELLO project. The accompanying GELLO grammar as implemented provides a concise record of our current implementation.

Conclusion

GELLO is a powerful decision support tool capable of supporting highly complex querying of medical data in a very concise but readable manner. Its application to decision support is highly productive and with the relevant necessary extensions for practical use, we believe that is entirely suitable to the purpose for which it is designed.

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GELLO, A Practical Implementation through the Application of Real World Examples

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Choice of GELLO for decision support

- Project to build advanced decision support and registry reporting tools for the treatment of Lymphoma.
- GLIF was vehicle for Guidelines.
- Decision was made to use GELLO encoded logic.
- Originally envisaged that Arden would be the vehicle, however further investigation suggested that GELLO would be a better candidate to evaluate the clinical data to assist relevant decisions.
- GELLO features
  - Rich querying facilities.
  - Object oriented
  - Integrates well with HL7
- Implemented what we believe to be one of the first practical implementations of GELLO worldwide.

Working with GELLO specifications

- GELLO is a work in progress
- Developed in coordination with HL7 Decision Support Group
- Based on OCL 2.0
- Started in Dec 2003
- Most recent draft of specification dated May 2005
- Mailing list started Dec 2006 with active discussion
- Implementation raised many issues with specifications

Limitations with GELLO Language and Grammar

- Typographical errors
- Incomplete language elements
- Incorrect language elements
- Ambiguous constructs
- Discrepancies between grammar and examples used
- Semantic limitations of the language
- Typically formal grammar and actual grammar differ in practice due to implementation details
- Even so, formal grammar in specification is incorrect, incomplete and does not even parse the examples in the specification

Minor Corrections

- Had to cut & paste grammar from HTML document
- Built a tool to process the BNF into a useful form
- Found syntax errors in the BNF and corrected.
  - Misspellings
    - Fixed by inferring correct names.
  - Undefined and unused symbols using reachability analysis
    - Symbols “GELLOType”, “ReferenceToClass” undefined
      - Fixed by changing “GELLOTypes” to “GelloType”, and adding “ReferenceToClass” to point to “ReferenceToInstance”
    - Symbols <IMPLIES>, <NEW>, <ENDCONTEXT> unused
      - Fixed by including <IMPLIES> in “ConditionalExpression”, and omitting <NEW> and <ENDCONTEXT>
  - Syntax errors in terminal regular expressions
    - Fixed
  - Fixed errors in some of the terminal regular expressions
    - <DECIMAL_LITERAL> only generated numbers without digit “0”!!
    - <REAL_LITERAL> is ambiguous with <INTEGER_LITERAL>
    - <NUMBER> was removed by simplifying grammar.

Completing the Language

- Various Elements in language appear to be stubs
- Referred back to OCL to figure out what elements should look like
- Elements fleshed out
  - "CollectionLiteral" defined

    CollectionLiteral::= CollectionType "{" (CollectionLiteralElement ("," CollectionLiteralElement)*)? "}"

    CollectionLiteralElement::= Expression (".." Expression)?
  - "TupleLiteral" defined

    TupleLiteral::= <TUPLE> "{" TupleLiteralElement ("," TupleLiteralElement)* "}"

    TupleLiteralElement::= <ID> ":" GELLOType "=" Expression
  - "EnumerationType" extended

    EnumerationType::= <ENUM> "(" <ID> ("," <ID>)* ")"
  - "CollectionType" extended

    GELLOType::= BasicType
    | CollectionType "(" GELLOType ")"
    | TupleType
    | EnumerationType

Trivial Extensions to language

- Added comments
  - // A comment to end of line.
  - /* A comment which is
    more than one line.
    */
- Allow “ to be used synonymously with ‘ for strings
- Generalized parameters to standard functions to be “Expression”s rather than specific typed literals.
- Allow identifiers to be case insensitive.

Significant Enhancements to Language

- Many of the examples refer to lists of Statements rather than a single GELLO Expression or Statement.
- Based on implementation experience and recent discussions on the mailing list, a significant extension to allow for multiple declarative statements to be specified.
- These issues were resolved by the following constructs:
  - Introduction of "Block" construct.

```
GELLOExpression::=     Block
Block::=               Declarative* ExpressionNP
Declarative::=         LetStatement
                     | ContextNavigationStatement
```

  - Redefining "IfStatement" and "ComparisonExpression" and introducing "IfExpression"

```
IfStatement::=     <IF> Expression <THEN> Block <ELSE> Block <ENDIF>
ComparisonExpression::=                              IfExpression (<EQUAL> IfExpression |
                        <NEQ> IfExpression | <LT> IfExpression  |
                        <LEQ> IfExpression | <GT>  IfExpression  |
                        <GEQ> IfExpression)*
IfExpression::=          AddExpression
                       | IfStatement
```

- Resolution of no statement separator
  - The introduction of multiple statements introduced a difficulty in the grammar in that statements do not have a terminator or separator (e.g. ";").
  - Problem occurs when two GELLO expressions appear next to each other within the language.
  - Resolved by restricted form of Expression in the grammar
- Included the [and] operators to index into collections.
  - By reference to OCL V2.0
  - Shorthand method for the ElemAt() collection operator

Unambiguous Grammar Constructs

- Many of the constructs as defined in the original specification result in a highly ambiguous grammar.
- Constructs which look superficially correct for descriptive purposes end up generating an ambiguous grammar.
- The importance of an unambiguous grammar is two-fold
  - Being able to specify the language in a portable way to a wide range of users and implementers
  - Being able to generate practical parsers for the language
- A great deal of time was spent trying to resolve the ambiguous nature of the GELLO language as specified by the original grammar.
- The general nature of the ambiguities fell into several categories
  - Places where one construct overloaded another.
    - E.g. when a “Name” and an <ID> were derivable in the same place.
  - Places where one construct next to another resulted in an ambiguity i.e. when an “Expression” appeared next to another “Expression”. These two examples are identical syntactically but have different meaning
    - Example 1.

      Let A: Integer = C + D

      (A * 20)
    - Example 2.

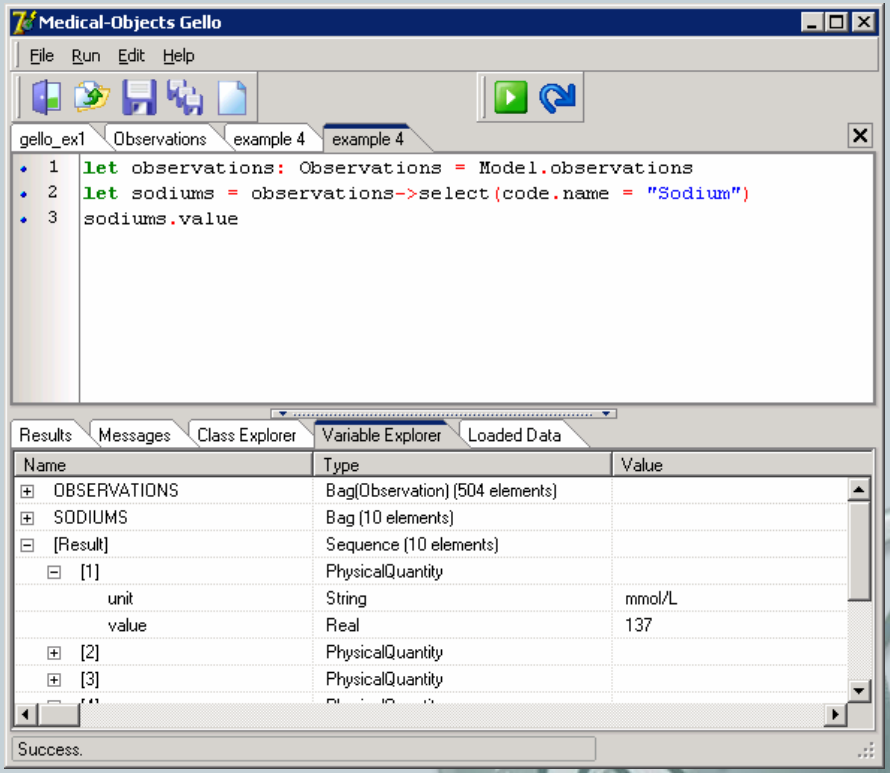
      Let A: Integer = C + D(A *20)
- The changes to resolve the ambiguities were many and varied. The more significant of these are
  - A restricted form of “Expression”, “ExpressionNP” which does not start with “(“, “+” or “-”.
  - Introducing the “Operand” construct from which variable references, attribute references, method operators and collection operators are formed.

Rich HL7 infrastructure

- The GELLO and GLIF modules have been built to operate over a Rich HL7 infrastructure developed over many years by Medical-Objects
- HL7 version 3 Data Model (RIM) is incorporated into GELLO
  - Observation
  - Patient
  - Medication
- Model data and GELLO results visible from IDE
- Can dynamically bind Model data to GELLO infrastructure
- Uses Windows COM to manage data ownership.
- Also includes SNOMED engine access.
- Supports concept of Medical Logic Modules (MLM) as in Arden

Embedded GELLO

- The GELLO as implemented by MO-GELLO has been developed as an embedded component within a GLIF and Archetypes framework.
- It was developed using a LALR(1) parser framework in conjunction with a Delphi Object Pascal HL7 framework.
- It is interpretive in nature.
- Gello expressions are compiled at run time and stored as an internal object oriented expression tree.
- Execution speed is facilitated by the use of object oriented techniques.
- There is no “byte code” to execute, all calls are made natively to the HL7 framework.
- GELLO expressions can be implemented using an embedded IDE called “Mowgli”.
- Library facilities have been developed whereby frequently used GELLO expressions can be run indirectly from within another GELLO expression



References

- The GELLO Specification
- Medical-Objects GELLO
- Original GELLO Grammar
- Revised GELLO Grammar

Intelligent Scheduling in Complex Dynamic Distributed Environments

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Motivation

"The scheduling problem is far from solved" [1]

"Most existing tools provide only a user-interface for manual roster generation and various facilities to check the validity of the prepared schedules" [2]

"As at 1 January 2007, 35,058 Queenslanders were waiting for elective surgery. Of these, 29% had waited longer than a clinically desirable time" [3]

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Scheduling

OR SCHEDULE

Date	Time	Patient	Procedure	Surgeon
22/12/2004	7:30 AM	J. Smith	Colonoscopy	Dr. K. Andrews
22/12/2004	9:25 AM	D. Jones	Knee Surgery	Dr. E. Cardiac
22/12/2004	1 M	D. Brown	Laproscopy	Dr. Z. Chan
22/12/2004	4	M. Clark	Laproscopy	Dr. K. Andrews
22/12/2004	1	R. Evans	Eye Surgery	Dr. J. Iris
22/12/2004	2			
22/12/2004				
22/12/200				
22/12/200				
22/12/20	6			

- *"Scheduling deals with the temporal assignment of activities to limited resources where a set of constraints has to be regarded" [4]*
- *"Scheduling problems are decidedly complex, combinatorial problems that are in general NP - hard" [5]*

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Scheduling for Complex Dynamic Distributed Environments

Problems with current systems [6] :

- Do not react well to dynamic environments
- Do not react well to time
- Leave difficult scheduling decisions up to the user of the system
- Are expressively limited – not good for modelling complex system requirements

A complex scheduling environment is one which has a large number of variables, a large number of constraints between them, and multiple, often conflicting, scheduling goals

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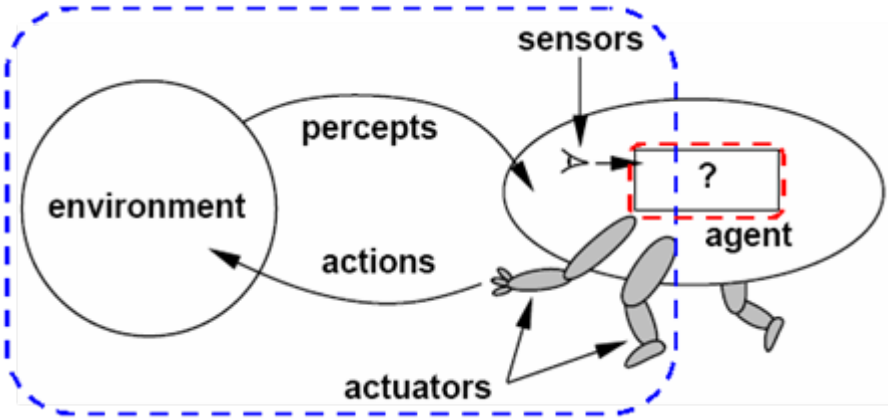
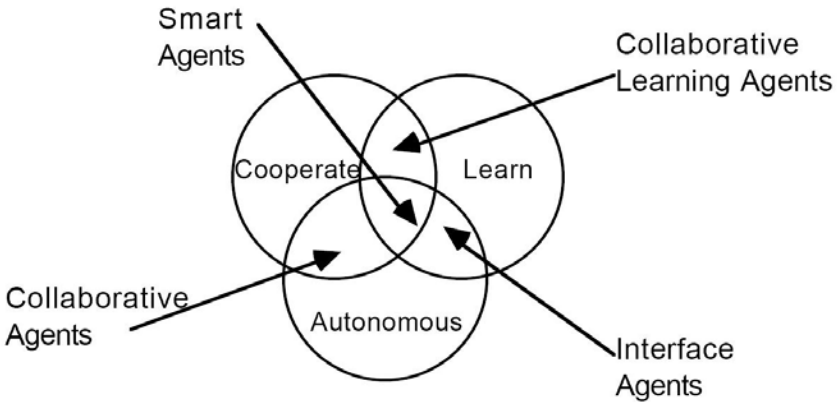
Understanding Agents



An Agent and its Environment [7]



Nwana's Smart Agent [8]

"Autonomous agents are computational systems that inhabit some complex, dynamic environment, sense and act autonomously in this environment, and by doing so realize a set of goals or tasks for which they are designed" [9]

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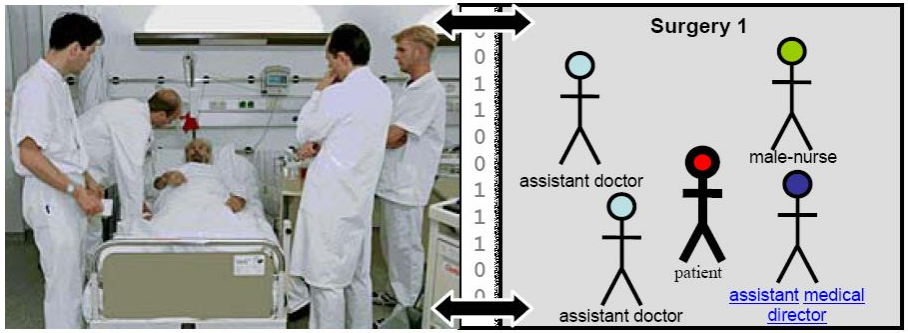
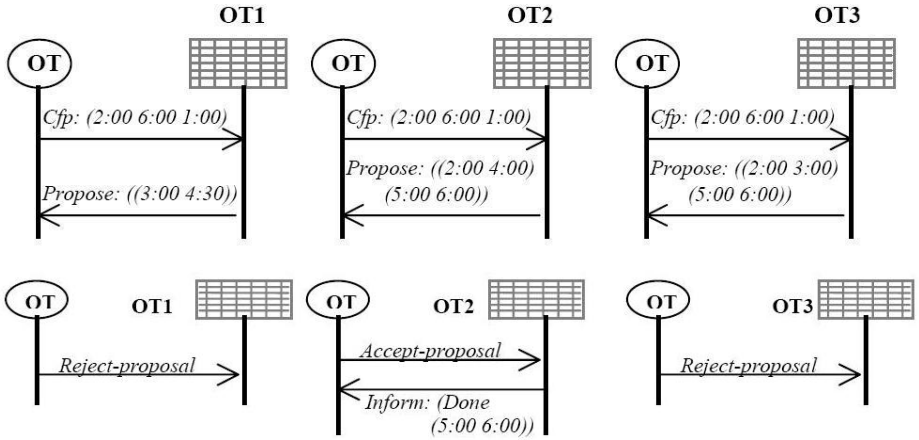
Multi Agent Systems



Using Agents to Model the Physical World [10]

"A multi-agent system is a system that consists of a number of agents, which interact with each other, typically by exchanging messages through some computer network infrastructure" [11]

"The central problem of multi-agent systems is how to achieve coordinated action among agents in a way yielding problem solving capabilities that exceed those of any individual agent" [12]



The Contract Net Protocol at Work [13]

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Distributed Constraint Satisfaction [DisCSP]

DisCSPs offer an excellent framework for modelling and solving complex distributed problems

A DisCSP [14] consists of :

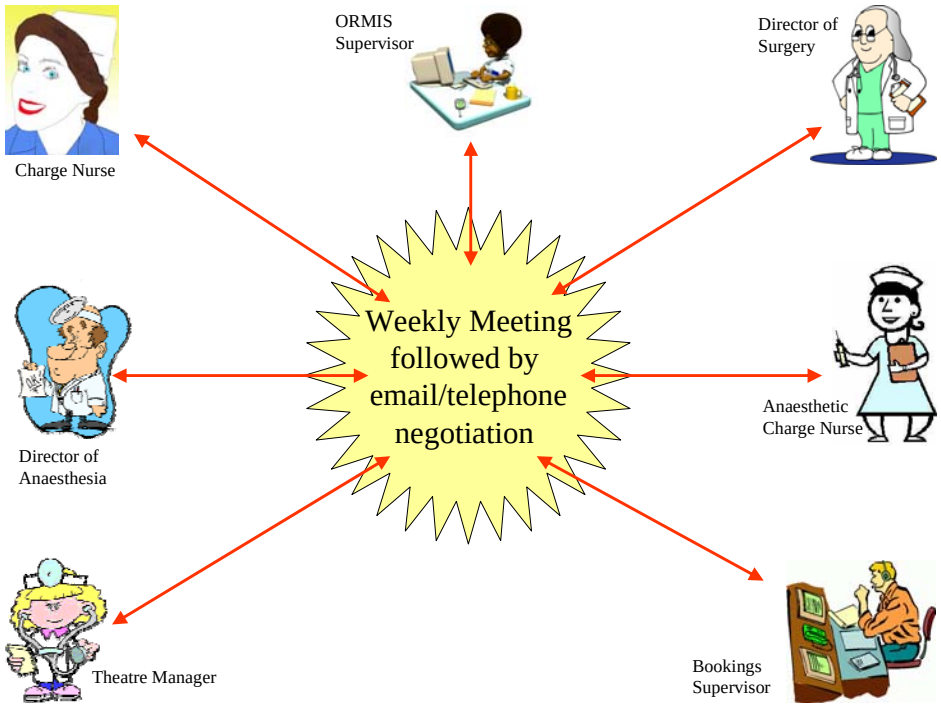
- A finite ordered set of Agents A = {A1,A2,A3,…,An | n∈Z+}
- For each Agent there exists :
  - A finite ordered set of variables V = {V1,V2,V3,...,Vn | n∈Z+}
  - A finite and discrete domain set D = {D1,D2,D3,...,Dn}
  - An intra-agent constraint set C = {C1,C2,...,Cm}, m∈Z+
  - An inter-agent constraint set IC={IC1,IC2,...,Icm}, m∈Z+
  - An ordered solution set S = {v1,v2,v3,..., vn | vi∈Di,∀i ∈ [1,m]}
- The solution set of the DisCSP is the set of solution sets of each agent

Most current DisCSP efforts at modelling real world complexity however suffer from several limitations

Case Study … PA Hospital, Brisbane

Scheduling Elective Surgery at the PA Hospital

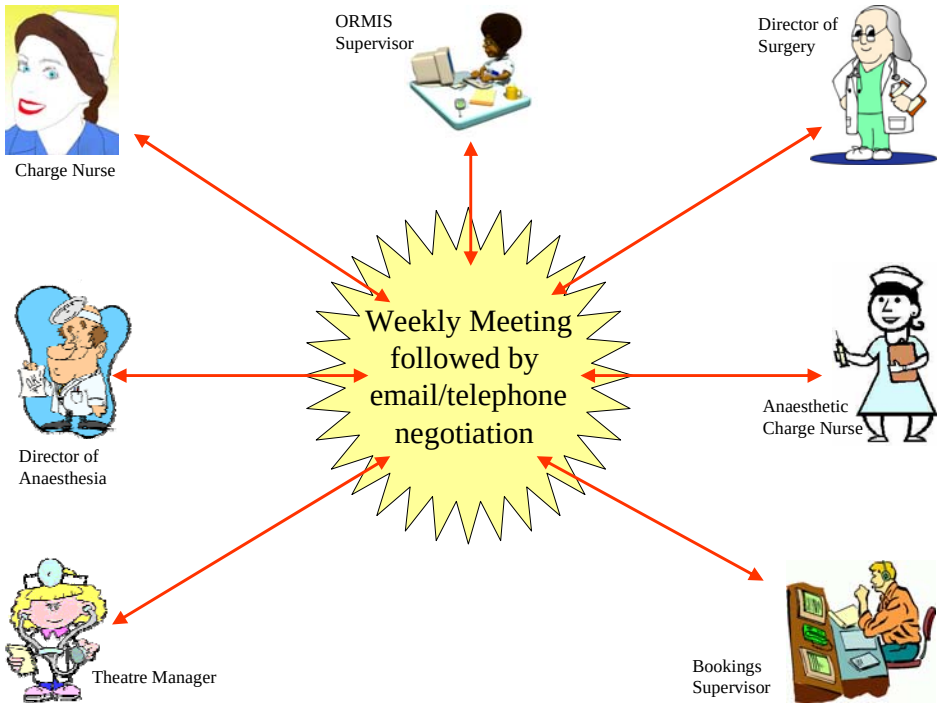
- There are 21 theatres dedicated to Elective Surgery at the PA Hospital
- The Bookings department books patients into the ORMIS system after discussions with surgical teams
- The updated Theatre schedule is posted online everyday at 3pm
- Each Department schedules its own staff/resources while maintaining the requirements of the Theatre schedule
- Every Thursday, the heads of the various departments get together to discuss and coordinate their schedules for the coming week



Case Study … PA Hospital, Brisbane

Scheduling Elective Surgery at the PA Hospital

- During the scheduling meeting, conflicts between schedules are manually resolved. At this point, the theatre bookings list is typically 70%~80% complete
- After Thursday, all readjustments and conflicts are resolved on a case-by-case basis using email, phone or in-person communication
- If a conflict cannot be resolved in time, it may lead to the creation of a bad or compromised schedule
- Temporary absence of the domain expert from the scheduling process may also lead to a bad or compromised schedule



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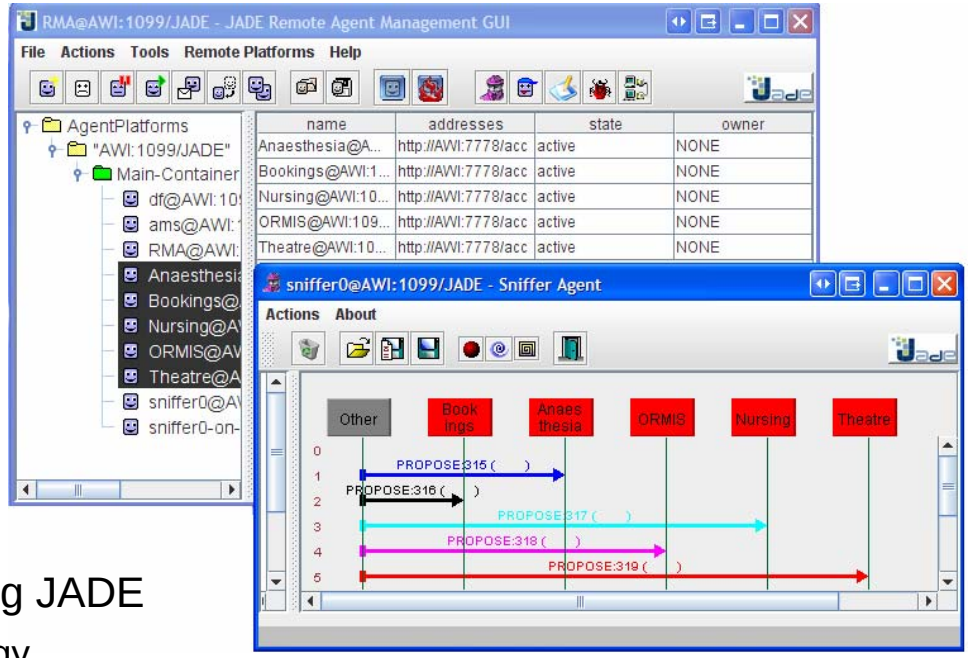
Current State of the Project

We are currently developing a methodology that can :

- Handle the inherent complexity
- Incorporate complex negotiation
- Select the solver based on problem characteristics
- Incorporate intelligent decision making
- Learn from user feedback & the decision making process



We are also building a prototype system using JADE

- **To Demonstrate :** The developed methodology
- **To Evaluate :** Performance of the methodology
- **To Establish :** Benchmarks that aid future research

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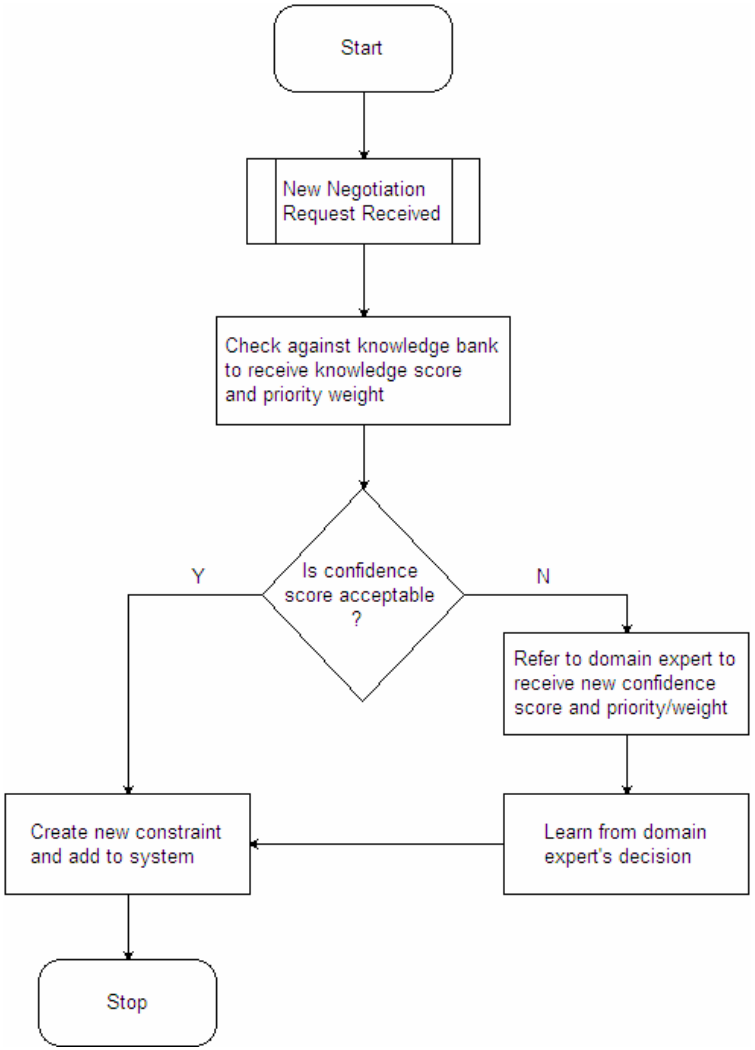
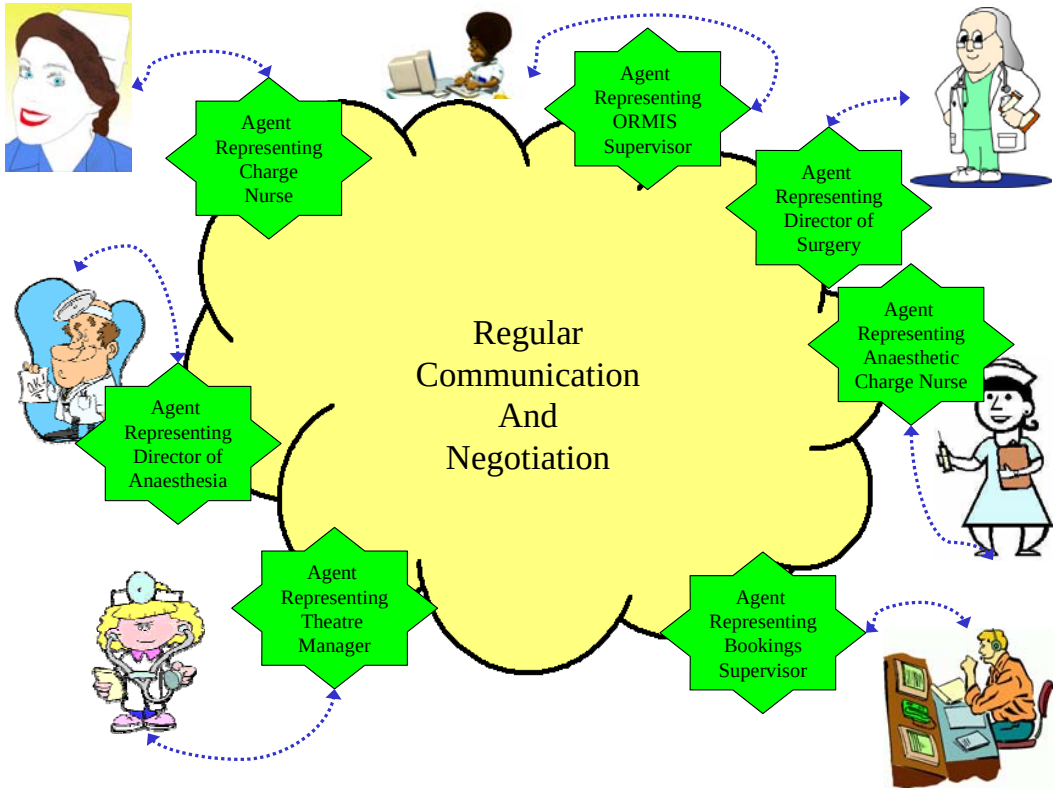
Improving Scheduling at the PA Hospital





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Abstract

The complexity and changeability of interacting factors affecting scheduling in a distributed environment demands a very flexible and dynamic solution, in order to achieve a high level of utilisation and cater for many different competing priorities. A typical example of the problem domain can be found in elective surgery scheduling where efficient scheduling is critical to ensure optimum utilisation of the public health system. Current approaches have however failed to offer an efficient solution. The task of making complex resource allocation decisions is still left up to the operators of the system.

We propose a multi-agent approach to modelling distributed environments that employs distributed constraint satisfaction for intelligent scheduling. The proposed model is based on a case study of elective surgery scheduling at the Princess Alexandra Hospital in Brisbane, Australia.

Keywords:

allocation of resources, distributed systems

Introduction

Scheduling in a complex, dynamic environment is an open research problem. The problem is compounded further in the case of a distributed environment where each unit is working at optimising its own resources. In this situation, several units, and thus several schedules, need to be optimised simultaneously to ensure proper utilisation of resources.

While scheduling has been a long studied problem in Artificial Intelligence, no concrete intelligent solutions exist for real-world complex scheduling problems. The core of the problem lies in the inability of current systems to effectively model the inherent distributed structure and distributed decision-making of real-world scheduling environments. What is needed is an intelligent flexible methodology that can adapt itself to the problem at hand, instead of modifying or scaling down the problem to suit its structure. What is also needed is a series of real-world benchmarks to aid proper experimental analysis of current and future methods [1][2].

The hospital elective surgery scheduling problem is chosen as the foundation for building this study as it is an inherently distributed and complex real world problem and begs for an urgent solution. As at 1 January 2007, 35,058 Queenslanders were waiting for elective surgery. Of these, 29% had waited longer than a clinically desirable time [3].

Elective surgery at the PA Hospital

The Princess Alexandra hospital in Brisbane offers 21 operating theaters that can be utilised by various departments for emergency and elective surgery. For the process of scheduling, the theatre schedule is divided into AM and PM slots of 3.5 hours each. These slots are allocated to various doctors, departments, trauma or emergency.

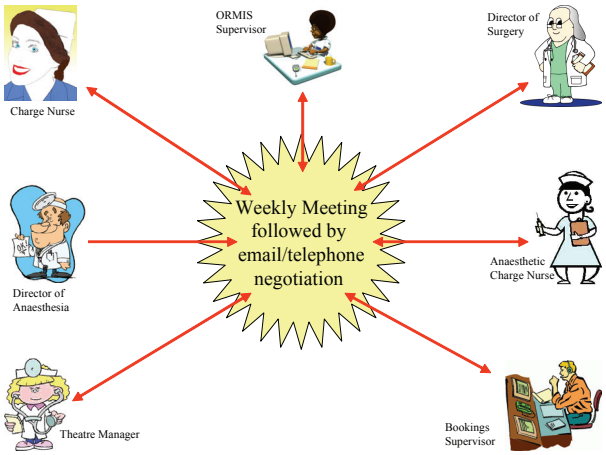

Figure 1- Current scheduling model at PA Hospital

Each department connected with the surgery (i.e. allocating staff or other resources to the surgery) carries out their individual scheduling activity. As elective procedures are booked into the ORMIS[1] (Operating Room Management Information System) system by the bookings department, they become visible to each of the other departments and any rescheduling required because of the nature or demand of the booking is carried out.

Every Thursday, the managers of the different departments meet and review bookings for the week ahead. Each session is discussed and if any of the managers has a problem, they bring it to everyone's notice and a solution is worked out by negotiation. Unexpected emergencies, variation in patients' health state, sudden perturbations in staffing and surgeon availability etc. lead to further changes being

1 http://www.isoftplc.com/corporate/products/2593.asp

required often. However, all changes made to the system after this meeting are dealt with individually by the departments, and resolved on a case-by-case basis using conventional communication such as telephone and emails, or even by face-to-face meetings. In keeping with the dynamics of the domain, the schedule needs to be updated quickly and efficiently. This is often not possible, because of the delays in communicating with the different departments to make the change, and leads to the adoption of an easy but inefficient solution resulting in a bad or compromised schedule.

Methods

Recent advances in the fields of Distributed Constraint Satisfaction (DisCSP) [4] and Multi Agent Technology offer powerful tools including autonomous, intelligent agents for solving complex distributed problems efficiently. "Autonomous agents are computational systems that inhabit some complex dynamic environment, sense and act autonomously in this environment, and by doing so realize a set of goals or tasks for which they are designed" [5]. An intelligent agent also possesses the capability to act without explicit user intervention and to learn and self correct itself. Given the decentralized and highly dynamic nature of hospital decision making, an intelligent agent based approach is a promising paradigm for modelling the environment. Using the DisCSP formalism further provides promising structured and reusable techniques to model complex and distributed problem domains efficiently and to handle the dynamics of the environment.

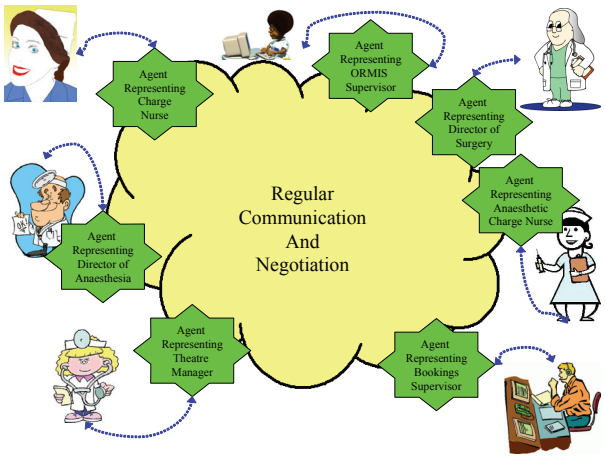

Figure 2- Proposed scheduling model

We are currently developing a methodology where intelligent agents trained with the medical constraints, preferences, priorities etc. of the administrators would carry out scheduling for their respective departments. They would also collaborate with each other to resolve conflicts and align themselves. As changes affect the system, the agents would automatically negotiate to realign themselves. It is proposed that the methodology will allow each unit(agent) to solve their local problem using independent algorithms and then negotiate with each other to maintain global requirements. By translating negotiation requests and strategies to constraints, it will also allow multiple negotiation strategies to be applied within the framework. The system as a whole would be intelligent – learning and self-correcting from user feedback.

We are also building a prototype application using JADE[2] (Java Agent DEvelopment Framework) as a proof of concept and to perform an experimental evaluation of the proposed methodology and its component algorithms. Scheduling process information and data from the case study is being used to construct problems for analysis. These problems, along with the performance data collected, will be used to create suitable benchmarks to further assist evaluation and aid future research.

Conclusion

An approach to intelligent scheduling in complex distributed environments is presented. The proposed method effectively models the distributed domain and uses DisCSP techniques to solve the scheduling problem. We are currently designing efficient scheduling algorithms and an implementation of the concept based on this case study in scheduling elective surgery.

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2 http://jade.tilab.com

MEDINFO 2007
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Development of Team Competence and IT Projects at Hospital

Tokiharu Miyahara [a], Hiroyuki Ohtsuka [a], Kiyohiro Ishii [a], Kenji Kato [a], Naoko Nagai [a] Shigefumi Morioka [a]

[a] *Department of Medical Informatics, Kobe City Medical Center General Hospital, Japan*

Abstract

So-called "upper process", that is from the process of System Requirements to External design, is very important for developing good performed Health Information System (HIS). But there are few who understand both information technology (IT) and medical field. We trained some medical staff for understanding IT at our hospital. So that, more than 30 staff have been certified as Healthcare Information Technologists, given to capable persons who understand both IT and medical field by Japan Association of Medical Informatics (JAMI), so far. An IT project team was formed officially with these staffs and given some short courses of Unified Modeling Language (UML) and the method of modern project management (PMBOK) for HIS innovation project. Our team achieved successfully writing documents of System Requirements of our new HIS consists of more than 30 subsystems within ca.2 months at our hospital.

Keywords:

system requirements, UML, project management, PMBOK, healthcare information technologist

Introduction

It is widely known that so-called "upper process" is very important for developing good performed HIS. JAMI began to certify Healthcare Information Technologist (HIT) in 2003, for bringing up a capable person who understand both IT and medical field. We trained some medical staffs for understanding IT at our hospital, and more than 30 members have been certified as Healthcare Information Technologists. After training of some short courses of Unified Modeling Language (UML) and learning the method of modern project management (PMBOK), HITs are thrown into IT project of HIS innovation of our new hospital which will be built 4 years later.

Methods

IT Project Team and competence development

Our IT project team is constructed by 30 members (5 medical doctors, 6 medical lab technologists, 5 radiological Technologists, 4 nurses, 4 pharmacists, 1 clinical engineering technologist, 1 Physical Therapist, 4 medical secretaries). All members are certified as HIT by JAMI. The team is organized officially in our hospital, so that it enable us to use several resources of the hospital, and to make up environment for studying and/or practicing IT technology.

Every members select one of 3 Special Interest Groups in our team; network technology, information security, database technique, to develop their own competence for achieving various services in each field. Members have been given some short courses of Unified Modeling Language (UML) and Project Management (PMBOK) for developing their competence.

Results

To innovate our hospital HIS, we organized IT project team and developed our team competence in advance. Our team achieved successfully to writing documents of System Requirements for new HIS, which is made up more than 30 subsystems, within ca. 2 months.

Development of Team Competence and IT Projects at Hospital

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Hiroyuki Ohtsuka, Kiyohiro Ishii, Kenji Kato, Naoko Nagai, Shigefumi Morioka, M.D.,Ph.D.

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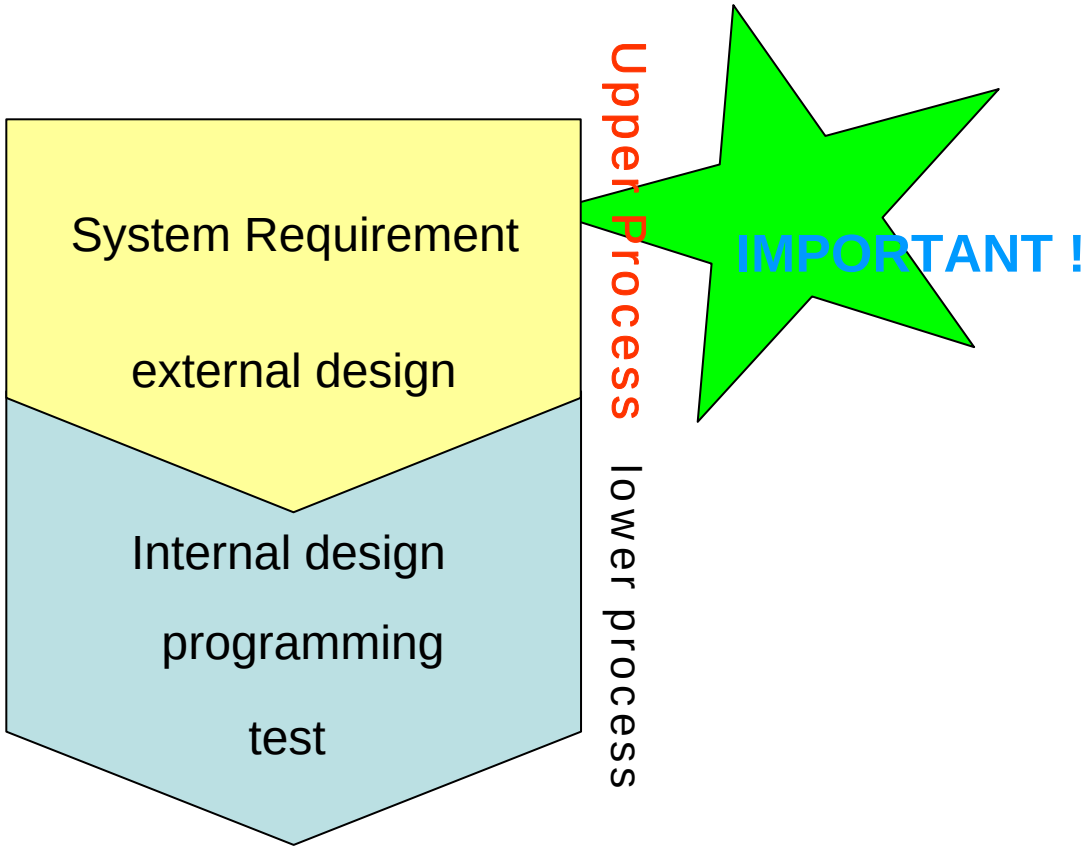
Objectives

To know how to organize IT Project Team at Hospital

To know how to develop competence of IT Project Team/Members at Hospital

To know how to manage the "upper process" of developing Healthcare Information Systems at Hospital

Process of the System Development



Healthcare Information Technologist

since 2003

certified by

Japan Association for Medical Informatics (JAMI)

3 categories of the Exam.

Health Care

Health Information Systems

Information Technology

Healthcare Information Technologist ® Exam. Short Course at our Hospital

Instructors: successful applicants of the last year exam.

10 – 15 lectures of "Information Technology" for the exam.

Pass Rate: 35 % (avr.)

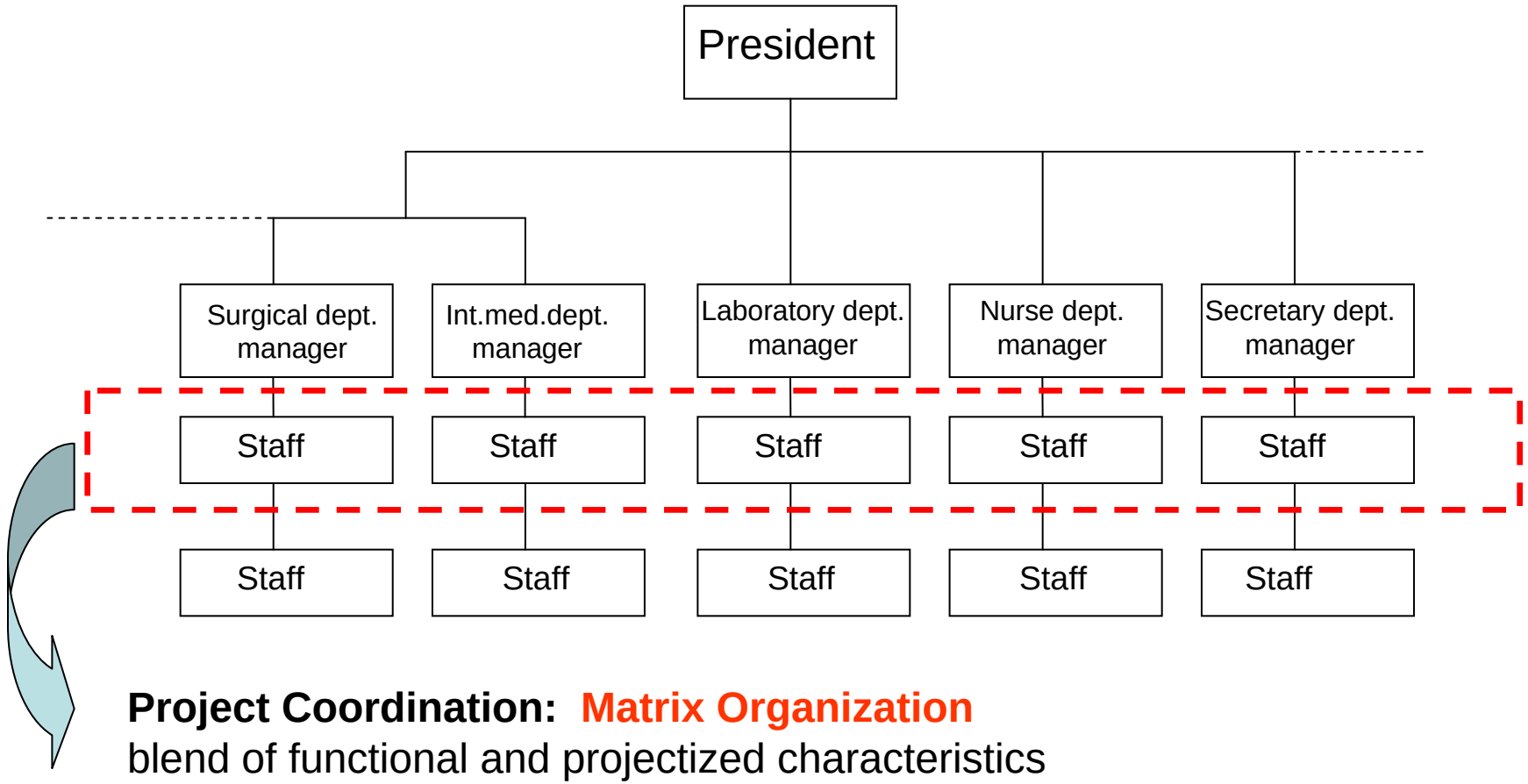
Photo-Retouch: Candidates attending the Exam. Short Course

IT Project Team Members at our Hospital

Doctor	5
Nurse	4
Pharmacist	4
Medical Laboratory Technologist	6
Radiological Technologist	5
Clinical Engineering Technologist	1
Physical Therapist	1
Secretary	4
Total	**30**

Healthcare Information Technologists

Organizational Structure of our IT Project Team



Project Coordination: **Matrix Organization**

blend of functional and projectized characteristics

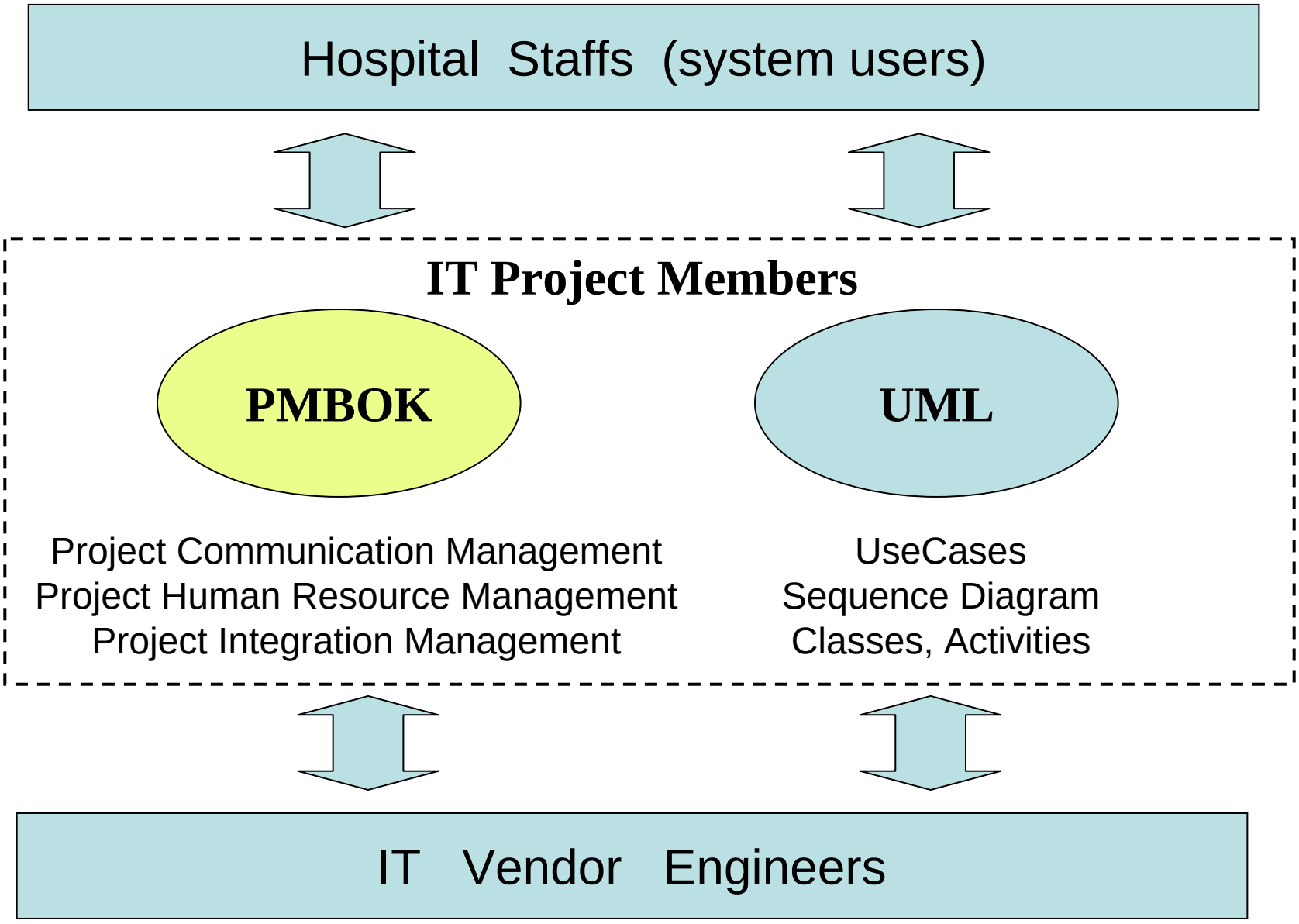
3 SIGs (Special Interest Groups) in our IT Project Team

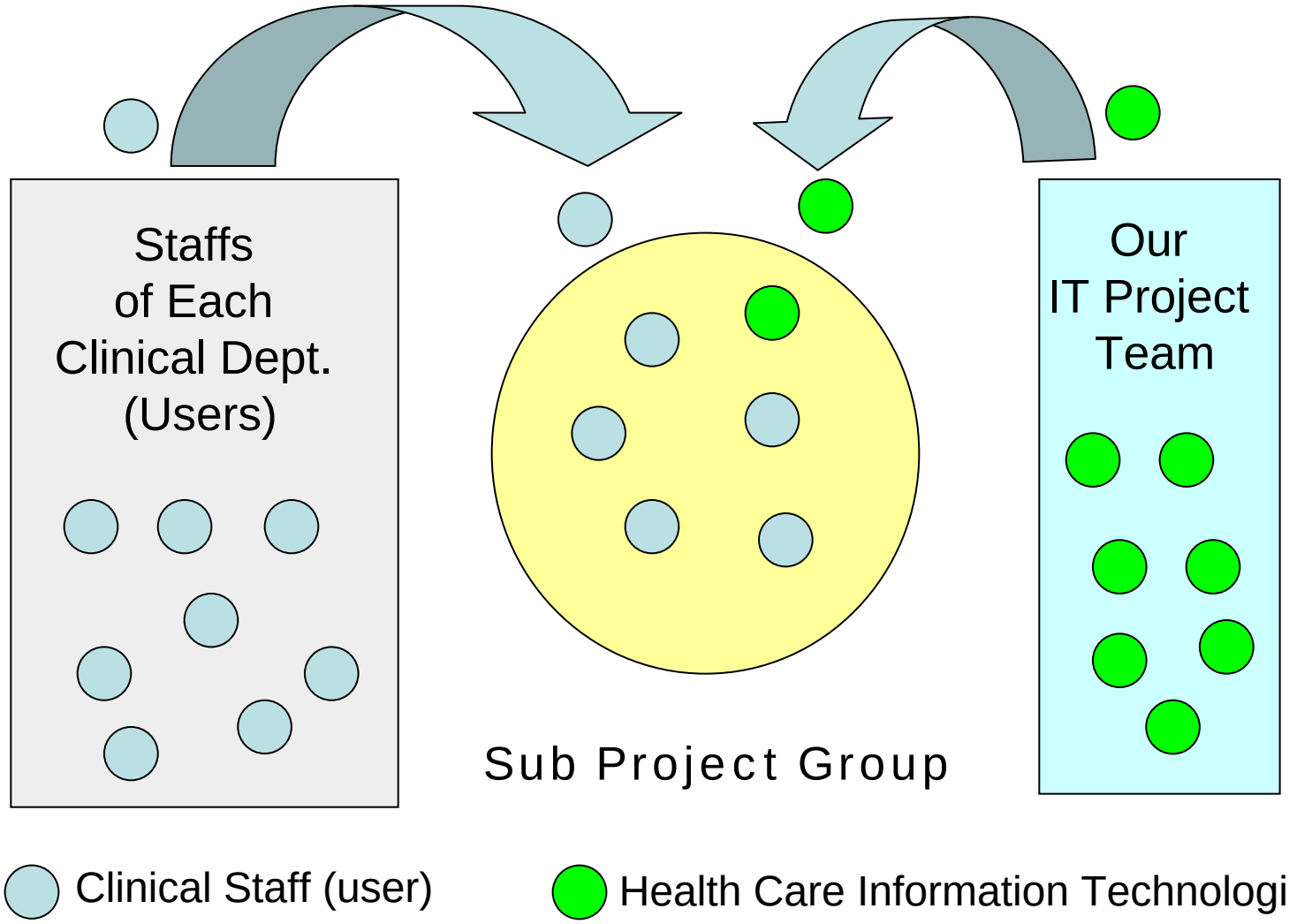
1) Network SIG

2) Data Base SIG

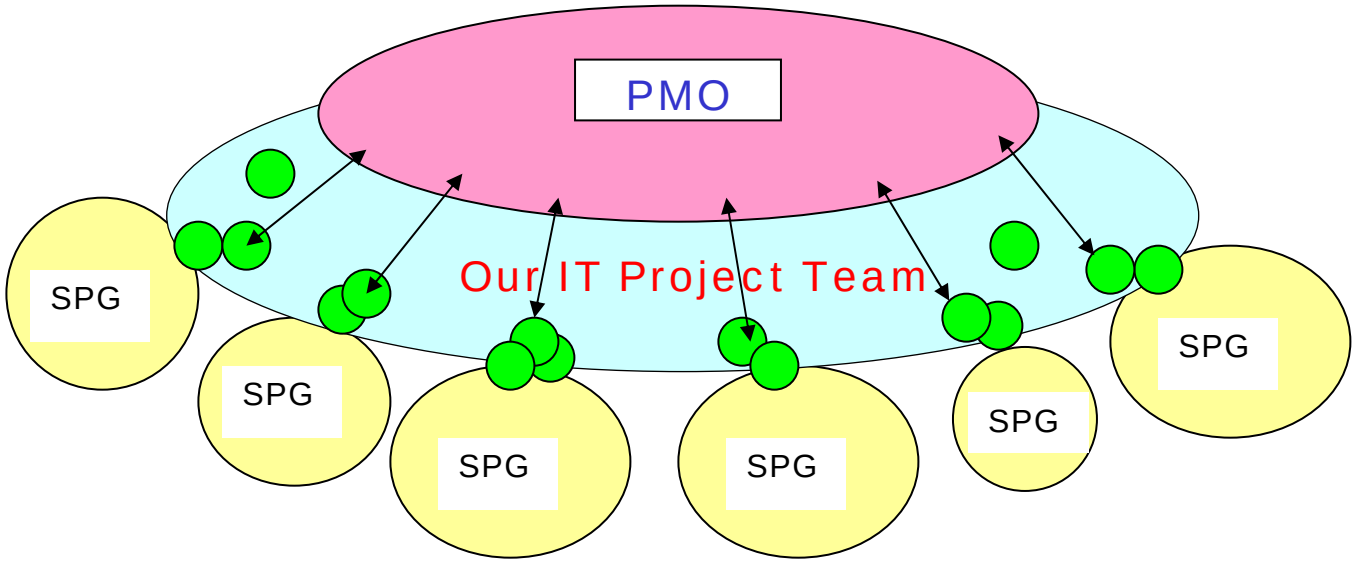
3) Information Security SIG

Photo:
Network SIG members are training with a router and a few switches under the instruction of Cisco network engineer.


Hospital Staffs (system users)
IT Project Members
PMBOK
UML
Project Communication Management
Project Human Resource Management
Project Integration Management
UseCases
Sequence Diagram
Classes, Activities
IT Vendor Engineers


Staffs
of Each
Clinical Dept.
(Users)
Sub Project Group
Our
IT Project
Team
Clinical Staff (user)
Health Care Information Technologist

Set Up the PMO (Project Management Office)



SPG： Sub Project Group (each Clinical Department)

： messages and/or documents flow

： IT Project Team Member（Health Care Information Technologist）

Result

After developing our competency for IT Projects, Our IT Project Team could complete “System Requirements” process, constructed by mote than 30 sub systems, within 2 months.

MEDINFO 2007
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Smart House Infrastructure for Chronic Disease Management

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Abstract and objective

Information and Communication Technologies are enablers for next generation home healthcare. This poster describes a proposed ICT-based home care system for chronic disease management. Key characteristics are patient-centred data ownership, broadband Internet connectivity, self-configuring networked instruments for measurement and treatment, individualized treatment rules and regimes, and automatically cascading levels of alarms and interventions.

Keywords:

chronic disease management, internet, home care services

Introduction

Over the next 50 years, Australia can expect to see an increasingly aging population. A particular problem, most pronounced in the aged, is appropriate care and management of chronic conditions, whilst maintaining quality of life and opportunity for independent living.

The most common 10 chronic diseases (illness which has lasted longer than 6 months) accounted for 43% of the total disease burden in Australia in 2002-3. In that time, more than 17% of hospital admissions were for management of chronic disease which cost $11 billion from the total health budget of $60 billion. These ten diseases were: Coronary Artery Disease; Lung Cancer; Cerebrovascular Disease; Dementia; Chronic Obstructive Pulmonary Disease (COPD); Diabetes; Depression; Colorectal Cancer; Asthma; Osteoarthritis.[1]

A model of health care delivery whereby the diagnosis, treatment and ongoing management of chronic conditions occurs in total or in part, remote from a hospital is clearly of benefit. Hospital-based care of chronic conditions is expensive, and an inefficient use of hospital resources. The benefit in terms of psycho-social wellbeing of the individual, the family and community is an additional bonus if care can be migrated to the home setting.

Many health home-monitoring projects have aimed to provide very low-cost, low-bandwidth solutions, using technologies such as modems and phone-lines, and these continue to be an area of active interest amongst many groups. However, the more widespread availability and adoption of broadband Internet, home computers, mobile phones and wireless technologies suggests better solutions are possible.

Methods

This paper presents our initial system design, based on analysis of existing telemedicine solutions for diagnostics and health-care management, combined with insights regarding the changing population demographics and societal attitudes to healthcare.

The results presented below include both our analysis of the relevant aspects of current western healthcare systems, plus our predictions of how to better address the requirements of such systems.

Results

Assertive, well-educated and politically astute baby boomers are now taking a major role in caring for their parents, and will soon start to enter old-age themselves. There is already a move away from professionally-centred patient care models (where doctors take primary responsibility for health care decisions) to patient-centred care models where patients (and their families and friends) take an increasingly dominant role in health care management, with professional staff assuming more the roles of consultants and advisors.

With an increasingly aging population and increasingly costly health-care, future health care models for health management in the aging will necessarily depend on a distributed community of volunteer carers. Jointly with the move to patient-centred care regimes, and with the desire to maintain independent living well into old age, this all suggests a substantial shift in models of care for the chronically ill will occur in the coming decades.

Current practitioner-centred medical records systems and health monitoring systems are inadequate to deal with these forthcoming significant changes in models of care. There will be an increasing emphasis on the role that modern Information and Communications Technology (ICT) can play in enabling and supporting these new models of care. Our project investigates new models of care, and the Smart House technologies that will assist in implementing them.

1 Australian Institute of Health & Welfare Report. 2002-3.

In terms of diagnosis, ICT technologies can extend the range of scenarios and locations where extended diagnostic testing can be done. For example, in Obstructive Sleep Apnoea, first level diagnostic filtering can be done with low-cost Pulse Oximetry in general hospital wards, or even at home rather than in specialized sleep-medicine wards, with just the diagnostic information (not the patient!) being relayed to the sleep specialist. However, detailed information needs to recorded and validated before meaningful remote diagnosis can be done.

In terms of long-term home-based care, ICT technologies can assist in patient-centred record keeping, in recording care regimes (diet, exercise, drugs), in implementing those regimes (eg. automatic monitoring of drugs taken, physiological monitoring), in remote communications with other volunteer carers such as friends and relations, and also with health professionals, and in automated alerts of atypical behaviour (perhaps indicating a fall or a chronic episode).

Incorporating Smart Home technology into new housing developments might differentiate such developments by making Smart Home technology an agency for improved health outcomes, not just improved convenience and entertainment. The same technologies might be applied to residential aged care facilities, particularly those with independent and semi-independent living units.

Such new models of patient care need input from clinicial researchers who would design, implement, trial and evaluate the health care regimes. There appears ample scope for significant clinical research outcomes from such a program.

The electronics of an ICT-based home health-care support system centres on a secure home healthcare portal device, basically an inexpensive embedded computer, which provides local data storage, a broadband Internet connection, a secure web-server for remote access and data analysis, and a wireless networking capability to connect to instruments.

Measurements can be analysed and filtered on the basis of required level of care. Basic measures of body attitude, activity and daily weight can be progressively augmented with electrocardiographs, pulse oximetry and blood glucose levels for example. Instrumentation can be ambulatory for some sensing modalities. Wireless is the preferred means of communication from sensor to the portal. Therapeutic devices (such as automated medication dispensers) are similarly connected.

The software of the system (running on the portal) consists of a home healthcare monitoring executive, whose particular characteristics are customized for the disease and the patient. Reminders for measurements to be taken, and medications to be taken can be scheduled into the executive. Customization of care regimes occurs at three levels. Firstly, dosing can be customized to the individual patient. Secondly, dosing can be adjusted (within approved limits) in response to measurements. Thirdly, a remote practitioner can review and manually change either of these first two regimes.

The system can also initiate cascading levels of alarms in response to events. Lack of user input might trigger a notification to a nurse, unexpected measurements might trigger notification to a doctor, a panic button might trigger an ambulance.

Discussion

Clinical/Systematic research issues include:

- How can new patient-centred care regimes be designed so as to put more control into the hands of the patient, and what should the role of the health care professional be?
- What sorts of technological assistance might be required to implement such care regimes, which are not adequately addressed by current mechanisms?
- How are patient outcomes measured, and what improvements can be made to patient outcomes by such technologically-enabled patient-centred care regimes?
- What are the cost/benefit tradeoffs of such home-based, technology-enabled care regimes?
- How can such benefits be realised within the constraints of the current health funding systems? – Who would pay for such models to be developed and implemented?

Computer systems research is needed to investigate appropriate devices, communications, networking and database technologies that are needed to implement such a system in a cost-effective manner

Human Computer Interaction (HCI) research is needed to investigate appropriate interaction methodologies between patients and the Smart Home technology.

Trials are needed to validate the potential of such an ICT system to better facilitate patient-centred healthcare. Figure 1 shows the change in data-management.

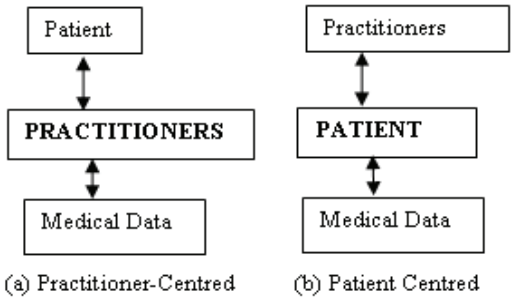

Figure 1 - (a) Current and (b) proposed models of medical data ownership and control

Conclusion

If patient-centred healthcare is to become a reality, with an emphasis on keeping the aged and chronically ill out of hospitals and nursing homes, then the ICT support for the management of patient care also needs to be devolved to the Smart Home under the control of the patient. This requires new ways of thinking about ICT support for healthcare, based on patient-centred, semi-autonomous, widely-distributed and highly networked patient information systems.

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NSC (New Songdo City: Newly Developed City as Free Economic Zone in South Korea) Ubiquitous Healthcare Project: Developing Prospective Health Management Model, Integrating On-line and Off-line Healthcare Service

Dae Hyun Yoon[a], Jin Ho Park[a], Cheol Min Lee[a], Hyuk Tae Kwon[a], Min Jeoung Park[a], Dong Hee Kim [a], Seung Ho Choi [a], Su Yeon Choi [a], In Kyong Jeong [a], Won Hee Sim [a], BeLong Cho[b], Chan Soo Shin [ac], Sang Heon Cho[ac] , Byung Hee Oh[ac]

[a] *Gangnam Center, Seoul National University Hospital,*
[b] *Department of Family Medicine,*
[c] *Department of Internal Medicine, Seoul National University College of Medicine, Seoul, Korea*

Abstract and objective

We are developing and will operate advanced Information Technology based health management program for 10,000 families at NSC, and want to share our idea and experience with members of IMIA.

Keywords :

telehomecare, ubiquitous healthcare, prospective medicine

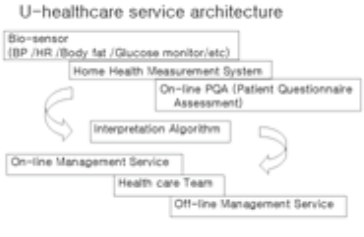
Background

Ubiquitous Healthcare Service is a Mega Trend

- Increasing interest of consumers toward health & well-being
- High speed ñ innovation of IT environment
- Rapid progress to Aging Society & Increasing prevalence of Chronic Disease
- Cost-benefit issues about traditional healthcare

Methods

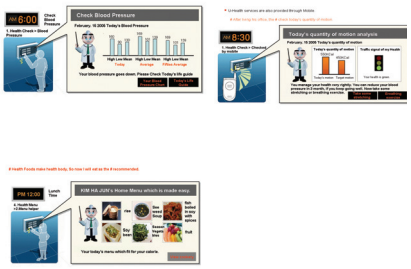
Figure 1 - U-healtcare service architecture

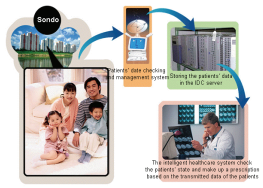


Developing device for telehomecare

Results and conclusions

Examples of Developing web pages for on-line service





Service Outline and Anticipated Benefit

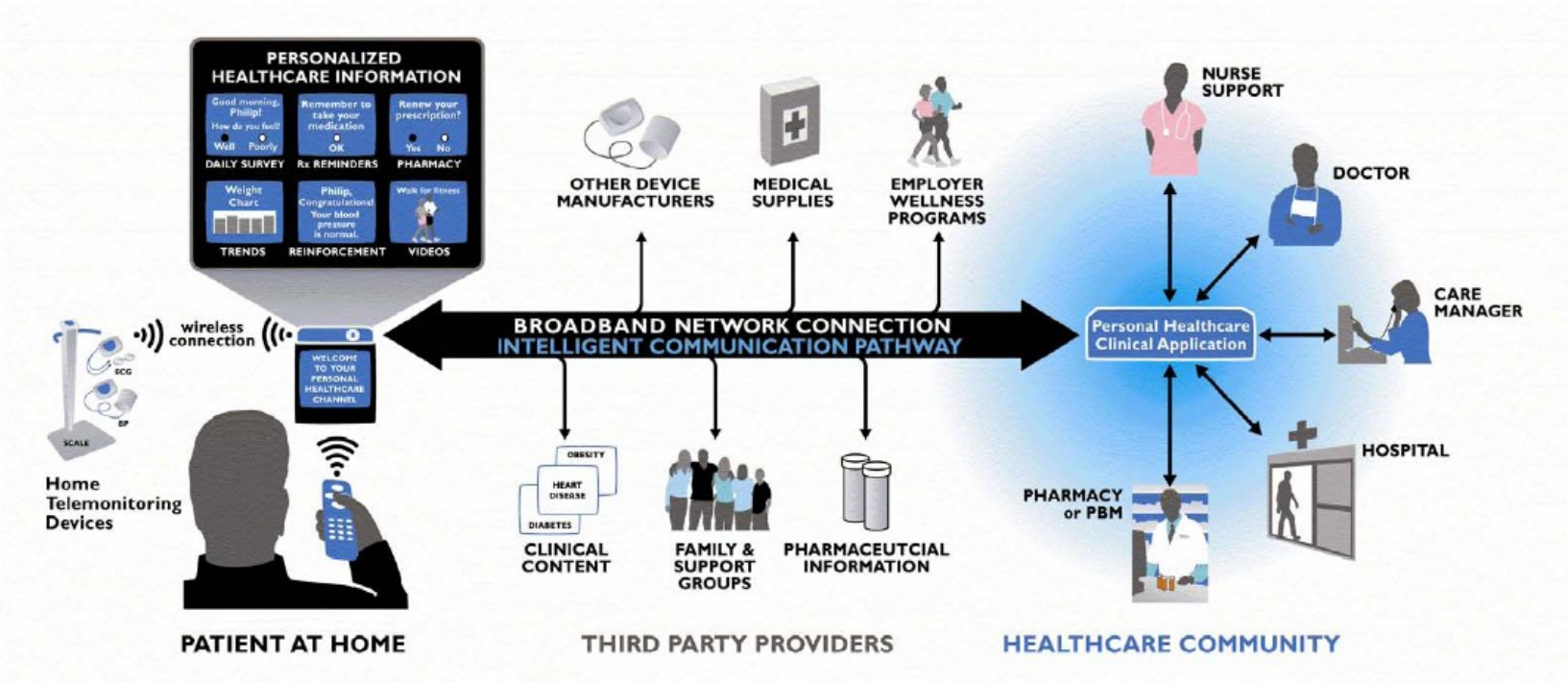
- U-Healthcare service is composed of U-Healthcare device and Service Application. U-Healthcare device gather customerís vital sign and it transmit that information to IDC Center Server.
- Intelligent Healthcare system, which is installed On IDC Server, check the information periodically, and give some advices, code of conduct and many contents.
- U-Healthcare Service consist of Online Service and Offline Service.
- Online Services are measurement and response Service and Contents Service. Offline services support Online Service
- We expect our experience will contribute to developing ì prospective healthmanagement model ì and might increase health status of our subjects.

NSC (New Songdo City: Newly Developed City as Free Economic Zone in South Korea) Ubiquitous Healthcare Project:
Developing Prospective Health Management Model, Integrating On-line and Off-line Healthcare Service

Dae Hyun Yoon[a], Jin Ho Park[a], Cheol Min Lee[a], Hyuk Tae Kwon[a], Min Jeoung Park[a], Dong Hee Kim[a], Seung Ho Choi[a], Su Yeon Choi[a], In Kyong Jeong [a], Won Hee Sim [a], BeLong Cho[b], Chan Soo Shin [ac], Sang Heon Cho[ac] , Byung Hee Oh[ac]

a *Gangnam Center, Seoul National University Hospital,*
b *Department of Family Medicine,*
c *Department of Internal Medicine, Seoul National University College of Medicine, Seoul, Korea*

Service Concept



- Abstract and Objective

  We are developing and will operate advanced Information Technology based health management program for 10,000 families at NSC, and want to share our idea and experience with members of IMIA.

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Ubiquitous Healthcare Service is a Mega Trend

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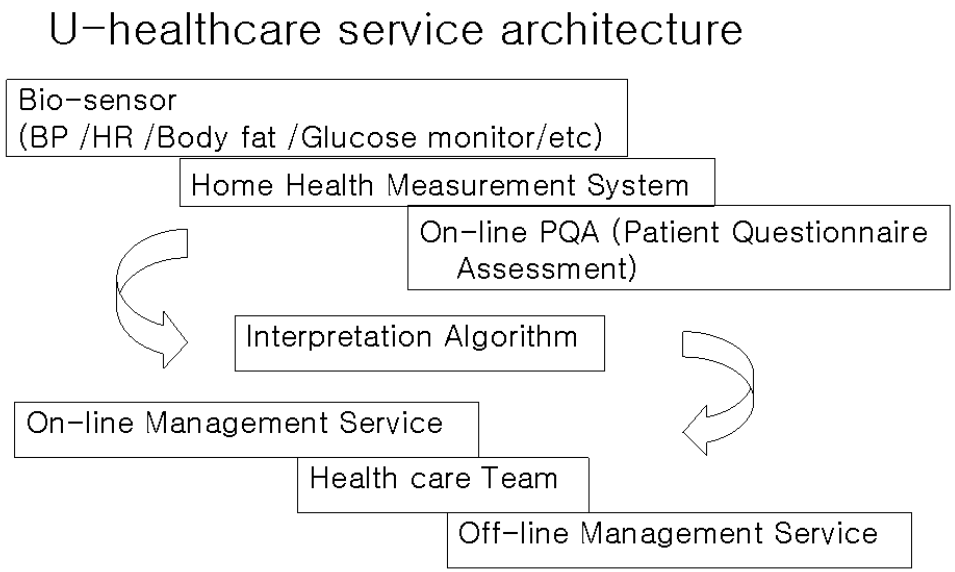
Methods


U-healthcare service architecture
Bio-sensor
(BP /HR /Body fat /Glucose monitor/etc)
Home Health Measurement System
On-line PQA (Patient Questionnaire Assessment)
Interpretation Algorithm
On-line Management Service
Health care Team
Off-line Management Service

- Results & Conclusions

Developing Device for Telehomecare

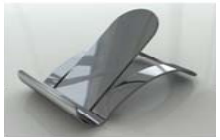




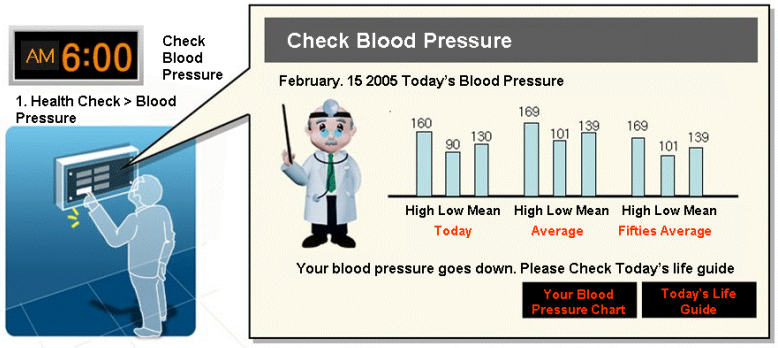


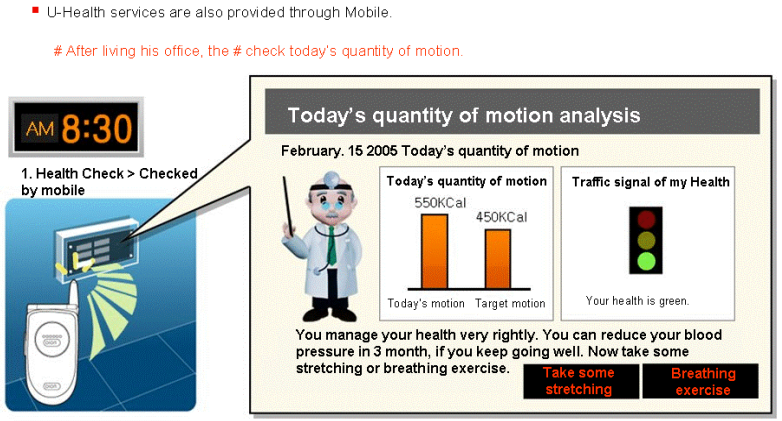




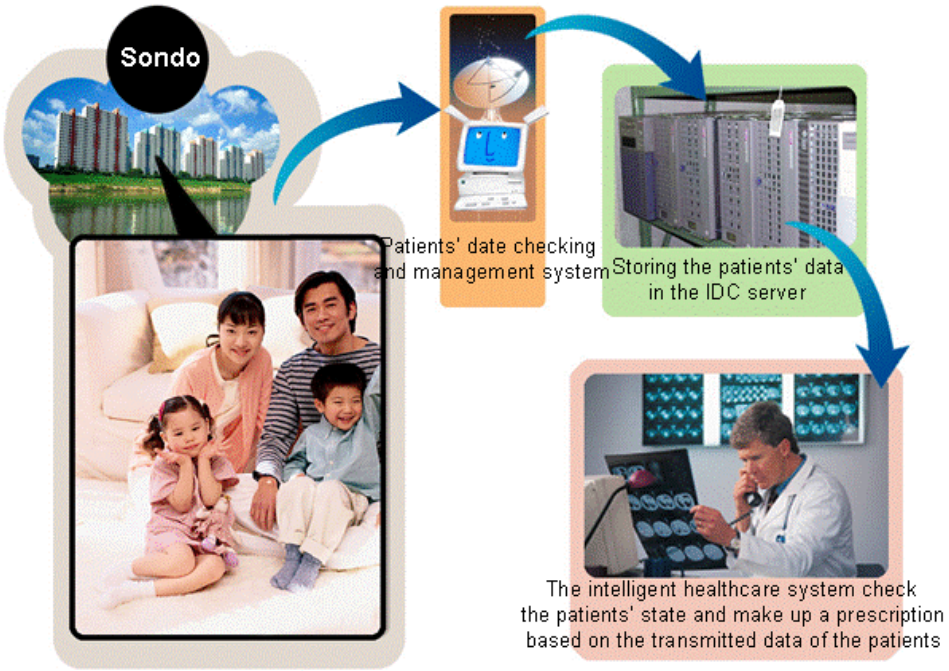


- *Examples of Developing web pages for on-line service*





- *Service Outline and Anticipated Benefit*



1. *U-Healthcare service is composed of U-Healthcare device and Service Application. U-Healthcare device gather customer's vital sign and it transmit that information to IDC Center Server.*

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5. *We expect our experience will contribute to developing " prospective healthmanagement model " and might increase health status of our subjects.*

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Experiences in Implementation of a Statewide Telemedicine System at a Medical College with Multi-speciality Hospital in Kerala

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Academy of Medical Sciences, Pariyaram, Kerala INDIA

Abstract

This is an extended abstract of a paper which narrates the authors' experiences in implementing a telemedicine system in their institution in the southern Indian state of Kerala, as a part of a state-wide telemedicine network. The focus was to achieve the maximum with the limited resources available. Though the project is running smoothly as outlined in the initial phase, scaling up to more rural centres only will make it a cost-effective and sustainable solution.

Keywords:

telemedicine, telehealth, low-resource setting, developing country

Introduction

Academy of Medical Sciences, Pariyaram is one of the new generation medical colleges in the southern Indian state of Kerala. It has been chosen as one of the specialist nodal centres under the Kerala Government's Tele-Medicine project connecting various Medical Colleges in the state with District Head Quarters Hospitals in the first phase and later to be extended to the Primary Health Centres.

The Project

The project is partly funded by the Indian Space Research Organization (ISRO) and is christened as the Kerala Tele-Health & Medical Education Project. An IP based system, working on satellite technology, it has got its own merits and a few demerits as well. This paper discusses the issues faced by the authors and their fellow officers in implementing this project statewide. Though ISRO has been providing such connectivity elsewhere in the country it is the first time where it has been declared to be used for educational activities as well.

Figure 1- Map of India showing Kerala in the South

Figure 2 – Map of Kerala showing Pariyaram

Currently we are getting consultations from district hospitals and at times from other specialist centres as well. Similarly we can seek expert opinion from other specialist centres as well. There is customized software for using this, which helps in transmitting electronic medical

records and imaging data from a tele-nodal centre to a tele-specialist centre like ours. (Store and forward method) Based on the patient record, an appointment is fixed for videoconferencing between the consultant at the specialist centre and the treating doctor at the nodal centre (Real time method). But the above software does not support consultations between the tele-specialist centres - this is a major drawback to be worked upon - for which videoconferencing alone has to be used.

The connectivity is extended from the main tele-medicine room to the operation theatre complex, one lecture theatre and a small seminar hall. The connectivity for operation theatre is being used both for seeking expert advice as well as to conduct Tele-Education programmes on surgical techniques. The connectivity with the lecture theatre and seminar hall again is intended for scaling up the continuing education activities. In the next phase of the project, apart from extending the connectivity to more centres, plans are put forward for using the connectivity for sharing electronic resources and also to use it for enhancing surveillance and epidemiological research.

Conclusion

Here we have tried to give just an overview of this large scale eHealth programme. A detailed account of the project from its planning stage to the implementation stage has to be narrated in order to derive lessons and best practice guidelines, which shall be dealt with in the full paper. Finally the paper will compare with other institutions within our community and from outside and shall highlight the best practices. Definitely there is a lot to be learnt from the Kerala State Tele-Health & Medical Education Project.

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MEDINFO 2007
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Videophonic System for Cancerous Patients Receiving Chemotherapy at Home

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[b] Département d'informatique Médicale, Centre Hospitalier Universitaire de Grenoble, Grenoble, France
[c] Pôle de Médicine Aiguë et Communautaire, Centre Hospitalier Universitaire de Grenoble, Grenoble, France

Abstract

Videophonic systems have been used for several homecare applications in various medical specialties including oncology. The purpose of this poster is to describe the methodology and the materials of a controlled non randomized study; concerning the evaluation of the feasibility and the utility of a videophonic system used for following-up cancerous patients receiving chemotherapy at home. The study aims to show the patient and patient's family acceptability of videophony and their satisfaction, the clinical effects of using videophone on the patients' physical, functional and mental state, on their quality of life, and on the quality of healthcare provided at home. We use standard measurements (SF36, ADL index, index of Karnofisky, POS) and personal questionnaires (for the acceptability and satisfaction) prepared in the Medical Home care (MHC) service at the Grenoble university hospital.

Keywords:

videophone, satisfaction, acceptability, home healthcare, oncology, chemotherapy

Introduction

With the increase of social, medical and economic needs of dependent people (old, sick, disabled), and with the growth of health resources consumption, the Telemedicine Applications (telemonitoring, telesupport, teleconsultation) favor a medicalized maintenance at home. This one allows: preserving the patients and patients' carers quality of life, saving patient and hospital staff time, and eventually reducing health costs [1- 3]. Several studies evaluated the feasibility, the utility and the effectiveness of technology for providing and sharing various and necessary oncological expertises. However, no study evaluated the use of videophony for the delivery of home healthcare in oncology. The goal of our study is to evaluate the feasibility and the utility of a videophonic system used for following-up cancerous patients receiving chemotherapy at home. This study is carried out in the MHC service at the Grenoble university hospital. It is one of the MCC* (Medical Care Continuity) project clinical experimentations.

Materials and methods

Population:

The study concerns adult cancerous patients hospitalized at home * http://www.eten-mcc.org. The patients are selected according to the following criteria: having cancer and receiving chemotherapy, older than 18 years, life expectancy more than 12 weeks, stable vital state (vital parameters), specialized medical care provided at home, patient and general practitioner consent.

Videophonic system:

A videophonic system (Fig. 1) is used to link the patient at home with the hospital staff. The communication is established between tow stations: one is installed at the hospital/ call centre (central station) and the other one is installed at the patient's home (patient station). Each station is equipped with a videophonic kit composed of a Personal Computer, remotely operated camera, modem, microphone, loudspeaker, and keyboard. The central station enables to remotely control some elements of the patient station: the camera (move, rotation, zooms), the sound heard by the patient. The patient uses a remote control with unique button, having three functions: receiving a call, sending a call, and finishing a communication. The phone works independently of the videophonic apparatus so in case of problem with the videophone, the phone is still working.

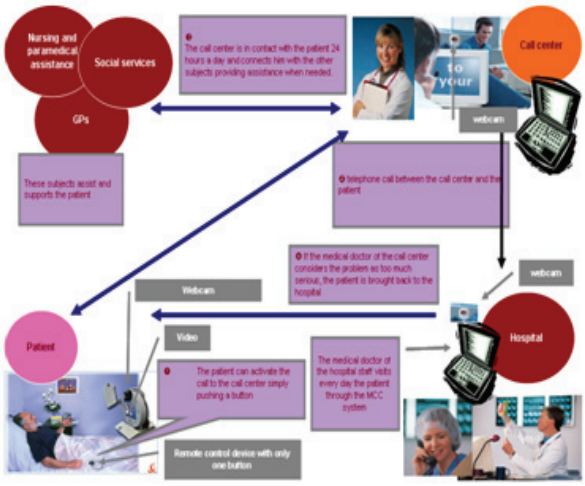

*Figure 1 - MCC videophonic system**

Clinical evaluation

Specific tools are used to evaluate each of the following items:

- Patient and patient's family satisfaction and acceptability of videophone: evaluated using three questionnaires for the patient and three others for the family. These questionnaires wear prepared for the study, by the healthcare team of MHC service at the Grenoble University Hospital.
- Patient functional state evaluated using functional
- capacity index of KARNOFSKY[4].
- Patient independence in daily activities evaluated using
- the index of KATZ ADL (Activity Daily Living)[5].
- Patient's anxiety and depression evaluated by the Hospital Anxiety and Depression Scale (HAD) [6].
- Patient quality of life evaluated using the SF36 scale [7].
- Life and care qualities evaluated using the POS
- (Palliative patient Outcome Scale)[8].

A controlled non-randomized method is used in the clinical evaluation. The comparison is realized between two groups of patients receiving home healthcare: the first one is the telemedicine group which benefit from the videophonic equipment, and the second one is the control group which does not have a videophonic system at home. The same evaluation tools are used for the two groups, except the evaluation of patient and patient's family acceptability and satisfaction; which are evaluated only in the telemedicine group. The Questionnaires and the scales are filled in three times during the study, every 4 - 6 weeks (at the beginning, at the middle and at the end).

Discussion

The use of telemedicine in usual practice at health institutions is still very limited. Following reasons can justify this limitation: patients and healthcare providers reject of telemedicine, non covering of telemedicine activities costs by health insurance systems, and lack of relevant research methodologies which provide proof of its efficiency and its utility [9]. To get a valuable and efficient telemedicine evaluation, it is necessary to consider the following items: diagnostic test reliability, clinical effects, patient and healthcare provider satisfaction, patient quality of life and economic analysis [10]. Until now the studies related to the videophonic application in oncology were interested in: radiotherapy, teleconsultation, multidisciplinary meeting, e-learning, and professional update [11 -15]. Few studies considered the clinical effects of using technology on cancerous patient quality of life and on their physical and mental state. No experience has been done to evaluate the videophone utility for following-up patients receiving a chemotherapy treatment at home. This study evaluates patient acceptability and satisfaction, videophone effects on the patient functional state and quality of life, and quality of healthcare provided at home. It is in progressing so there are no results yet.

Conclusion

Videophone applications favour medicalized maintenance at home, but there is still a lack of proofs which confirm the benefits of using technology to provide homecare for cancerous patients. Therefore, new clinical researches, like this study, are still necessary in this field.

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Videophonic system for cancerous patients receiving chemotherapy at home

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Introduction

- Nowdays progression of various medical phenomena:
  - ✓**Increase of social, medical and economic needs of dependent people(old, sick, disabled).**
  - ✓ **Progression of nosocomial infections specially in cancerous patients.**
  - ✓**Growth of health resources consumption and healthcare expenditure.**

  ⇨ Increase of medicalized home care request
- Telemedecine applications (telemonitoring, telesupport, teleconsultation) favor a medicalized maintenance at home
- Medicalized maintenance at home represents an interesting alternative to the placement/stay at health institutions (1-2).

Introduction

Goal of study

- Evaluation of the feasibility and utility of videophonic system used to provide healthcare for patients having cancer and receiving chemotherapy at home.
- The study is carried out in HMC(Home Medical Care) service at the Grenoble University Hospital, in the framework of MCC*(Medical Care Continuity) Project

* http:// www.eten-mcc.org

Materials and methods

- Controlled non randomized study:
  - Telemedicine group: patients receiveing home healthcare and beneficiary from videophonic system.
  - Control groupe: patients receiveing home healthcare and non having videophonic system at home.
- Population:

Adult cancerous patients receiving chemotherapy treatment at home.

Materials and methods

- Inclusion criteria

✓ Having cancer and receiving chemotherapy.
✓ Older than 18 years.
✓ Life expectancy more than 12 weeks.
✓ Stable vital State (vital parameters).
✓ Specialized medical care provided at home.
✓ Patient and general practitioner consent
✓ Logistic feasibility

Materials and methods

- Videophonic system (figure 1) links patient at home to hospital staff and consists of:
  - ✓ **Central station (central station) installed at HMC unit.**
  - ✓ **Mobile station (patient station) installed at patient's home.**

- Each station (patient and central), is equipped with a videophonic kit: personnel computer, digital camera, modem, Microphone, loudspeaker, keyboard.
- Remote control with unique button, allows the patient to receive, send, and finish a call.
- Functions availables at central station: piloting of camera at patient home , control of sound heard by the patient.
- Communication established by HMC staff ⇒ directe contact with the patient at home.
- Communication established by the patient ⇒ call centre ⇒ HMC staff or urgency service

Materials and methods

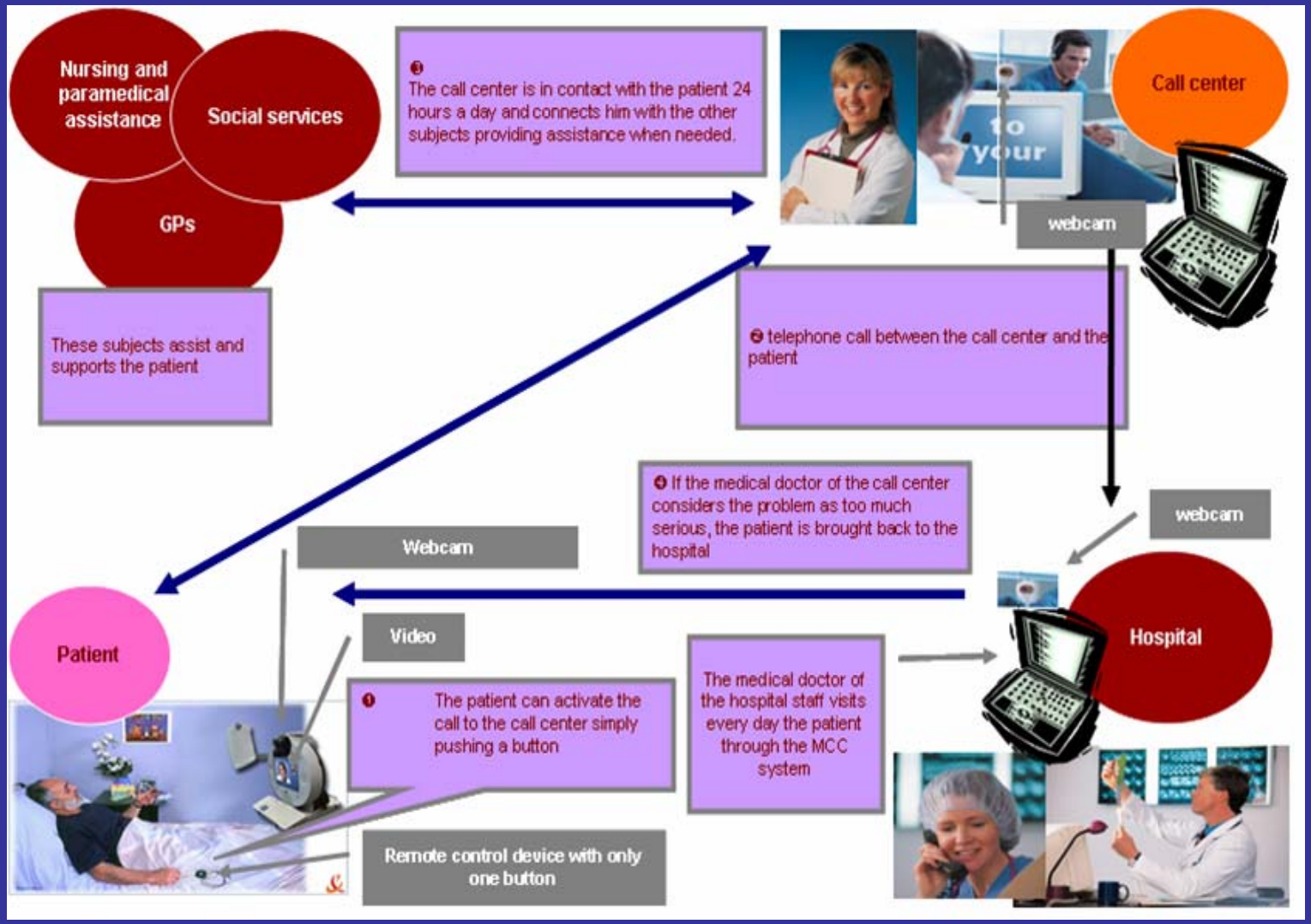

Figure1: Videophonic system for medical care continuity

Materials and methods

- Clinical evaluation
  - ✓**Patient and patient's family satisfaction and acceptability of videophone (questionnaires prepared at the HMC unit for this study).**
  - ✓**Patient functional state (functional capacity index of KARNOFSKY)[3] .**
  - ✓**Patient independence in the daily living activities (index of KATZ ADL)[4] .**
  - ✓**Patient's anxiety and depression(Hospital Anxiety and Depression: Scale HAD)[5].**
  - ✓**Patient quality of life and healthcare quality (SF36 scale and POS scale)[6,7].**

Materials and methods

- The same evaluation tools are used in the two groups, except the patient and patient's family acceptability and satisfaction which are evaluated only in the telemedicine group.
- For each patient:
  - ✓Inclusion duration for 3 months
  - ✓3 clinical evaluations carried out during the study (at the begining, at the midle and et the end).

Discussion

- In spite of the large developement achived in telemedicine field, its use in usual practice at health institutions is still limited(8):
  - ✓ **Patient and careprovider reject (not enough familiar in the socio-medical milieu).**
  - ✓ **Lack of pertinent studies about its utility and effectiveness.**
  - ✓ **Telemedicine activities not covered by health insurance systems.**
- Following items are necessary for telemedicine evaluation :diagnostic test reliability, clinical effects, patient and care provider satisfaction, patient's life quality and economic analysis[9].
- Experience related to using videophony in oncology concerned radiotherapy, teleconsultation, multidisciplinary meeting, e-learning, and professional update[10,11,12]. No one evaluated the delivery of home healthcare.

conclusion

- Telemedicine applications favor a medicalized patient maintenance at home.
- There is a lack of proofs showing the benefits of using technology to provide home healthcare for cancerous patients.
- New clinical researches, like this study, are still necessary in this field.

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Hierarchical Expansion for Concept-Based Search

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Abstract

Although many digital libraries are indexed using a hierarchical conceptual structure, improving the performance of traditional free text search is not trivial. We present a preliminary evaluation of a novel method of a hierarchical concept based search, as implemented in the Vaidurya search engine, with the innovation of using automated query mapping. Using MetaMap, textual query is mapped into MeSH concepts, which are later abstracted. Preliminary encouraging evaluation results on the TREC Genomics 2004 test collection are presented.

Keywords:

information storage and retrieval, concept based search

Introduction

While the idea of concept based search is researched for several decades, not too many studies shown that it outperforms traditional free text search. Recently we introduced Vaidurya, a search and retrieval tool developed originally within the DeGeL library, which in a rigorous evaluation a significant improvement was observed when concept based search was used. In this study we propose a novel approach, in which the user has to enter only a textual search phrase, which is converted into a concepts using *MetaMap*.

Vaidurya

Vaidurya implements a free text search (FTS) and concept based search (CBS). For the FTS, documents are represented and indexed using the *vector space model* introduced by Salton. The CBS in Vaidurya uses the logical operators *conjunction* (AND) and *disjunction* (OR) at two step of retrieval, called *inner-op* and *outer-op.* All the documents classified along a queried concept and its descendent are retrieved. Based on the *inner* the documents sets are intersected of unified to represent each tree, which then processed similarly based on the *outer* operator.

Methods

Based on the previous evaluation, we concluded that adding a query for concepts at the top levels will enhance FTS results, since the relevant documents commonly share abstract concepts. Our goal was to avoid the need in specifying explicitly the concepts, thus, enabling querying using a normal textual query, while exploiting the CBS. Given a set of *query terms*, a set of concepts at *varying* levels of the hierarchy is extracted using *MetaMap*. Then, the concepts are abstracted to their ancestors at a required level *k*, by climbing up through the MeSH hierarchy. In order to evaluate our method we used the TREC 2004 Genomics Track test collection, which offers 50 queries, and in which the documents are classified along MeSH concepts. As evaluation measures we refer to the precision measured at the top *5, 10 and 100* retrieved documents, and mean average precision (MAP). We report the preliminary evaluation of three important variables: (1) *CBS method (2) abstraction level (3) CBS weight.*

Results

Table 1 shows some of the best runs compared to the baseline. Results for runs which are higher than the baseline are bolded.

Table 1 – The best results compared to the baseline, the algorithm is specified by inner^{op}-outer^{op}/level/weight

Algorithm	MAP	P@5	P@10	P@200
OR-OR/3/0.2	0.228	**0.508**	**0.486**	0.196
AND-AND/2/0.2	0.226	**0.508**	**0.490**	**0.199**
OR-AND/4/0.2	0.222	**0.512**	**0.496**	0.193
Free Text Baseline	*0.231*	*0.488*	*0.480*	*0.198*

The improvement noticed at P@5 for run OR-AND/4/0.2 was significant with p=0.067 and for P@10 with p=0.079.

Discussion

We introduced an extension of Vaidurya which enables CBS through an automatic conversion of textual to conceptual queries using MetaMap. The evaluation done with the TREC-G showed a slight improvement. In the 10 and 15 queries, having the worst FTS performance, a significant relative improvement was observed. These are encouraging results for further development of the method**.**

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Virtual Reality Assessment of Checking Symptoms in Patients with Obsessive Compulsive Disorder

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Abstract

Virtual reality(VR) is being used in many field of psychiatry and psychology. However, there are few cases of its application to ob-sessive compulsive disorder(OCD). We developed virtual reality system for OCD. The aim of this study is to assess the checking symptoms in patients with OCD using Severance virtual reality system for OCD(SeVROS).

Keywords:

virtual reality, obsessive-compulsive disorder, assessments

Methods

The sample population comprised the checking-type OCD group (n=11), non checking-type OCD group (n=10), and a control group of matched healthy volunteers (n=14). The virtual environment was designed to induce checking behavior. Two virtual environment was implemented: a home environment with a gas burner, a gas valve, a water tap, a window, a light switch, a door, and a lock to a gate; an office with a heater, a computer, a cabinet, a light switch, a door, and a lock to a gate. After leaning and distracting tasks, participants were given a mission that checks whole things in the environment. During ckecking session, response time, behavioral response (object operation, gazing, and trajectory) and checking urge were measured by computer. We also used Yale-Brown Obsessive-Compulsive Scale(Y-BOCS) for severity of symptoms.

Results

There was no significant difference in accomplishment of task between patients and matched healthy controls (age, gender, education, VR experience and intelligence matched controls). There was significant difference in checking time in checking-type OCD group as compared to that of other groups.

Conclusion

Virtual reality is useful in assessment of symptoms in patients with obsessive compulsive disorder. Furthermore it can give us more profound data of attention and visuospatial function in OCD patients. Further study for cognitive and behavioral treatment of OCD patients using SeVROS is being executed.

		Checking type	Non-checking type	Control group	p-value
Demographic	N	11	10	14	
characteristics	Age	31.91 ± 10.88	28.90 ± 6.59	28.93 ± 7.37	0.63
of participants	Sex (M:F)	10:01	7:03	8:06	0.19
	Education (years)	13.73 ± 2.83	14.60 ± 1.96	15.07 ± 2.73	0.44
Patients'	YBOCS	26.36 ± 8.56	24.20 ± 6.91		0.53
characteristics	HAMD	12.36 ± 8.80	7.40 ± 7.41		0.18
	Total checking time	333.64 ± 128.49	224.42 ± 82.76	176.44 ± 27.05	0
VR parameters	Total number of over operation	6.45 ± 10.83	2.50 ± 2.72	1.14 ± 1.10	0.12
	Total gazing time	66.05 ± 41.06	39.46 ± 23.01	30.50 ± 12.19	0.01
	Incomplete items	3.55 ± 2.25	5.7 ± 4.27	4.79 ± 2.01	0.24

Table 1 - Y-BOCS: Yale-Brown Obsessive-Compulsive Scale, HAMD: Hamilton Depression Scale

Virtual Reality Assessment of Checking Symptoms in Patients with Obsessive Compulsive Disorder

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Objective

Virtual reality(VR) is being used in many field of psychiatry and psychology. However, there are few cases of its application to obsessive compulsive disorder(OCD). We developed virtual reality system for OCD. The aim of this study is to assess the checking symptoms in patients with OCD using Severance virtual reality system for OCD(SeVROS). the primary or first author.

- Obsessive-compulsive disorder (OCD) is a clinically heterogeneous disorder.
- Two main types of compulsions in OCD : Checking and Cleaning.

Jenike et al., 1990

Causes of checking compulsion in OCD

Impairment of memory

1. More nonverbal memory deficits
2. Less verbal memory impairments

Moritz et al., 2005

Low confidence of memory

1. Doubt of one's ability to recall
2. Whether correctly completed

Rachman and Hodgson, 1980

Limitations of previous studies

- Paper and pencil test or 2-D computerized test for assessment of visuospatial memory
- Self-report measures for confidence

Aim of this study

To find behavioral factors related to checking compulsion in patient with OCD using virtual environment.

ECHOLOGICAL STUDY

Methods

Twenty five patients with OCD and 14 normal controls volunteered for this study. The SeVROS-checking-type is Head Mounted Device(HMD) based VR system and has two virtual environment; office version and home version. Each virtual environment has 5 checking items with 5 distracting items. We used complete MINI(Mini International Neuropsychiatric Interview) for psychiatric evaluation. Other scales for assessment of OCD, depression, anxiety, quality of life, and feeling of presence were used. Intellectual function was also assessed.

Results

We classified the patients into 3 sub-group; checking-type, contamination-type, and symetric-type. The patients have more checking behavior than normal controls. The checking type patients have more checking behavior than other type patients. Two patients show low function of working memory. The SeVROS cuased anxiety to patients only.

		Checking type OCD	Non-checking type OCD	Control group	p-value
Demographic characteristics of participants	N	11	10	14	
	Age	31.91 ± 10.88	28.90 ± 6.59	28.93 ± 7.37	0.63
	Sex (M:F)	10:1	7:3	8:6	0.19
	Education (years)	13.73 ± 2.83	14.60 ± 1.96	15.07 ± 2.73	0.44
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	Incomplete items	3.55 ± 2.25	5.7 ± 4.27	4.79 ± 2.01	0.24

Conclusion

Virtual reality is useful in assessment of symptoms in patients with obsessive compulsive disorder. Furthermore it can give us more profound data of attention and visuospatial function in OCD patients. Further study for cognitive and behavioral treatment of OCD patients using SeVROS is being executed.

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Delivering Structured, Multi-modal Clinical Guidelines via Cell Phones

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Abstract

The widespread penetration of cellular (mobile) telephones worldwide, along with their increasing power and sophistication as computing devices, makes them an attractive telehealth platform. Cellphone-GuideView is a technology designed to deliver multi-modal clinical guidelines on cell phones. The system is intended to assist non-physician healthcare providers by presenting diagnosis and treatment advice in a simple discourse structure. The advice is augmented simultaneously by images, animations/video, text, and voice instructions. The contents of the guideline are stored primarily on the cell phone. If the guideline determines that a medical situation requires expert advice, the system automatically calls a remote physician or treatment facility. Cellphone-GuideView represents a model of telehealth in which synchronous assistance of experts is requested only when needed, thus decreasing costs and enhancing productivity.

Keywords:

practice guidelines, cellular phone, multimedia, telemedicine

Introduction

Low physician density is endemic in developing countries, as well as in rural/remote areas of developed nations[1]. In these situations, non-physician care providers (NPCPs) are often the primary providers of medical care to a large segment of the population. Such individuals typically have uneven levels of clinical training and thus the care they provide often falls short of medical standards. While strict adherence to clinical guidelines can help alleviate the problem, clinical guidelines are typically designed for physicians and presented in text form (see www.guidelines.gov, and are often beyond the understanding of NPCPs..

GuideView was designed to overcome these issues and enforce standardization of care. It has two main components: GuideView Author and GuideView Viewer. GuideView Viewer delivers the guidelines in a rich and easy-to-use multi-modal format that includes voiced instructions, text, images, video and animations simultaneously. Each mode compliments the other, resulting in a rich content delivery environment.

GuideView Author enables development of GuideView-compatible guidelines (referred to as *GuideViews*) using a GUI-based authoring environment.. Typically, a team consisting of clinicians and subject-matter experts develops GuideViews. The architecture of the GuideView system enforces clear separation between presentation and content. A benefit of this approach is that content can be integrated in multiple languages. The GuideView Viewer is agnostic to such content variations.

Further details of GuideView can be found in [2],[3]. In the remainder of this paper, we describe the implementation of GuideView on mobile phones.

Mobile phones and healthcare

Currently, worldwide adoption of cellular phones is without precedent in the history of technology. While the number of cellular phone users in developed countries in Western Europe is estimated to be close to 380 million, it is the growth in cell phone usage in developing countries in Latin America, Asia, and Africa that is the most stunning [4]. Growth in the cellular phone market in this regions is around 17%. In India, it is estimated that there are currently (October 2006) 100 million to 125 million cellular phone users and new subscribers sign up at the rate of 3 to 5 million every month [5]. Media reports have documented the innovative ways in which rural and economically disadvantaged populations utilize cellular phones to improve their daily lives [6]. Previous research have noted that digital media tends to benefit already privileged users, but that cell phones can help to close the gap[7]. In Colombia people with income levels below the country's mean represent 72% of those with cellular phones [8]. The number of cellular phone subscribers worldwide is estimated at 2 Billion (32.2% of world population). These subscribers give access to mobile telephony to more than 5 billion people (80.6% of world population) [4].

Competition among cell phone manufacturers and service providers results in constant introduction of new cell phone models with increasingly powerful processors, higher data storage capacities, and higher display resolutions. Cell phones have gone from being purely a communications device, to becoming a sophisticated, powerful, mobile communications-computing device.

A strong motivation for exploring the use of cell phones in health care is that in developing countries care providers are mobile, traveling from village to village. This is due to limited resources in the general population and poor transportation infrastructure. Thus, portability and availability of medical information at the point of care is highly desirable. These are some reasons why cellular phones can potentially contribute to telehealth and health care delivery in general.[9]

Cellular phones have been used to monitor cardiac function for occurrences of arrhythmias that are then transmitted to medical experts[10]; short messages services for data exchange between nurses and patients [11]; traditional on-demand direct voice connection between caregivers and patients [9].

While there is worldwide interest in exploring the use of mobile phones in health care, it appears that delivery of multi-modal clinical guidelines on cell phones, as in C-GuideView, is novel.

Methods

In this paper we present a technology called *C-GuideView* (CGV) that enables delivery of clinical guidelines using cellular phones. While the use of cell phones for data gathering and communications with specialists has been investigated [9-11], to the best of our knowledge, delivering clinical guidelines via cell phones is novel.

Our interest, based on previous work with the GuideView system [2], is to support decision-making and treatment by non-physician care providers (NPCPs) using clinical guidelines presented in an effective, easy-to-use format.

We evaluate different cellular phones platforms and selected one based on price and back compatibility with standard versions of GuideView.

Results

Recently (4th quarter of 2006), several cellular phones based on Windows Mobile, such as the Cingular 3125 and T-Mobile SDA have appeared. These models have the same form-factor as conventional phones and are also significantly cheaper.

CGV targets such cell phones and has been tested on the Cingular 3125. Challenges that had to be overcome were related to the small (albeit high resolution) screen size and the necessity to develop a new navigation paradigm using the cell-phone keypad and soft-keys. Quality of voice, image display, and video playback were found to be comparable from that on PDAs or lap/desktop machines.

As in the case of GuideView, target users of CGV are NPCPs. A notable feature of CGV is that these guidelines are kept locally on the cell phone itself. However, when the guideline determines that the NPCP needs expert help, it automatically dials the pre-stored phone number of a physician, a specialist, or to other expert facility. In contrast to other forms of telehealth that typically require the physician to participate in a voice or video-conferencing session, CGV initiates such synchronous communication only when needed. This feature enables better utilization of all care providers, ensuring that routine care is handled in an appropriate and standardized form locally by the NPCP. Expert assistance from physicians and specialists is called upon only if and when necessary.

Conclusions and future work

Due to their ubiquity and increasing sophistication, even in less developed areas of the world, cell phones have great potential as a powerful medium for Telehealth. The goal of Cell-GuideView is to help realize this potential. The technology is being improved in several directions such as improving screen formatting, voice commands, data compression, documentation of care in a simple EMR, porting to Symbian OS, and others. Usability and field testing studies are also being planned currently.

Acknowledgements

We thank the following for their support and encouragement. Kathy A. Johnson, PhD, Director, Medical Informatics, NASA Johnson Space Center; John R Svirbely, MD, TriHealth, Cincinnati, OH; Kevin Montgomery, PhD. Tommy Morris, Telemedicine & Advanced Technology Research Center (TATRC). This research was supported in part by Grant number # W81XWH-04-00035, administered by the U.S. Army Medical Research & Materiel Command's (USAMRMC) Telemedicine & Advanced Technology Research Center (TATRC), (MSI, JF-A); and NCRR Grant No. 1UL1RR024148 (MSI).

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Delivering Structured, Multi-modal Clinical Guidelines via Cell Phones

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Abstract

The University of Texas
Health Science Center at Houston

- Cellular (mobile) telephones are powerful computing and communications devices potentially useful for Telehealth
- Cell phones are cheap and ubiquitous world wide, including in developing countries
- GuideView is a technology designed to deliver structured, interactive multi-modal clinical guidelines to assist non-physician care providers (NPCPs)
- Cellphone-GuideView (C-GV) is an implementation of GuideView on mobile phones
- Cellphone-GuideView supports a model of telehealth in which synchronous assistance of experts is requested only when needed, thus decreasing costs and enhancing productivity.

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Introduction

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- In many areas of the word health care is typically provided by non physician care providers (NPCPs)[1]
  - Includes developing countries such as India, Colombia
  - Also remote and rural areas of developed countries
- These individuals often end up providing non-standard care due to uneven quality of training
- Clinical guidelines, if adhered to strictly, can alleviate this problem and improve quality of care
- However, clinical guidelines are complex and many NPCPs find them difficult to understand and implement

Introduction - 2

- GuideView was designed to overcome these issues and enforce standardization of care.
- GuideView has two main components:
  - GuideView Author
  - GuideView Viewer
- GuideView system enforces clear separation between presentation and content. A benefit of this approach is that content can be integrated in multiple languages.
- GuideView delivers the presents guidelines in a rich and easy-to-use multi-modal format that includes voiced instructions, text, images, video and animations simultaneously. [2,3]

Mobile Phones Worldwide

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- Worldwide adoption of cellular phones is without precedent in the history of technology.
- In Western Europe there are 380 million.[4]
- Cellular phone usage in developing countries in Latin America, Asia, and Africa is growing around 17% per year. [5]
- Media reports have documented the innovative ways in which rural and economically disadvantaged populations utilize cellular phones to improve their daily lives.[6]
- It has been observed that digital media tends to benefit already privileged users, but that cell phones can help to close the gap.[7]
- The mobile phone is rapidly becoming a ubiquitous and portable computing device, in addition to communications capabilities
- For example: In Colombia people with income levels below the country's mean represent 72% of those with cellular phones[8]

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Mobile Phones and Healthcare

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- The number of cellular phone subscribers worldwide is estimated at 2 Billion (32.2% of world population). These subscribers give access to mobile telephony to to more than 5 billion people (80.6% of world population)
- Cellular phones can potentially contribute to telehealth and health care delivery in general:[9]
  - In many countries healthcare providers often travel and approach the needy
    - This happens even in developed countries where NPCPs visit elderly populations in their homes
  - Healthcare is community based.
- Portability, easy communications with specialists, and availability of medical information at the point of care is highly desirable.

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Use of Mobile Phones in Healthcare

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- In healthcare, mobile phones have been used for
  - Data transmission
    - Example: monitor cardiac function for occurrences of arrhythmias that are then transmitted to medical experts.[10]
  - Communication of small snippets of information
    - short messages services for data exchange between nurses and patients.[11]
  - Synchronous voice communication
    - on-demand direct voice connection between caregivers and patients.[9]
- However, the use of cell phones to deliver clinical guidelines appears to be novel.

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Methods

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- In this paper we present a technology called C-GuideView (CGV) that enables delivery of clinical guidelines using cellular phones.
- This is an extension of GuideView that supports decision-making and treatment by non-physician care providers (NPCPs) using clinical guidelines presented in an effective, easy-to-use format
- Notable feature: If the guideline (developed previously by physicians and nurses) determines that the medical condition being treated is beyond locally available facilities and expertise, it will automatically seek help by telephoning the pre-programmed phone number of a clinic or physician

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Results

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- In 4th quarter of 2006, several cellular phones based on Windows Mobile, such as the Cingular 3125 and T-Mobile SDA have appeared.
- Same form-factor as conventional mobile phones and significantly cheaper than PDAs
- C-GV targets such cell phones and has been tested on the Cingular 3125

When C-GV was evaluated we found that

- Quality of voice,
- Image display,
- and video playback

Are comparable with PDAs or lap/desktop machines. However, small screen size is a challenge

C-GV in action

General Aspect
Multimodal display
Softkey navigation

Video Playback

C-GV automatically calls remote specialists and clinics as & when needed

Conclusions and Future Work

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- Cellphone-GuideView enables better utilization of all care providers, ensuring that routine care is handled in an appropriate and standardized form locally by the NPCP.
- Expert assistance from physicians and specialists is called upon only if and when necessary, thus optimizing resources and minimizing costs.
- The technology is being improved in several directions such as improving screen formatting, voice commands, data compression, documentation of care in a simple EMR, porting to Symbian OS, and others.
- Usability and field testing studies are also being planned currently.

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Use of Emerging Technologies in Healthcare: A future Vision For u-Nursing

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Abstract

The plethora of emerging technologies provide the impetus to consider a future vision of nursing that maximizes the benefits of technology supported health care for consumers. An international group of nurse informatics leaders at the International Medical Informatics Association – Nursing Informatics Working Group (IMIA-NIWG) Post Congress considered the potential trends in health informatics, with particular regard to technology and health care for the future, looking forward to 2020. The focus is on how technology could be used to provide health care in tomorrow's world and the impact this might have for nursing. Technology use will increase, be everywhere and part of everyday life – technology will be ubiquitous. This will impact significantly on nursing practice and we propose that ubiquitous nursing (u-nursing) will be the future trend.

Keywords:

nursing practice; diffusion of innovation

Introduction

This poster is a representation of the deliberations of an international group of nurses who were charged with contemplating the potential trends in health informatics. Due to the rapid developments in technology and the myriad of possibilities, the group looked forward to the year 2020. We predict that technology use will be ubiquitous and this will impact significantly on nursing practice and the future role of nurses.

Scenario for healthcare in 2020

A consumer with diabetes is discharged from the Clinical Care Facility after bypass surgery with personal sensors in a wristwatch and as most others, they live in a 'smart house'. The wristwatch has near infrared spectroscopy sensors (NIRS) monitoring blood glucose, peripheral arterial oxygen saturation and carbon dioxide, pH, electrolytes, ECG, BP and peripheral temperature. Sensors in chest and leg dressings send messages to the nurse when it is time to change them. The radio frequency identification (RFID) medication cabinet monitors prescribed medication use and need for supplies. The consumer's exercise program and diet for the day is scheduled and appears on screen and the consumer can log onto a chronic disease support / post operative education group Sensor data is forwarded to U-Health Center, processed and any values outside the range are returned to consumer with correctional suggestions. The consumer is supported by a communication system (voice activated - video phone) between home and the nurse at the community-based U-Health Center.

U-Nursing

Extending the current understanding of nursing to u-nursing in 2020 the authors decided on the following definition of U-nursing: "Provision of nursing for anyone or any organization, anytime, anywhere, through any networks and any devices". Further discussion identified many challenges and issues, as well as opportunities for nursing the future.

Nursing in 2020

The nurse of the future will have a key role as info-mediator to facilitate the consumers' use of technology. It is recognized that nursing education as it is currently provided will not adequately prepare the nurse we envisage for the future. Patients are redefined as consumers, as users and partners in health care. We are united in emphasizing that the focus should be on consumers and not the technology. Rather the consumers and health priorities should drive technology development. International trends of the aging population and the increase in chronic diseases indicate that the consumers of the future are likely to be older and many may have chronic diseases. Health services will be

needed to support these consumers. However, an additional important focus will be on health promotion and maintenance to reduce the burden on the health services.

Use of emerging technologies in healthcare: A future vision for u-nursing

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Anneli Ensio, *Department of Health Policy and Management, University of Kuopio, Finland*
Elvio Jesus, *Nursing Research Group of Madeira, Portugal*

Background

- Authors - an international group of nurse informatics leaders at the International Medical Informatics Association – Nursing Informatics Working Group (IMIA-NIWG) Post Congress held in Korea 2006.
- Considered the potential trends in health informatics, with particular regard to technology and health care for the future (2020).
- Focus on how technology could be used to provide health care in tomorrow's world and the impact this might have for nursing.

Our assumptions for 2020

- Technology use will increase, be everywhere and part of everyday life – technology will be ubiquitous.
- This will impact significantly on nursing practice and we propose that ubiquitous nursing (u-nursing) will be the future trend.

U-Nursing

Definition

"Provision of nursing for anyone or any organization, anytime, anywhere, through any networks and any devices".

Trends

- International trends of the aging population and the increase in chronic diseases indicate that the consumers of the future are likely to be older and many may have chronic diseases.
- An additional focus will be on health promotion and maintenance to reduce the burden on the health services.

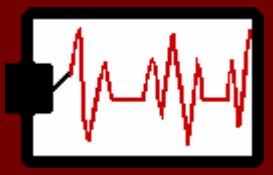
Nursing in 2020

- Patients are redefined as consumers
  - users and partners in health care.

- Nurse as info-mediator
  - facilitates the consumers' use of technology.

Scenario for healthcare in 2020

- A consumer with diabetes is discharged from the Clinical Care Facility after bypass surgery with personal sensors in a wristwatch to their ‘smart house’.
- The wristwatch monitors blood glucose, pH, ECG, BP, peripheral arterial oxygen saturation, carbon dioxide, electrolytes, and peripheral temperature.
- The radio frequency identification (RFID) medication cabinet monitors prescribed medication use and need for supplies.



Community based U-Health Centre

- Sensors in chest and leg dressings send messages to the nurse when it is time to change them.
- Sensor data is processed and any values outside the range are returned to consumer with correctional suggestions.
- Nurse can see data and is sent alerts.

Supported in their ‘smart house’

- Consumer’s daily exercise program and diet appears on screen.
- The consumer can log onto a chronic disease support / post operative education group.
- Consumer supported by a communication system (voice activated - video phone) between home and nurse at U-Health Center.

Issues

- Current nursing education will not adequately prepare the nurse we envisage for the future.
- Focus should be on consumers and not the technology.
- Consumers and health priorities should drive technology development.

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Application of Wireless and Mobile Computing Technologies to Improve the Efficiency of Patient Care and Education: The Role of Medical Engineering and Information Technology

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Abstract

This study explored the potential of the application of wireless and mobile computing technologies to be used in improving the efficiency of patient care and education and future developments in information and communication technologies to support healthcare professionals and medical students in healthcare research, medical education and training. The design used for this study was a systematic review of published materials obtained from EMBASE and MEDLINE online databases, and the Cochrane Library database, including personal observations. Today, more than 50% of healthcare professionals and medical students are using Personal Digital Assistant with expected growth of more than 75% by year-end 2007. In addition, wireless and mobile computing technologies allows Personal Digital Assistant to connect directly to networks or the Internet. Studies relating to processes of patient care and should evaluate mobile computing technologies as a potential timesaving tool. Wireless and mobile computing technologies is only beginning to take its first step in improving patient care and education. They have shown a positive impact on patient safety, health care efficiency, and ultimately patient satisfaction.

Keywords:

wireless and mobile computing technologies, patient care and education, efficiency, personal digital assistant

Introduction

Wireless is a term used to describe telecommunications in which electromagnetic waves (rather than some form of wire) carry the signal over part or all of the communication path.[1] Mobile Computing is a generic term describing your ability to use technology 'untethered', that is not physically connected, or in remote or mobile (non static) environments.[2] The term of wireless and mobile computing technologies is evolved in modern usage such that it requires that the mobile computing activity be connected wirelessly to/through the application of internet or to/through a private network. This connection ties the mobile device to centrally located information and/or application software through the use of battery powered, portable, and wireless computing and communication devices.[1, 2] This includes devices like laptops with wireless LAN or wireless WAN technology, smart mobile phones, wearable computers and Personal Digital Assistants (PDAs) with Bluetooth or IRDA interfaces.

This study explored the potential of the application of wireless and mobile computing technologies to be used in improving the efficiency of patient care and education and future developments in information and communication technologies to support healthcare professionals and medical students in healthcare research, medical education and training.

Design and methods

The design used for this study was a systematic review of published materials obtained from EMBASE and MEDLINE online databases, and the *Cochrane Library* database, including personal observations. Materials that match the set criteria on the application of wireless and mobile computing technologies in medical engineering and information technology research for healthcare professionals and medical students to improve the efficiency of patient care and education were selected and analysed following the United Kingdom National Health Service Centre for Reviews and Dissemination Guidelines. A variety of data collection approaches were developed to ensure data were collected on the various aspects.

Results

Wireless and mobile computing technologies is seen to be convenient to get in touch, compact, fast and portable, but problems are attached to the levels of security, confidentiality and scalability of the hardware. It is also apparent that most commonly used wireless and mobile computing technologies within the health contexts is the Personal Digital Assistant. Today, more than 50% of healthcare professionals and medical students are using Personal Digital Assistant with expected growth of more than 75% by year-end 2007.[3] Not only can the healthcare professionals and medical students use the tool on the Personal Digital Assistant as a quick look-up resource at the bedside, but

can also flag a topic for further research when back in the office. Changes in treatment guidelines, concerns about patient safety, efforts to contain costs, time limitations, and better informed patients make it critical to have clinical reference information at the point of patient care and education.[4] In addition, wireless and mobile computing technologies allows Personal Digital Assistant to connect directly to networks or the Internet.

Discussion

According to the results of this systematic review of this study, wireless and mobile computing technologies has become a valuable resource for both healthcare professionals and medical students over the past decade. This has enabled new perspectives to be developed on the interface between hardware, software and education and training processes for those involved in delivering healthcare research. Studies relating to processes of patient care and should evaluate wireless and mobile computing technologies as a potential timesaving tool, as they can be synchronised with hospital information systems to facilitate retrieval of patient information. The findings also indicate that the healthcare professionals and medical students would benefit from some technologies that they can easily use to search for such sources as database, E-journals and the Internet. At a theoretical level, wireless and mobile computing technologies such as Personal Digital Assistant is ideal for meeting these needs. Further study on processes of patient care and education should also explore wireless and mobile computing technologies as vehicles for disseminating evidence-based guideline recommendations.

Conclusion

Wireless and mobile computing technologies is only beginning to take its first step in improving patient care and education. They have shown a positive impact on patient safety, health care efficiency, and ultimately patient satisfaction. The integration of the Internet and wireless and mobile solutions will transform the use of information and communication technologies in patient care and education and take it in the role of medical engineering and information technology. The potential of wireless and mobile computing technologies is vast and its principles, application and practices are seen as a choice for healthcare professionals and medical students to be in the right place at the right time. In the future we will see more valuable resources in improving patient care and by developing wireless and mobile computing technologies.

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APPLICATION OF WIRELESS AND MOBILE COMPUTING TECHNOLOGIES TO IMPROVE THE EFFICIENCY OF PATIENT CARE AND EDUCATION: THE ROLE OF MEDICAL ENGINEERING AND INFORMATION TECHNOLOGY

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Background

- Wireless is a term used to describe telecommunications in which electromagnetic waves (rather than some form of wire) carry the signal over part or all of the communication path.[1]

- Mobile Computing is a generic term describing your ability to use technology 'untethered', that is not physically connected, or in remote or mobile (non static) environments.[2]

- The term of wireless and mobile computing technologies is evolved in modern usage such that it requires that the mobile computing activity be connected wirelessly to/through the application of internet or to/through a private network. This connection ties the mobile device to centrally located information and/or application software through the use of battery powered, portable, and wireless computing and communication devices.[1, 2]

Devices

- This includes devices like laptops with wireless LAN or wireless WAN technology, smart mobile phones, wearable computers and Personal Digital Assistants (PDAs) with Bluetooth or IRDA interfaces.

Figure 1: Presentation of Computer Assisted Learning
Source: http://www.pocketpcguide.info

Aims and Objectives

- Explored the potential of the application of wireless and mobile computing technologies to be used in improving the efficiency of patient care and education

- Future developments in information and communication technologies to support healthcare professionals and medical students in healthcare research, medical education and training.

Design and Methods

- **Systematic review of published materials obtained from EMBASE and MEDLINE online databases, and the *Cochrane Library* database, including personal observations.**

- **Materials that match the set criteria were selected and analysed following the United Kingdom National Health Service Centre for Reviews and Dissemination Guidelines.**

Advantages & Disadvantages

- **Advantages: convenient to get in touch, compact, fast and portable**

- **Disadvantages: levels of security, confidentiality and scalability of the hardware.**

Results (1)

- Most commonly used wireless and mobile computing technologies within the health contexts is the Personal Digital Assistant.
- More than 50% of healthcare professionals and medical students are using Personal Digital Assistant with expected growth of more than 75% by year-end 2007. [3]
- In addition, wireless and mobile computing technologies allows Personal Digital Assistant to connect directly to networks or the Internet.

Results (2)

- Changes in treatment guidelines, concerns about patient safety, efforts to contain costs, time limitations, and better informed patients make it critical to have clinical reference information at the point of patient care and education. [4]

Discussion (1)

- This has enabled new perspectives to be developed on the interface between hardware, software and education and training processes for those involved in delivering healthcare research.

- Studies relating to processes of patient care and should evaluate wireless and mobile computing technologies as a potential timesaving tool, as they can be synchronised with hospital information systems to facilitate retrieval of patient information.

Discussion (2)

- The findings also indicate that the healthcare professionals and medical students would benefit from some technologies that they can easily use to search for such sources as database, E-journals and the Internet.
- At a theoretical level, wireless and mobile computing technologies such as Personal Digital Assistant is ideal for meeting these needs.
- Further study on processes of patient care and education should also explore wireless and mobile computing technologies as vehicles for disseminating evidence-based guideline recommendations.

Conclusions

- The potential is vast and its principles, application and practices are seen as a choice for healthcare professionals and medical students to be in the right place at the right time.

- More valuable resources in improving patient care and by developing wireless and mobile computing technologies.

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Evaluation of Wireless Teleradiology System for Emergency Care with Mobile Network

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Abstract and objective

The wireless mobile service with a high bit rate using CDMA-1X EVDO is now widely used in Korea. Mobile devices are also increasingly being used as the conventional communication mechanism. In this study, we have developed JPEG 2000 compression module. We have also developed a web-based mobile system that communicates patient images using CDMA-1X EVDO for emergency care. A wireless mobile emergency patient imaging communication system is developed by using Microsoft Visual Studio.NET, and JPEG 2000 ActiveX control for PDA phone was developed by using the Microsoft Embedded Visual C++. Also, the CDMA-1X EVDO is used for connections between mobile web server and the PDA phone, and between ambulance car and hospital. In particular, images were compressed into a JPEG2000 format and transmitted from the hospital to the radiologist using a PDA phone located outside of the hospital. We successfully demonstrated this system for moving using an RW-6100 PDA phone used in the Yonsei university medical center in Korea.

Keywords :

PDA phone, JPEG2000, CDMA-1x EVDO, emergency care

Methods

A system development environment

The develop environment for mobile imaging communication system was composed a mobile web application system by using a Microsoft Window 2003 server, and internet information service and it is developed by using the Microsoft Visual Studio.NET, and the JPEG 2000 ActiveX control for a PDA phone was developed by using Microsoft Embedded Visual C++. In this study, we used a CDMA-1X EVDO service provided by the KTF communication firm in Korea. The CDMA-1X EVDO transmits data by using a maximum forward bandwidth of 2.46 Mbps and this is used for connection between a mobile web server and a PDA phone.

Composition of the whole system

Considering three spaces of the ambulance car, the hospital to where the emergency patient will be evacuated, and outside, we composed the whole system layout. Emergency patient images which are acquired using the portable imaging acquisition modality are sent in advance to the hospital where the emergency patient will be taken so the emergency doctor in the hospital can quickly receive and confirm transmitted information. CDMA-1X EVDO is also used for mobile communication. Also, it will be possible to refer to received information in the hospital where the emergency patient is taken, using a PDA phone anytime, anywhere.

System evaluation properties

In this study, we evaluated two items using wireless mobile imaging communication system. First, when we refer to JPEG 2000 images using a PDA phone, display time is measured. Second, PSNR values are measured by peak signal-to-noise ratio (PSNR) measurement function in order to compare image quality between the original image and the JPEG 2000 compressed image. In order to evaluate two items, various brain CT images (530KB, 512x512, 16bit) are used. And, PSNR values are measured in proportion to the increase of the JPEG 2000 compression ratio.

Results

The compression of 10:1 is a clinically reasonable maximum compression ratio for emergency care according PSNR measurement in this study. Also, JPEG2000 images of 10:1 compression ratio are transmitted approximately 0.08s from hospital to PDA Phone for moving using CDMA-1X EVDO.

Ratio	File Size	Theoretical Trans. Time (s)	Actual Trans. Time (s)
Original	543kB	1.78s (at 2.4Mbps)	5.43±1.22s
5:1	36.4kB	0.11s (at 2.4Mbps)	1.93±0.22s
10:1	24.1kB	0.08s (at 2.4Mbps)	0.65±0.07s
30:1	12.9kB	0.04s (at 2.4Mbps)	0.44±0.03s
40:1	9.87kB	0.03s (at 2.4Mbps)	0.22±0.02s
50:1	7.59kB	0.02s (at 2.4Mbps)	0.19±0.02s
100:1	4.45kB	0.01s (at 2.4Mbps)	0.14±0.02s

Table 1 - The result of average transmission time of various compression ratios from hospital to portable mobile device – brain CT image (attempt number = 30)

Conclusion

The results of this study are expected to play an interface role between the mobile emergency medical system and ubiquitous healthcare.

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[1] Chan KK, Ricky KT System integration for PACS. Comp Med Imaging Graph 1991; 15: 177-181

[2] Choi BY, Lee HJ, Yoo DJ, Huh W A study on implementation of telemedicine system, Proc KOMBE 1992; 14: 105-108

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Introduction

❖ Background

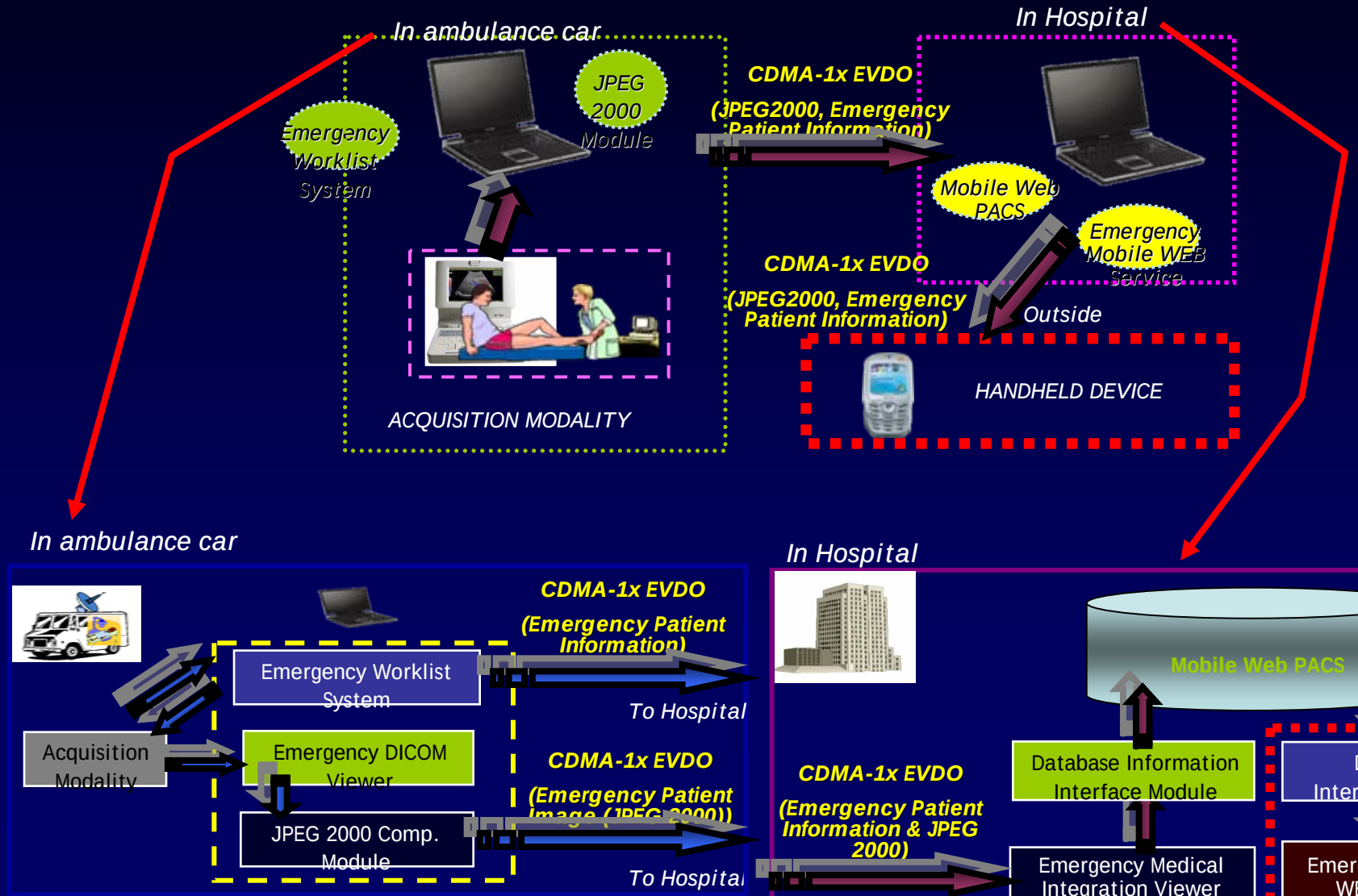
- Recently, study about Emergency Medical Information System is actively in progress to improve quality of Emergency Medical diagnosis.
- Study about Installation of Portable acquisition modality in ambulance car is also in progress.
- Although, the exact and rapid consultation from medical specialist is necessary to further treatment… especially for emergency surgery..
- If the specialist is in outside of hospital in that time, → Can not perform next treatment process!!
- If using wireless LAN based PDA, it is impossible to read the images where access point (AP) is not exist.
- Recently, the technique and infrastructure of commercial wireless network such as CDMA-1x EVDO have been dramatically promoted.

❖ Objective

- In this study, we designed a wireless mobile emergency patient information and imaging communication system using CDMA-1x EVDO service based personal digital assistant (PDA) phone for emergency care.
- And we evaluated the performance of this system which is a Wireless Teleradiology System for Emergency Care with Mobile Network

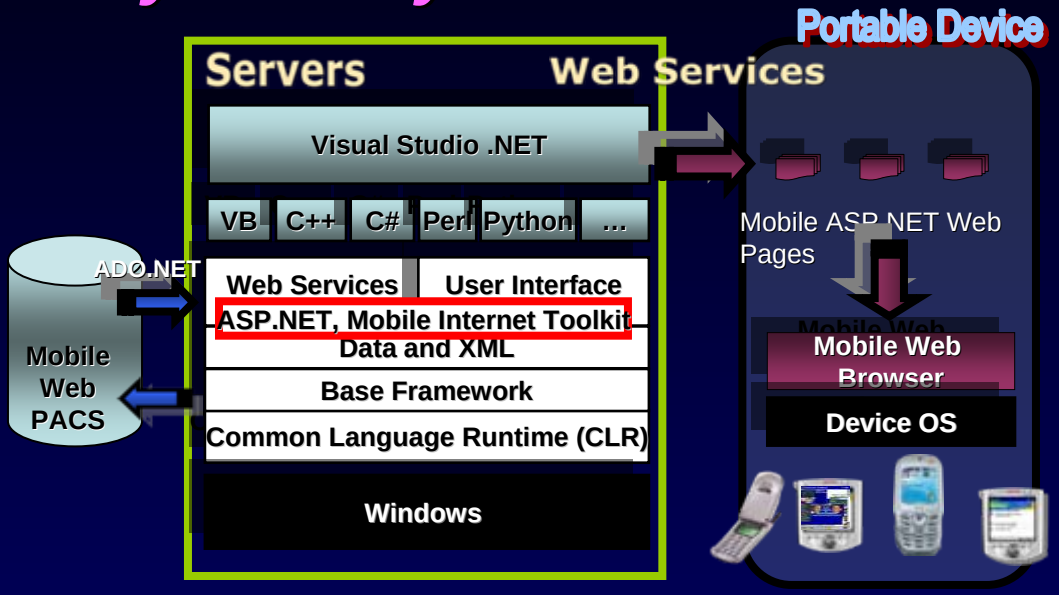
Materials and Methods

❖ System Layout



Materials and Methods

❖ System Layout



❖ Material

❖ Development Environment

Emergency Worklist System
- ❖ *Microsoft Visual C++ 6.0 (Microsoft, USA)*

JPEG2000 Compression Module & Emergency Info. Viewer :
- ❖ *Microsoft Visual C++ 6.0 (Microsoft, USA)*
- ❖ *Lead tool JPEG2000 SDK (Lead tool Corporation, USA)*

Mobile Web PACS:
- ❖ *Microsoft Access 2003 (Microsoft, USA)*

Mobile Web Service Module:
- ❖ *Microsoft Visual Studio .NET 2003 (Microsoft, USA)*
- ❖ *Embedded Visual C++ 4.0 (Microsoft, USA)*
- ❖ *Microsoft Window 2003 Server (Microsoft, USA)*

RW6100, LG Electronics, Korea
- *Intel Bulverde PXA270 520 MHz Processor*
- *Windows Mobile 2003 SE (Second Edition)*
- *128M Intel State Flash ROM*
- *240 x 320 pixels*

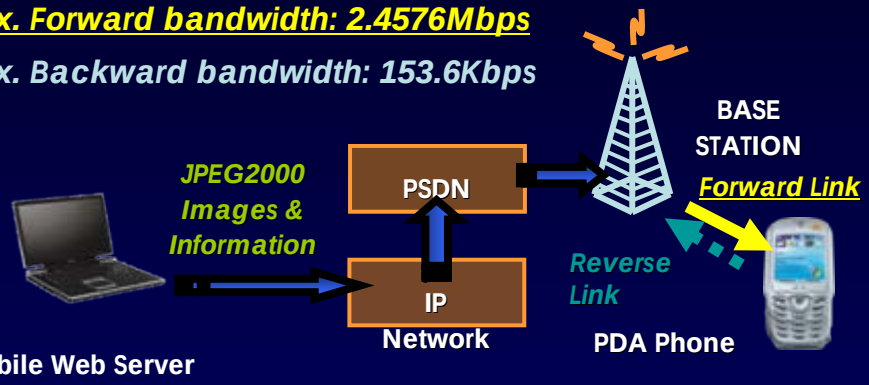
- *Support both Wireless local area network (WLAN) and CDMA 1x EVDO service*

Materials and Methods

❖ Forward Link vs. Reverse Link

CDMA2000 1x EVDO has asymmetric data rate structure.

- ***Max. Forward bandwidth: 2.4576Mbps***
- *Max. Backward bandwidth: 153.6Kbps*



❖ System Evaluation

Transmission Time Measurement

- *for evaluation about medical image application in the Mobile Network*
- *from emergency car and hospital*
- *from hospital and outside*
- *using X-Note Express LW20-EV3MK (CDMA -1x EVDO Support)*

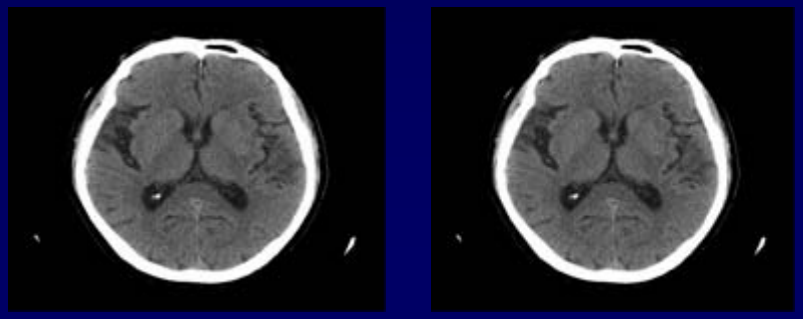
❖ System Evaluation

- *Transmission time of JPEG 2000 image on the PDA phone was measured using our system outside hospital.*
- *PSNR measurement according to JPEG2000 Compression Ratio of Medical image Compression*
- *Evaluation of Medical Image Compression*

❖ System Evaluation

PSNR (Peak Signal to Noise Rate)

- *for evaluation image usability according to compression ratio using mathematical factor*
- *Using PSNR measurement function which is included in Aware Image Compression Factor Measurement System*



Original image : JPEG2000 Image

Materials and Methods

❖ System Evaluation

Test Images were selected..

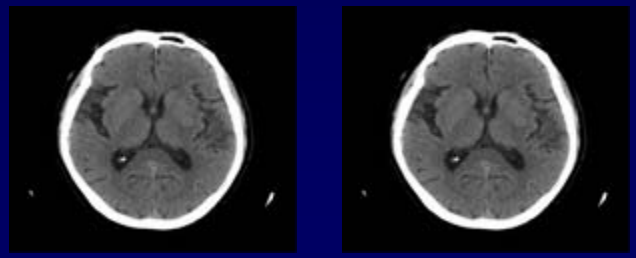
- *For measurement of PSNR*
- *brain axial and sagital CT Images (512x512 -16bit)*

Compression Ratio was.. (for each image)

- *5:1, 10:1, 15:1, 20:1, 25:1, 30:1, 35:1, 40:1, 45:1, 50:1 and 100:1*

Evaluation of Medical Image Compression

- *using both DICOM image and JPEG2000 image (according to Compression Ratio)*
- *brain CT image (512x512, 16bit) – 12 case study(360 images)*
- *Desktop Environment vs UMPC, PDA Phone*



Original image : JPEG2000 Image

❖ System Evaluation

Evaluation Method of Medical Image Compression

- *Implementation Alberta Stroke Program Early CT Score (ASPECT) Test to evaluate medical image diagnosis possibility (Random)*
- *One radiologist*
- *Wilcoxon signed rank test – Statistic Process Method*

Evaluation of Medical Image Compression

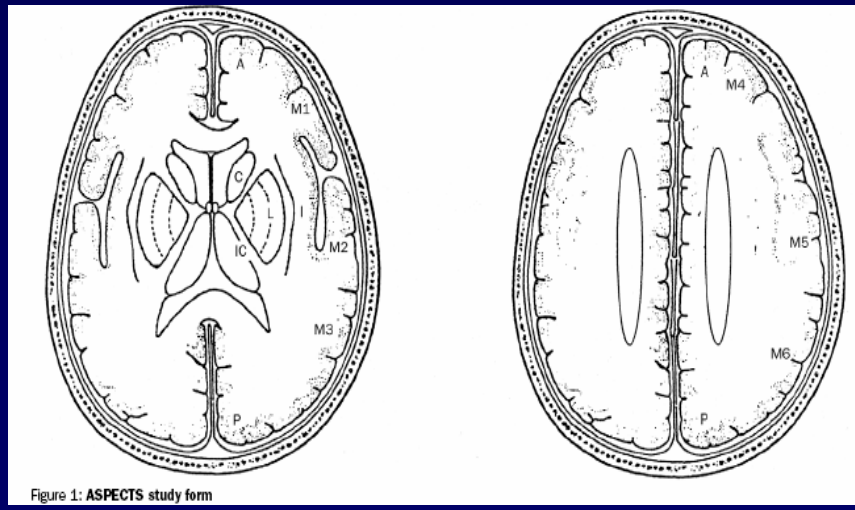
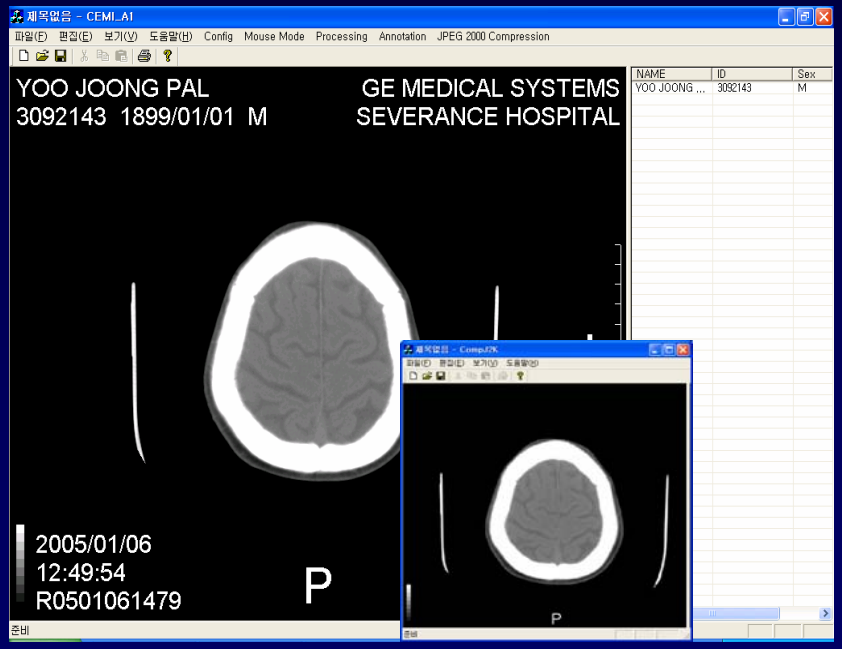


Figure 1: **ASPECTS** study form

Results

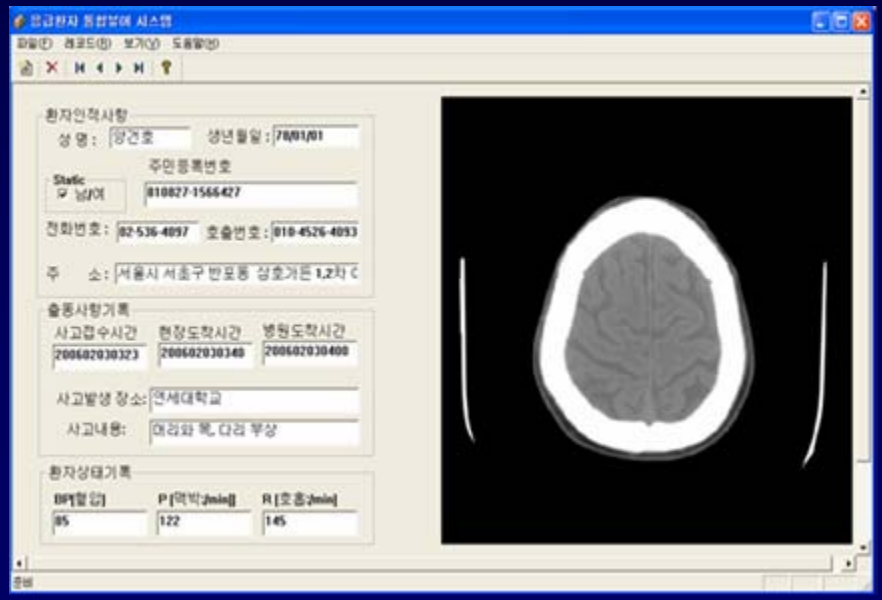
❖ JPEG2000 Transmission Module

- Compress DICOM images from acquisition modality to JPEG2000 files and Send JPEG 2000 Image to the hospital



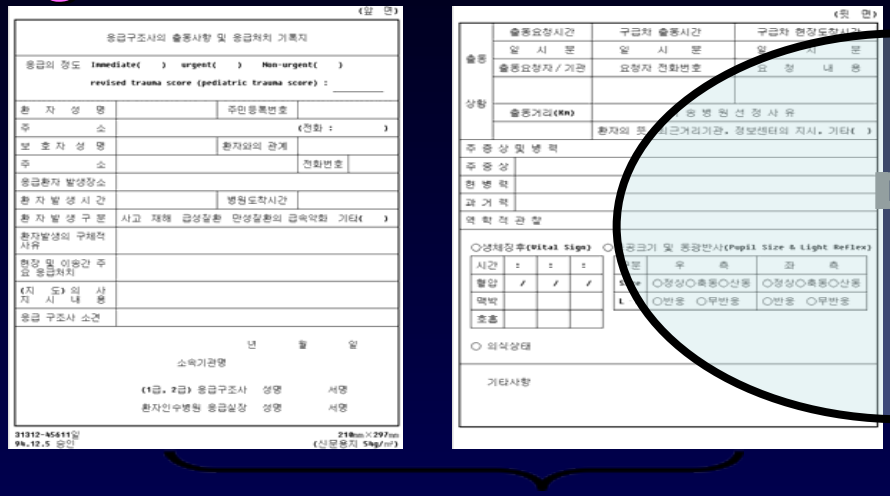
❖ Emergency Medical Integration Viewer

- View Emergency Patient Information and JPEG 2000 Image
- Storing Emergency Patient Information & JPEG 2000 image to Mobile Web PACS of the hospital

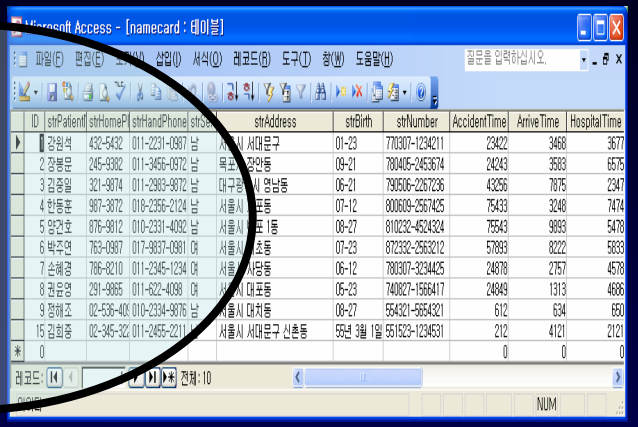


Results

❖ Design of Mobile Web PACS

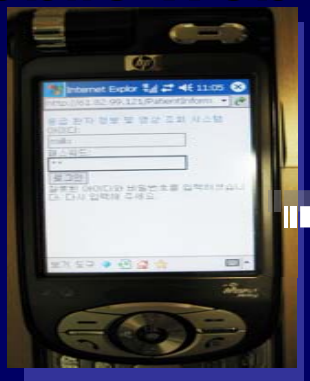


Structure of Emergency Patient Information



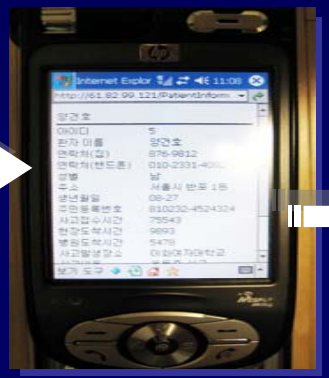
Design of Database using Access

❖ EM Mobile Web Service using PDA Phone



Login Process

EM Patient List



EM Patient Info.

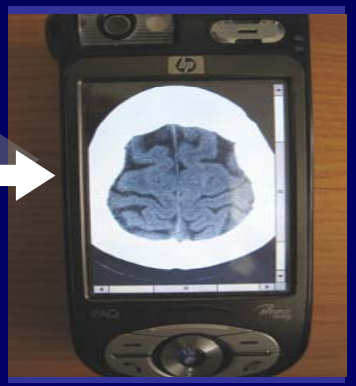


Image View

Results

❖ PSNR (Peak Signal to Noise Ratio)

Ratio	PSNR	Ratio	PSNR
5:1	52.64±0.22	35:1	25.36±0.47
10:1	40.54±0.17	40:1	24.18±0.53
15:1	34.96±0.07	45:1	23.35±0.64
20:1	31.12±0.25	50:1	22.70±0.32
25:1	28.44±0.40	100:1	19.08±0.55
30:1	26.47±0.24		

❖ Evaluation of Medical Image Compression

	M 1	M 2	M 3	M 4	M 5	M 6	C	L	IC	I	Tota l
2556249	1	0	0	0	0	0	0	0	1	0	2
3021141	1	1	1	1	1	1	1	0	1	0	8
3092143	1	1	1	1	1	1	1	0	1	1	9
3756925	1	1	1	1	1	1	1	1	1	0	9
3784945	1	1	0	1	1	0	1	0	1	0	6
4124531	0	0	0	0	0	0	0	0	1	0	1
4157412	1	1	1	1	1	1	1	1	1	0	9
4172456	0	0	0	0	0	0	0	0	1	0	1
4189776	1	1	1	0	0	0	1	1	1	0	6
4243230	1	1	1	1	1	1	1	1	1	1	10
4243232	0	1	1	1	1	1	1	1	1	0	8
4262154	1	1	1	1	1	1	1	0	1	0	8

The ASPECT test result of original image

❖ Transmission Time

Ratio	File Size	Theoretical Trans. Time (s)	Actual Trans. Time (s)
Origi nal	543kB	1.78s (at 2.4Mbps)	5.43±1.22s
5:1	36.4kB	0.11s (at 2.4Mbps)	1.93±0.22s
10:1	24.1kB	0.08s (at 2.4Mbps)	0.65±0.07s
30:1	12.9kB	0.04s (at 2.4Mbps)	0.44±0.03s
40:1	9.87kB	0.03s (at 2.4Mbps)	0.22±0.02s
50:1	7.59kB	0.02s (at 2.4Mbps)	0.19±0.02s
100: 1	4.45kB	0.01s (at 2.4Mbps)	0.14±0.02s

The result of average transmission time of various compression ratios from hospital to PDA Phone – brain CT image (attempt number = 30)

❖ Transmission Time

Ratio	File Size	Theoretical Trans. Time (s)	Actual Trans. Time (s)
Origi nal	543kB	28.1s (at 154Kbps)	39.11±6.11s
5:1	36.4kB	1.93s (at 154Kbps)	5.21±0.09s
10:1	24.1kB	1.54s (at 154Kbps)	3.89±0.03s
30:1	12.9kB	0.97s (at 154Kbps)	2.26±0.04s
40:1	9.87kB	0.73s (at 154Kbps)	2.13±0.03s
50:1	7.59kB	0.42s (at 154Kbps)	1.98±0.03s
100:1	4.45kB	0.33s (at 154Kbps)	1.88±0.02s

The result of average transmission time of various compression ratios from ambulance car to hospital – brain CT image (attempt number = 30)

Results

❖ *Evaluation of Medical Image Compression*

	M 1	M 2	M 3	M 4	M 5	M 6	C	L	I C	I	Tota l
2556249	1	0	0	0	0	0	0	0	1	0	2
3021141	1	1	1	1	1	1	1	0	1	0	8
3092143	1	1	1	1	1	1	1	0	1	0	8
3756925	1	1	1	1	1	1	1	1	1	0	9
3784945	1	1	0	1	0	0	1	0	1	0	5
4124531	0	0	0	0	0	0	0	0	1	0	1
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4172456	0	0	0	0	0	0	0	0	1	0	1
4189776	1	1	1	0	0	0	1	1	1	0	6
4243230	1	1	1	1	1	1	1	1	1	1	10
4243232	0	0	1	1	1	1	1	1	1	0	7
4262154	1	1	1	1	1	1	1	0	1	0	8

The ASPECT test result of 5:1 compression image

❖ *Evaluation of Medical Image Compression*

	M1	M2	M3	M4	M5	M6	C	L	I C	I	Total
2556249	1	0	0	0	0	0	0	0	1	0	2
3021141	1	1	1	1	1	1	1	0	1	0	8
3092143	1	1	1	1	1	1	1	0	1	0	8
3756925	1	1	1	1	1	1	1	1	1	0	9
3784945	1	1	0	1	0	0	1	0	1	0	5
4124531	0	0	0	0	0	0	0	0	1	0	1
4157412	1	1	1	1	1	1	1	1	1	0	9
4172456	0	0	0	0	0	0	0	0	1	0	1
4189776	1	1	1	0	0	0	1	1	1	0	6
4243230	1	1	1	1	1	1	1	1	1	1	10
4243232	0	0	1	1	1	1	1	1	1	0	7
4262154	1	1	1	1	1	1	1	0	1	0	8

The ASPECT test result of 10:1 compression image

Discussion

- *In this study, we evaluated two items using wireless mobile imaging communication system. First, when we refer to JPEG 2000 images using a PDA phone, display time is measured. Second, PSNR values are measured by peak signal-to-noise ratio (PSNR) measurement function in order to compare image quality between the original image and the JPEG 2000 compressed image. In order to evaluate two items, various brain CT images (530KB, 512x512, 16bit) are used. And, PSNR values are measured in proportion to the increase of the JPEG 2000 compression ratio.*

- *The compression of 10:1 is a clinically reasonable maximum compression ratio for emergency care according PSNR measurement in this study. Also, JPEG2000 images of 10:1 compression ratio are transmitted approximately 0.65s from hospital to PDA Phone for moving using CDMA-1X EVDO.*

Conclusion

- *The results of this study are expected to play an interface role between the mobile emergency medical system and ubiquitous healthcare.*

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A Miniaturized Telemetry Module for Bio-Signal Transmission at Wearable Computing

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Abstract and objective

In order to monitor the variation of body temperature from multi-patient in real-time in the hospital room based on body sensor network (BSN), a miniaturized wireless telemetry module based on PAN was designed and implemented in this paper. The transmitting part of telemetry system consists of a temperature sensor, a miniaturized UHF transmitter with a transmitting antenna, a microprocessor for data encoding, and a battery. The diameter and thickness of implemented transmitter are 20 mm and 3 mm respectively. The receiving part consists of a receiving antenna, a RF receiver, and a processor for data decoding, and the decoded data was transformed to RS232C format to be transferred to computer. From the experimental result in the simulation environment that resembles a hospital room, the implemented telemetry module was verified to operate well with sufficient reliability.

Keywords[1]:
telemedicine, physiologic monitoring, medical electronic

Introduction

The wireless sensor network is becoming a significant enabling technology for a wide variety of applications. The rationale behind the distributed sensor network is for detecting, identifying, localizing, monitoring, or tracking one or more subjects of interest. One of its potential deployments is in the form of body sensor network (BSN) for measuring physiological parameters. The aim of having a ubiquitous monitoring environment for wearable sensors is to provide continuous management of patients under their natural physiological states so that transient but life threatening abnormalities can be detected and predicted.

The wireless telemetry system at the environment of wearable computing system must be small and have sufficient bandwidth for transmission of various biomedical signals. In this paper, a miniaturized telemetry module was designed and implemented based on personal area network, which uses a wireless RF transmission at ultra high frequency.

Methods

The wireless communication system for wearable computing needs miniaturized device size and wide band width that is possible to transmit various bio signals. In this paper, the UHF (ultra high frequency) bio signal telemetry module which based on the PAN (personal area network) is designed and implemented.

The designed system consists of a signal pre-processor which includes an A/D convertor, digital encoder which prevents a noise and divides a communication channel, a RF transmitter, an antenna, and a crystal oscillator. The designed receiving system includes a receiving antenna, a RF amplifier, signal post-processor which consists of the decoder and demodulator, and an interface circuit. The biomedical signal which is divided with each channel and restored to original data, is changed to the RS-232 format and transmitted to the computer.

The μ-processor C8051F330 (Silicon Labs, USA) was used as the pre-processor for A/D converting and encoding of analog data. This μ-processor consists of a 10-bit ADC, several digital I/O ports, and a high speed control core. The control core supports the CPU, flash memory, SRAM, and interrupt controller. The speed of CPU is 25 MIPS at the 25MHz clock, and the power consumption is 6 mA at the range from 2.7 to 3.6 volt.

The biomedical signal pre-processed in analog part is converted to the suitable stream for digital transmission in the digital I/O part, and the transmission rate is controlled by the controller core. All data steam was converted to 100 kbps because the maximum transmission bandwidth of implemented transmitter was 100 kbps.

In this paper, the target signal for wireless transmission was the variation of body temperature. The temperature data are accumulated to the register in the u-controller without a parity and garbage bit. 12 bit temperature data is accumulated to the register during 10 times. It is added to 4 bit address data, so whole stream for transmission at a time is 124 bit. If the various signals or many patients' data

1 * This work was supported by the grant No. RTI04-01-01 from the Regional Technology Innovation Program of the Ministry of Commerce, Industry and Energy(MOICE).

has to be transmitted simultaneously, each of signals can be distinguished by the address, which can be extended by simple programming. The sleep mode guarantees the lower power consumption of whole system, and this sleep time can be controlled by programming.

The whole data stream is encoded by the Manchester encoding method, which has the clock information, so the synchronization of transmitted data in the receiver is easy to be implemented. The RF transmitter consist of a MAX7044 (Maxim, USA), a crystal oscillator, and some passive elements. The MAX7044, which is a crystal-referenced phase-locked-loop (PLL) VHF/UHF transmitter, is designed to transmit OOK/ASK data in the frequency range from 300 to 450 MHz. The transmitter circuit was consisted to support the transmission rate of 100 kbps, with was designed in considerations of channel extension and increasing resolution. The RF transmission power was set up to minimize and distance guarantee is 5 m radius.

The receiver was designed and implemented using a MAX1473 (Maxim, USA). The minimum sensitivity of receiver was 109.3 dB at the 433.92 MHz. The block diagram of implemented receiver is illustrated in figure 5. The RF signal which is received in the antenna is amplified and controlled by low noise amplifier (LNA) and auto gain control (AGC). The amplified signal is mixed with the signal from the local oscillator. The mixed signal is changed to the digital data by a data slice circuit, and the sliced data is sampled with over sampling method by μ-controller. Then, the μ-controller decodes the Manchester-encoded data and distinguishes it to the address and temperature data. The decoded data is transmitted to PC using the RS-232 cable.

Results

From the designed circuits and algorithms for signal processing, a miniaturized transmitter which can be attached to human skin and a portable receiver was implemented respectively. The whole elements were placed on a top layer because the bottom side of the PCB was stock to the human skin. The diameter and thickness of implemented transmitter was 20 mm and 4 mm respectively. The implemented receiver using a Max1473 chip was illustrated in Figure 7, and the width, height, and thickness was 20 mm, 25 mm, and 12 mm respectively.

The wireless communication experiments were performed using the implemented system in laboratory environment, where has the same conditions as a hospital room. In the experiments, the transmitted temperature signal from the miniaturized transmitter was received in the RF receiver and restored to original data. This data was transmitted to PC using RS-232c interface and displayed on the monitor. The experiments for verification of implemented system were performed as following methods respectively;

(a)Leaving alone the transmitter module for wireless measurement of room temperature.
(b)Gripping the transmitter module on the hand for measurement of hand temperature.
(c)Blowing breath to the transmitter module for measuring the steam of breath.

From all experimental result in the environment that resembles a hospital room, the implemented telemetry system was verified to operate well with sufficient reliability. The system response of temperature variation was in real-time and the displayed waveform reflected well the variation of temperature.

Results

A miniaturized telemetry system that can simultaneously measure the variation of patients' body temperature was designed and implemented. The miniaturized transmitter and receiver were implemented respectively and the stable operation was confirmed from all experiments, which was performed in the environment similar to the hospital room. The implemented telemetry is expected to be useful solution for the ubiquitous technology in the field of non-intrusive measuring from the human body.

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Development of Smart Stretcher Equipped with Continuous Vital Signs Monitoring and Location Detection

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Abstract

Ubiquitous communication technologies are transforming medical practice. In these technologies, especially RFID or small sensor networks can provide information about medical practices and patient status in real time and therefore improve the quality of medical care. We developed a new system named "smart stretcher" which is continuously monitoring patient's vital signs during transfers within the hospital. This system consists of a small air-mat type pressure sensor measuring both heart and respiration rate and a wireless network transmitting these vital data as well as patient ID to the alert system to notify patient's emergency. Also we added function of location detection to the smart stretcher by using a wireless sensor network. We conducted experiments in the clinical settings. It was found that this system showed reliable performances in continuous respiration monitoring and detection of apnea during patient's transfer on this stretcher, suggesting its high feasibility for real clinical usage.

Keywords:

medical errors, safety of medical care, wireless network

Introduction

Ubiquitous communication technologies are transforming medical practice. Conventional hospital information systems have not been yet been able to make use of all information that can be collected with simple sensors. RFID or small sensor networks can provide information about medical practices and patient status and therefore improve the quality of medical care. As an example of this application, we developed a new system named "smart stretcher" which continuously monitors patient's vital signs during transfers within the hospital. This monitoring system consists of air-mat type supersensitive pressure sensor measuring heart rates and respiration rates and an ad hoc wireless communication network ZigBee that transmits these vital data to the hospital LAN and to an alert system to notify patient's emergency immediately when it happens. Patient ID read from the RFID wristband is transmitted to prevent misidentification of the patients. Also we addedÅ@a function of location detection to the smart stretcher by using a wireless sensor network.

We conducted experiments to estimate the feasibility of this wireless monitoring system in real clinical situation to examine whether it can detect apnea of the patient reliably during patient's transfer within the hospital.

Methods

To realize the smart stretcher, we equipped three kinds of measurement devices with the stretcher: one is the measurement system for the vital signs such as heart rates and respiration rates, the second is the system for automatic patient ID recognition and the last is the detection system for patient location within the hospital.

These kinds of information are transmitted by ZigBee wireless network.

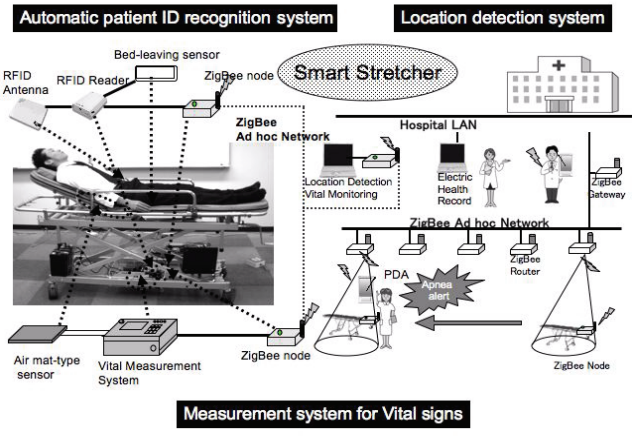

Figure 1- Smart stretcher system

These measurement systems work together to monitor the patient physiological status and give a warning against patient emergency such as apnea and transmit this

emergency information to the alert system in the ward (Fig. 1).

We conducted the feasibility experiment of the smart stretcher in the real clinical setting. In the experiment, three experimental subjects, two males and one female, were taking the role of the patients transferred on the stretcher who wore the RFID wristband on their left hands and were asked to stop respiration for 7 seconds during their transfer in the hospital.

First, the readability of wristband patient ID was examined. The readable distance in which patient wristband ID can be recognized by the RFID reader equipped on the left side surface of stretcher was measured. Secondly, the experimental subject was transported on the stretcher for fifteen meters in one minute, and was asked to stop breathing intentionally in the mean time to investigate whether the monitoring system would detect the apnea in spite of the stretcher movement and emitting the warning signal. This experiment was repeated with three subjects.

Results

Readability of patient ID

In almost all cases, the RFID was recognized within 15 seconds after the reader started reading and patient ID was displayed on the monitoring screen in real time. Readable distances were increased in proportion to the size of a tag. The difference of readable distance between the patient postures of a face-up position and a semi-sitting position was not found. In the case we set the RFID reader antenna under the stretcher mat, RFID was difficult to read, whereas in the case an antenna is setting in left side, RFID was able to well read. RFID was most reliably to read, when the patient's hand wearing RFID wristband is straight along with the edge line of the stretcher, whereas RFID was rather difficult to read if the direction of the hand is other direction.

Measurement of vital signs and detection of apnea

The three subjects were reliably measured for their respiration rate during their transfer. Figure 2 shows an example of experimental results of respiration waveforms. We can see from this figure that apnea was detected for about 10 seconds. Apnea was detected in all subjects. In contrary to the respiration rate, it was difficult to reliably detect the heart rate during the movement of the stretcher. Through the ZigBee wireless network, the patient's name, respiration rates and heart rates were correctly displayed on the PDA screen. The apnea warning alert and the warning screen in PDA were displayed mostly in real time. As the conclusion it was found that the aimed functions of the smart stretcher work in good performance.

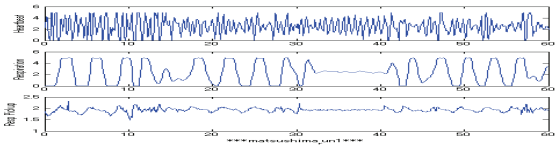

Figure 2 – Result of respiration waveform

Location detection of the Smart Stretcher

We detected the location of the smart stretcher within the hospital by location detection system using ZigBee ad hoc network. For the experimental settings, we installed five ZigBee routers and one gateway configured at even intervals onto the ceiling of the hospital corridor. Two members of hospital staffs carried the experimental subject on the smart stretcher in the hospital corridor for eighty meters. We monitored the patient location in the display by floor map in the terminal connected to the ZigBee network. The location detection system showed good performance providing the correct location in real time (Shown in fig.3). Serious errors and delays in the display of the detected location were not observed in this location detection experiment.

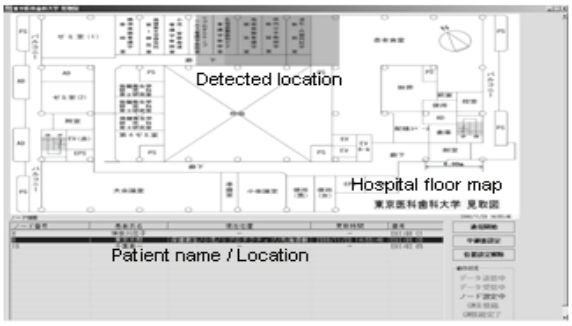

Figure 3 –The floor map of detecting Location

Discussion

From these primary results, the patients' vital signs, patient IDs and locations could be obtained in real time during a patient's transfer on the smart stretcher. By utilizing of the three kinds of information, the smart stretcher may be able to contribute to medical safety in the clinical settings.

However, the measurement precision in this system is sometimes sensitive to the various environmental factors. We should investigate the factors that influence the precision of the measurements in details to improve precision in recognition of RFID and in monitoring of vital signs. A further direction of this study will be to apply these basic technologies for medical use in a wheel chair or bedside care in home health environments.

Conclusion

This system was able to show the feasibility of the medical malpractice preventive measures by ubiquitous technology. This study is another step towards the ultimate goal to realize a smart medical space with security and safety.

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Pressure Ulcer Formation Prevention in Paraplegics using Computer and Sensory Substitution via the Tongue: First Steps in a Sustainability Study.

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Abstract

Since pressure ulcers remain a major health issue in individuals with spinal cord injuries, a new medical device is being developed. Based on the principle of sensory substitution, it aims at compensating the sensory deprivation in the buttock area by the tactile sensory modality in the tongue area. This paper concisely describes the last homemade medical device and reports the first methodological steps of a sustainability study: an open pilot prospective clinical study in 10 healthy seated subjects with 92% success in 100 performed tests; a current open randomized prospective controlled clinical trial with the methodology used.

Keywords:

medical device, evaluation studies, sensory substitution, paraplegia, deprivation

Introduction

The prevalence of pressure ulcers ranges from 23% to 39% in adults with spinal cord injuries and remains high in this population. Pressure ulcers are recognized as the main cause of rehospitalization for adults with paraplegia. Their treatment is always long difficult and expensive. This pathology appears thus to be a major health issue for this population.

The concept of sensory substitution has its origins in the works of P. Bach-y-Rita for blind people. To demonstrate his statement "we do not see with the eyes but with the brain" - the visual image does not go beyond the retina, but is turned into patterns of pulses along nerves and is carried to the brain - a human-machine interface, the Tongue Display Unit (TDU), was developed. It consists in an array of electrodes put in contact with the tongue surface. Visual information is then transmitted from the digitalized signal of a TV camera to this array of electrical stimulator which transmits information to the brain. Evidential results were obtained, as, for instance, the capacity of executing complex "eye-hand" coordination tasks.

Our research aims at particularizing works of P. Bach-Y-Rita for blind people to paraplegics by compensating the sensory deprivation in the buttock area through the tactile sensory modality in the tongue area. This compensation would indeed enable paraplegics to feel again "information" arising from the buttock area, from which they could adopt suitable movement in order to prevent the formation of pressure ulcer in this area.

Materials and method

A new medical device has been developed to compensate for sensory loss in paraplegics in the buttock area. It consists of three components: a ***pressure mapping system***, the **T**ongue **D**isplay **U**nit (***TDU***), and a ***laptop***.

The ***pressure mapping system***, built by the Vista Medical® Company, connected with the laptop, enables the real-time acquisition of the pressure applied on the seat/skin interface. The **TDU**, initially developed by P. Bach-y-Rita and colleagues, has been improved and miniaturized by the Coronis-Systems® Company to put the whole human-machine interface into an orthodontic retainer with real-time reliable wireless transmission from the laptop to the TDU. The ***laptop***, which enables communication between the pressure mapping system and the homemade TDU, has been programmed to send electro-stimulations to the tongue. According to the detection of pressure maximum applied at the seat/skin interface during one minute, the best direction of chest movement that the paraplegic has to adopt to correct this detected pressure maximum (and thus to prevent the tissue suffering) is then sent.

Two first steps have been performed to study the potential sustainability of this new approach to prevent the formation of pressure ulcers in paraplegics. The first one is a pilot open prospective clinical study in 10 healthy subjects. In this study, each subject has to move his chest according to an electro-stimulated direction. The detection of an adapted resulting movement is established by the adequacy between the electro-stimulatory information and the recorded pressure changes induced by the chest move-

ment. The second one, performed in paraplegics, is a randomized double-blind prospective controlled biomedical study. The primary outcome is to evaluate the possibility of improving, in a determinist way, the spatio-temporal distribution of the pressure applied at the seat/skin interface in order to avoid tissue suffering. The secondary outcomes are related to the quantitative and qualitative evaluations by paraplegics of the tongue calibration step which is required because of the personal spatial anisotropy of the tongue sensibility, and of the potential acceptability by paraplegics of this new medical device in everyday life.

Results

With 92% success in 100 performed tests, the first study in healthy subjects demonstrates three main points: first, the healthy subjects have a strong perception of the electro-stimulated information on the tongue; second, this information is both meaningful and correctly interpreted; and third, the action resulting from the interpreted information is adapted, with changes in pressure, to the electro-stimulatory information.

The second study is currently performed according to the French biomedical research law. This clinical study takes place in the Grenoble Clinical Investigation Centre (GCIC) in collaboration with the Grenoble Technological Innovation Centre (GTIC). Two arms (with and without electro-stimulation) have been planed in the clinical trial (cf. figure 1) to evaluate the potential impact of the electro-stimulation on the spatio-temporal distribution of the pressure. The statistical unit is the difference, by subject, of the results adapted with changes in pressure. The statistical analysis will compare means (medians) between the two groups. The statistical tests will be performed after verifying the conditions of use. The secondary outcomes will be principally analyzed in a descriptive way.

Discussion

To our knowledge, there has been no study to date that uses sensory substitution via the tongue in order to prevent the formation of pressure ulcers in paraplegics.

One of the main difficulties of using sensory substitution reported by P. Bach-y-Rita was the development of a practicable user-friendly human-machine interface. As this device has to be wholly accepted by paraplegics, we built a new cosmetically acceptable interface into an orthodontic retainer, with RF transmission of the signals from the laptop connected to the pressure mapping system to the tongue device unit for relay to the brain.

The first study showed that communication from the organ of sensory substitution “towards” the region of sensory loss is achieved (pressure changes adapted to the electro-stimulatory information). The reverse communication from the buttock area to the tongue is currently evaluated in the randomized prospective controlled clinical trial. If this reverse communication is confirmed, it would then enable the simulation of the whole conscious or subconscious loop defined in the healthy subject by ***perception*** of a stimulus coming from the buttock area (alert), ***analysis*** of this signal and ***action*** adapted to the signal in order to correct the cause of this alert.

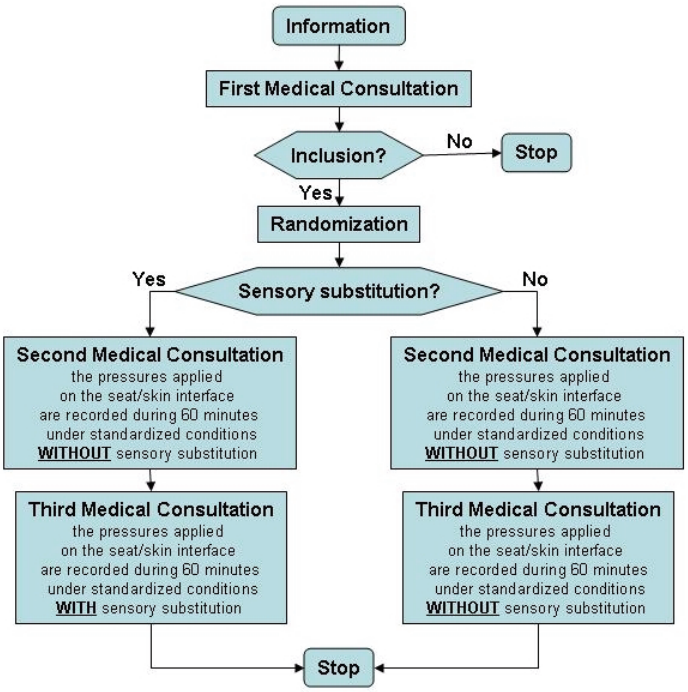

Figure 1 – An open randomized prospective controlled biomedical research

Further research has to be performed to determine the type of information that will be applied through tongue electro-stimulation as well as the electro-stimulation scheme. For instance, in the first case, should low-level information (pressure) be used with the subject having to interpret this “raw” information? Or should high-level information be used, such as an optimal direction of movement computed in an automated way from pressure maps?

The sustainability evaluation of new medical innovative devices is always difficult because of the complexity of the different components that have to be taken into account. Our studies are made easier by the Grenoble Technological Innovation Centre, a French structure which is playing a real interface part between the three essential actors of the innovation: the University, the Hospital and the Companies.

To determine the real sustainability of this new medical device, future evaluations would have to be as exhaustive as possible, from a clinical relevance point of view to a public health point of view, as, for instance, by taking into account the economic point of view (cost-effectiveness analysis).

Conclusion

Because pressure ulcers are still a major health issue for individuals with spinal cord injuries, a new health strategy to address this problem is developed. This paper reports the principles of a new approach using computer and sensory substitution via the tongue and the first steps performed in a sustainability study.

Pressure Ulcer Formation Prevention in Paraplegics using Computer and Sensory Substitution via the Tongue

First Steps in a Sustainability Study

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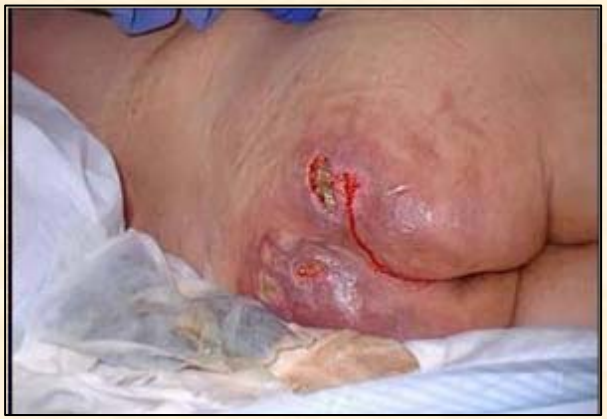
WHAT IS A PRESSURE ULCER?

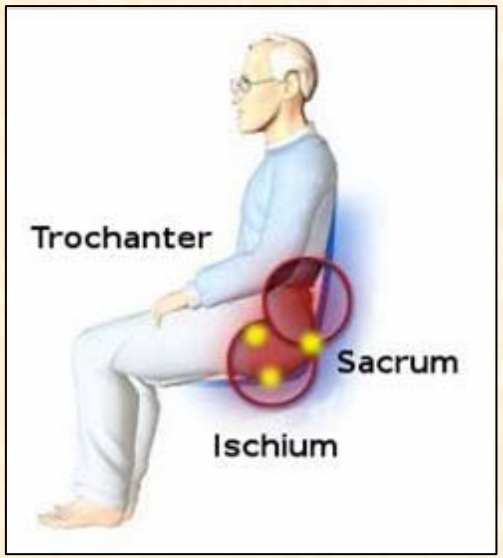
Pressure Ulcer

- « Working definition *(EPUAP)* : a pressure ulcer is an area of localized damage to the skin and underlying tissue caused by pressure, shear, friction and or a combination of these. »

Most Common Sites

- Ischium
- Sacrum
- Trochanter





Consequences

- Main cause of rehospitalization for patients with paraplegia
- a - Aggravation of existing pathologies ***(septicemia)***
- b - Functional, psychological and social outcome
- c - Increase in health care costs.

A NEW APPROACH

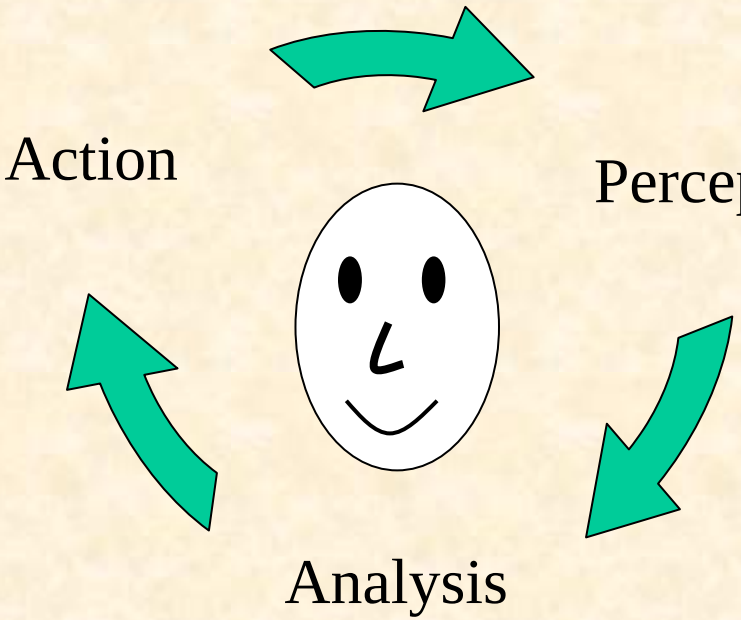
Why do pressure ulcers occur in paraplegics?

Healthy Subject

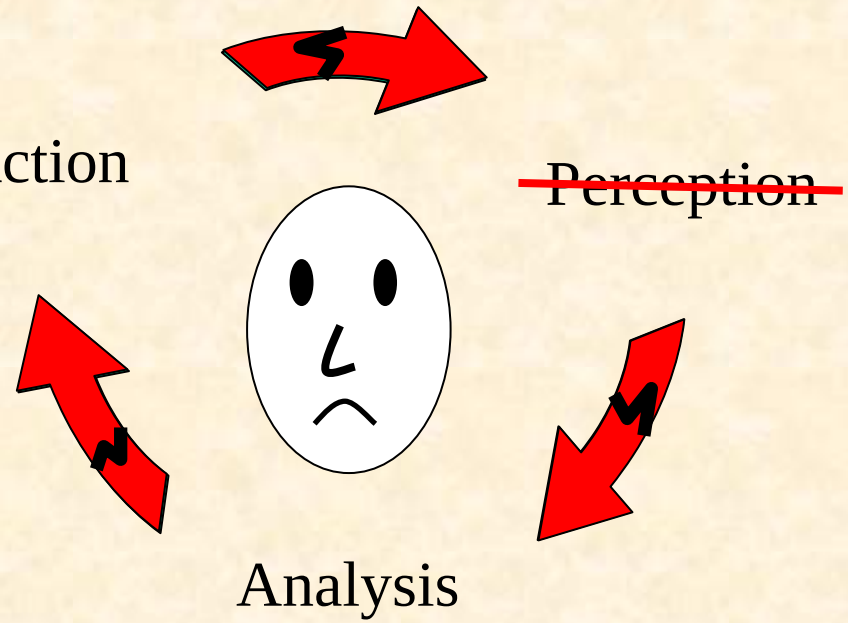
Paraplegics

Control loop for pressure ulcers formation prevention

Functional



Not Functional



A NEW APPROACH

To restore Perception by using **SENSORY SUBSTITUTION** but

- Auditory modality
- Visual modality

are already very often used in everydaylife.

Another « way » of communication ?

Tactile sensory modality of the TONGUE

Sensory and motory nervous pathways for the tongue are preserved in paraplegia after spinal cord injury.

A NEW APPROACH

Literature

P Bach-Y-Rita

- « **We do not SEE with the eyes** » : the visual image does not go beyond the retina, where it is turned into patterns of pulses along nerves. It is the brain which recreates the image from the patterns of pulses.
- **Tactile Vision Substitution System (TVSS)**
  - To deliver visual information from a TV camera to arrays of stimulators in contact with the skin of one of several parts of the body (abdomen, back, forehead, fingertip, …)
  - To perform complex perception and “eye”-hand coordination tasks
- **TONGUE INTERFACE**
  - Oral perceptual and sensory capacities have long been recognized to be superior to other tactile areas
  - the electrode geometry and driving circuitry can be simplified for tongue possibly because the electrode-skin interface on the tongue is very different from that on the fingertips.
  - A cosmetically acceptable interface built into an orthodontic retainer, with FM transmission of the signals from the artificial sensor carrying the information wirelessly to the tongue device unit for relay to the brain.

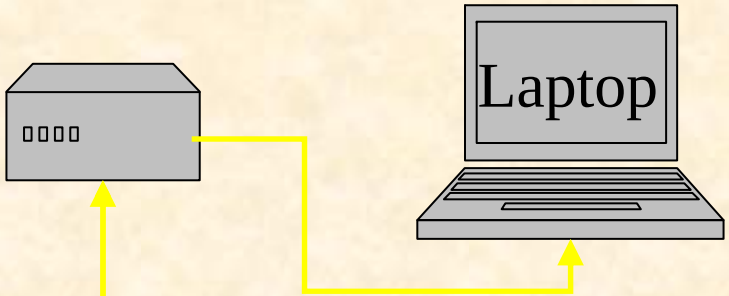
A NEW APPROACH

Literature

- **No such approach** exists for the pressure ulcer prevention

- To develop and use a new device
  - Pressure Mapping System
  - Tongue Display Unit
  - Laptop

A NEW APPROACH

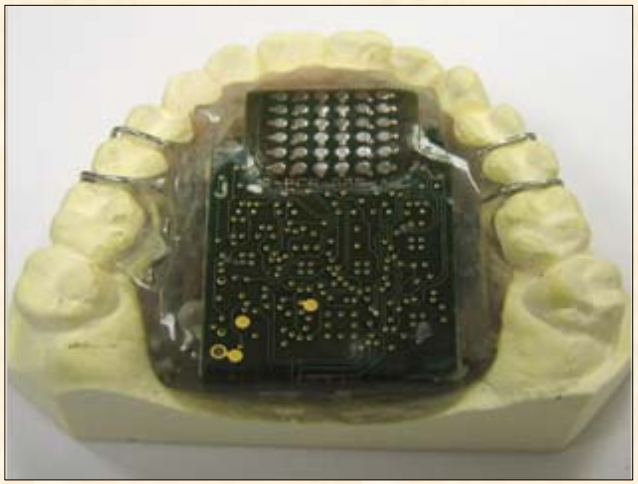


Real time reliable wireless transmission

The pressure mapping system

A pressure mapping system connected to a laptop

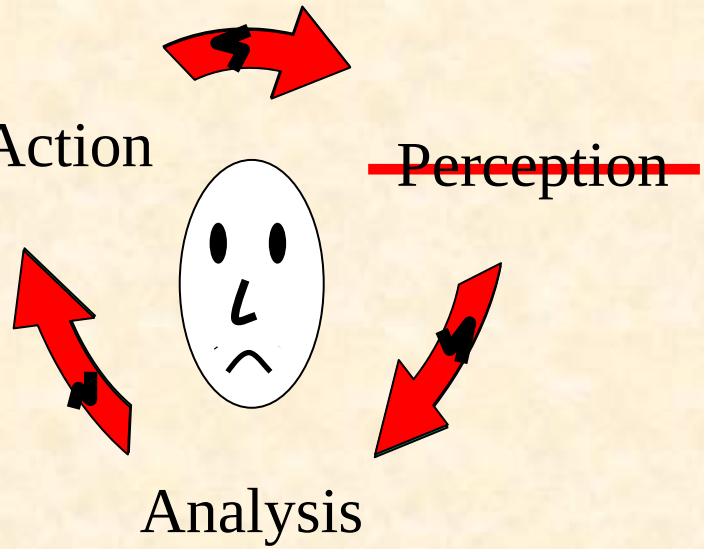
A human-machine interface into an orthodontic retainer with real-time reliable wireless transmission from the laptop to the TDU.



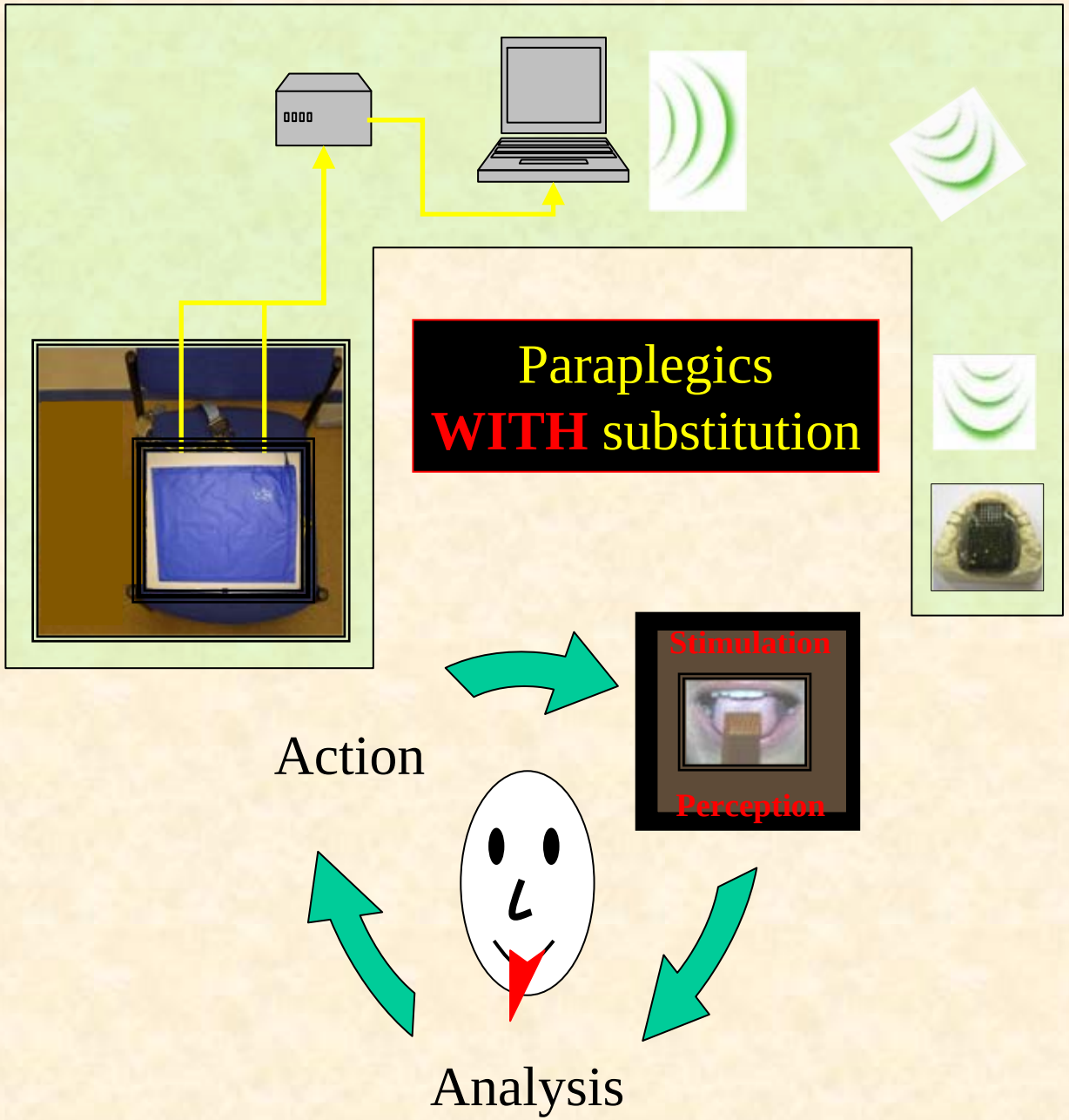
The human-machine interface into an orthodontic retainer

A NEW APPROACH

Paraplegics
without substitution



Paraplegics
WITH substitution



PRELIMINARY STUDY

Healthy seated subjects, at rest

Pressure map recorded (1)

Electro-stimulation of the tongue

Chest Mov. To Left.

Pressure map recorded (2)

Evaluation of the behavioral answer

X10 Score/10

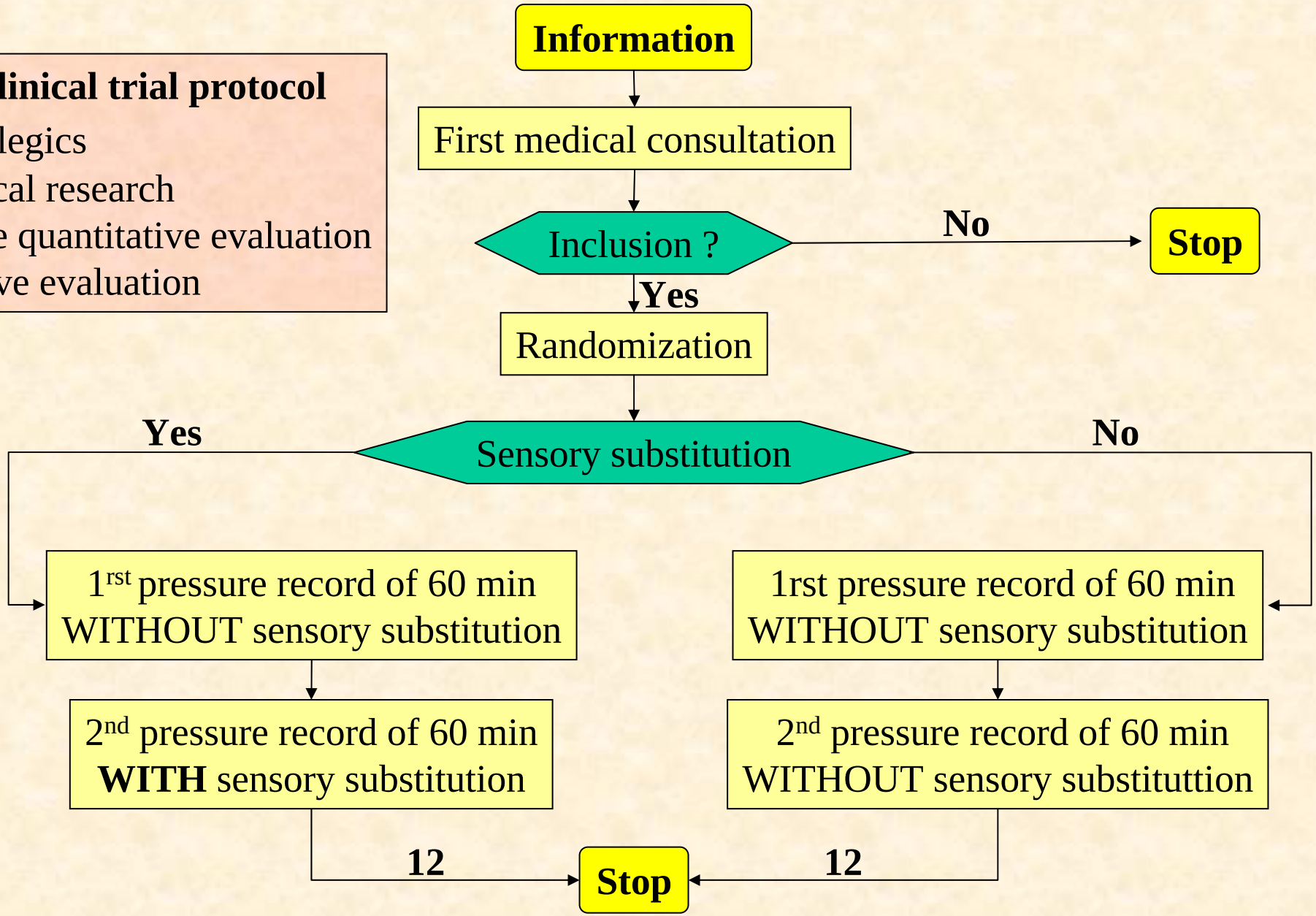
RESULTS

Population	10 healthy subjects 100 scores marked out of 10
Clinical protocol	Electro-stimulation of the tongue was well accepted Protocol realized totally
Results	Score : 9.2 +/- 0.79 (8-10) Perception-Analysis-Action

APPLICATIONS

Current clinical trial protocol

- 24 paraplegics
- Biomedical research
- Objective quantitative evaluation
- Qualitative evaluation



Thanks for your attention

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Stud Health Technol Inform. 2006;124:926-31

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Vista Medical® Company - Coronis-Systems® Company
Guglielmi Technologies dentaires ® Company

Design of an instrument for the renal patient information

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BPrograma VINCAT. Institut Català de la Salut ….

Introduction

Health education is essential to facilitate the adaptation process of patients who initiate hemodyalisis treatment. Nurse provide individual counseling , at that same that use printed health educational materials. However, printed materials are expensive and not content modifiable, hence in few time these educational resources become moss.

Objetive

On line presentation an educational triptych for the patients who initiate treatment with hemodyalisis.

To know the degree of acceptance this document

Keywords

Kidney Failure, Chronic
hemodyalisis
Patient Education
Medical Records Systems, Computerized
Nursing Records

Methods

AE became a provisional design by Delfhi technique consensus with 42 professionals and 10 people in treatment with Hemodyalisis.

It was validated with the National Association of Renals Patients. After using the document, 34 nurses and 52 patients were questioned to obtain facility, quality and utility data.

Results

The document is a triptych in Word, that includes images and text. Divided in different sections: Presentation, Contact, Hemodyalisis, Organization, Treatment, Signs of alarm, Medication, Quality of life, Diet and Vascular Access

All the fields can be modified, in order to adapt it to each patient. It is included in the Web page of the "Sociedad Española de Enfermería Nefrológica" http://www.seden.org.

The nurses considered the document: very useful (25), useful (5), little useful (4); ready to print it (7) the greater difficulty. The patients considered: very clear (40); clear (7) poorly clear (5). It provides confidence (46) have any influence (6)

Conclusion

An on line educative document, that the content can be modified; it facilitates the adaptation of the patients submissive hemodyalisis

MEDINFO 2007
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Developing an Integrated System Supporting Contemporary Home–Care

B. Spyropoulos, A. Tzavaras, M. Botsivaly, D. Kligopoulos, A. I. Filippas, K. Mertika, T. Athanassiadis, E. Koulouris, D. Liargovas, A. Lychounas, K. Koutsourakis

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Abstract

The merging of Informatics, Communication Technology, and Microelectronics in the field of Biomedical Technology facilitates gradually the development of a new Hi-Tec home-care environment. The aim of the present project was the development of an integrated system, addressing crucial aspects of contemporary home – care that comprise of: First, the employment of low-cost commercially available components, supporting home-care patient's vital-signs monitoring and mechanical ventilation. Second, software means for the processing of the acquired health data and the evaluation of the treatment schemata. Finally, software tools for the planning, the documentation, and the management of the corresponding home-care case.

Keywords:

mobile homecare, monitor, CPAP, CCR, homecare planning

Introduction and system description

The aim of the present project was the development of an integrated system, addressing crucial aspects of contemporary home – care that comprises of: First, a high-performance, C-programmable controller Rabbit Semiconductor® with a compact form factor supporting home-care patient's vital-signs monitoring and/or regulating mechanical ventilation, second, software means for the processing of the acquired health data and the evaluation of the treatment schema, and finally, software tools for the planning, the documentation, and the management of the corresponding home-care case. The system is designed to cover the monitoring, treatment, and managerial needs for the most frequent home-care case.

The *monitoring hardware* part of the system comprises presently of, first, a custom-made ECG (Eindhoven leads I-III) acquisition module based on a JFET Operational Amplifier TL074 (300 Hz sampling rate), equipped optionally with a 433 MHz RF link between an amplifier and a PC. Second, a Nellcor finger pulse oximetry probe for typical plethysmography based Oxygen Saturation (SpO_2) measurements and the estimation of Heart Rate (HR) and Respiration Rate (RR). Finally, a custom-made Carotid Sounds (CS) acquisition module, comprising of a stethoscope, a microphone, and an amplifier, for the extraction of Heart Rate (HR) and Respiration Rate (RR). The biosignals' sensors can be connected to a commercially available high-performance, C-programmable controller with a compact form factor, equipped with a Rabbit 2000 microprocessor operating at 25.8 MHz providing fast data processing. The system comprises of an additional development board, and the essentials needed for the design of a custom-made microprocessor-based system. A complete software development system (Dynamic C) is also included. The acquired row data and trends of SpO_2, HR, RR, ECG waveforms, Oxygen Therapy advice etc. are appropriately processed to produce decision supportive data.

The *ventilation hardware* part of the system comprises of a custom-made prototype CPAP-ventilator, driven by a brushless direct current (BLDC) motor. A sensor-less signal conditioning method of identifying the rotor position of a brushless DC (BLDC) motor was employed. A six steps technique is applied to drive the motor smoothly from standstill without any position sensors, by monitoring the current responses to the inductance variation on the rotor position. Rotation is achieved by employing a three phase bridge, comprising of six Metal Oxide Semiconductor Field Effect Transistors (MOSFETs). The rotor position at standstill is detected by comparing the first and second differences of six current pulses injected into every two phases of the motor. Once the motor starts up, a pulse train, is injected into the commutation phases corresponding to the maximum torque production and the next commutation phases in alternating fashion. A 6x256 Reference Matrix provides for information about the next commutation timing, when the current responses of the pulses cross each other in the same time delay. The method can drive a BLDC motor smoothly without any vibration or time delay up to medium speed. Beyond this medium speed, the classical back-EMF method is employed to drive the BLDC motor at high speed. The Pulse Width Modulation driven BLDC motor can provide for adequate air – oxygen flow and subsequently an appropriate pressure cycle, for the developed home-care CPAP, to support home ventilation in the case of, for example, of a patient, suffering from Chronic Obstructive Pulmonary Diseases (COPD). The output pressure was measured by employing differential pressure transducers (Freescale MPX 2010, 0-100 cm H_2O

and HoneyWell XCA400.3DN 0.0-0.3 psi respectively) attached to a Data Acquisition Card (16 channels Advantech PCI 1710, 12 bit A/D, and 100 kHz sampling rate). The system is based on relatively low-cost commercially available components and devices, and allows for the creation of various home-care hardware modules, tailored to the specific individual patient.

Processing of the acquired data and management of home-care

The software means of the system, for the processing of the acquired health data and the evaluation of the treatment schemata, comprise presently of, first, software for the detection of Ventricular fibrillation (VF) and malignant ventricular tachycardia (VT), and second, software for producing advice on home-based Oxygen Therapy management. A home computer equipped with the above mentioned 433 MHz RF link between the ECG amplifier and the PC, enables the quasi real time acquisition and processing of the necessary ECG data to recognize critical situations, as Ventricular fibrillation (VF) and malignant ventricular tachycardia (VT) that cause the patient to be pulseless and unconscious are life threatening cardiac arrhythmias. Early defibrillation is the key to achieve a satisfactory survival rate from cardiac arrest and the general medical consensus is that VF and malignant VT should be shocked and all other rhythms should not. The detection of shockable rhythms was made by employing two developed methods, based on Image Analysis and on the CDF-SKEW techniques. Further, a Fuzzy logic algorithm was designed and implemented for producing advice on Oxygen Therapy management. The system's response is best described with the graphical representation of the relationship between a pair of input parameters and the system's output. Three of the physiology parameters acquired by the acquisition modules, the Oxygen Saturation (SpO_2), the Heart rate (HR) and the Respiration Rate (RR) are used as inputs for the algorithm. The change in Oxygen Saturation over time ($dSpO_2$), which is a reliable factor for evaluating stability, deterioration or improvement of patients' health status, is also included in the model as an indication of the effectiveness of oxygen therapy. The inputs are translated from crisp values to linguistic variables and the system's response is dictated by a set of fuzzy rules, which were derived based on well established respiration physiology principles. The system actually produces an advice on the percentage change of Oxygen flow to the patient and the translation of its output back to crisp values is performed with the centroid defuzziation method.

Sharing of healthcare related information among the different healthcare providers is a crucial aspect for the continuity of the provided care. The developed home-care management system is to be used upon the transition or the referral of a patient, and especially in transition from hospital to homecare. The function of the developed system is based upon the creation of a structured subset of data, concerning the most relevant facts about a patient's healthcare, organized and transportable, in order to be employed during the post-discharge homecare period, enabling simultaneously the planning and the optimal documentation of the provided homecare. The structure and the content of the created data sets are complying with the ASTM E2369-0 Standard, Specification for Continuity of Care Record (CCR). The developed system consists of two modules. The first module is responsible for the creation of a typical CCR that contains the appropriate demographic and administrative data, as well as the relevant clinical information, while the second module is responsible for the creation of a homecare plan which will be included in the Care Plan section of the CCR. The system is intended to be used upon the transition of a patient from hospital to homecare, although the first module alone could actually be used in any case of transition or referral. The typical–CCR module can either collect the necessary data from an already installed EHR system or allow the user to enter the data manually by filling special forms. In any case, the user decides which parts of the patient's medical record (electronic or paper) are the most significant ones or are the necessary ones for the description of the current health status of the patient and should be included in the CCR. The second module is responsible for the creation of the homecare plan by creating a structured subset of data, containing monitoring, treatment, diagnostic, and nursing activities that should be employed during the post-discharge home-care period. The developed model allows for every Hospital Department or Medical/Nursing group, to individually assign an appropriate set of homecare activities to specific diagnoses codes that are coded according to Diagnosis Related Group (DRG) codification. These activity sets consist of diagnostic, monitoring and treatment activities that can be actually performed in home-environment, together with an appropriate nursing – activity treatment plan. These profiles of home-care activities are custom-made and every user, i.e. every physician responsible for discharging a patient from hospital, is actually allowed to set up his own profiles. During the formation of these profiles the user can attach to each activity a set of nominal fees. Thus, the developed system ignites, when relevant, the corresponding revision of an implicitly associated latent financial record that allows for an approximation of the individual case-cost.

Results and conclusions

The described solution is set up by employing simple, low-cost, commercially available components, supporting home-care patient's vital-signs monitoring and assisted ventilation. The system includes software means for the processing, the evaluation, and the targeted transmission

of the acquired health-data, and software tools, for the planning, the documentation, and the management of the corresponding home-care case. The on-going testing of the system shows that it is able to contribute to an effective home – care package solution, supporting not only well organized nursing care, but further, a structured total Patient Supervision and Treatment home-care approach.

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Developing an integrated system supporting contemporary Home–Care

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A. I. Filippas, K. Mertika, T. Athanassiadis, E. Koulouris,
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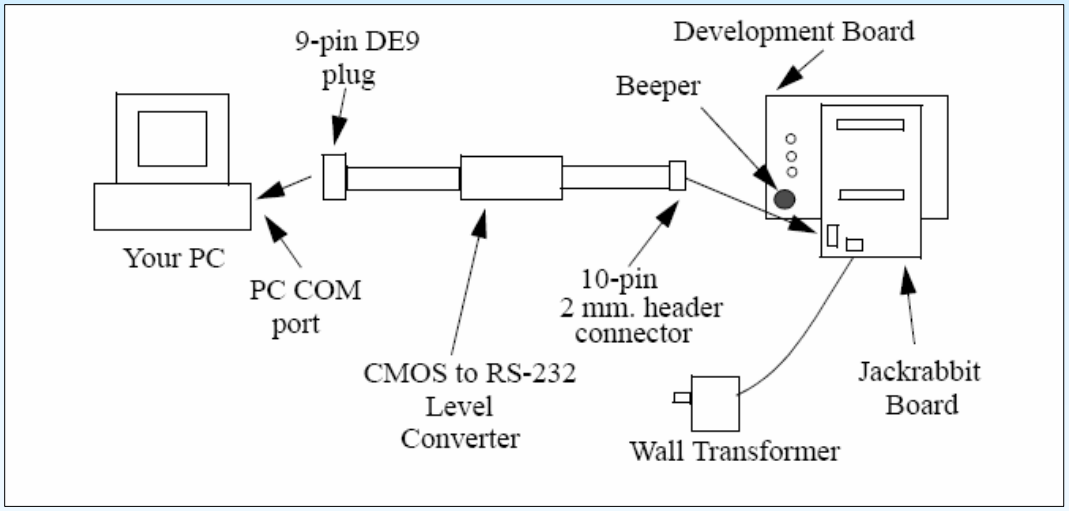
The aim of the project

- The aim of the present project [1] was the development of an integrated system, addressing crucial aspects of contemporary home – care that comprises of:
  - *First, a high-performance, C-programmable controller Rabbit Semiconductor® with a compact form factor supporting home-care patient's vital-signs monitoring and/or regulating mechanical ventilation.*
  - *Second, software means for the processing of the acquired health data and the evaluation of the treatment schema.*
  - *Finally, software tools for the planning, the documentation, and the management of the corresponding home-care case. The system is designed to cover the monitoring, treatment, and managerial needs for the most frequent home-care cases.*
- The system is designed to cover the monitoring, treatment [2], and managerial needs for the most frequent home-care cases.

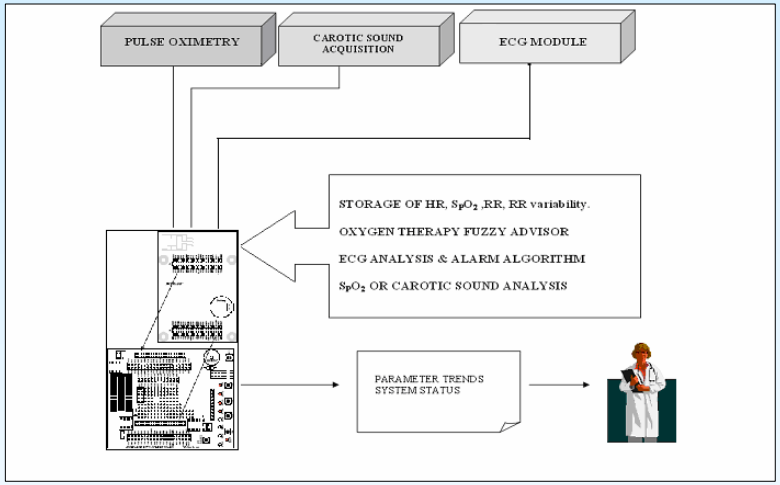
The monitoring hardware part modules of the system

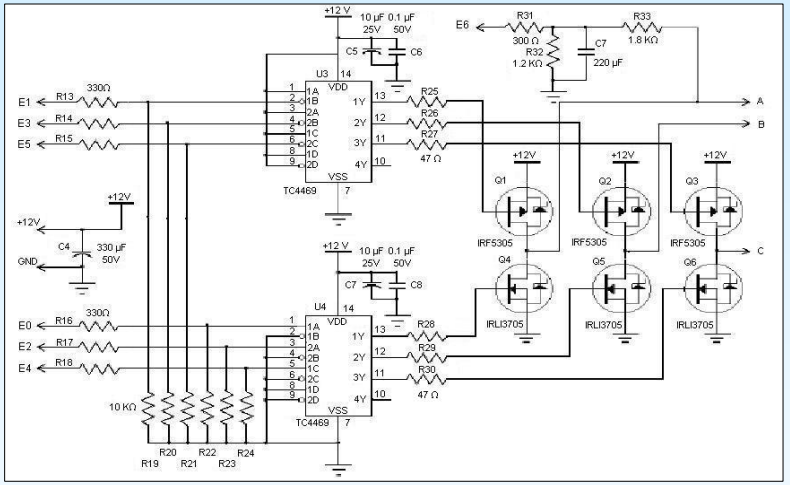


Hook-up connection of the development board (Jackrabbit®) to any PC for the development of software [Source: Rabbit Semiconductor]

- First, a custom-made ECG (Eindhoven leads I-III) acquisition module based on a JFET Operational Amplifier TL074 (300 Hz sampling rate), equipped optionally with a 433 MHz RF link between an amplifier and a PC.
- Second, a Nellcor finger pulse oximetry probe for typical plethysmography based Oxygen Saturation (SpO2) measurements and the estimation of Heart Rate (HR) and Respiration Rate (RR).
- Finally, a custom-made Carotid Sounds (CS) acquisition module, comprising of a stethoscope, a microphone, and an amplifier, for the extraction of Heart Rate (HR) and Respiration Rate (RR).

The monitoring hardware and the BLDC driving system block diagrams





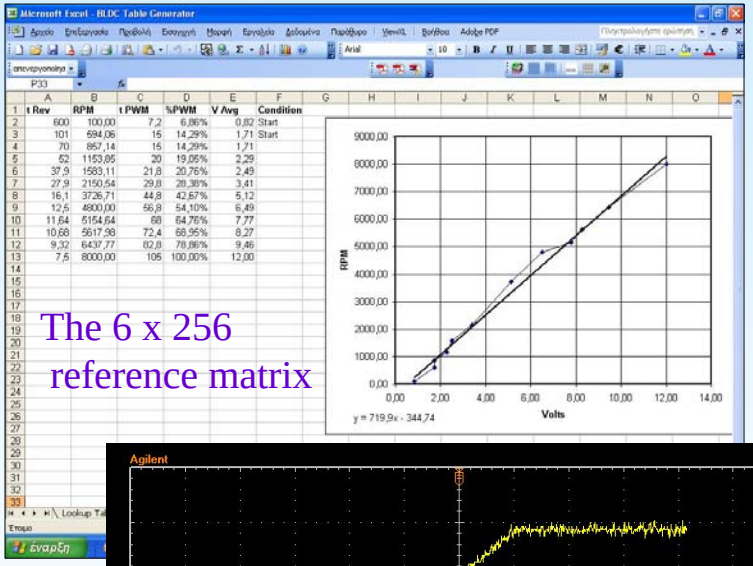
- The biosignals' sensors can be connected to a commercially available high-performance, C-programmable controller with a compact form factor, equipped with a Rabbit 2000 microprocessor operating at 25.8 MHz providing fast data processing.
- The system comprises of an additional development board, and the essentials needed for the design of a custom-made microprocessor-based system. A complete software development system (Dynamic C) is also included.
- The acquired row data and trends of SpO2, HR, RR, ECG waveforms, Oxygen Therapy advice etc. are processed to produce decision supportive data.

The custom-made prototype CPAP-ventilator operation description

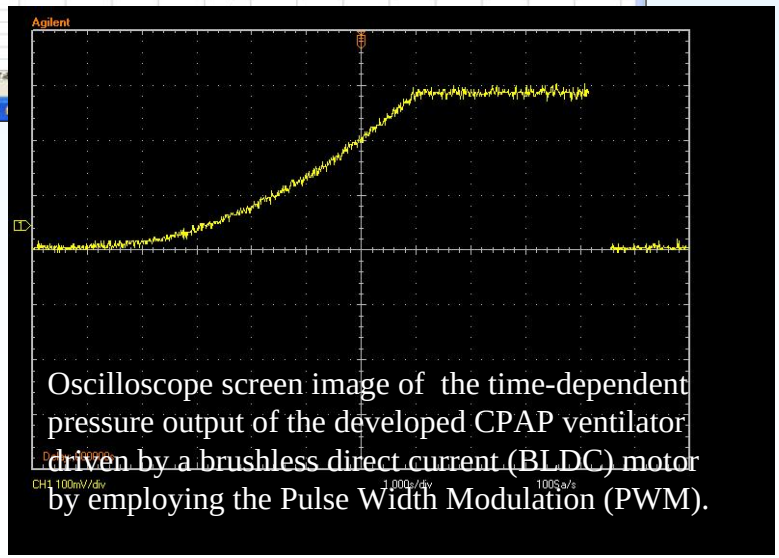
- The *ventilation hardware* part of the system comprises of a custom-made prototype CPAP-ventilator, driven by a brushless direct current (BLDC) motor.
- A sensor-less signal conditioning method of identifying the rotor position of a brushless DC (BLDC) motor [3] was employed.
- A six steps technique is applied to drive the motor smoothly from standstill without any position sensors, by monitoring the current responses to the inductance variation on the rotor position.
- Rotation is achieved by employing a three phase bridge, comprising of six Metal Oxide Semiconductor Field Effect Transistors (MOSFETs).
- The rotor position at standstill is detected by comparing the first and second differences of six current pulses injected into every two phases of the motor.
- Once the motor starts up, a pulse train, is injected into the commutation phases corresponding to the maximum torque production and the next commutation phases in alternating fashion.
- A 6 x 256 Reference Matrix provides for information about the next commutation timing, when the current responses of the pulses cross each other in the same time delay.
- The method can drive a BLDC motor smoothly without any vibration or time delay up to medium speed. Beyond this medium speed, the classical back-EMF method is employed to drive the BLDC motor at high speed.

The switching configuration regulating the cycle of the Pulse Width Modulation driven BLDC motor

- The Pulse Width Modulation driven BLDC motor can provide for adequate air – oxygen flow and subsequently an appropriate pressure cycle, for the developed home-care CPAP, to support home ventilation in the case of, for example, of a patient, suffering from Chronic Obstructive Pulmonary Diseases (COPD).
- The output pressure was measured by employing differential pressure transducers (Freescale MPX 2010, 0-100 cm H2O and HoneyWell XCA400.3DN 0.0-0.3 psi respectively) attached to a Data Acquisition Card (16 channels Advantech PCI 1710, 12 bit A/D, and 100 kHz sampling rate).
- The system is based on relatively low-cost commercially available components and devices, and allows for the creation of various home-care hardware modules, tailored to the specific individual patient.



The 6 x 256 reference matrix

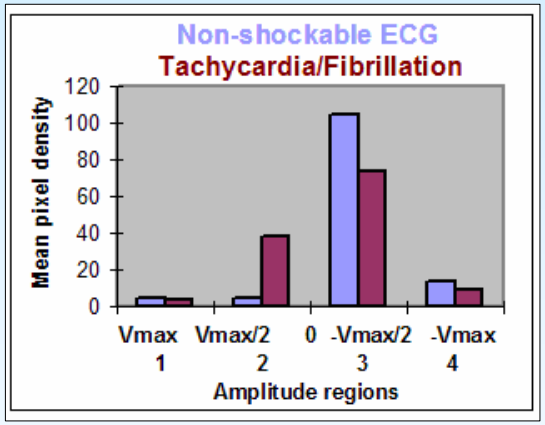


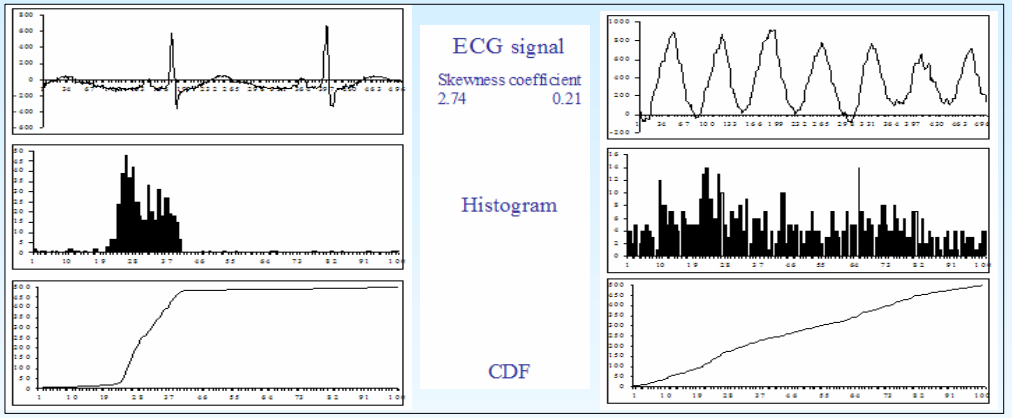
Oscilloscope screen image of the time-dependent pressure output of the developed CPAP ventilator driven by a brushless direct current (BLDC) motor by employing the Pulse Width Modulation (PWM).

Processing and evaluation of the acquired data

- The software means of the system, for the processing of the acquired health data and the evaluation of the treatment schemata, comprise presently of:
  - *First, software for the detection of Ventricular fibrillation (VF) and malignant ventricular tachycardia (VT).*
  - *Second, software for producing advice on home-based Oxygen Therapy management.*
- A home computer equipped with the above mentioned 433 MHz RF link between the ECG amplifier and the PC, enables the quasi real time acquisition and processing of the necessary ECG data to recognize critical situations.

The detection of shockable rhythms

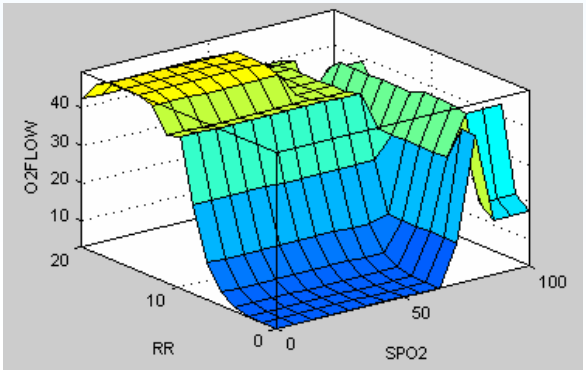




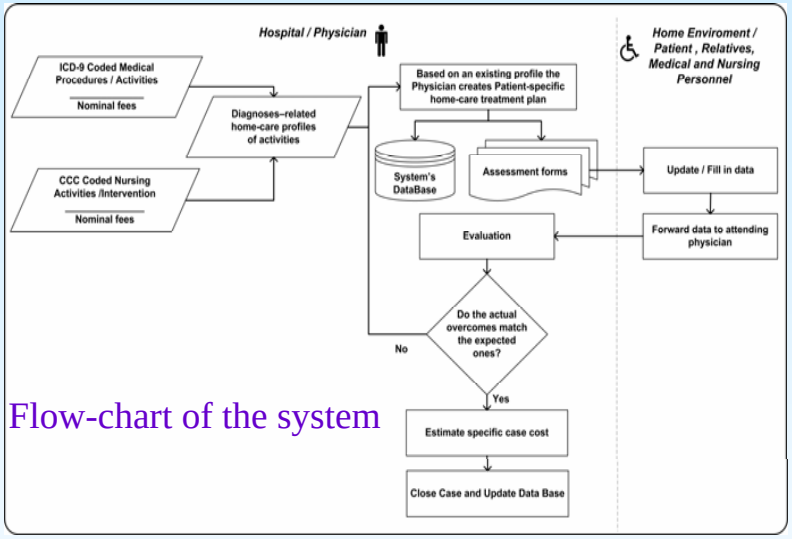
- Early defibrillation is the key to achieve a satisfactory survival rate from cardiac arrest and the general medical consensus is that VF and malignant VT should be shocked and all other rhythms should not.
- Life threatening cardiac arrhythmias are Ventricular fibrillation (VF) and malignant ventricular tachycardia (VT).
- The detection of shockable rhythms was made by employing two developed methods, based on the Image Analysis (left) and on the CDF-SKEW techniques (right).

A Fuzzy logic algorithm producing advice on Oxygen Therapy management

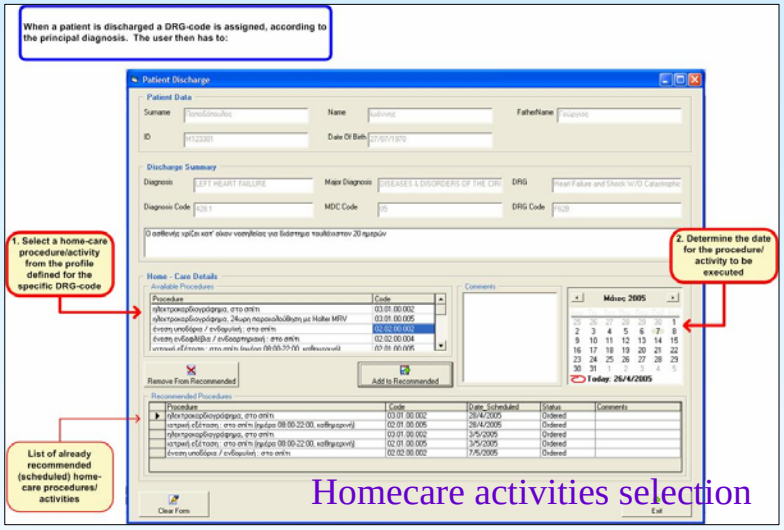
- Further, a Fuzzy logic algorithm was designed and implemented for producing advice on Oxygen Therapy management.
- The system's response is best described with the graphical representation of the relationship between a pair of input parameters and the system's output.
- Three of the physiology parameters acquired by the acquisition modules, the Oxygen Saturation (SpO2), the Heart rate (HR) and the Respiration Rate (RR) are used as inputs for the algorithm.
- The change in Oxygen Saturation over time (dSpO2), which is a reliable factor for evaluating stability, deterioration or improvement of patients' health status, is also included in the model as an indication of the effectiveness of oxygen therapy.
- The inputs are translated from crisp values to linguistic variables and the system's response is dictated by a set of fuzzy rules, which were derived based on well established respiration physiology principles.
- The system actually produces an advice on the percentage change of Oxygen flow to the patient and the translation of its output back to crisp values is performed with the Centroid Defuzziation method.



Management of home-care

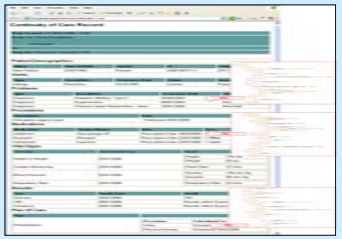


Flow-chart of the system



Homecare activities selection

- Sharing of healthcare related information among the different healthcare providers is a crucial aspect for the continuity of the provided care.
- The developed home-care management system is to be used upon the transition or the referral of a patient, and especially in transition from hospital to homecare.
- The function of the developed system is based upon the creation of a structured subset of data, concerning the most relevant facts about a patient's healthcare, organized and transportable, in order to be employed during the post-discharge homecare period, enabling simultaneously the planning and the optimal documentation of the provided homecare.
- The structure and the content of the created data sets are complying with the ASTM E2369-0 Standard [4], Specification for Continuity of Care Record (CCR). The developed system consists of two modules.



Detailed description of the Home-care Management System

- The first module is responsible for the creation of a typical CCR that contains the appropriate demographic and administrative data, as well as the relevant clinical information, while the second module is responsible for the creation of a homecare plan which will be included in the Care Plan section of the CCR. The system is intended to be used upon the transition of a patient from hospital to homecare, although the first module alone could actually be used in any case of transition or referral. The typical–CCR module can either collect the necessary data from an already installed EHR system or allow the user to enter the data manually by filling special forms. In any case, the user decides which parts of the patient's medical record (electronic or paper) are the most significant ones or are the necessary ones for the description of the current health status of the patient and should be included in the CCR.
- The second module is responsible for the creation of the homecare plan by creating a structured subset of data, containing monitoring, treatment, diagnostic, and nursing activities [5] that should be employed during the post-discharge home-care period. The developed model allows for every Hospital Department or Medical/Nursing group, to individually assign an appropriate set of homecare activities to specific diagnoses codes that are coded according to Diagnosis Related Group (DRG) codification. These activity sets consist of diagnostic, monitoring and treatment activities that can be actually performed in home-environment, together with an appropriate nursing – activity treatment plan. These profiles of home-care activities are custom-made and every user, i.e. every physician responsible for discharging a patient from hospital, is actually allowed to set up his own profiles. During the formation of these profiles the user can attach to each activity a set of nominal fees. Thus, the developed system ignites, when relevant, the corresponding revision of an implicitly associated latent financial record that allows for an approximation of the individual case-cost.

Results and Conclusions

- The described solution is set up by employing simple, low-cost, commercially available components, supporting home-care patient's vital-signs monitoring and assisted ventilation.
- The system includes software means for the processing, the evaluation, and the targeted transmission of the acquired health-data, and software tools, for the planning, the documentation, and the management of the corresponding home-care case.
- The on-going testing of the system shows that it is able to contribute to an effective home – care package solution, supporting not only well organized nursing care, but further, a structured total Patient Supervision and Treatment home-care approach.

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Pressure Ulcer: Statistics Analysis of an Electronic Database

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Abstract

An information system is analyzed on defining quality indicators for pressure ulcer which is recommended by the American Nursing Association. Objective: Analyzing statistically a large sized hospital electronic database of São Paulo City. Methods: Descriptive retrospective study, sample frame of convenience of 51,414 hospital discharges. Results: Predominance of female sex 60%; average age 52 years old and length of stay of 4 days. Pressure ulcer occurred in 1% of the sample frame. The statistical analysis pointed out the age and hospitalization time as significant for the appearing of pressure ulcer. The chance rate of occurrence is 10 times higher for patients aged 65 years old compared to the ones of <65 years old ($p<0.001$). When permanence is over 4 days the chance is 18 times higher of developing pressure ulcer compared to patients whose permanence was up to 3 days ($p<0.001$). Final considerations: This study proved the worth of an electronic database about clinical practice in planning and managing nursing assistance; validating the indicator and consequently improving quality.

Keywords:
medical informatics, decubitus ulcer/nursing, decubitus ulcer/prevention and control, quality indicators

Introduction

The comparative analysis results indicators in health care constitutes an important tool for monitoring the performance of service providers, and the contribution of each professional in the attending process. Therefore, many studies have been developed to define indicators which would be specific for showing quality in nursing service.[1] The American Nursing Association (ANA) has developed a project for defining specific indicators for nursing. These nursing indicators intend to capture nursing care and its results, and the impact on nursing practice. Accordingly, the following indicators are recommended by ANA: pressure ulcer, patient's fall, patient's satisfaction on pain management, patient's satisfaction on educational information, patient's satisfaction with nursing care, patient's satisfaction with general care, and staff mix of nurses, technicians and nursing assistants, total of hours of nursing care per patient per day, nursing staff satisfaction.[1]

The use of information technology has contributed to facilitate and provided agility to the evaluation of health services and consequently the nursing services.[2] It can be said that information technology in health services evolved from a situation where the computer was used for simple and isolated tasks to integration of information level, whose objective is integrating through a single system, the diverse recording points and using them into the service, creating great data banks that have often been used on the evaluation of health services performance.[3]

These database avail patients' clinical data about the care they received while in hospital, so this work intends to analyze a pressure ulcer monitoring database which is one of the indicators recommended by ANA. Pressure ulcer is an impact phenomenon that occurs in many health services, affects all ages, has a high cost and causes much human suffering for it affects individuals' life quality.

Cuddigan reports that the incidence of pressure ulcer has an extension from 2% to 29%.[4] The treatment costs of an ulcer can vary from US$ 2,000 to US$ 70,000 according to Gallagher.[5]

Pressure ulcer can be defined as particular areas of skin damage and surrounding tissues. This damage can be caused by pressure, cut and/or friction, combined with effects of intrinsic and extrinsic factors. Among the intrinsic factors stand out the age, nutritional state, tissue pervasion, use of some medicines and chronic degenerative diseases; and among the extrinsic factors the pressure, shear, friction and humidity.[6,7] Although it is known this is a multi-factorial phenomenon, nursing has the unique opportunity of performing on these extrinsic factors preventing its occurrence.

Therefore this study has the objective of analyzing the pressure ulcer monitoring data contained in an electronic data base of a large hospital of São Paulo City.

Material and method

A retrospective descriptive study was accomplished through the analysis of data collected from an electronic system about pressure ulcer, about all hospital discharges from June 2002 to December 2004.

In this hospital all admitted patients are assessed for pressure ulcer risk through the Norton[8] table, which evaluates

five criteria (physical state, mental state, activity, mobility and incontinence and scores from 1 to 4, classifying the risk in: low, moderate and high. Once the risk is assessed, the nurse starts to use practice guidelines for pressure ulcer prevention. The patient is re-evaluated whenever clinical condition changes or every 48 hours.

The criterion for classification of pressure ulcer stage used in this hospital is derived from the National Pressure Ulcer Advisory Panel[7], which classifies pressure ulcer in 4 stages. Stage I corresponds to altering on integral skin color under pressure; in Stage II there is loss of thin skin layer, involving epidermis, dermis or both; Stage III is characterized by signifying loss of skin, involving cellular subcutaneous and adipose tissue damage or necrosis, which can extend to fascia, but does not surpass it; and stage IV is characterized by significant skin loss, with extensive destruction and necrosis of cellular subcutaneous tissue, or muscle, bone, tendon or particular capsule damage.[9]

During the period in hospital, the nurse prescribes and records the provided service to the patient, so at the discharge it is filled in a summary of evaluations and the outcomes of care are described in a proper form called Nurse's Discharge summary. On this sheet it is also noted the moment of risk assessment: at admittance, during hospitalization and presence of pressure ulcer at admittance.

Since 2002 the data from these summaries feed the information system. The risk assessment data, presence and classification of the ulcer are fed into the information system. Each patient has a single hospital record number and at each hospital attendance it generates a passage number which can be internal (admitted patient), external (office appointments and/or exams), emergency (emergency room). This study only analyzed the passages of admitted patients.

Place of study

The study was accomplished in a large hospital of São Paulo City, which has 87,000m2 built area distributed in four buildings, with 460 beds, 30 surgery rooms and 53 ICU beds; the Diagnosis and Treatment Support Service assists more than 220 thousand patients per year. It is classified as a large sized hospital and of high complexity with kidney, liver, marrow, cornea, skin and bone transplants.

In search of solutions for health matters, the hospital started a quality program in 1989. Currently it has various quality certifications and it was the pioneer in the Crediting of the Joint Commission International and the implementation of normative requirements of ISO 9002 among other.

Population

The population was composed by all hospital discharges within 01/ Jun/ 2002 and 31/ Dec / 2004 generating a total of 57,487 discharges; however, mistakes were found on the nurse's discharge summary feeding into the information system. For this reason an audit was necessary and a validation of records on 1,220 data (2.1% of total) and loss of 252 data (0.4%) which had mistakes on hospital records and passage numbers. After these audits a convenient sample was selected for this study, considering only adult patients aged equal or over 18 years old, who were assessed for pressure ulcer risk and had outcomes of clinical practice in the database. Therefore, the sample obtained was of 51,414 hospital discharges, which were analyzed and characterized by age, sex, hospitalization time, presence of pressure ulcer risk, classification of pressure ulcer risk and International Classification Diseases (ICD).

Results

The study analyzed 51,414 hospital discharges of both sexes, with ages between 18 and 103 years old, with length of stay between 0 (admission and discharge on the same day) and 1,346 days.

In the distribution of sample by sex there was predominance of the female sex 60% and 40% of male sex. For this sample, the starting age chosen was 18 years old and the maximum age found was of 103 years old, the average was 52 years and the median 50 years. The age range from 18 to 59 years old corresponded to 66% of the patients, and the age range above 60 years old corresponded to 34%.

For the distribution of sample by days of hospitalization it was considered the patients with zero day of length of stay, that is, when the date of admission was equal to the day of discharge; therefore the period of hospitalization varied from zero to 1,346 days. The average of hospitalization was of 4 days and the median of 2 days, and the highest percentage of patients 79% had a length of stay of until 4 days and only 21% stayed over 4 days.

The general sample frame 21% (10,521) patients had pressure ulcer risk assessed during the hospitalization period, distributed as follows: 12% at admittance and 9% during hospitalization; and the distribution concerning pressure ulcer risk classification for patients who had the risk assessed was 9% high risk, 24% moderate risk and 67% low risk according to table 1.

Table 1 - Distribution of patients with assessed risk according to risk classification

Classification Pressure Ulcer Risk	n	%
High risk	1060	9
Moderate	2751	24
Low risk	7673	67
Total	11484	100

The occurrence of pressure ulcer in the general sample was of 1% of the total; the distribution concerning the stage in the general population was of 0.63% stage I, 0.25% stage II, 0.11% stage III and 0.05% stage IV.

The distribution of total sample per diagnosis shows predominance of five ICD chapters, Chapter XV (Pregnancy, Childbirth and Puerperium) 12.7%, Chapter XI (Digestive System Diseases) 12.2%, Chapter II (Neoplasms (Tumors)) 11.3%, Chapter IX (Circulatory System Diseases) 11.2%, Chapter XIV (Genitourinary System Diseases) 9.2%.

Sorting the patients who presented PU it was verified that 50% of the patients are predominantly distributed in three diagnosis chapters: Chapter X (Respiratory System Diseases) 21%, Chapter IX (Circulatory System Diseases) 16%, Chapter II (Neoplasms (Tumors)) 13%.

Discussion

There is a consensus about the multi-factorial causes for the pressure ulcer event. The present work made it possible to test some of these factors in order to verify if they had statistic significance applied to this population.

Patients have a variety of intrinsic factors which deserve consideration. Age seems to be one of them. Analyzing the data in this study, it was verified that the chance ratio of developing pressure ulcer for a patient aged 65 is 10 times higher compared to a patient aged < 65 years old ($p<0.001$) as displayed on table 2.

Table 2 – Distribution of patients with and without ulcer per age group

	Age Group					
	< 65 anos		≥ 65 anos		Total	
Event	n	%	n	%	n	%
Ulcer	103	0,3	389	2,7	492	1,0
Without ulcer	36945	99,7	13838	97,3	50783	99,0
Total	37048	100	14227	100	51275	100

This finding is confirmed in the literature which reports that elder patients present a great risk related to the skin change that occurs within this age group.[10] Age is also related to other factors as immobility, activity limitation, incontinence (hydration and humidity) and nutritional damage, which have been consistently reported as predisposing factors.[9]

Another factor that presented significant results was hospitalization time. It was noticed that patients with permanence > 4 days have a chance ratio 18 times higher to develop PU compared to the ones whose permanence was up to 3 days $p< 0.001$ as shown on table 3.

Table 3 – Distribution of patients with and without ulcer per hospitalization time

	Hospitalization Time					
	< 4 days		≥ 4 days		Total	
Evento	n	%	n	%	n	%
Ulcer	58	0,2	434	2,8	492	1,0
Without ulcer	35570	99,8	15213	97,2	50783	99,0
Total	35628	100	15647	100	51275	100

This factor may be related to these patients' diagnosis since 21% of them had diagnoses related to Respiratory System Diseases, 16% Circulatory System Diseases and 13% Neoplasms (Tumors), diseases which have a hospital permanence superior to 4 days; of 5 days for Respiratory System Diseases, 6 days for Circulatory System Diseases and 5 days for Neoplasms (Tumors), at the studied hospital.

It was also verified that the use of a pressure ulcer risk assessment is useful in order to identify the higher risk population, that is, the population who developed ulcer 99% and 1% respectively had or not ulcer risk assessment. The patients who had risk assessment have a chance ratio 358 times higher of developing PU compared to the patients who have not had the risk assessed ($p<0.001$). This finding is confirmed in the literature which describes the reliability and validity of pressure ulcer risk assessment.[11]

Analyzing the data related to ulcer stage classification it could be verified that from the total of ulcer assessed they were positioned as: stage I 61%, stage II 24%, stage III 10% and stage IV 5%. It is important to notice that 26% of the identified ulcer was present at patient's admittance. Evaluating only the patients who developed ulcer during hospitalization the distribution was: 62% stage I, 24% stage II, 09% stage III and 04% stage IV.

Table 4 – Distribution of patients with ulcer per ulcer stage classification

PU Stage Classification	n	%
E-I	248	62
E-II	97	24
E-III	37	9
E-IV	17	4
Total	399	100

This classification not only helps selecting proper treatment, but also predicting prognostic.[12] The quality indicator measured at the studied hospital is the ratio between number of new cases of assessed pressure ulcer and the population's total number with assessed risk,[1] incidence was 4%. Tracking pressure ulcer incidence provides a more exact panorama of success and efficiency on risk assessment and prevention, and the policies which identify those people who developed it at a determined time and assistance location.[9] The prevalence of ulcer on this same population was 1%. In the literature the most wide-ranging were accomplished on hospitalized populations and the results show an incidence that varies from 2.7% to 29.5% and a prevalence between 4 and 69%, depending on the population studied.[13] In the United Kingdom (UK), in a district general hospital, new cases of PU strike 4% to 10% of admitted patients. [9,14]

It is understood that assistance quality improvement is certainly an activity which should be carried out in a continuous basis in order to perfect the offered assistance. This is an interactive process which requires a sense of duty from the whole organization. The evaluation of the information database about pressure ulcer proved valuable since this analysis may allow quality improvement implements like patient's more intense monitoring when staying longer than 4 days and aged 65 years old or over.

This analysis can also serve as a feedback to the assisting nurses who generate the data for the information system, validating this information and aggregating value to it in establishing the planning and management of quality nursing care.

Validating the quality indicator, starting from an information system guarantees the establishment of assisting protocols based on pertinent information to this population and consequently training the team related to pressure ulcer.

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Nursing Time Analysis in a Tertiary Hospital after ENR Introduction

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Abstract and objective

The purpose of this study was to analyze the direct and indirect nursing time after introducing the Electronic Nursing Record (ENR) system in a tertiary hospital. This research used descriptive survey and the data was collected from 28 nurses from 14 wards in a general hospital. Each nurses recorded their day, evening, and night activities according to time order.

The study results reported reduction of indirect nursing time including recording & reporting and increase of direct nursing time and patient education. In general, they showed satisfaction with the system and revealed positive responses to the IT team's support. The nurses commented on changes to be needed such as computer speed and physical discomfort from computer using. This study identified the positive time effect of ENR and the need for user friendly nursing information system.

Keywords:

electronic nursing record, nursing time

Introduction

The electronic record system is increasingly being deployed within health care organizations to improve the safety and quality of care[1]. However, to achieve these goals, the electronic record system must be verified as effective by clinicians, and this remains a major challenge. Nurses spend the majority of their time providing direct care to patients and expect that an electronic nursing record system could increase the patient-interaction time and consequently the quality of care delivered [2]. Thus, nurses will consider a system to be efficient if the system reduces their indirect nursing time, even if the time savings do not translate into better patient care [3]. For this reason, in evaluating the impact of electronic nursing record on nurses' activities, some studies use activity time as a primary outcome. However, few studies have explored the effect of ENR on nursing staff' activity time.

Methods

This research was designed as a descriptive study and the data was collected from February to April, 2006. The subjects consisted of 28 nurses from the 14 nursing units who have experienced both paper nursing record system and electronic nursing system. The participants worked regularly at day, evening, and night shift. Nurses were requested to record their nursing time at each shift using the checklists provided by the researchers. Group interviews were done about their perceptions of nursing time changes after ENR introduction.

Results

1) During the day shift, direct nursing activities took 37.04% of the whole day time nursing, indirect nursing 40.74%, ward management 18.52%, and personal time 3.70% respectively. In evening shift, nurses used 29.41% of working time on direct nursing, 45.10% on indirect nursing, 19.61% on ward management, and 5.88% on personal time. In night shift, direct nursing time took 17.91% of working time, indirect nursing 46.27%, ward management 17.91%, and personal time 11.98%.

2) The total time of direct nursing was 200.57 minutes (37.04%) in day shift, 150. 71 minutes (29.41%) in evening shift, and 120.42 minutes (17.91%) in night shift. Among the direct nursing activities, observation and monitoring took the most of nursing time.

3) The total time for indirect nursing was reported as 220.28 minutes (40.74%) of the day shift, 230.07 minutes (45.10%) for evening shift, and 310.71 minutes (46.27%) for night shift respectively.

4) Ward management totally took 100.21 minutes (18.52%) of day shift, 100.85 minutes (19.61%) of evening shift, and 120.57 minutes (17.91%) of night shift. Ward meeting and patient reporting took the largest portion of the ward management time.

5) The personal time took 20.57 minutes (3.70%) for day shift, 30.42 minutes (5.88%), and 80.92% minutes (11.98%) for night shift.

6) The analysis of the group interview indicated the following results: improved work speed and convenience in job, the precise and fast recording, reduction of indirect nursing time including management of nursing record and other documents, and increase of direct nursing time and patient education. Along with these changes, the nurses commented about the problems such as computer speed and physical discomfort from using mobile laptop computer with standing position.

Table 1 - Nursing time by shift

Classification	Day	Evening	Night
		Mean (min) (%)	
Direct nursing	200.57 (37.04)	150.71 (39.41)	120.42 (17.91)
Min	168.23	138.58	115.71
Max	204.43	158.34	124.17
Indirect nursing	220.28 (40.74)	230.07 (45.10)	310.71 (46.27)
Min	202.75	218.21	304.59
Max	230.24	240.35	315.09
Ward management	100.21 (18.52)	100.85 (19.61)	120.57 (17.91)
Min	70.92	88.71	101.42
Max	106.74	108.14	126.01
Personal time	20.57 (3.70)	30.42 (5.58)	80.92 (11.98)
Min	10.21	16.04	70.43
Max	30.53	34.50	90.63

Discussion

The study results indicated the introduction of ENR system made a change on nurses' job and nursing time, increasing direct nursing time and decreasing indirect nursing time [4]. Time efficiency can be one of many benefits and especially electronic nursing record systems can generate time savings in activities, such as accessing a patient chart or maintaining patients' report forms [5], [6]. Next steps in our research will involve monitoring nursing time with direct measurement tool such as video-taping and observation.

Conclusion

Future research is required to examine whether the capacity of the electronic nursing record system to improve the overall care delivery process of patients. New methods to measure the impact of the ENR on time efficiency from an organization's level will have to be developed.

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Web Components for End-User Computing in Nursing

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Abstract

In this paper, we apply component technology to design a shared infrastructure that supports the nursing practice. A component model has been designed to develop flexible and tailorable web applications. The platform called NURSE serves as an environment in which web components can be run and tailored. The environment empowered nurses to create their own web component and creating web application.

Keywords:

web component, End-User Computing, nursing information system

Introduction

The limited available applications that support the tasks of nurses do not yet sufficiently address nursing needs. Nurses are dissatisfied with support provided by the information centers. Component-based Software Engineering (CBSE) has become recognized as a new sub-discipline of Software Engineering. Our work has centered on developing a software sharing environment as a research prototype 'Nurse Utilities Resource Sharing Environment' (NURSE).

The nurse utilities resource sharing environment

The platform is available under Microsoft Windows Sharepoint Services. The NURSE comes with common components that users can use right away. The web components are based on the technology 'Web Part**'.** A Web Part is a modular unit of information that has a single purpose and that forms the basic building block of a Web Page. Based on this environment, nurses are allowed to modify an application by reassembling components without programming. The NURSES deliver a set of core functionalities that allows nurses to develop their own specific web applications through the web-browser. It offer flexibility, ease of use can enhance the productivity of applications.

The architecture

The NURSE is web-based and operated by browser. Using internet based approach build components. Nurses can create more easily customizable application that brings a team together. The architecture forming by the component development steps:

(1) To create the infrastructure with templates to interact. The framework building a catalog of ready-to-use web component templates enable faster development that provides facilities to address a wide range of problems. The templates include: 'survey' ,'announcement list' ,'discussion board' ,' task list' ,' events list' ,'document library'. The ability to quickly develop using web modules componentized web page elements that empower nurses to create their own Web applications.(2) Components were developed for specific information needs. Extensible component architecture gathers various specialists to contribute their artifact. NURSE deposits web component resources. (3) Integration of components makes an application. By the way of providing the standards-based blocks build applications.

Discussion

We proposed an approach to empower nurses to create or assemble web applications, rather than to build the systems from scratch. Component can be reused, once a nurse write a web component and publish it, which can be used in multiple hospitals and nurses. The infrastructure provides a low cost solution to solve nurses' information demand. Future research would need to establish a mechanism to motivate sharing their artifacts and get rewards. Creation, cooperation, contribution for the sharing mechanisms are necessary prerequisites.

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A Nursing Minimum Data Set in Occupational Health: Items and elements for professional Practice

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Abstract

This article consists of a descriptive retrospective study that describes how the items and elements on the Nursing Minimum Data Set in Occupational Health were determined. The medical files of 106 patients were chosen for study and, from them, 777 records of first and return consultations between August 1998 and August 2003 were identified. They were analyzed on the basis of the categories and elements of the Nursing Minimum Data Set (NMDS) and the Nursing Management Minimum Data Set (NMMDS). The results showed that the lack of specific nursing data and faulty filing of documentation may be related to the failure by professionals to agree on a clear, permanent, validated, reliable and standardized set of data. A Nursing Minimum Data Set in the Occupational Health (NMDSOH) is presented, containing 31 items and divided into four categories: demographic elements, elements on nursing care, elements on the clinic, and elements on occupational health.

Keywords:

occupational health nursing, medical informatics,

data collection

Introduction

Information systems in nursing were first defined and implemented to support the practice of caring and to facilitate the work of nurses in collecting, storing and analyzing data on patients, with the objective of defining needs and planning the care to be provided [1]. However, factors such as difficulties in standardizing nursing vocabulary and the fact that the measures taken are often planned in a more intuitive than systematic way, have led nurses to make little use of computerized systems. They therefore produce little information, based on the data collected, which could describe and sustain their practices.

One of the first attempts at standardizing a set of essential data for the practice of nursing was developed by Werley and Lang [2] in 1988, known as the *Nursing Minimum Data Set* (NMDS). Elements on nursing divided into categories provide much inter-related data through which the essential data is organized, classified, processed, accessed and studied, in order to support the management of the care provided by health professionals in varying contexts. Another set of data, developed with the objective of addressing the needs of data for nursing management, was the *Nursing Management Minimum Data Set* (NMMDS), as presented by Delaney and Huber [3].

In the same vein, it is of utmost importance to standardize and identify a minimum set of data that will provide the necessary information regarding nursing care in occupational health. In other words, it is possible to gather data on the nursing process and standardize it into a set of items that describe nursing activities and serve as support to the work of nurses in occupational health. Such data also makes it possible to produce information aimed at evaluating the quality and results of the health care provided to clients or patients. In the process, the related decision-making and research can also be evaluated.

Considering these aspects, the present study has the objective of describing how of the items and elements on the Nursing Minimum Data Set in Occupational Health (NMDSOH) were identified.

Methodology

The present article consists of a descriptive retrospective study [4]. The data analyzed here were taken from the agenda of Occupational Health Nursing (ESO) at the Public Health Nursing Out-patient Clinic (SESP) at the General Hospital of Porto Alegre (HCPA), Brazil. More specifically, the information was obtained from the nursing records kept at the outpatient clinic and from the records in the institution's database, collected between August 1998 and August 2003. On the 106 medical files analyzed, 777 records of first and return consultations were identified. The categories and elements on the concepts of the Nursing Minimum Data Set (NMDS) and the Nursing Management Minimum Data Set (NMMDS) were used to choose the terms to be used on the basis of the records of nursing consultations. In a second stage, an instrument was submitted to eight specialists in the area of occupational health. This instrument was designed to measure the level of agreement, appropriateness and priority of the data chosen for the proposed model. Preliminary tests on the questionnaire were also carried out in regard to its suitability and pertinence, based on a sample, by conve-

nience, of 19 computerized records of nursing consultations from the agenda at the ESO/SESP/HCPA.

The data were treated and analyzed with the help of descriptive statistics (frequency and percentages) on *Excel for Windows®* and *Statistical Package for the Social Sciences (SPSS)®* [4] [5].

Results

Categories and elements identified in the nursing documentation

Patients/clients demographic items

Among the data on the elements for *Identifying patients/clients,* the most frequent were Name (29.9% of all records) and Age (28.3% of all records). The data include Gender, Date of birth (age), Ethnic group and Residence (phone contact, origin).

Nursing care items

The most frequent data from *Anamnesis* are nutrition (93.0% of all the records), humidity (89.4% of all the records), physical activity (79.9% of all the records) and urinary and intestinal elimination (42.8% of all the records). The most frequent data related to *Physical examination* were blood pressure (96.6% of all records), body weight (95.1% of all the records), behavior (62.3% of all the records), height (29.9% of all the records), laboratory and clinical examinations (28,8% of all the records) and emotional state (28.3% of all the records).

Elements on *Nursing diagnosis* were frequently identified in the documentation (92.3% of all the records). The elements on *Nursing intervention* identified were also categorized for better presentation, including orientation on nutrition and health, physical activity, life-style practices, orientation on measures for occupational promotion, protection and rehabilitation. Among the most frequent findings were data on orientation for improving patients' information regarding the process of the disease and regarding self-care (95.4% of all records). Among the elements on *Nursing results,* the most frequent data identified in the documentation analyzed were related to clients' behavior toward the proposed treatment (84.4% of all the records).

Service items

The data included in the elements in this category (elements on the unit, or clinic, elements on a single patient/ client file, and elements on nurses) are standardized in the identification forms found in the patients' files and made available as data referring to hospital management, taken from the Porto Alegre General Hospital's information system.

Occupational health items

Among the most frequent data found among the elements on Occupational history are "Current job situation" (25.2% of all records) and "Current type of work" (20.8% of all records). Among the most frequent data in the elements on Occupational health and safety are "Symptoms of current disorder" (86.5% of all records) and "Current treatment" (63.3% of all records).

It should be noted that no elements or data were found in the records regarding *Items on the environment, on Nursing resources, or on Financial resources.*

Evaluation by specialists

A questionnaire was prepared for evaluating the elements. A group of specialized consultants was set up consisting of eight persons [n=8], including four university professors and four social service nurses. Using this questionnaire, each consultant was asked to indicate his or her opinion as to each of the elements listed, in terms of the degree of its pertinence as a quality that should appear in the data set, and its degree of priority. It was decided to present only the results shown in the columns of answers [I agree] and [Important], as they addressed the specific objectives for validating the contents based on judgment [4].

According to the specialists, it is important to include data from the patient's/ client's demographic items, service items, nursing care items and occupational health items (100%) on the NMDSOH. The percentage of agreement is lower regarding administrative data involving management of the care provided. These aspects include complaints about the treatment (62.5%), the duration of the nursing consultation (62.5%), availability for treatment (62.5%), time taken to get to the clinic (50%), and number of patients/clients per nurse (50%). These data are all present on the NMMDS.

However, it can be said in general that the specialists agree with the list of data included in the set. Their observations and suggestions were therefore made used of in terms of their understanding, objections and suggestions for refining the instrument, and later definition of the items and elements on the NMDSOH.

Discussion

Very little of the information included in the category of the patients'/clients' demographic data was present in the documents analyzed because it is present on the standard computerized form used at the institution.

The predominance of data from anamneses, physical examination, and laboratory examinations can be understood in the light of Maslow's theory of Basic Human Needs, adopted for the nursing process at the HCPA. The prevalence of the evaluation of nursing in terms of the patients'/clients' biological needs can also be explained by

the fact that professional practices are still deeply impregnated with a tradition of referring only to epidemiological and clinical aspects when planning modes of intervention [6].

The high frequency of diagnostic nursing elements shows the importance attributed to this phase in the nursing documentation at the HCPA. Since the 1970s, this hospital has applied systematic descriptions of the services it provides, and the results are consistent with the frequency of data from anamneses and physical examinations in the files. Evidence also shows that the subsequent stages of the nursing process depend on the quality of the initial evaluations and their respective documentation [7].

In the category of Items on occupational health, the records showed a low percentage of data from elements on environmental risk factors and from elements regarding occupational history. It is especially important to note that the lack of data such as the current and previous types of work performed, work processes, working conditions, working environment, workplace, and work sector in the initial phase of application of the nursing process may indicate a lack of information to support the patients' / clients' real or potential needs, especially in the causal relationship between health and work.

It can be inferred that the lower frequency of the data in the initial gathering does not mean that no data at all were collected. The diagnostic impressions and the nursing interventions mentioned in the records take into account information that indicates that such data were processed. Another possible explanation for this finding might be the precaution by the nurses to avoid duplicating information contained in the records of medical anamnesis. But one can nevertheless criticize the lack of visibility and availability of nursing data that contain specific elements on occupational health to be applied in professional practice.

Unfortunately, in terms of the items listed on the NMMDS, one could criticize the failure of the specialists to evaluate the elements [data] on quality and level of solution of the steps in relation to the attributes of the caring process. It would seem that quality in health has caught the attention of researchers but not of those who actually provide occupational health services, as these latter do not seem concerned with having records that describe information that might facilitate the evaluation of the care provided. Therefore, the commitment of professionals involved in caring – the continual work of defining and measuring the quality of the assistance provided, as indicated by Delaney and Moorhead [8] – loses its importance in the definition of "quality." In addition, as Donabedian [9] has stressed, approaches for evaluating quality in health include components related to the resources needed for treatment, as well as components related to activities carried out between professionals and patients, where these administrative data on care management can be included.

Elements of the Minimum Nursing Data Set in Occupational Health (MNDSOH)

Chart 1 summarizes the list of essential, or minimum, data identified on the basis of the terms chosen in the systematic nursing records and evaluated by the group of specialists for presenting the NMDSOH.

Elements of the Nursing Minimum Data Set in Occupational Health (NMDSOH)

Patient/Client Demographic Elements
- Patient's/Client's Registration Number
- Patient's/Client's Name
- Age
- Ethnic Group
- Gender
- Origin
- Marital status
- Occupation
- Schooling (in years)
- Full address

Nursing Care Elements
- Anamnesis and physical examination (evaluation protocol)
- Nursing diagnosis
- Nursing interventions
- Nursing results
- Patient/client treated
- Accessibility for patient/client

Service Elements
- Name of Institution
- Name of service/clinic
- Type of health insurance plan
- Date of out-patient admission
- Date of out-patient release
- Date of nursing consultation
- Team responsible
- On-duty nurse
- Type of nursing activity
- Volume of nursing care
- Complexity of nursing care
- Costs of nursing Care

Occupational Health Elements
- Professional history
- Environmental risk factors
- Occupational health and safety

Chart 1 - Elements of the Nursing Minimum Data Set in Occupational Health (NMDSOH)

The data included in ***Patients/clients demographic elements*** are described extensively in the literature regarding routine admission records of patients/clients. The basic demographic information allows data to be summarized, which, when combined with other elements or groups of elements, provide important information [10]. Formal education provides information on access to culture, consumption, income, and professional training.

Two pieces of data are found on the NMDS [2,3] regarding these aspects, and, three other types of data were included to cover the occupational health area.

In ***Service elements,*** the data on the element of *Complexity of the nursing care*, which include the perception of factors that are internal to the care given as well as other that are external, and serve as possible indicators for evaluating the results regarding the care aspect.

The data on *Volume of nursing care* refer to the total time dedicated to nursing care and to the size of the nursing team involved in caring. These aspects include the number

of professionals involved and their availability for individual, collective or group support services, and the number of patients/clients per professional.

Nursing information adds a perspective of the patient/client that goes beyond the costs of the disease or disorder and the medical service provided, as it also considers the *Costs of the nursing care.*

These data can be processed to generate useful information for planning strategies to integrate health education, procedures, services and management. Only in this way can the health system be placed under the control of society in order to provide qualified health practices and proper training of health professionals. Four of these elements are included on the NMDS and two on the NMMDS. Other elements were selected according to the specific needs of the area of occupational health.

In ***Nursing care elements,*** the following data are included under *Anamnesis and physical examination:* review of systems, nutrition, humidity, sleep/rest, physical activity, leisure, rashes, family risk factors, elimination, physical measurements, measurement of vital signs, laboratory and clinical examinations and images, capillary glycemia, general conditions of the body and members, mobility and movement, and emotional state.

The data on *Nursing diagnosis* include the description of the current diagnosis based on analysis and interpretation of the information obtained. The patient's/client's health can be evaluated on the basis of such information.

The data on *Nursing intervention* include the description of the intervention performed. Interventions refer to orientation for occupational promotion, protection and rehabilitation, as well as education in health for self-care (nutrition, physical activity and life-style habits), indications for laboratory examinations, referrals to other professionals, and release procedures.

The data on *Nursing results* include the patient's/client's evaluation of the state of resolution of the nursing diagnoses and interventions. This refers to the difficulties in controlling or managing treatment, the need for information about the current disorder or damage and/or treatment, and behavior toward the nurse's orientations: acceptance vs. non-acceptance, decided vs. undecided (transferred or referred).

The data on *Patient/client treated* include the characteristics of the population attended in the area of nursing in occupational rehabilitation (off work or not, pending examination by the federal health program, and follow-up by other professionals).

The data o*n Patient's/client's accessibility* include the time patients take to get to the clinic and the time spent during the nursing consultation.

The data on Nursing diagnosis, Nursing interventions and Nursing results show the characteristics indicated by Werley and Lang [2], whereas the data related to Patients'/ clients' accessibility, Patient/client treated, and Volume of nursing care are in accord with the characteristics indicated by Delaney and Huber [3].

It is felt that the inclusion of the above types of data should improve the production of information on which to base clinical decisions, manage quality, and determine the most suitable care to be given. As Delaney and Moorhead [8] stated, it is important to include nursing data in statistics on health care, both for the health community and for the patients/clients themselves.

In the ***Occupational health elements*** the data included in *Occupational history, Environmental risk factors,* and *Occupational health and safety* were already listed in Lynch's [11] study, where he proposes a structured information system structured around four databases in occupational health.

The data on *Occupational history* include the current and previous types of work, the characteristics of the work, how long the person was on the job or in the occupation, and his or her working hours, in order to understand the relationship between work, occupational health, and disorder.

The data on *Risk factors* include the type of exposure to the risk, the use of individual safety equipment, ergonomic aspects, and workplace, thus completing the study on the factors present in the working environment.

The data on *Occupational health and safety* deal with each patient's/client's morbidity and mortality rate, as this information provides data on working situations, which is important for making health diagnoses.

The use of the NMDSOH facilitates analyses that will identify the structure for determining individual or collective health-sickness processes and the characteristics of social groups where they occur. This makes it possible to draw up a clearer description of the real and potential living and working conditions. The information processed should contain the elements necessary to explain and understand causal processes, together with the list of factors that are sensitive to intervention. This also enables the professionals involved to become more aware of the patient's/ client's health situation before taking decisions and following-up on and evaluating the results of the measures taken.

Conclusions

The final results of this study recommend the inclusion of 31 items on the NMDSOH, divided into four categories, to wit, patient's/client's demographic elements, elements on

the nursing care, elements on the clinic, and elements on occupational health.

The conclusion here is that a Nursing Minimum Data Set in Occupational Health (NMDSOH) based on terms used in nursing records can serve as a frame of reference when groups set out to make changes in information systems in health in the Brazilian context. The frames of reference for the NMDS and the NMMDS adequately addressed the analytic and theoretical needs for including items and elements [data] that described nursing care in the context of occupational health. In addition, the elements [data] on the NMDSOH can effectively be related to a database and a computerized information system in order to address the needs of the practice, research, decision-making and quality of the treatment provided by nursing in this health specialty.

This study also emphasizes the importance of determining a set of minimum data that should be included in the forms and records that make up the databases. The data can thus be better documented and structured in the information systems. There is a real need of adequate methodological tools to provide not only the survey on health conditions and harmful occupational factors, but also the relation or association of elements that comprise the work-health-sickness process, taking into account both organizational and environmental aspects, as well as life conditions of workers. Nurses could then make better use of such data, to the extent that the correct information is produced for the performance and description of their caring practices in occupational health.

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Austin Health

Development and Implementation of an Electronic Risk Assessment tool for Acute Hospital Patients

Part 1: Current Use and Effectiveness of Paper Based Risk Assessment Tools in Clinical Practice

Fresenius Kabi
Caring for Life

Funded by: Pharmatel Fresenius Kabi Pty. Ltd.
Authors: Heather Davis, Caitlyn Green, Genevieve Jepsen & Associate Professor Graeme K Hart

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- Are there time constraints?
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- Do they value the current paper based risk assessment form?
- Have they been educated about the current form?
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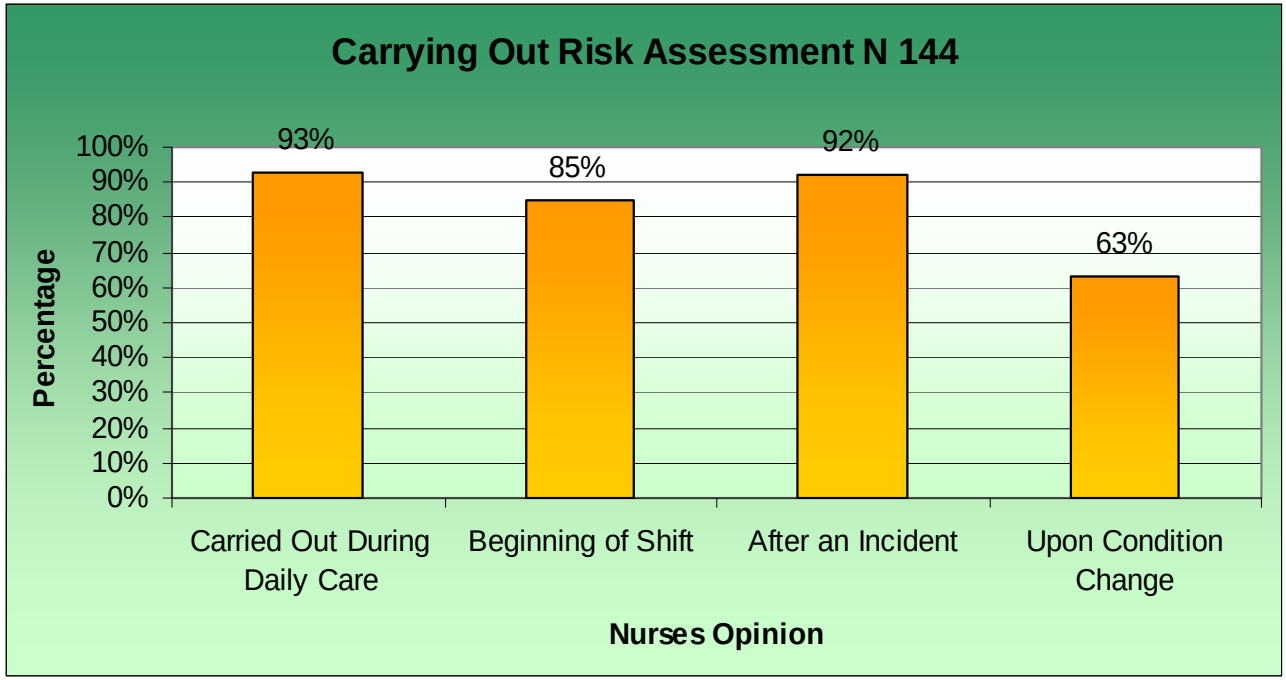
Methodology

- Purpose developed questionnaire
- 10 randomly selected wards wards surveyed
- Over 3 campuses
- 415 surveys distributed
- 144 completed
- 35% Response rate

When Risk Assessment is Done



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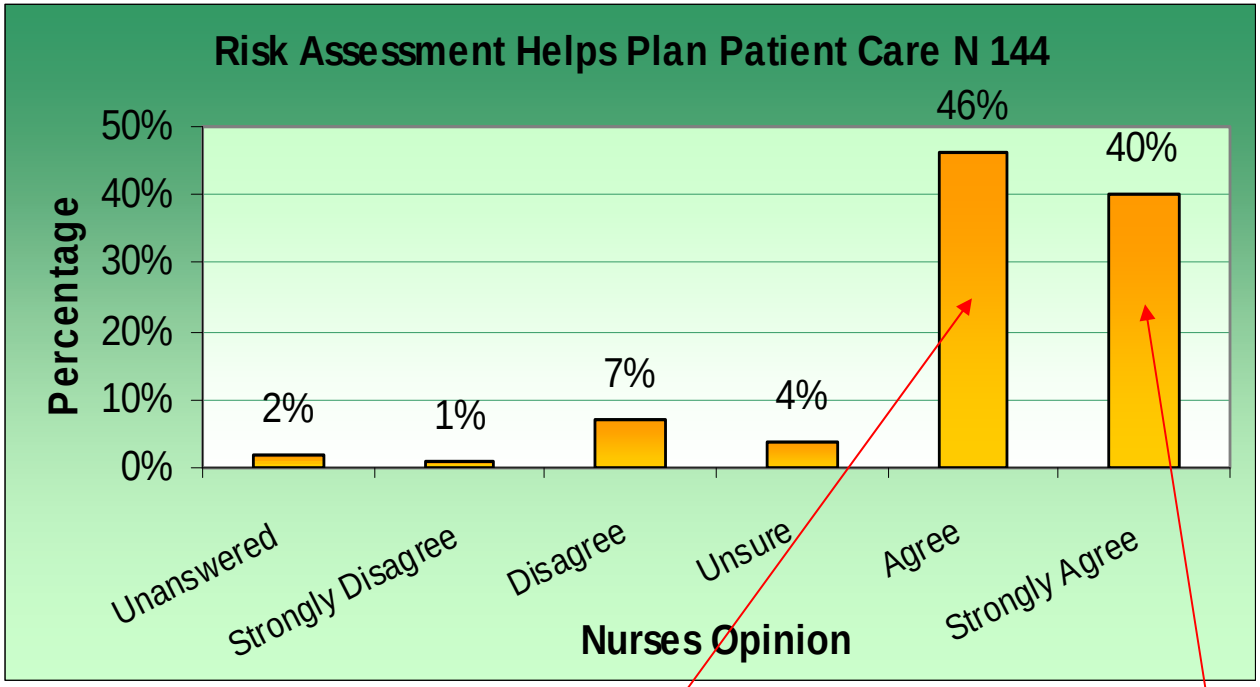
Assists Nurses Plan Care



The majority of nurses agree (46%) or strongly agree (40%) that carrying out a risk assessment assists with care planning.

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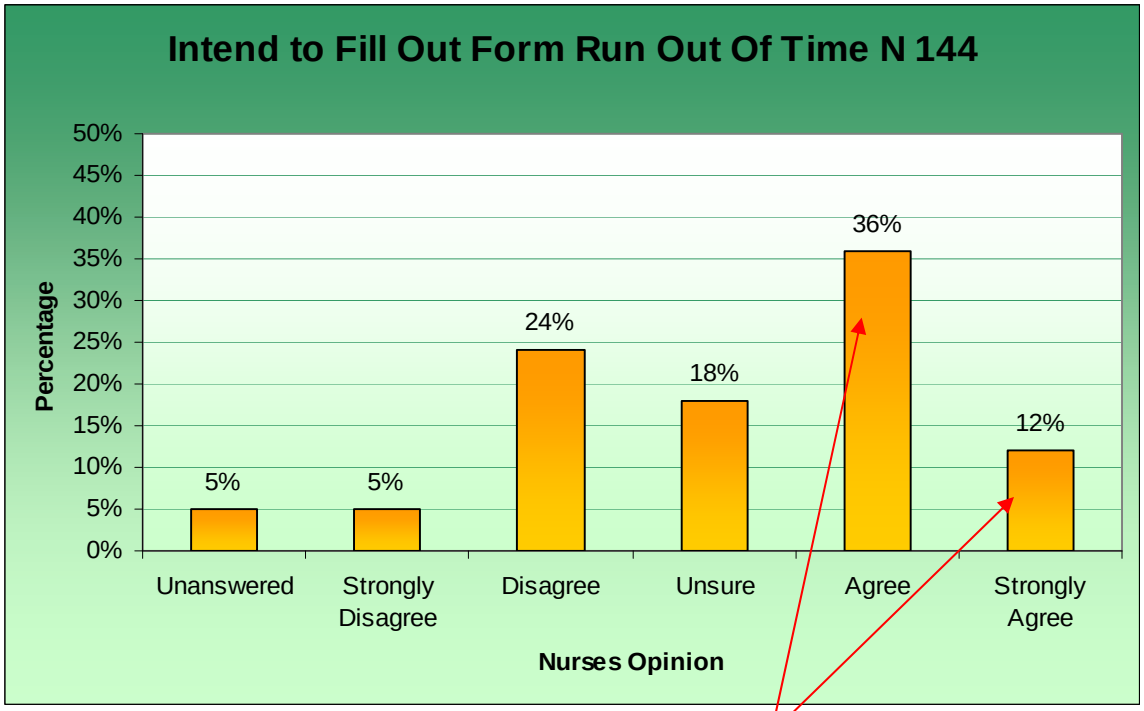
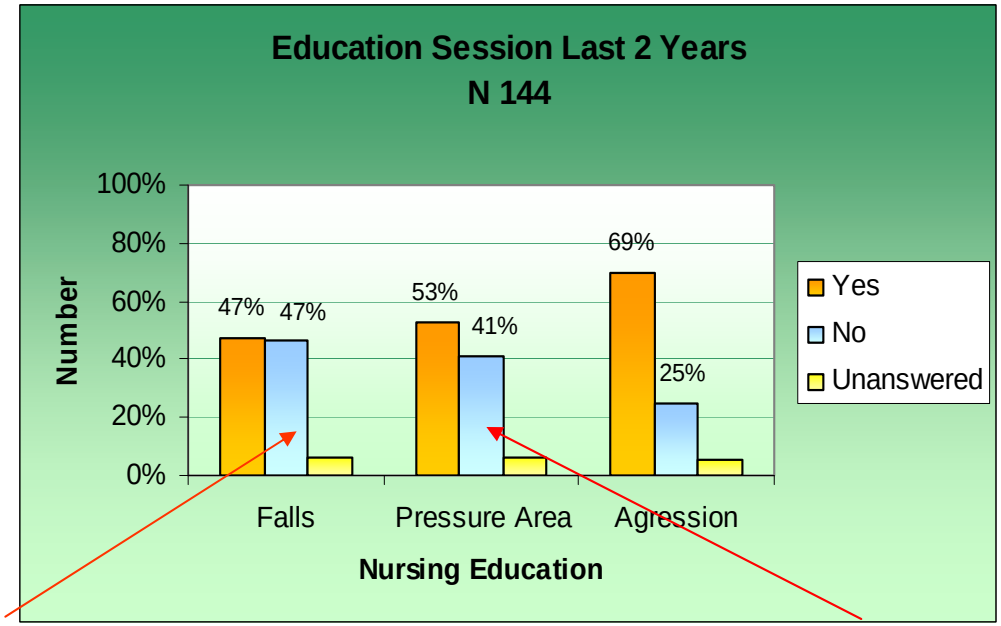


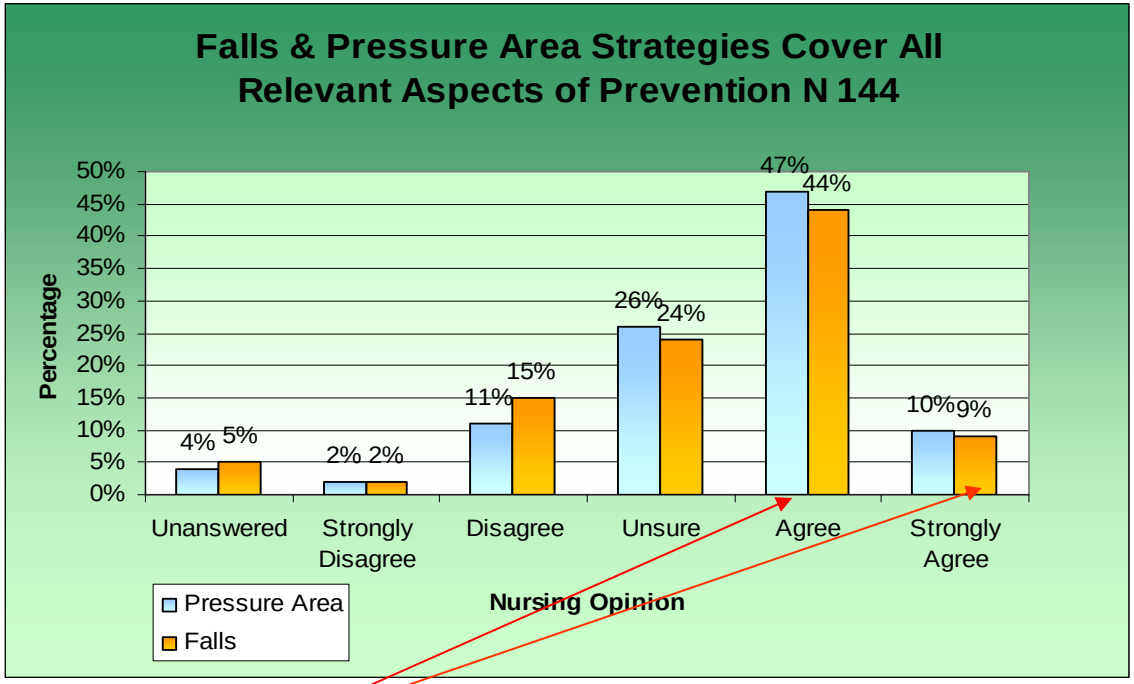
48% of nurses indicated that they often intended to fill out the current risk assessment form but then ran out of time.

Educated on Risk Assessment



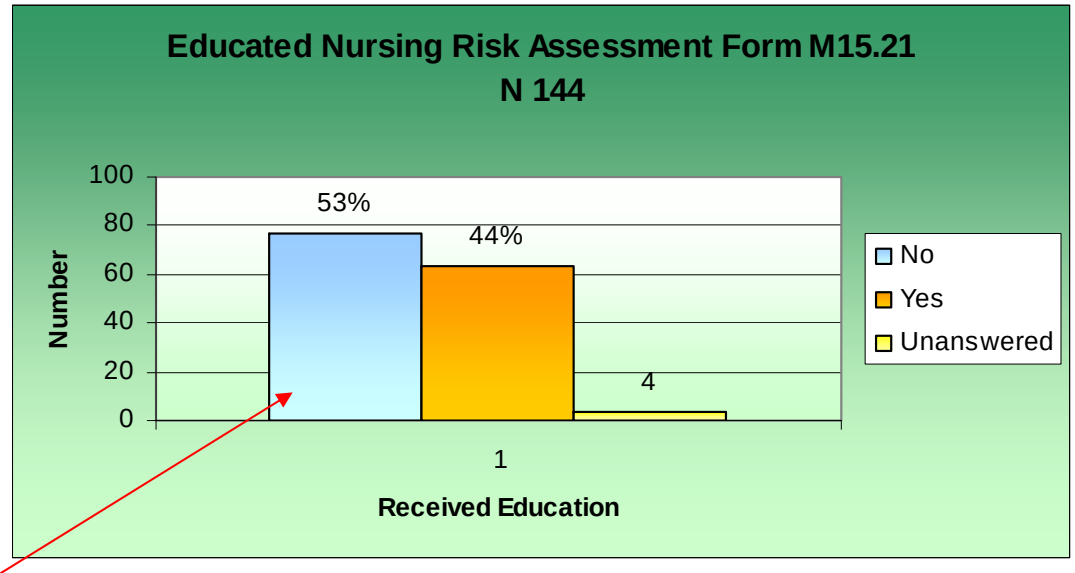
There is still a significant percentage of nursing staff who require education on risk assessment, with pressure areas and falls showing the largest gap.

Value Strategies on Current Form



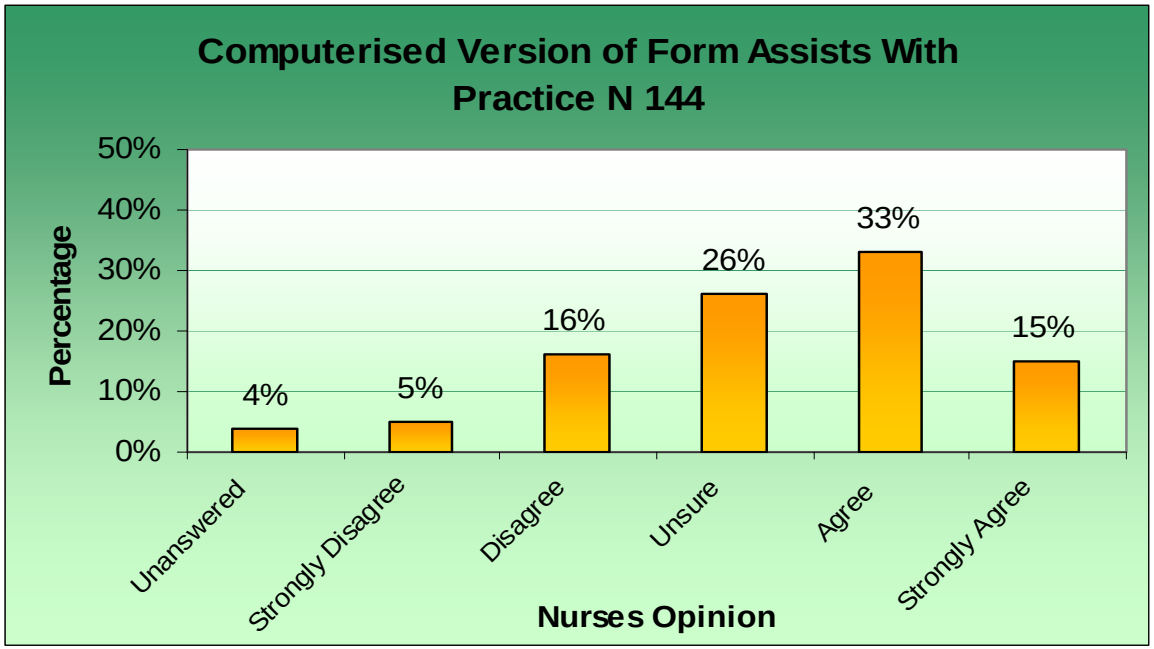
Greater than 50% of nurses agree or strongly agree that the strategies on the current risk assessment form cover all relevant aspects of prevention

Educated on Risk Assessment Form



53% of nurses surveyed indicated that they had not received any education on the use of the current nursing risk assessment form.

Computerised Form Assists With Practice



33% of nurses agreed and 15% strongly agreed that a computerised risk assessment form with risk strategies, equipment ordering, and referral capabilities would assist in their practice. 26% were unsure and 16% disagreed.

Conclusion

Electronic tool development will need to encompass :

- Current nursing workflow
- Interactions within the multidisciplinary team.
- Time saving features
- Decision Support functionality
- Strong change management & education of staff

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Development and Implementation of an Electronic Risk Assessment Tool for Acute Hospital Patients.Part 1: Current Use and Effectiveness of Paper Based Risk Assessment Tools in Clinical Practice

Heather Davis, Caitlyn Green, Genevieve Jepsen, Graeme Hart

[a] *Austin Health, Heidelberg, Victoria, Australia*
[b] *Department of Austin Centre for Applied Clinical Informatics, Austin Health, Heidelberg, Australia*

Abstract

The implementation of any electronic system first requires an assessment of the current system to determine it's effectiveness.[1] This paper reports on results from a nursing survey that was conducted to explore nursing opinion of the current paper based Inpatient Nursing Risk Assessment tool in use at Austin Health. Areas explored focused on a) when nurses carried out risk assessment, b) it's importance to care planning, c)the use of the hospital nursing risk assessment form in relation to their practice, d) time factors d)education pertaining to risk assessment and the form and e) whether a computerised form would assist their practice.

Keywords:

risk assessment, electronic, paper based, acute hospital patients, current use, effectiveness, clinical practice, nursing

Introduction

The Victorian Quality Council identified falls and pressure areas as two components of a strategic approach to reducing the risk of harm and improving health care safety and quality in Victoria.[2] [3] Austin Health introduced a paper based inpatient nursing risk screening and assessment tool [4] in response to these initiatives in 2004. The form was designed to carry out a risk triage for pressure areas and falls, with a single question relating to aggression. The tool is intended to be filled out for every patient upon admission, repeated upon a designated review date, and again, if a patient's condition changes. Once a patient has been assessed at risk of falls, or pressure ulcers, falls minimisation strategies and pressure ulcer prevention strategies are initiated and recorded in the strategies section of the form. Since the introduction of this form the health service has also developed and implemented a comprehensive aggression risk assessment and management form,[5] which has eight risk screening questions, aimed at identifying risk level. It too has actions, interventions and a suggested management plan.

Chart audits of 60 randomly chosen charts, carried out prior to the nursing survey indicated that the inpatient nursing risk assessment form was not being used effectively[6]. Only 68% of charts had the form present, with just 43% of those having the initial triage section of the form completed, or partially completed. With this in mind, it was important to gain a better understanding of nursing staff values and opinions regarding risk assessment and the use of the current paper based forms[7]. This survey forms part of the project designed to address one of the strategic priorities of Austin Health i.e "the development of an IT strategy to support improved safety and quality, including clinical audit"[8]. This will take the form of an electronic risk assessment tool . The initial focus will be upon the development of a nutrition risk screening tool, with pressure areas and falls risk to follow.

Methodology

Purpose developed nursing surveys were distributed to 10 randomly selected acute and sub acute wards on 3 campuses during a two week period. Both division one and division 2 nurses were surveyed. Of the 415 surveys handed out, 144 were completed, giving a 35% response rate.

Results

Risk Assessment

Participants in the survey group indicated that carrying out a risk assessment was important, that it is usually done during day to day care (93%), and that it helps them plan

1 Hawryszkiewycz IT, *Systems Analysis and Design.* 1994, Sydney : Prentice Hall
2 Victorian Quality Council, *VQC Strategic Plan 2002 – 2005* VQC, Melbourne www.health.vic.gov.au/qualtiy council
3 *VQC State-wide PUPPS Report* - 2003
4 Austin Health " *Nursing Risk Assessment – Inpatient Form M15.21"*
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7 Spencer R, Logan P, Coiera E, Socio-technical factors surrounding practices related to telephone, paging and information system use in an emergency department, HIC 2003 RACGP
8 Austin Health Strategic Plan 2006-2008

their patient care (85%). They felt it was important to carry out a risk assessment at the beginning of every shift, when the patient had an incident and when the patient's condition changed.

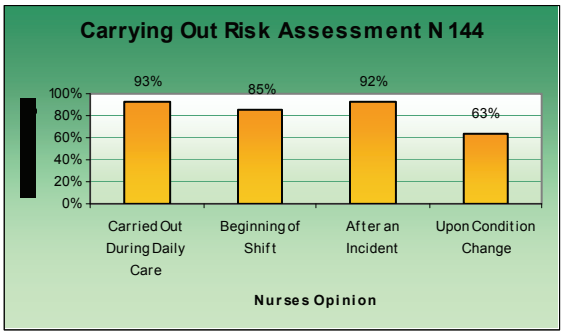

Figure 1 - Nursing Risk Assessment Tool

When the efficacy of the current paper based tool was addressed, the nurses were divided as to whether it fits in with day to day practice, however, 48% of nurses indicated that they often lacked the time to fill it out. They agreed that the suggested falls and pressure area strategies had value and were practical to implement. When questioned as to whether a computerised version of the form, with prompts to assist with initiating risk strategies, such as ordering equipment, and placing referrals to allied health services would assist in their practice, 15% of the nurses strongly agreed 33% agreed.26% were unsure with 16% disagreeing.

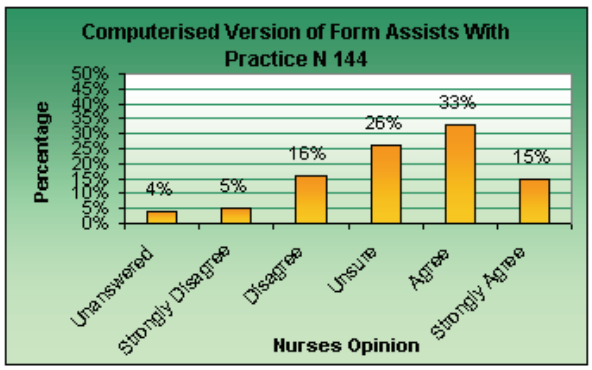

Figure 2 - Computerised version of form assists with practice. Nurses opinion

Education

When questioned about education on risk assessment, a large percentage of the nursing staff reported that they had not received recent education in the areas of; falls (47%), pressure area (41%) and aggression risk (25%). In addition a further 53% of nursing staff still require education on the use of the paper based tool.

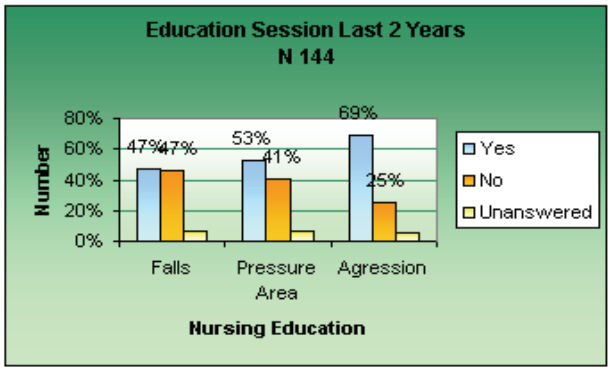

Figure 3 - Nursing Education

Discussion

Within the contemporary health care environment managers are constantly under pressure to find better and more efficient ways of transitioning patients through the system. This quest for streamlining processes needs to be supported by the development of equally streamlined health information management system. Risk Assessment is one component of that system.

The challenges we face in implementing electronic risk assessment are varied and require a multidisciplinary approach. We are relying on the frontline nursing staff to carry out risk screening upon patients, therefore it is imperative that we design a system that can be integrated into the way that nurses work.

Austin Health currently utilises a dual electronic and paper based patient health record. The nursing staff gathering patient information at the bedside are still using paper based nursing documentation which includes the current risk assessment tools.

Our results indicate that nurses believe risk assessment is instrumental in caring for patients, however, it is clear that a significant gap exists between their perceived values and documentation of their practice. To narrow this gap, we need to ensure that we design a system that enables nursing staff to document their practice in a streamlined and efficient manner. We believe the solution to this problem is an integrated electronic risk assessment tool that encompasses time saving features.

We can then improve the quality of nursing documentation. A recent study by Moody[9] of 100 nurses in a large

9 Moody L, Slocumb E, Berg B,Jackson D, *Electronic Health Records Documenation in Nursing: Nurses'Perceptions, Attitudes and Preferences* Comput Inform Nurs 22(6): 337-344, 2004. Lippincott Williams & Wilkins

Florida magnet hospital indicated that 75% of nurses thought electronic health records had improved the quality of documentation and 76% believed electronic charting would lead to improved safety and patient care.

We can further consolidate this practice improvement by the implementation of a planned, recurrent and accessible education programme. This will enable us to raise awareness of patient risk as an issue.

The education programme will be multidisciplinary in focus and be conducted in conjunction with an extensive change management initiative based around the importance of clinical risk management. Moody's study refers to need to seek input from potential users of systems as many problems that occur with the implementation of electronic health records are organizational and behavioural in nature[10].

10 et al

Early assessment of nursing practice will allow for identification of possible barriers to the uptake of an electronic system. In turn, this will enhance our chances of reaching our goal which is to - achieve a world class system which represents best practice principles of clinical risk assessment and subsequent management.

Conclusion

The development of an electronic risk assessment tool will need to encompass current nursing workflows and interactions with the multidisciplinary team. The design will have to take into account the time pressures of nursing and incorporate time saving productivities into the system. Change management and education are an important part of any quality improvement strategy. To improve the usage of the paper based risk assessment tool it is clear that the a concerted effort to educate the staff on it's usage is required. The same will be true of any electronic system.

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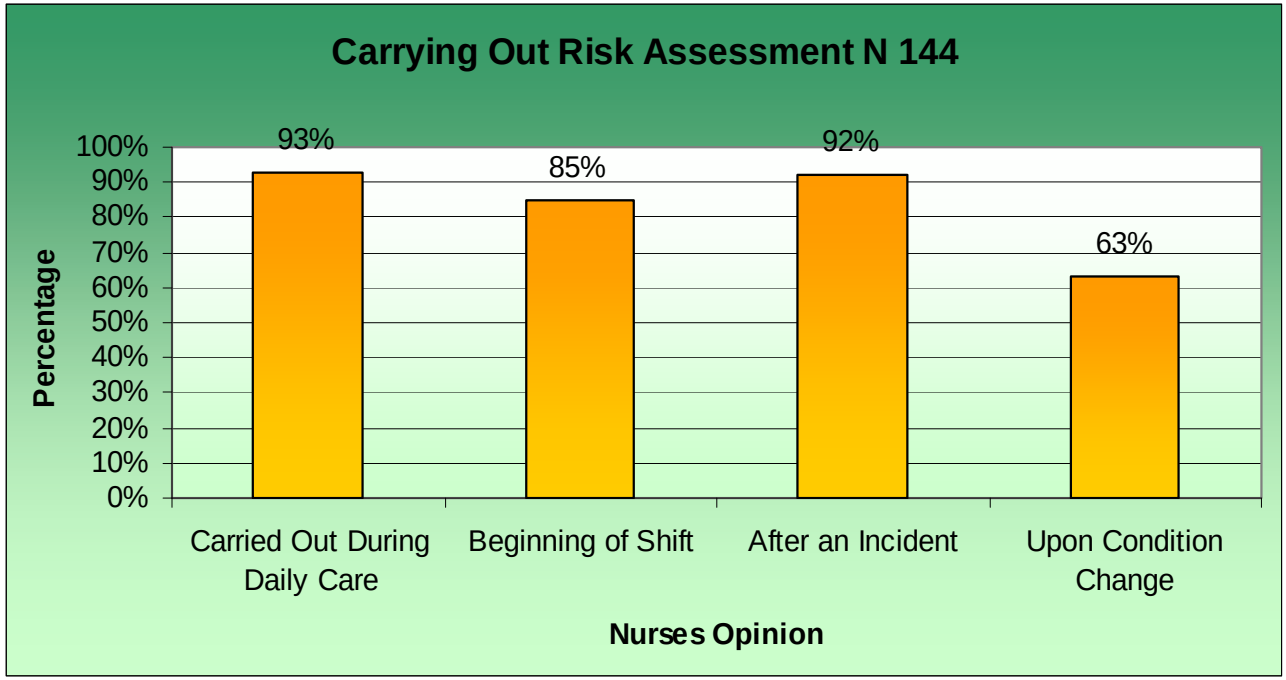

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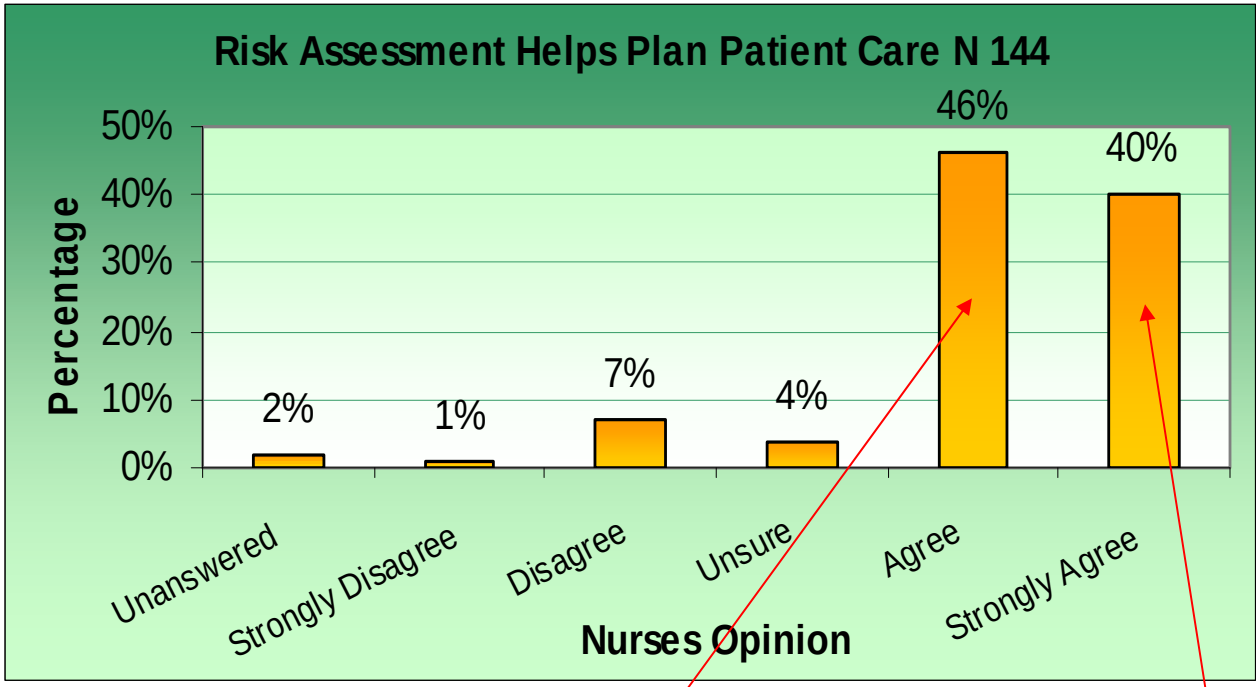

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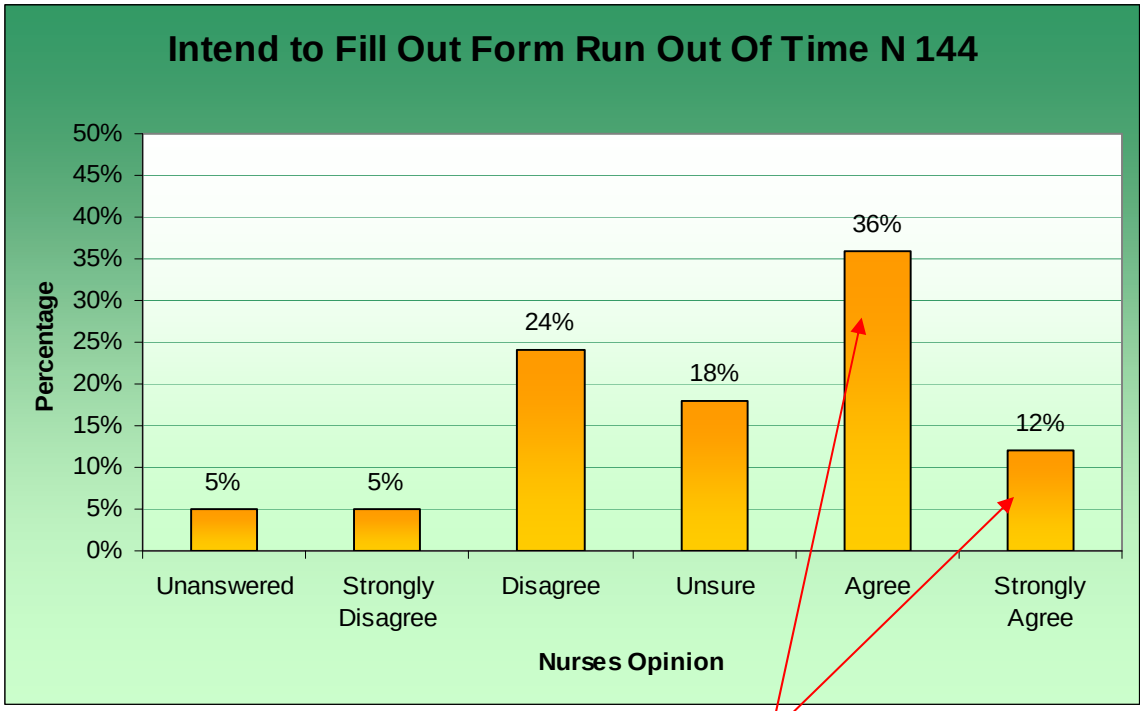

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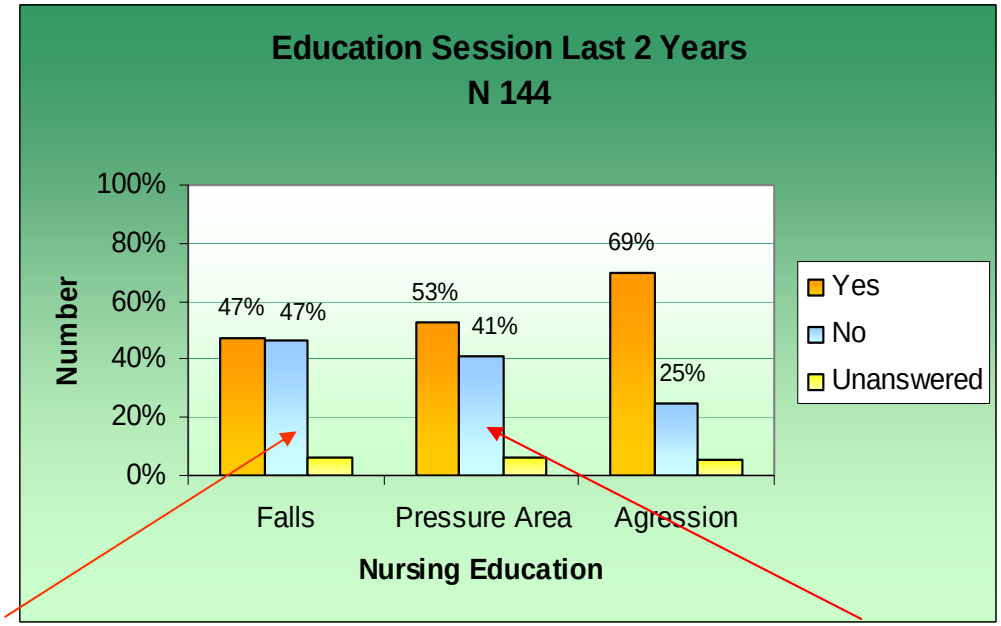
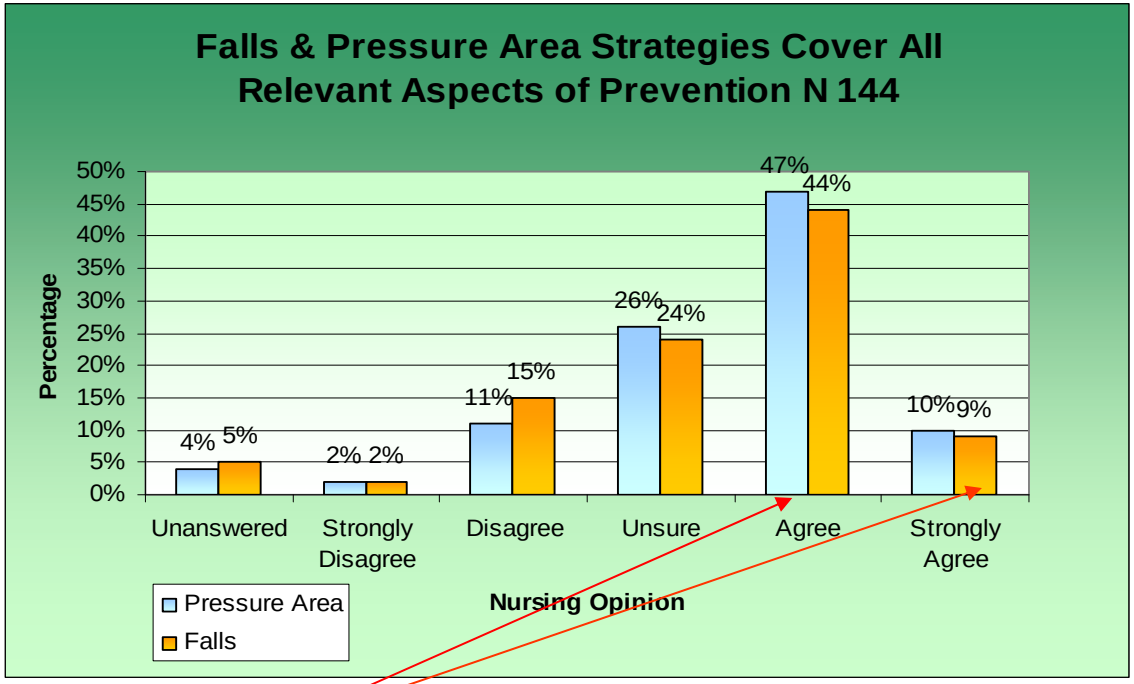


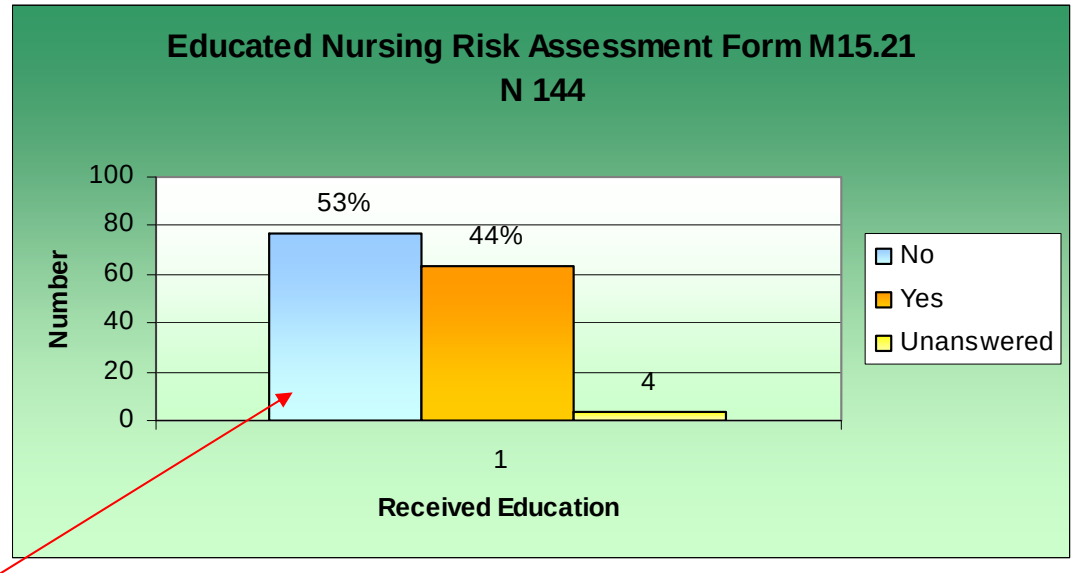
There is still a significant percentage of nursing staff who require education on risk assessment, with pressure areas and falls showing the largest gap.

Value Strategies on Current Form



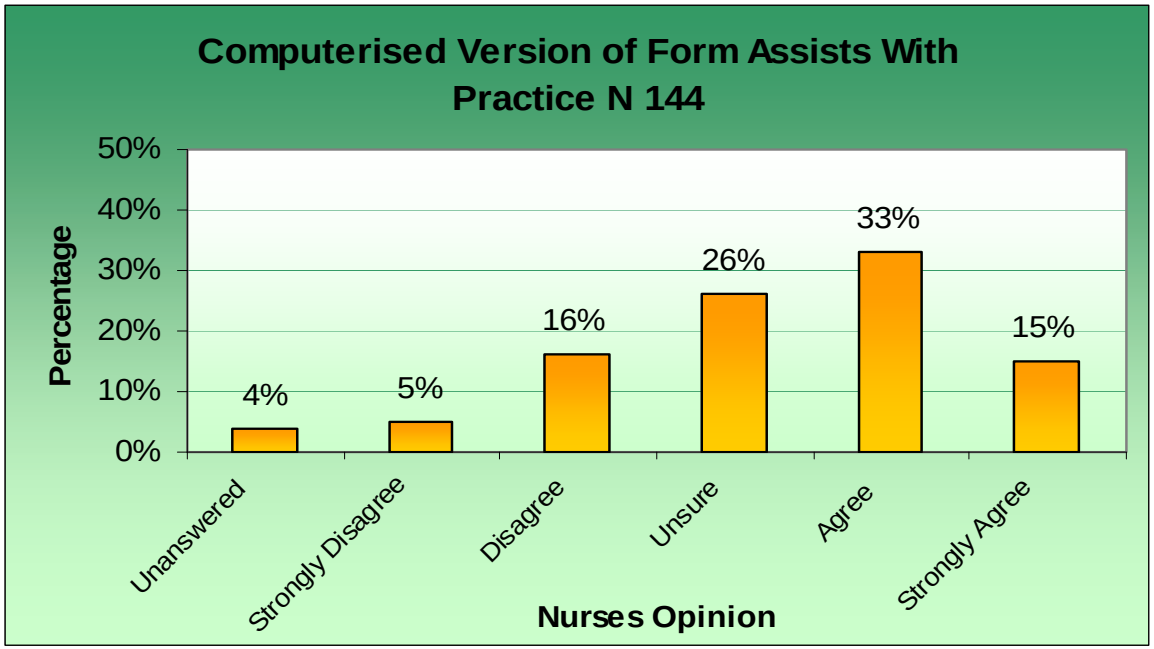
Greater than 50% of nurses agree or strongly agree that the strategies on the current risk assessment form cover all relevant aspects of prevention

Educated on Risk Assessment Form



53% of nurses surveyed indicated that they had not received any education on the use of the current nursing risk assessment form.

Computerised Form Assists With Practice



33% of nurses agreed and 15% strongly agreed that a computerised risk assessment form with risk strategies, equipment ordering, and referral capabilities would assist in their practice. 26% were unsure and 16% disagreed.

Conclusion

Electronic tool development will need to encompass :

- Current nursing workflow
- Interactions within the multidisciplinary team.
- Time saving features
- Decision Support functionality
- Strong change management & education of staff

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Nurses as Social Fabric: Role of Nurses in the Implementation of Health Information Systems

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Abstract

The social fabric of healthcare can be seen as a set of cultural ideas and practices and the social patterns and organizations by which they are interpreted. (Janzen, 2002). Nurses are now expected to function well within a technologically advanced healthcare environment, carry out higher-level, complex activities, and are held responsible and accountable for the systematic planning of humanistic nursing care for patients and their families.

Keywords:

organizational culture; nursing informatics; nursing care management

Background

Nurses provide the social glue that holds the organizational culture of a hospital together. The social fabric of healthcare can be seen as a set of cultural ideas and practices and the social patterns and organizations by which they are interpreted. (Janzen, 2002). People interact with each other with elements of trust and meaning that is embedded. These embedded social layers have special consequences in the context of implementation. They are the communication coordinators. The successful implementation of health information systems depends on the weaving and social interplay between nurses and other clinicians.

The role of the nurse is not fully understood in light of implementation of health information systems. The nurse's role in the delivery of patient care is intensified by refinement and modification of the practice of nursing (Hannah, Ball & Edwards, 1996). Nurses are now expected to function well within a technologically advanced healthcare environment, carry out higher-level, complex activities, and are held responsible and accountable for the systematic planning of humanistic nursing care for patients and their families. They are expected to keep abreast of technological implementation within their work environment.

Health information technology functions within a social fabric interacting with other individuals in an organization. Nurses are learning to integrate technology into their respective organizational culture. (Richards, 2001). Nurses shape organizational culture through their actions, bearing, conduct, attitudes, narrative and interactions in relation to others (Cronin & Rawlings-Anderson, 2004) Wolf (1988) delineated two main issues regarding nurses and their work environment. One was the underlying notion of doing good and avoiding harm; the second was that the transfer of cultural knowledge was mainly transmitted by word of mouth and demonstration.

Methods

We have utilized a purposive sample of chief nursing officers from across the US. Then we conducted a series of key informant interviews and focus groups with nursing leaders. These organizations were selected for the sample based on actual productive use/deployment of HIS. Multiple interview formats were used with the key informants. We utilized member checking and peer review to corroborate our findings to help ensure trustworthiness of our analysis. (Crabtree & Miller, 1999).

Observations from interviews.

"Involving nursing in the process allows them to understand, use, and value the technology tools that make a difference between safe care and risky/harmful or work around care."

"Our nursing staff was part of the initial phased roll out of HIS. This built in support system has been a critical factor in driving physician adoption. "The reality is at 2 am who are you going to turn to for answers to the questions… nurses are at the center of care for the patient and can provide the insight to those questions".

Conclusion

Organizational culture is the backdrop for all change processes. Nurses can help implement constructive organizational cultures by weaving a complex social fabric (Wooten, 2003).
Constructive cultures create high-performance work environments, increasing both nurse and patient satisfaction. A constructive culture emphasizes people-centered values through a collective mission and a compassionate patient service-oriented philosophy. Furthermore, constructive organizational cultures create work environments where nurses have positive colleague interactions and approach tasks in a manner that helps improve organizational performance.

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A Basic Study On Application of Voice Recognition Technology to an Electronic Nursing Record System

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Abstract

Computerization of a nursing record has progressed in Japan. However, the present electronic nursing record system using the conventional keyboard operation has some problems such as the input time and operationability for common nurses. In this study, we have planned to introduce voice recognition technology to the system and conducted a basic study for application of the technology. In the present study, a template for a focus chart as a progress record was contrived for simple information entry and easy processing of the entered information. An input experiment for evaluation of the template with the voice input tool was made and it was suggested our method might be useful.

Keywords:

electronic nursing record system, voice recognition technology, information entry, template, focus chart

Introduction

Recently, computerization in the nursing field has been progressing and an electronic nursing record system is gradually introduced in Japan. However, it is not said the present system can increase the time for nursing patients, because information entry for the system must be made by keyboard operation with which a common nurse is not familiar. Therefore, we intended to apply voice recognition technology to the information entry so as to increase in time for nurses to touch patients and improve the quality of nursing by shortening the recording time for an electronic nursing record system. The purpose of this study is to conduct basic investigation for applying a voice recognition tool as substitution of keyboard aiming at construction of the system which is appropriate to the field of nursing practice.

Method

In case of utilizing a voice recognition tool for only input of free sentences like input by using a word processor, it is very difficult to process the entered information. Therefore, we contrived a template for the information entry of an electronic nursing record system by which not only reduction of the input time and improvement of operationability but also easy processing of the entered information can be realized. The object of information entry for the system is fundamental nursing information by using Gordon's health pattern, information of a progress record by using a focus chart of patients and time-dependent record. For the focus chart, we made the template for the "focus", "action" , "data" and "response" in which words and phrases necessary for nursing registered in advance should be uttered by using Dragon Naturally Speaking ™ as a voice input tool. These words and phrases are hierarchically selected from the registered lists and have a dynamic connection to each other. Then, by using the template for the focus chart, a voice input experiment by four nurses as subjects was conducted for proving its utility and the input time, operationability and exactness of the information entry was evaluated.

Result

As the template, we tried to make windows for data of entering a progress record and time dependent record and a list of progress records. Figure 1 shows an example of the window templates for a focus chart as a progress record which is composed of entry items of a focus, data, action, responses etc. An example of a window of focus name selection for a respiratory conditions of a patient is shown in Fig 2. Figure 3 shows an example of the list. We can retrieve items shown in the list.

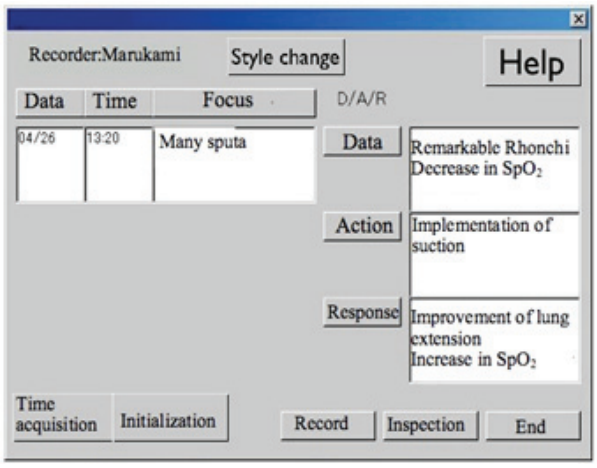

Figure 1 - Example of input screen of focus chart of voice input

We executed the afore-mentioned verification experiment by using the templates compared with keyboard input. The experiment revealed that the input time and operationability of the voice input was superior to the keyboard input although subjects who were nurses had no experience of the voice input. In addition, the misinput rate in the input of the free text part by the voice was 1.5% on the average and the misinput rate became 0% in the input of the selection part (Table1). Furthermore, it was clear that the words and phrases for the focus chart were exactly entered by using the template with the voice input tool.

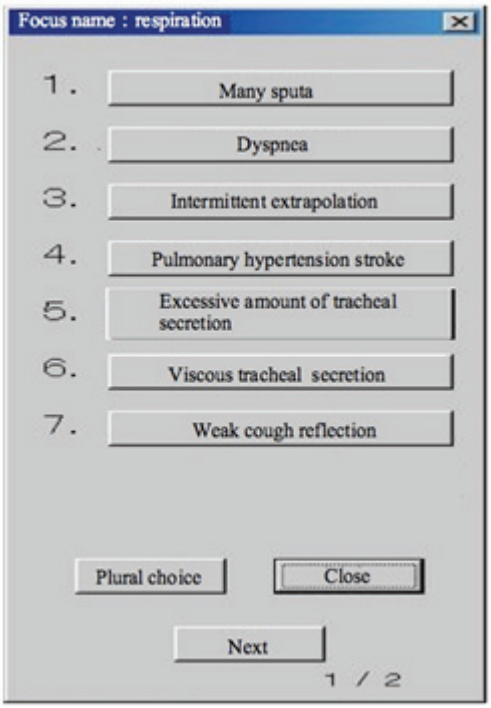

Figure 2 - Window of focus name selection of a respiratory cassification

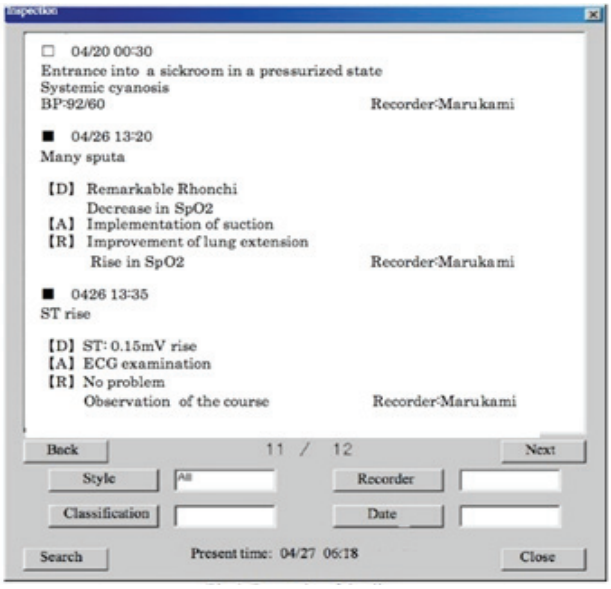

Figure 3 - Example of the list

Table 1- Result of the verification in experiment

Mis-input/Voice (Selective part)	Mis-input/Voice (Free input part)	Input time-Keyboard (Correction time is included)	Input time-Voice (Correction time is included)
0%	3%	520 sec.	155 sec.
0%	1.5%	899 sec.	197 sec.
0%	1%	294 sec.	204 sec.
0%	0.5%	500 sec.	122 sec.
average→ 0%	1.5%	533 sec.	170 sec.

Discussion and conclusion

From the experiment, it was suggested that the voice input using the template made by us was useful for information entry of the system. However, there is room for improvement of the operationability and exactness of the information entry concerning the template. In order to promote a voice input tool for an electronic nursing record system, it should be considered to use the tool together with the conventional keyboard input investigating the characteristics of the nursing field. Nevertheless, this study is thought to be significant, as it is the first trial of applying the voice recognition technology with the template to an electronic nursing record system.

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A Basic study on application of voice recognition technology to an electronic nursing record system

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Introduction

Computerization in the nursing field has been progressing and an electronic nursing system is gradually introduced in Japan.

But

- The present system cannot increase the time for nursing patients.

Because

- Information entry for the system is made by keyboard operation.

Common nurses are unfamiliar with keyboard operation.

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Purpose

We intended to apply voice recognition technology to the information entry of an electronic nursing record system.

To increase in time for nurses to touch patients and improve the quality of nursing by shortening the recording time for the system.

- Purpose of this study : Basic investigation for applying a voice recognition tool as substitution of keyboard.
- Construction of the system suitable for the filed of nursing practice.

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Method

- Contrivance of a template for the nursing record
  - Quick and easy input operation by voice recognition
  - Easy information processing after input
- Patient foundation information
  - Gordon's Health Pattern typology

The nursing record of the object

- Progress record
  - Focus charting
  - Time-dependent record
- Verification experiment
  - The comparison of the input time with the keyboard operation
  - Questionnaire investigation

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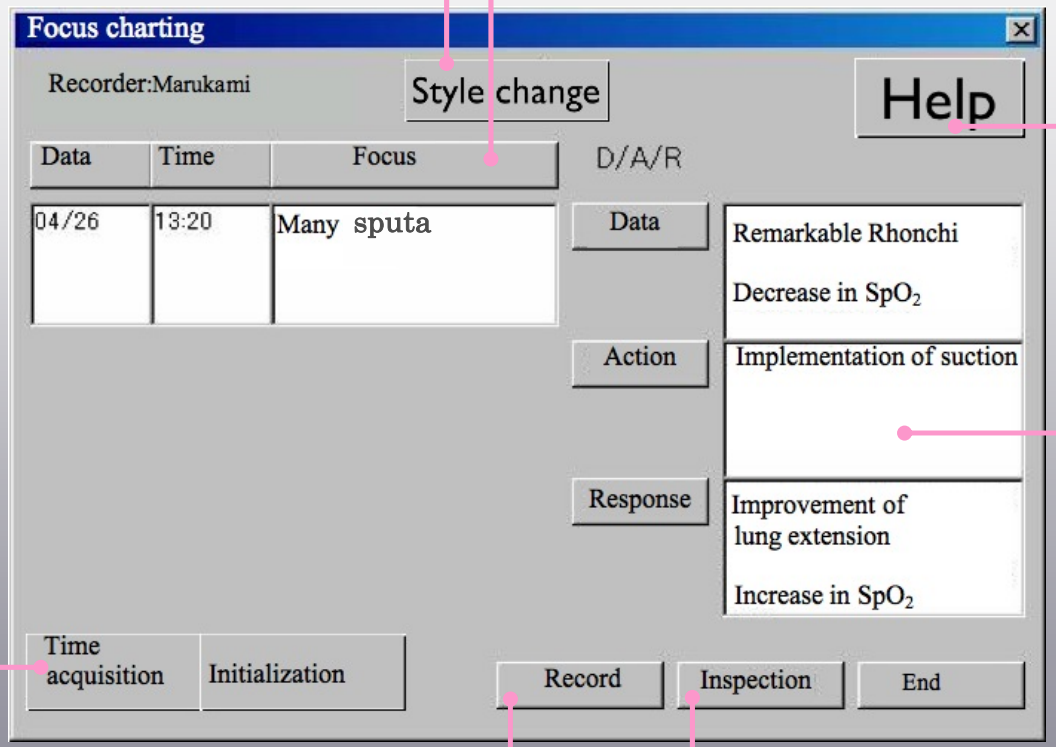
The input screen of the progress record
(focus charting)

The window selection can be made by saying “style change”.
Styles :
①focus charting
②time-dependent record
③summary

Referring to Screen shot 4.



Navigation function.
The next procedure is guided by saying "help."

Referring to Screen shot 4.

The date and the time is automatically entered by saying "time acquisition".

The entered contents are converted to a database by saying “record”.

All the records can be read by saying "inspection".
Referring to Screen shot 4.

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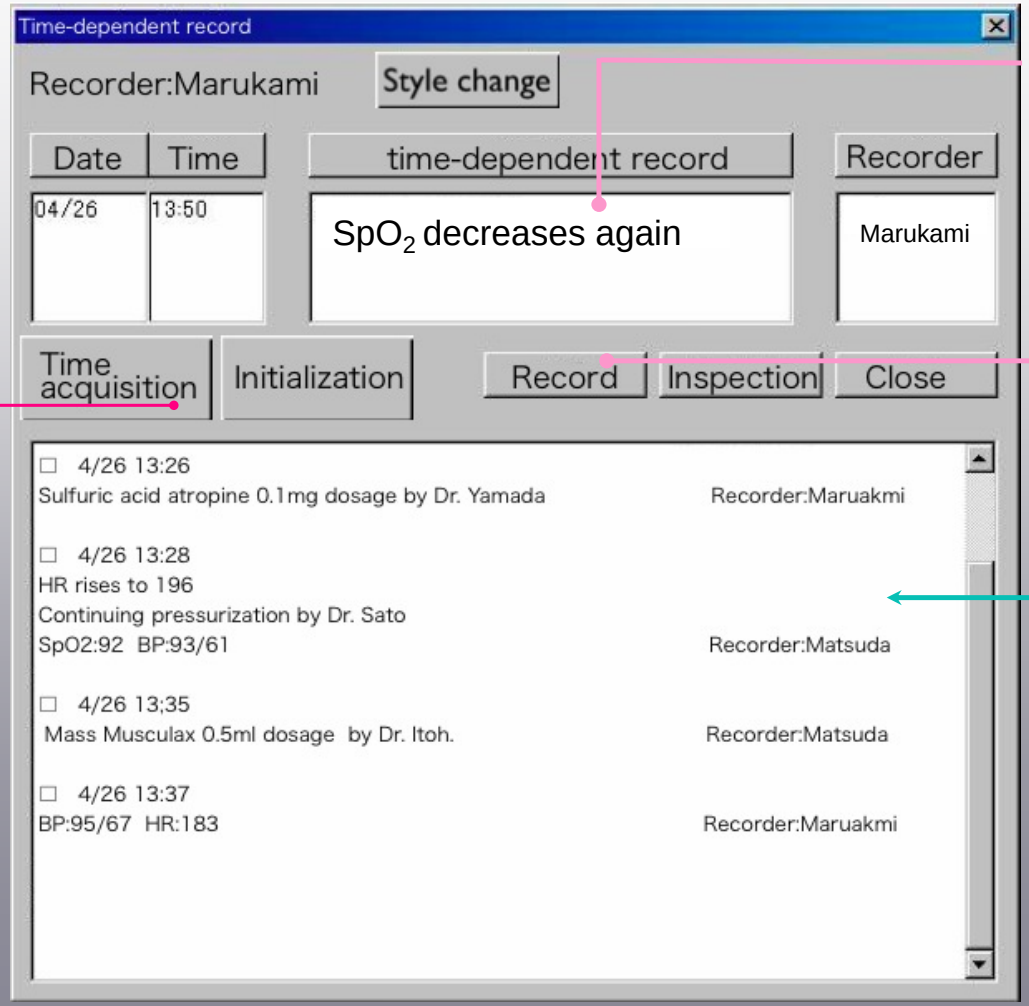
The input screen of the time-dependent record



Right after "time" is said, input of the time-dependent record becomes possible at once.

The date, the time and the name of the recorder is automatically entered by saying "time acquisition".

The content of the record is converted to a database by saying, "Record", and the content of the record is enumerated under the window in detail.

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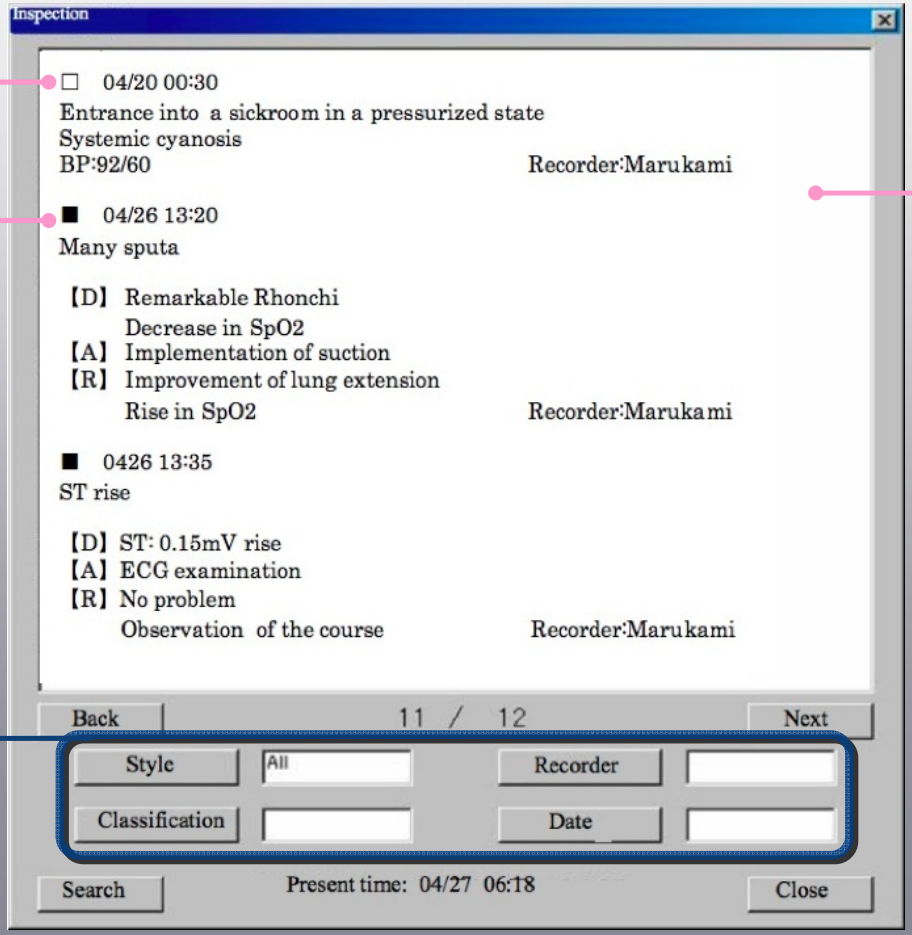
A display and a search of the record

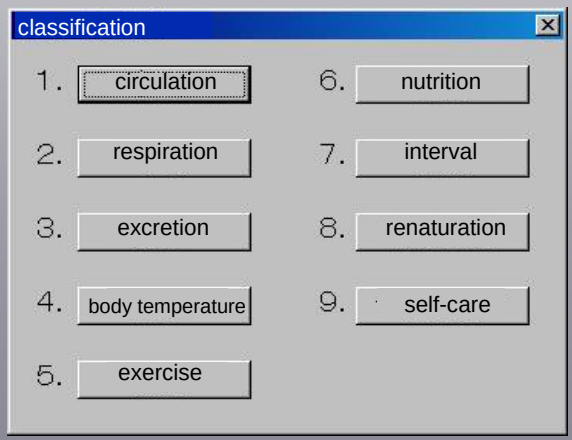
input screen of focusing or time-dependent record, this window is indicated by saying "inspection".

"□" should be inserted before showing the time-dependent record.
"■" should be inserted before showing the focus charting.



In default, the patient's latest record is indicated.

A record can be referred by the voice of keywords, "style", "classification", "recorder" and "date". When each keyword is given, the selection window is indicated except for the date.



An example of selection window

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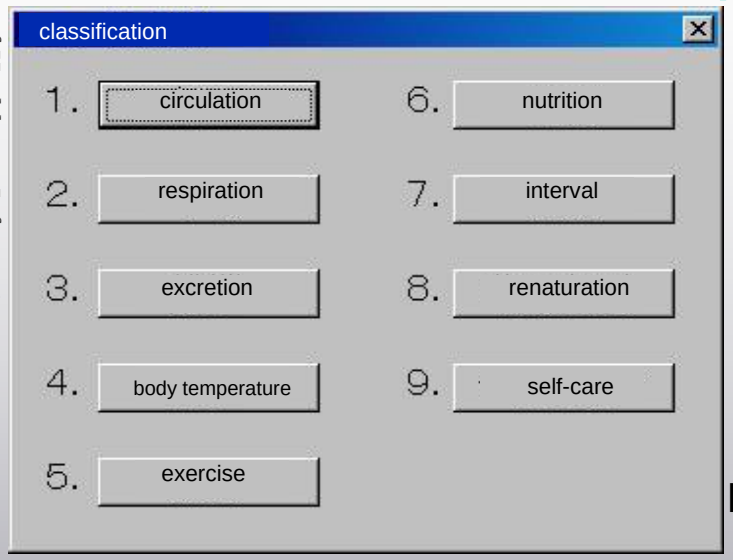
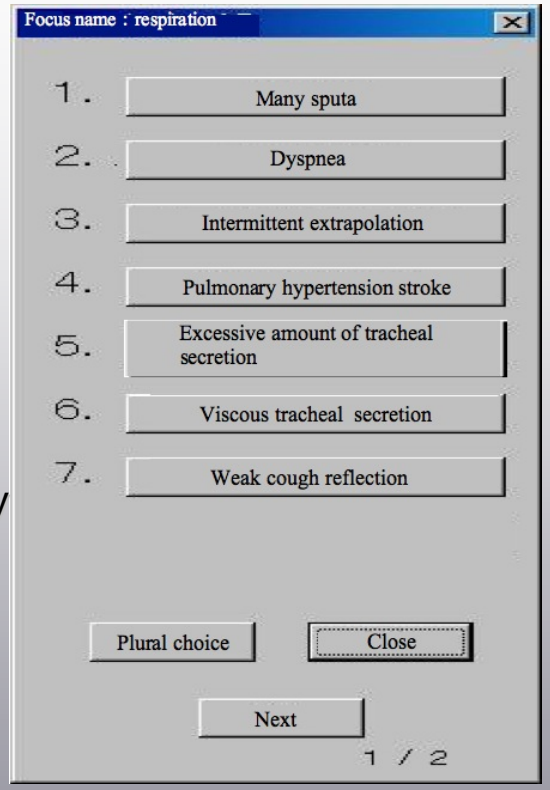
An example of the selection window



hierarchially



- Item selection is able to be made by saying not only the name of item (keyword) but also the number of the corresponding item.

- In the input window of focus charting, the selection window of classification is indicated first by saying "focus".

- An item is entered with a voice of the corresponding item with visual observation under the condition of the active window.

- The window of the classification is hierarchially linked with the focus name window.
- The window is indicated by saying “action”.

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Results of the verification experiment

	Mis-input/Voice (selective part)	Mis-input/Voice (Free input part)	Input time/Keyboard (correction time is included)	Input time/Voice (correction time is included)
subject 1	0%	3%	520 sec.	155 sec.
subject 2	0%	1.5%	899 sec.	197 sec.
subject 3	0%	1%	294 sec.	204 sec.
subject 4	0%	0.5%	500 sec.	122 sec.
average→	0%	1.5%	533 sec.	170 sec.

Touch typing

Usability→ keyboard ＜ Voice recognition

by questionnaire investigation

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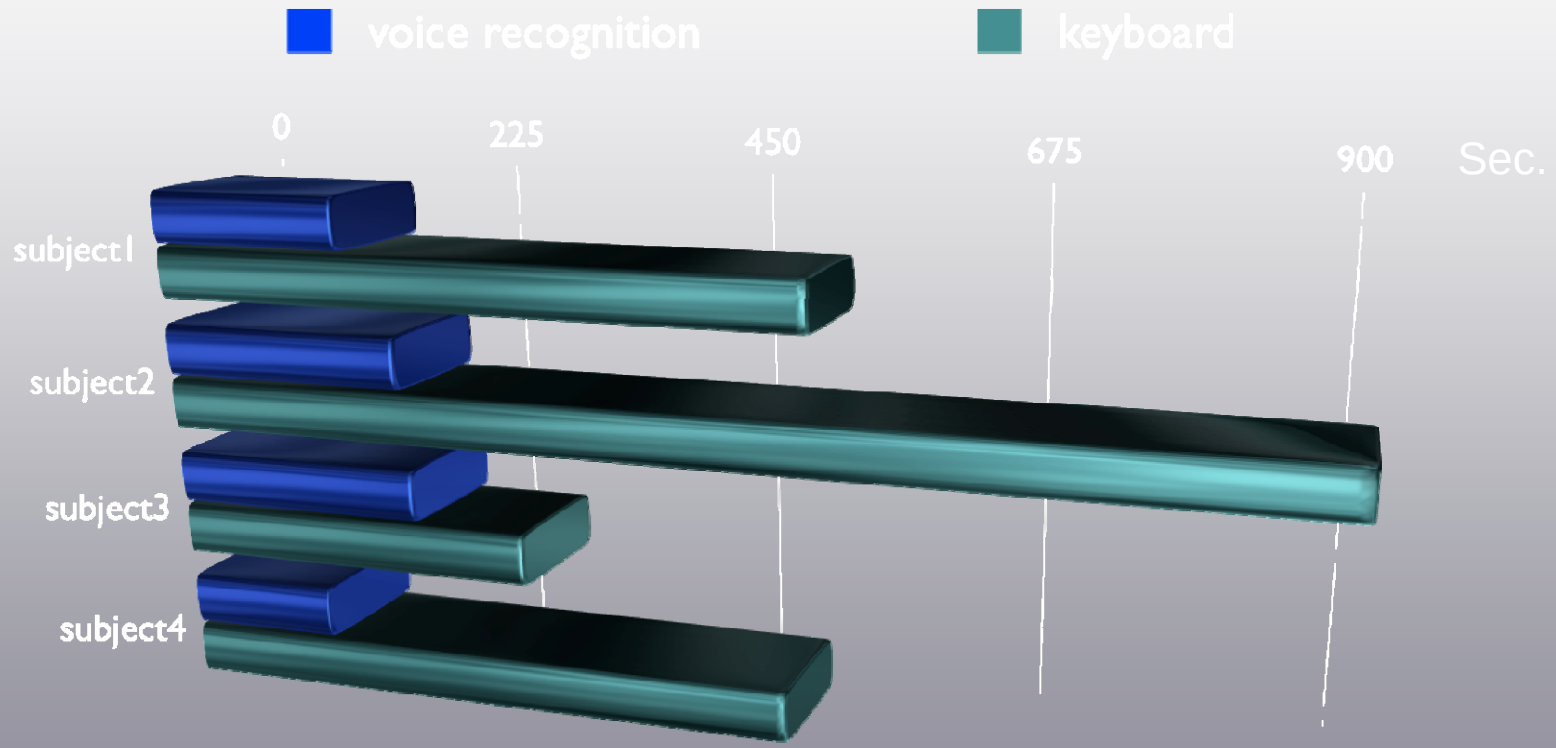
Result 2

Comparison of input time between voice recognition and keyboard operation.



- Subjects are nurse.
- Touch typing is possible by two people.

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Discussion and Conclusion

From the experiment, it was suggested that the voice input using the template made by us is useful for information entry of the system.

- However,
  there is room for improvement of the operationability and exactness of the information entry concerning the template.
- In order to
  promote a voice input tool for an electronic nursing record system, it should be considered to use the tool together with the conventional keyboard input investigating the characteristics of the nursing field.
- Nevertheless,
  this study is thought to be significant, as it is the first trial of applying the voice recognition technology with the template to an electronic nursing record system.

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A feasibility study of constructing electronic nursing record with nursing clinical pathway

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Abstract

The purpose of this study is to analysis and to develop a well-defined electronic nursing record system integrated with nursing clinical pathway for improving the proficiency and accuracy in nursing process. We try to distinguish three major factors which is schema, terminology, and working flow will figure out how to and what to construct a well-defined electronic nursing record system integrated with nursing clinical pathway.

Keywords: electronic nursing record, nursing clinical pathway

Introduction

The health insurance policy such as Diagnosis Relationship Group (DRG) and global budget always changes and influence clinical care style in Taiwan recently. Thus, the Clinical pathway gradually becomes a major care index for nursing care. [1]

Clinical pathway is a standard style for specify disorder that examination, treatment, nursing care, and health education since patient admission through discharge.

In Taiwan, there are 55 clinical pathways guiding support clinical practice in Medical, Surgical, Cardiologic, Obstetric, Urologic, Ophthalmologic, Orthopedics, and Pediatric department. [2] But many formats duplicate between clinical pathway records and nursing records. It makes double working for nurse in these records. Although computerize nursing record is develop for many hospitals, But defect the same style and couldn't to exchange for share patient's data and knowledge management. Therefore, it is importance for analysis and constructs well-defined electronic nursing record integrated with nursing clinical pathway.

Method

There are three ways for this feasibility study.

First, we will analysis some references by the PubMed and local database related to clinical pathway in policy, format, and information system were discussed. It will figure out what are important factors to construct a well-defined electronic nursing record system.

Second, we will collect information and problem about nursing clinical pathway in clinical practice by

questionnaire of 17 medical centers. It will figure out what are implication and limitation about integrate to electronic nursing record.

Finally, we will combine previous methods to integrate with standard of electronic health record such as Health Level 7(HL7) and Clinical Document Architecture (CDA), North American Nursing Diagnosis Association (NANDA), International Classification for Nursing Practice (ICNP), Nursing Intervention Classification (NIC), and Clinical Care Classification (CCC). It will become the three major factors which are schema, terminology, and working flow. We hope to figure out how to and what to construct a well-defined electronic nursing record system integrated with nursing clinical pathway.

Future works

To develop nursing care plan is helpful for personal interaction with in environment to got health. When set a nursing diagnosis will decide what nursing intervention to use. That is potential contribution of nursing diagnosis. [3]

Under challenge in DRG, nursing care model will toward to case management style. Therefore, the nursing care planning system will base on case management. Such as Clinical pathway that clarify important exam, treatment, health education, and care plan in everyday from patient admission through discharge. [4]

We had proposed to build a comprehensive ENR system based on the creative thinking model last year. [5] Therefore, a well-defined electronic nursing record system integrated with nursing clinical pathway is an important step and could more fit other information systems. We hope to create this research idea that will bring a new trend to the development of nursing informatics in Taiwan.

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Development of a Web-Service PrototType for Blood Bank Product Management According to the ISBT 128 Standard

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Abstract and objective

The aim of this project was the development of an ISBT 128 compliant prototype of interface descriptions, in Web Service Definition Language (WSDL), for Blood products management. ISBT 128 sets a global standard for the identification, labeling, and information processing of human Blood, Tissue and Organ products across international borders and disparate health care systems, and WSDL is an XML format for describing network services as a set of endpoints operating on messages containing either document or procedure oriented information. The web-services for Blood-Bank management of the developed system are grouped in Donation Centre, Laboratory, Transportation and Storage, and Hospital Services, according to the pending organizational reform in the Blood-Bank network in Greece, and the system is presently running successfully in a web environment in our laboratory.

Keywords:

ISBT 128, Blood Bank, web services

Introduction

ISBT 128 sets a global standard for the identification, labeling and information processing of human Blood, tissue and organ products across international borders and disparate health care systems. The standard has been designed to ensure the highest levels of accuracy, safety, and efficiency for the benefit of donors, patients and official ISBT 128 licensed facilities worldwide. The aim of this project was the development of an ISBT 128 compliant prototype of interface descriptions, in Web Service Definition Language (WSDL), for Blood products management. In the following, the approach of these tasks will be described in details.

The ISBT 128 compliant prototype of interface descriptions in WSDL

The developed Web service is a software system designed to support interoperable machine-to-machine interaction over a network. It has an interface that is described in a machine process able format such as WSDL. Other systems may interact with the Web service in a manner prescribed by its interface, by employing appropriate messages. These messages are typically conveyed using HTTP, and normally comprise of XML in conjunction with other Web-related standards.

Table 1 - The ISBT 128 specified entities of the developed web service system

Item	Description
1	A donation numbering system that ensures globally unique identification.
2	The information to be transferred, using internationally agreed reference tables.
3	An international product reference database.
4	The data structures in which this information is placed.
5	A bar coding system for transfer of the information on the product label.
6	A standard layout for the product label.
7	A standard reference for use in electronic messaging.

Software applications written, first, in various programming languages, and second, running on various platforms can use the web services, in order to exchange data over computer networks and over the Internet. The web services for Blood Bank management comprise of first, the Donation Centers Services, second, the Laboratory Services, third, the Transportation and Storage Services, and finally, the Hospital Services.

The ***Donation Centre Services*** group includes the Personal Data, Donation Data, Label and Transportation Services. The Personal Data Service registers the personal data of the donor, his medical history, and the examination results before the donation, and assigns a new Donor ID, according to the ISBT128 rules. The Donation Data Service assigns a new Donation ID and stores the Blood product type, the determined Blood group, the donor ID, the collection date and time, the container manufacturer catalogue number and LOT, and the Staff ID. The Label Service returns the ISBT128 codes for the labels on the container. The Transportation Service stores the data of the Blood product carrier, its destination, and forwards the Donation Data to the Transportation and Storage Services Group Server.

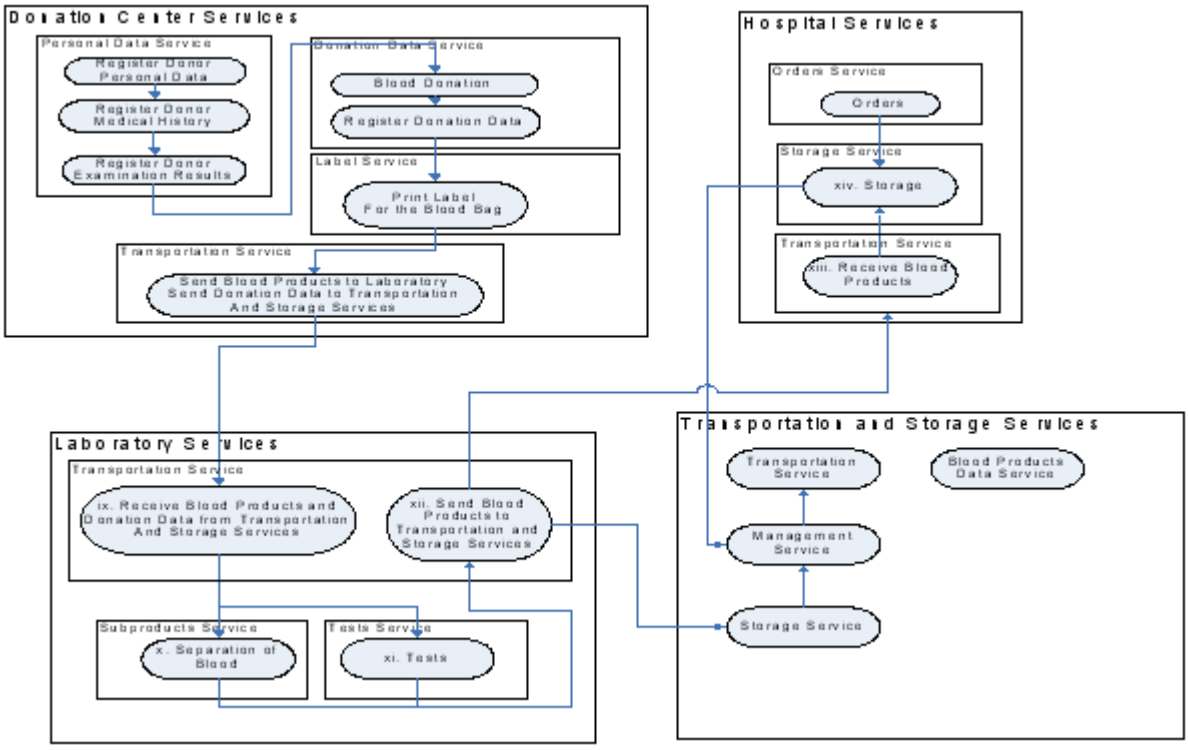

Figure 1: Schematic representation of the proposed work flow of a typical Blood Donation Centre.

The ***Laboratory Services*** group comprises of the Transportation, the Sub products, and the Tests Services. The Transportation Service records the incoming and outgoing Blood products, receives the donation data, and updates the Storage Services Group Server for the availability of Blood products. The Sub-products Service records, which products have been extracted from each donation. The Tests Service records the results of the Antigens tests, and of the HIV, HBV, HCV, HTLV, RPR etc. tests. The ***Transportation and Storage Services*** group runs the Transportation, Blood Products Data, Storage, and Management Services. The Storage Service provides information about the transportation availability of Blood products, from the Laboratory or from one hospital to another. The Blood Products Data Service stores the all the information about Blood products based on the Donation ID. The Management Service checks the availability of Blood products, administrates the orders, and manages the final destinations of the products. The Transportation Service stores the information of the number of Blood products are on their way, and the estimated transportation time. The ***Hospital Services*** group includes the Order, Storage and the Transportation Services. The Order Service takes orders for direct donation from the client program of the physicians in charge. The *Storage Service* manages the Blood products available in the Hospital and forwards the Orders to the Management Service of the Transportation Group. Finally, the Transportation Service stores the information of the overall Blood product movements.

Concluding remarks

The Hospital Blood-Banks in Greece are presently working almost quite independently from each other, they employ their own work-flow and the corresponding software from different vendors and it is rather difficult to find out the availability of Blood products. The developed system covers an existing managerial gap, by proposing a standard way of information and products exchange, between Blood processing and transfusion points, fully complying with ISBT128, 2002/98/EC and HL7. We have implemented one possible scenario of the pending organizational reform in the Blood-Bank network in Greece, however, the Donation Centre, Laboratory, Transportation and Storage, and Hospital Services grouping approach, allows for, the fast redesign of the system, in order to be easily adapted, to the final decisions of the Ministry of Health, to be made in the future. The system is presently running successfully in a web environment in our laboratory, and the next stage under development, will attempt to extend international consistency to support the transfer,

transfusion or transplantation, beyond the Blood, of cell and tissue products, according always to the ISBT 128 standard.

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Development of a Web-Service Prototype for Blood Bank Product Management according to the ISBT 128 Standard

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The aim of this project

- The aim of this project was the development of an ISBT 128 compliant prototype of interface descriptions, in Web Service Definition Language (WSDL), allowing for network based blood products management.
- ISBT 128 sets a global standard for the identification, labelling, and information processing of human blood, tissue and organ products across international borders and disparate health care systems.
- WSDL is an XML format for describing network services as a set of endpoints operating on messages containing either document or procedure oriented information.

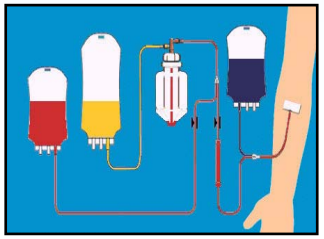
The web-services for Blood-bank management

- The web-services for Blood-bank management of the developed system are grouped in:
  - *Donation Centre.*
  - *Laboratory.*
  - *Transportation and Storage.*
  - *Hospital Services.*

  according to the pending organizational reform in the Blood-bank network in Greece.
- The system is presently running successfully in a web environment in our laboratory.

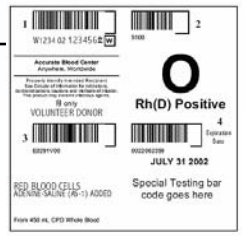
Properties of the system

- The developed Web service is a software system designed to support interoperable machine-to-machine interaction over a network.
- It has an interface that is described in a machine process able format such as WSDL.
- The features of the system comply with the ISBT 128 entities.
- Other systems may interact with the Web service in a manner prescribed by its interface, by employing appropriate messages.

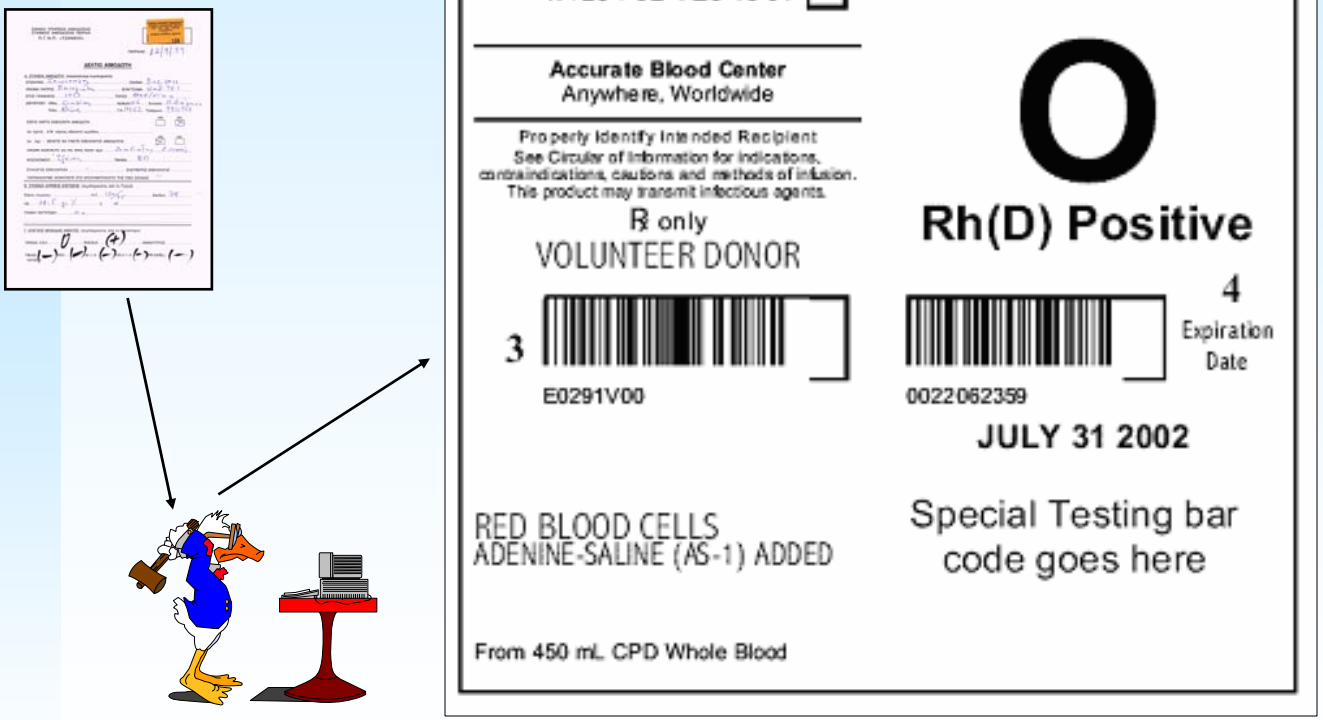


The ISBT 128 specified entities of the developed Web service system

Item	Description
1	A donation numbering system that ensures globally unique identification.
2	The information to be transferred, using internationally agreed reference tables.
3	An international product reference database.
4	The data structures in which this information is placed.
5	A bar coding system for transfer of the information on the product label.
6	A standard layout for the product label.
7	A standard reference for use in electronic messaging.



A typical ISBT 128 Label for red cells



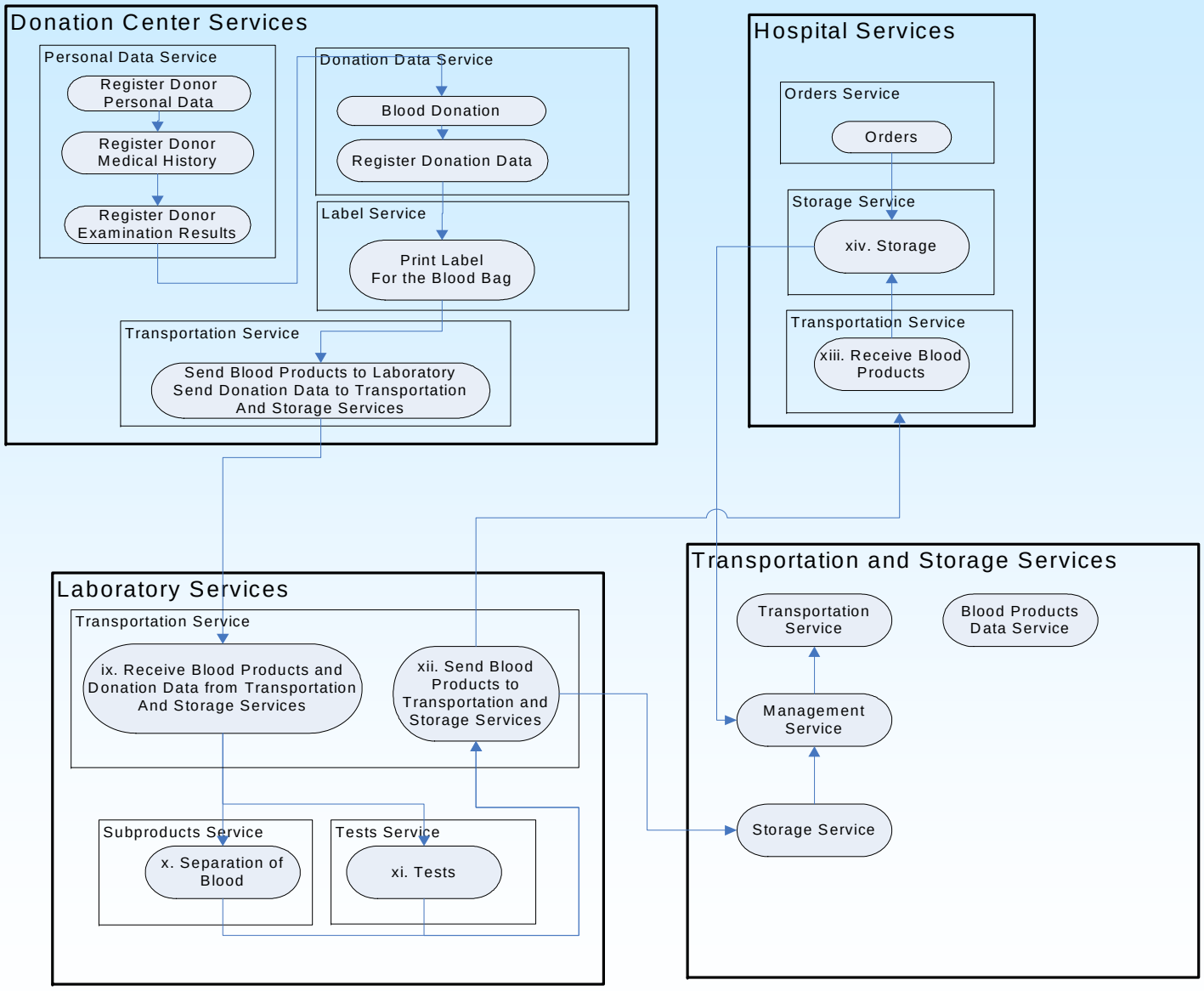
Structure of the Web services

- These messages are typically conveyed using HTTP, and normally comprise of XML in conjunction with other Web-related standards.
- Software applications written:
  - *First, in various programming languages.*
  - *Second, running on various platforms*

  can use the web services, in order to exchange data over computer networks and over the Internet.
- The web services for blood bank management comprise of:
  - *First, Donation Centres Services.*
  - *Second, Laboratory Services.*
  - *Third, Transportation and Storage Services.*
  - *Fourth, Hospital Services.*

Schematic representation of the outline of the developed web-services

Donation Centre Web services provided	**Laboratory** Web services provided	**Transportation & Storage** Web services provided	**Hospital** Web services provided
Personal Data	Transportation	Transportation	Ordering
Donation Data	Sub products	Blood Products' Data	Storage
Label	Tests	Storage	Transportation
Transportation		Management	


Donation Center Services
Personal Data Service
Register Donor Personal Data
Register Donor Medical History
Register Donor Examination Results
Donation Data Service
Blood Donation
Register Donation Data
Label Service
Print Label For the Blood Bag
Transportation Service
Send Blood Products to Laboratory
Send Donation Data to Transportation And Storage Services
Hospital Services
Orders Service
Orders
Storage Service
xiv. Storage
Transportation Service
xiii. Receive Blood Products
Laboratory Services
Transportation Service
ix. Receive Blood Products and Donation Data from Transportation And Storage Services
xii. Send Blood Products to Transportation and Storage Services
Subproducts Service
x. Separation of Blood
Tests Service
xi. Tests
Transportation and Storage Services
Transportation Service
Blood Products Data Service
Management Service
Storage Service

The Donation Centre Services and the Laboratory Services groups

- The ***Donation Centre Services*** group includes the Personal Data, Donation Data, Label and Transportation Services.
- *The Personal Data Service* registers the personal data of the donor, his medical history, and the examination results before the donation, and assigns a new Donor ID, according to the ISBT128 rules.
- *The Donation Data Service* assigns a new Donation ID and stores the blood product type, the determined blood group, the donor ID, the collection date and time, the container manufacturer catalogue number and LOT, and the Staff ID.
- *The Label Service* returns the ISBT128 codes for the labels on the container.
- *The Transportation Service* stores the data of the blood product carrier, its destination, and forwards Donation Data to the Transportation & Storage Services Group Server.

- The ***Laboratory Services*** group comprises of the Transportation, the Sub products, and the Tests Services.
- *The Transportation Service* records the incoming and outgoing blood products, receives the donation data and updates the Storage Services Group Server for the availability of blood products.
- *The Sub products Service* records, which products have been extracted from each donation.
- *The Tests Service* records the results of the Antigens tests, and of the HIV, HBV, HCV, HTLV, RPR etc. tests.

Transportation and Storage Services and Hospital Services groups

- The ***Transportation and Storage Services*** group run the Transportation, Blood Products Data, Storage, and Management Services.
- The *Storage Service* provides information about the transportation availability of blood products, from the Laboratory or from one hospital to another.
- The *Blood Products Data Service* stores the all the information about blood products based on the Donation ID.
- The *Management Service* checks the availability of blood products, administrates the orders, and manages the final destinations of the products.
- The *Transportation Service* stores the information of the number of blood products are on their way, and the estimated transportation time.
- The ***Hospital Services*** group includes the Order, Storage and the Transportation Services.
- The *Order Service* takes orders for direct donation from the client program of the physicians in charge.
- The *Storage Service* manages the blood products available in the Hospital and forwards the Orders to the Management Service of the Transportation Group.
- Finally, the *Transportation Service* stores the information of the overall blood product movements.

Concluding Remarks

- The developed system covers an existing managerial gap, by proposing a standard way of information and products exchange, between blood processing and transfusion points, fully complying with ISBT128, 2002/98/EC and HL7.
- We have implemented one possible scenario of the pending organizational reform in the Blood-bank network in Greece; however, the Donation Centre, Laboratory, Transportation and Storage, and Hospital Services grouping approach, allows for, the fast redesign of the system, in order to be easily adapted, to the final decisions of the Ministry of Health.
- The system is presently running successfully in a web environment in our laboratory, and in a next stage, we will attempt to extend international consistency to support the transfer, transfusion or transplantation, of cell and tissue products, according always to the ISBT 128 standard.

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Differences in Nursing Time Spent Performing Work by Task Category Between Intensive Care Units With and Without Computerized Provider Order Entry

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University of Wisconsin and Cerner Corporation, USA

Abstract

Previous studies of the impact of information technology have primarily focused on the impact of systems designed for use by the nursing staff, primarily documentation systems. This article focuses on the changes in nursing tasks between the medical and cardiac intensive care units of two hospitals. One hospital's two intensive care units (ICU) have computerized provider entry (CPOE) installed, while the other hospital did not installed CPOE in the two intensive care units studied.

Methods: Direct observation of nurses as they performed nursing tasks was conducted using work sampling technique. Observations were performed over ten 3-hour periods in each hospital. The data collected included the task being performed and the duration of each task performed by the nurse.

Results: The amount of time nurses spent conducting certain types of tasks was different between the two hospitals. Nurses in the ICUs with CPOE installed spent more time performing education and housekeeping tasks at the patient bedside. Nurses in the ICUs without CPOE installed spent more time on nursing documentation. Time spent performing personal and administrative tasks remained the same in both sites.

Keywords:
CPOE, nursing work, work sampling, activity theory

Introduction

Nursing has been described as job that involves considerable coordination and management of the patient care [1]. Previous studies examining the impact of information technology on nursing work have primarily been conducted upon the implementation of clinical documentation in an inpatient setting [2-5]. Nursing work has been described by the researchers as having different categories of tasks, including documenting or charting,, and patient care [2], with orders considered part of the charting activities of the nurse. The impact of these systems has been studied because there is a possibility that a change in the method of performing a task, for instance changing from documenting on paper to documentation on a computer, may impact the time available to perform patient care.

There has been a recent impetus toward implementing computerized provider order entry (CPOE) in the inpatient hospital setting. The primary drivers to the implementation of CPOE include increased patient safety [6] and private corporate pressure [7]. It has been proposed the implementation of CPOE will result in decreasing errors in medication order entry [8]. Although 9.6% of hospitals in the United States claim to have implemented CPOE, only 46.2% of these hospitals require use of the CPOE system by the physician [9]. Computer-based order review and order coordination result in nurses being indirect users of the CPOE system.

Nurses are also the direct users of CPOE system, by transcribing physician orders written by the physicians on paper into the CPOE system and entering verbal and telephone orders for future cosigning by the physician. Understanding the impact the implementation of CPOE would have on nursing work would enable clinical informatics and nurse managers to understand how to prepare clinical nurses for the change the implementation will bring to the work in the ICU.

With the current nursing shortage, the burden the working nurse performs under, and the increasing impetus to install CPOE systems, it is necessary to understand whether this system changes the work nurses perform to insure the implementation does not increase the workload of these nurses. Decreasing nursing time with the patient has the potential to negatively impact patient outcomes.

The Activity Theory, a structural theory of work having six concepts that could impact the work and the worker, was used to define the study. These concepts include the task, the environment, the organization, the worker, the role of the worker, and the technology being used to perform the task. Only a selected set of results are discussed here that pertains to the tasks the nurses performed.

Methods

Sample and site

The researcher observed nurses as they performed their work in two intensive care units located in two different sites. The first site did not have CPOE installed. This site was a large academic medical center in the upper Midwest. The medical ICU contained 24 beds and the cardiac ICU

had 8 beds. The nurse patient ratio was 1:1 or a maximum of 1:2.

The CPOE site was a large academic medical center in the southern eastern seaboard. The medical ICU contained 12 beds and the cardiac care unit contained 16 beds. Both hospitals had an all-registered nurse staff.

Permission was obtained from both hospitals institutional review board to conduct the study. Additionally, the medical directors, nurse managers, and clinical informatics personnel were informed of the study and permission was requested and granted to approach and observe the clinical nurses in the ICU.

Ten clinical nurses were observed at each site for a total of twenty nurses observed performing their work. The researcher followed the ten clinical nurses while they performed their work during a three-hour observation period during their normal workday.

Data collection

All tasks the nurses performed were entered into a computer-based instrument. The instrument consisted of 65 separate tasks divided into 11 different task categories (Table 1). The instrument was derived from an instrument used to observe nursing work in the ICU in earlier research [10]. Task categories included documentation, assisting, conversations, manual tasks, housekeeping, personal tasks, teaching/learning tasks, administrative, observational, conversational, transportation, and miscellaneous tasks. The instrument was developed with the cooperation of Dr. Matthew Weinger of the University of Vanderbilt. The instrument was reviewed by clinical nurses and nurse informaticians at a large Midwest University hospital to insure all the appropriate tasks were included. The instrument was installed on a tablet personal computer for use during the observations.

The instrument allowed the researcher to note the order of the tasks, the duration of the tasks and the number of instances of the tasks that were performed during each observation period. The instrument supported the ability to collect simultaneously performed tasks as well as tasks that were performed consecutively. Notations could also be made on the instrument by the observer. The eleven task categories were divided based on specific criteria shown in Table 1.

Table 1: Task category definitions

Task Category	Description
Manual	Care tasks provided to the patient at the patient bedside
Housekeeping	Cleaning tasks in the patient room or bed area
Transportation	Moving the patient
Observational	Looking at the patient or patient monitoring devices, but not performing care tasks
Documentation/ Reading	Reading or writing on the electronic or paper chart
Conversational	Talking to another caregiver
Assistance	Helping another caregiver perform work
Administrative	Performing schedules, email etc.
Teaching/Learning	Performing education for the patient or family
Personal	Taking a break away from patient care
Miscellaneous	Any task not easily categorized

Method

Observations were performed over a 14 day period. Each observation period lasted approximately three hours with observations conducted during both night and day 12-hour shift during the week and the weekend. Informed consent was obtained from the observed nurses before the observation was begun. Patients and family under the care of the nurse were informed of the research and were given the option to end the observation. No family or patient asked for the observation to end. No patient data was collected at any time.

Each task the nurse performed was selected on the instrument. Each observation period resulted in a text file consisting of the tasks, notations made by the researcher, task start times and task duration. The file was saved to the tablet hard drive. The text file was converted to a Microsoft Excel© file to enable data review and analysis.

Data analysis

Upon completion of the data collection, twenty files were available for analysis. Each file contained information about one observation period. Ten files were from observations performed in the ICUs with CPOE implemented; ten files were from observations from the ICUs without CPOE implemented. The tasks were aggregated into the eleven task categories. The percentage of time spent performing each task was calculated. Additionally, the percentage of time spent in each task category was calculated. A comparison of the means of the task categories of

the observations performed in the ICU with CPOE implemented and the means of the task categories of the observations performed in the ICU without CPOE implemented was performed.

Results

Table 2 shows the total time of observation at each site and total time spent performing each task category.

Table 2 - Observed time in minutes

Task Category	Non-CPOE	CPOE
Manual	635.20	637.15
Housekeeping	31.03	49.30
Transportation	3.18	6.62
Observational	5.80	62.40
Documentation/Reading	427.48	322.42
Conversational	671.22	490.87
Assistance	12.78	35.60
Administrative	46.85	57.60
Teaching/Learning	54.78	71.23
Personal	16.82	84.13
Miscellaneous	20.92	53.95
Totals	**1926.07**	**1871.27**

The percent of time the nurse spent performing tasks in the different categories in the ICUs for the non-CPOE hospital is illustrated in Figure 1.

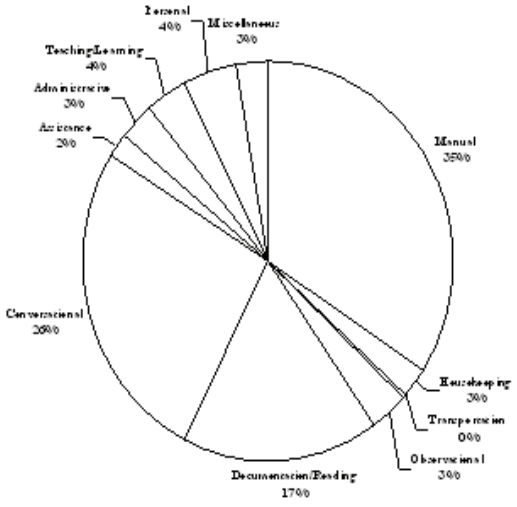

Figure 1- Percentage of work by Task Category in ICUs of non-CPOE hospital

The same task categories of nursing work obtained from the observations in the ICUs of the hospital where CPOE was installed are presented in Figure 2.

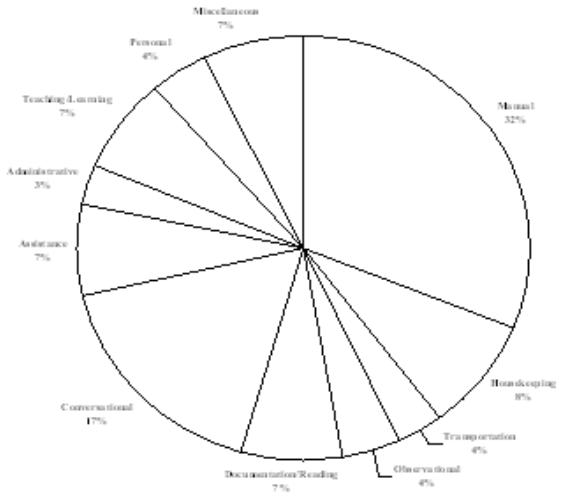

Figure 2 - Percentage of work by Task Category in ICUs of hospital with CPOE

Figure 2 above has larger sections than the equivalent sections of Figure 1; indicating more time performing housekeeping tasks, manual patient care tasks, and observing the patient, implying the nurses had more available time when CPOE was installed. Additionally, the nurses spent less time than in the non-CPOE site documenting, conversing with other clinicians, and on miscellaneous tasks.

Table 3 illustrates the percentage of time nurses spent performing work in each task category. Statistical significance was evaluated for each task category.

Task Category	Non-CPOE	CPOE	Significance
Manual	30.55	34.29	>0.05
Housekeeping	1.50	2.64	>0.05
Transportation	0.33	0.32	>0.05
Observational	0.39	3.34	>0.00
Documentation/Reading	21.25	17.38	>0.05
Conversational	35.59	26.05	>0.05
Assistance	0.63	1.83	>0.05
Administrative	2.13	2.89	>0.05
Teaching/Learning	2.63	3.86	>0.05
Personal	0.78	4.57	>0.05
Miscellaneous	4.23	2.82	>0.05
Totals	100.00	100.00	

Table 3 - Percentage of time worked by task category

Discussion

As Murphy points out, nursing is performed as part of a complex system [1]. A change in this complex system has the potential to increase nursing workload and burden for an already heavily burdened worker. The implementation of CPOE does have an impact on nursing work. The consequences of that impact have not been closely examined at this time. Because CPOE has not yet been implemented widely, although according to Ash there are many hospitals considering or beginning to implement this innovation [9], now is the opportune time to better understand the impact these systems will have on nursing.

The consequences of the additional time available to the nurse to perform manual patient care tasks and education/ learning tasks are also not clearly understood. It is assumed there would be improved patient outcome, however further research may be needed to verify this hoped for result of the implementation of CPOE.

Another area not understood that this study illustrates is the impact of decreased time spent on documentation/reading and conversing with other clinicians. The decrease of time spent in these tasks does not reflect the quality of the communication. Further research is needed to discover if less documentation and communication equates with better information communicated and if the communication results in a clear understanding of the patient care needs.

Conclusions

The results indicate there is a significant difference in the way nurses in an ICU utilizes the time at work. The impact of the implementation of CPOE on the division of time a nurse spends performing tasks would, at first, seem to show the nurses job tasks change with this information technology change. The nurse spends less time on work related to supportive tasks such as documentation and conversing with clinicians and more time performing manual and observational work at the patient bedside. The implementation of any information technology, even when not primarily designed for use by the nurse, should be examined to determine the possible impact the new system could have on the nurse.

Acknowledgements

The author would like to thank Dr. Patricia Flatley-Brennan and the professionals in the University of Wisconsin – Madison HealthSystem Laboratory.

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Development of a PDA-based Minimum Data Set for the Screening and Management of Type 2 Diabetes Mellitus in Primary Care

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Abstract

The ultimate goal of this project is to develop an informatics practice model in primary care to enhance evidence-based practice (EBP) by increase advanced practice nurse (APN) students' informatics competencies. This abstract describes a process of development of a PDA-based minimum data set (MDS) for the Screening and Management of Type 2 Diabetes Mellitus (DM) in primary care.

Keywords:
primary care, diabetes, minimum data set, PDA

Introduction

Past projects had been successfully developed in which informatics students had worked with APN students to develop their capstone projects that reflect the combined expertise of the informatics students and the APN students.[1] In the U.S., about 20.8 million people have diabetes, and surprisingly 30% of those are not aware that they have diabetes until they have developed this chronic condition that requires long-term management.[2] Based on the success of the collaborative projects, faculty from informatics and adult primary care, diabetes educators, and 3 APN students were involved with the development of the MDS for the screening and management of Type 2 DM to promote the delivery of EBP in primary care.

Methods

Literature on primary care database was extensively searched and retrieved in the U.S., the U.K. and Canada. The team basically considered the clinical practice guideline (CPG) recommended by the American Diabetes Association (ADA),[2] the Diabetes Continuing Care Reference Dataset (DCCRD)[3] published by the Primary Care Information Service (PRIMIS),[4] nursing minimum data sets (NMDS) published,[5] and additional indicators that meet the federal health indicators for this project.

Results

The following 4 modifiers- Assess, Care, Teach, and Manage- of the Clinical Care Classification (CCC) System[6] were used as a framework for nursing interventions of Type 2 DM (Figure 1)

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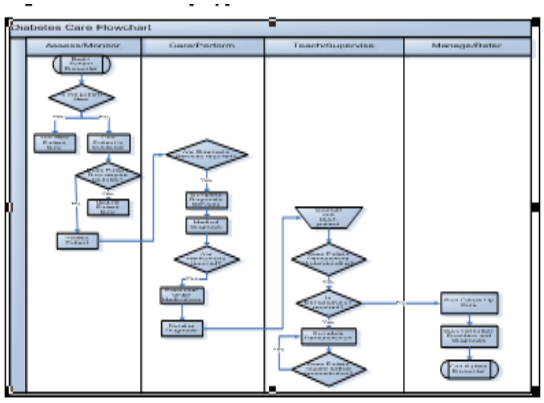

. Figure 1 Flowchart of Type II diabetes care

Figure 2 shows part of the PDA screen shots based on the MDS developed.

Figure 2 - PDA Screen shots of the PDA-based Minimum Data Set developed

Conclusions

Ultimately, this data set will be served as a research repository for future EBP planning in primary care. In

addition, this collaborative approach has resulted in the increase of informatics competencies for both APN students as well as faculty in various specialties.[1]

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Acknowledgments

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The Cognitive Work of Nursing

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Abstract

To build effective and sustainable health care systems, the design of these systems must be informed by an accurate understanding of how healthcare workers do their jobs. We show how we used this technique to develop requirements for a mobile decision support system for telephone triage. Finally we discuss the opportunities and challenges inherent in applying CWA to the design of healthcare systems

Keywords:

clinical nursing research, nursing models, psychological models, clinical decision support systems

Introduction

In this project, we explored the design of a mobile healthcare system for cardiac nursing coordinators (NCs). We began our design process phase by looking at the cognitive work of the NCs. We used an approach called Cognitive Work Analysis (CWA) for this phase of the project. From the CWA we developed information requirements that guided our design. We found CWA to be a useful tool for understanding cognitive work in a healthcare context.

Method

We followed the CWA approach of Vicente (1999) and used the phases of work complexities, task analysis, and strategies analysis. We did not perform a complete five analysis CWA. While a full CWA would provide a richer picture of the work of the nurses, the three phases were chosen strategically to maximize the information needed to provide effective decision support.

We used structured interviews and a case recall approach with nursing coordinators at the Ottawa Heart Institute.

Structured interview

We interviewed all the NCs using a predetermined question set. We did allow the interviewers to probe the NCs for more information at the interviewer's discretion. Our questioning process concentrated on the following elements:

- Were different strategies used for different types of patients?
- How do they accommodate initial conditions (e.g. patient's most recent surgery) in their subsequent strategy?
- How do they probe for information and what comparisons or references do they use to understand that information?
- At what point do they develop concepts or mental models?
- How do they perform differently with straightforward calls compared to more complex or difficult calls?
- Following the structured questions, the interviewers were allowed to probe opportunistically. The probing was to determine:
  1. Strategy differences between nurses
  2. Strategy differences by type of patient or condition
  3. Complex relationships that could benefit from decision support
  4. The differences between expert and novice nurses

Case recall

We asked the NCs to generate a number of typical calls representative of the types of calls that they receive from cardiac patients who have been discharged from hospital. The sequence was not constrained in any way and the NCs were able to answer freely. Twenty-five call types were generated.

The objective of the case recall was to develop best practice question algorithms for commonly seen cardiac symptoms.

Results: cognitive work analysis

We discuss the results of the CWA in three phases, the examination of work complexities, examination of tasks, and examination of strategies.

Phase 1: work complexities

The first phase of a CWA looks at complexities in work caused by features of the work environment itself. The objective of this analysis is to extract information requirements and to develop an understanding of complexities in the work. By complexities, we are looking for challenging problems to solve and tight relationships between different

factors. As these are identified, they are then explored further.

Specific work complexities that we examined through this analysis were:

1. Medications and their effect on patient health
2. Pain assessment
3. Patient care timelines

Phase 2: tasks

The tasks phase looks at sequences of tasks, task allocation and hand-offs between people, and various modes of operation.

Modes

Two clear modes were apparent, one mode for cardiology patients who were patients in cardiac treatment not directly related to a recent surgery, and cardiac surgery patients, who had recently had surgery.

Task allocations

Analyzing task allocations revealed that there were multiple decision makers in this environment. The first decision maker is the patient or their designate (usually a family member), who has direct experience with their condition, can monitor it regularly, and must at some point make the decision to call the NC for additional advice. Decision making is then allocated to the NC who can proceed to assess the patient further and make a recommendation, or in some cases, contact a physician for further advice. The final decision maker is the physician, who is contacted on a smaller number of more complicated cases.

Task sequencing

We focused on the sequencing of the nursing tele-triage task. Most nurses begin in an observational phase, often asking an open-ended question or letting the patient describe the situation. Their first decision is an assessment of the severity of the patient's condition, i.e. should the patient move to an emergency facility immediately, or should they proceed to describe their condition. If the patient is not in acute danger, the nurse may proceed to follow one of several questioning strategies to extract more information from the patient. These observations are used to make an assessment of the patient's condition and formulate a recommended procedure or action for the patient.

Phase 3: strategies for efficient work

We identified strategies from our semi-structured interview process and responses to typical questioning scenarios. We observed that NCs may ask open ended questions, may work from a standardized question list, may question for symptoms topographically, may build a hypothesis of the situation and test for confirming or refuting information, or may use a strategy of deliberately ruling out possibilities.

Discussion: requirements for design

The following list provides a summary of how each analysis phase contributed to our understanding of cognitive work. More importantly, each contribution maps to a specific design requirement.

CWA Phase: work complexities
Information on medication and side effects, pain assessment points, timeline points

Design requirements:

1. Medication reference

2. Pain assessment visualization

3. Timeline visualization

CWA Phase: Tasks
Teletriage task support, connection to patient and physician, support for cardiac surgery and cardiology modes

Design requirements:

1. Distinct modes for cardiac surgery and cardiology

2. Task stage support with support for observations and guidance

3. Information exchange with physicians

CWA Phase: strategies for efficient work
Multiple types of parallel support. support for mnemonic memory tools, standardized questioning patterns, hypothesis testing and rule out, topographical search

Design requirements:

1. OLDCAR support (onset, location, duration, characteristics, associate symptoms/aggravating factors, and relieving factors)

2. Decision trees with standardized questioning

3. Body topography mapping

4. Hypothesis test and rule out visualization

Conclusion

CWA developed a rich set of information requirements and led to the successful design of a tool that was flexible and able to support multiple tasks. The approach is unusually fruitful in generating design ideas. The support system that was developed and the results of the evaluation of the system are available in Momtahan et. al (2007) being presented at this conference.

Acknowledgement

We would like to thank the Ontario Ministry of Health and Long Term care for supporting this project and many team members throughout the duration of the project.

References

[1] Vicente K. J. (1999). *Cognitive work analysis: Toward safe, productive, and healthy computer-based work*, Mahwah, NJ: Erlbaum and Associates.

[2] Momtahan K, Burns C, Sherrard H, Mesana T and Labinaz M (2007). Using personal digital assistants and patient care algorithms to improve access to cardiac care best practices. Medinfo 2007.

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University of Waterloo
Advanced Interface Design Lab

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The Cognitive Work of Nursing

Catherine Burns
Yukari Enomoto
University of Waterloo, Canada
Kathryn Momtahan
The Ottawa Hospital and
The University of Ottawa Heart Institute, Canada

The Ottawa Hospital
L'Hôpital d'Ottawa

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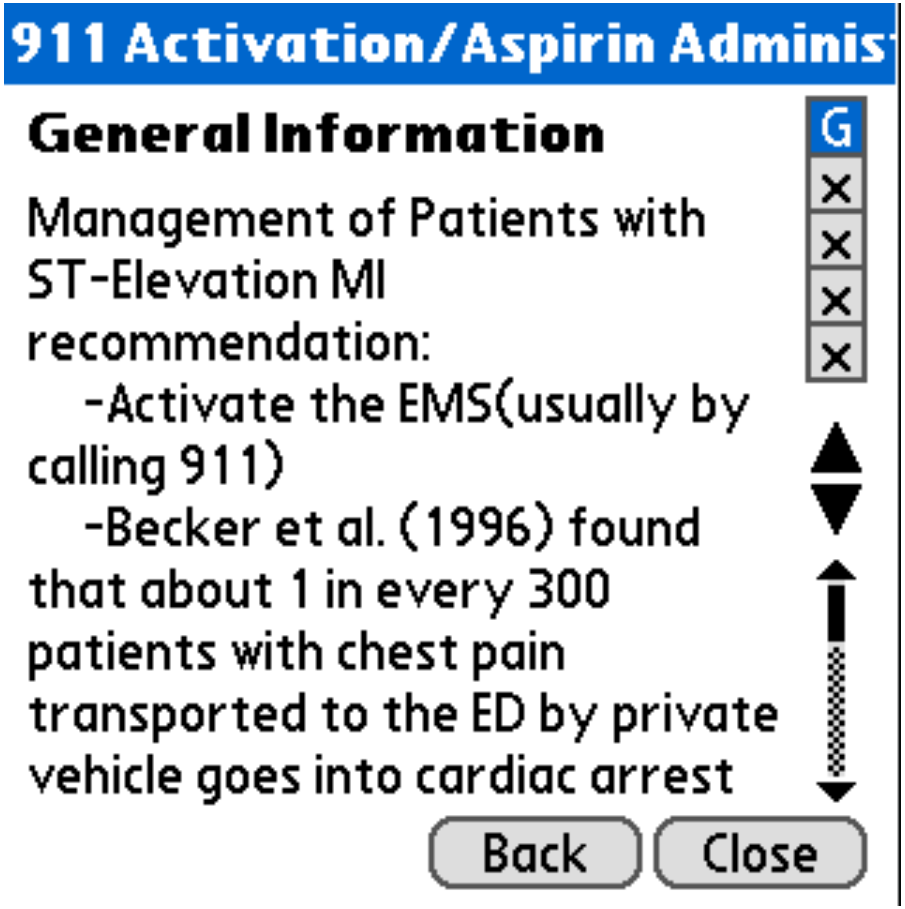
Effective healthcare systems

Require understanding cognitive work



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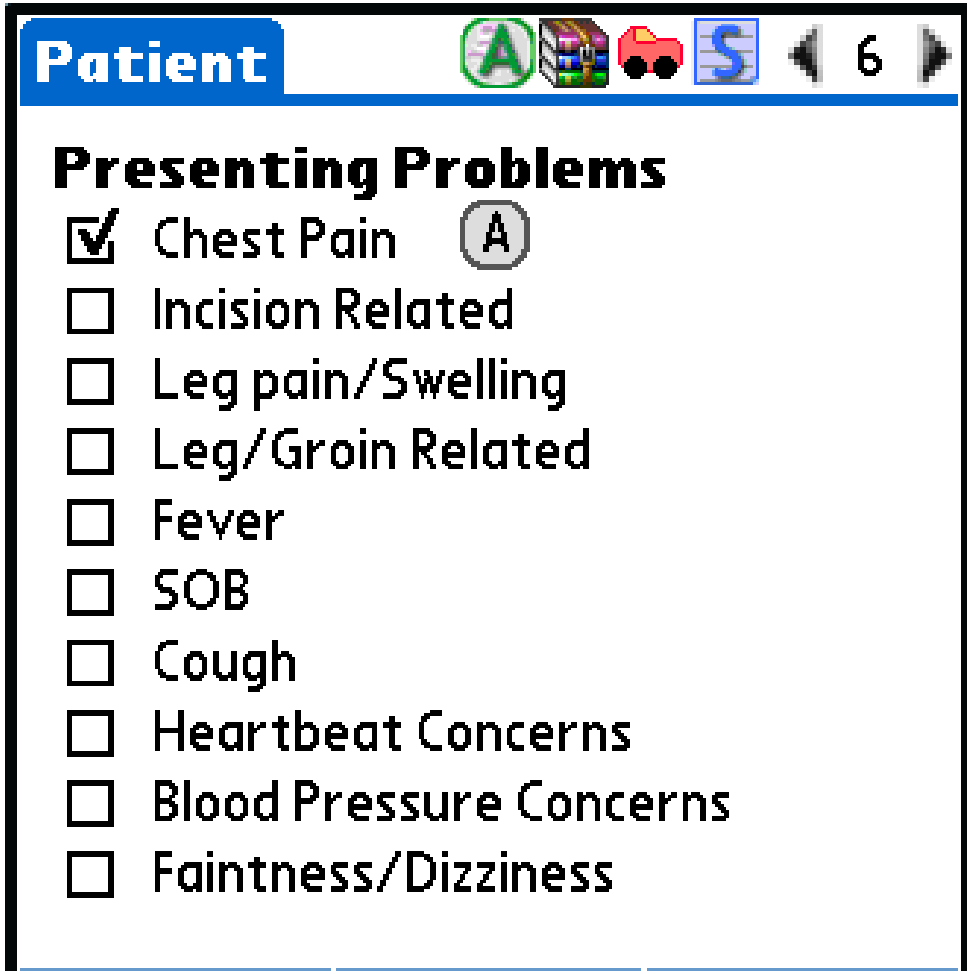
Cognitive work analysis

Understands effective work



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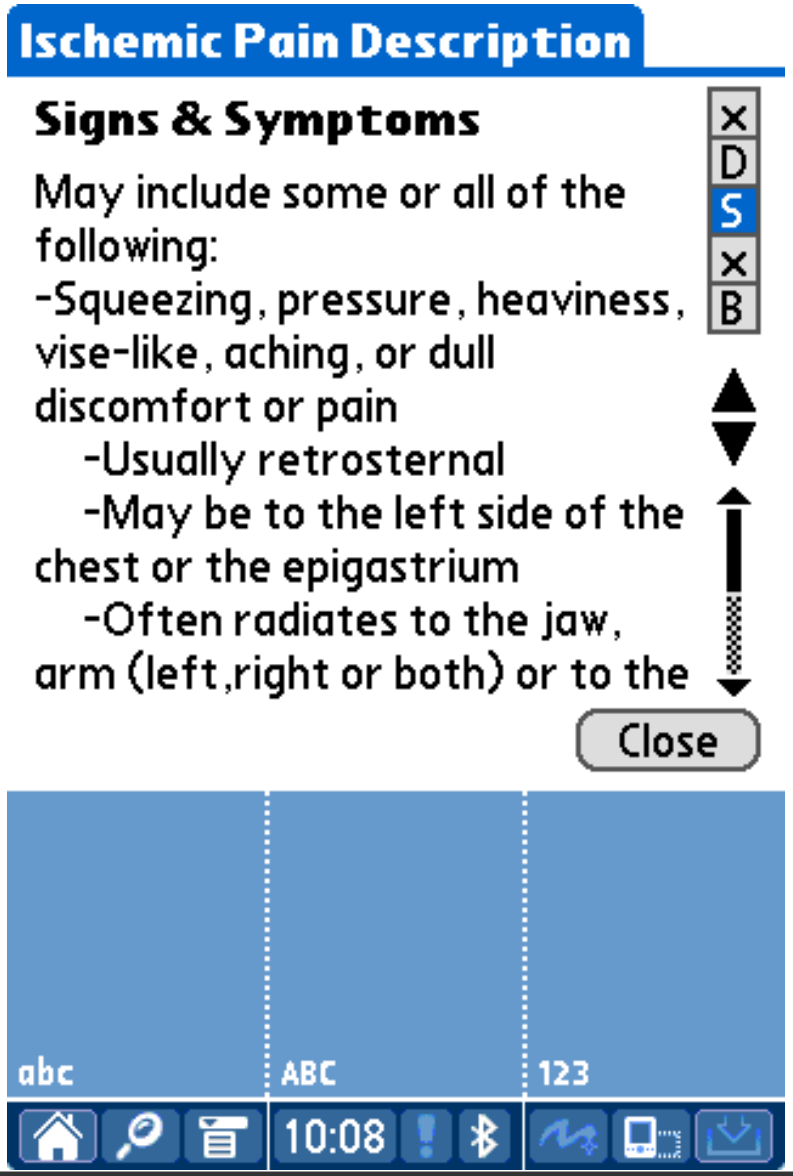
THE GOAL

Identify
Work complexities

Task allocation and hand-offs

Strategies of experienced workers



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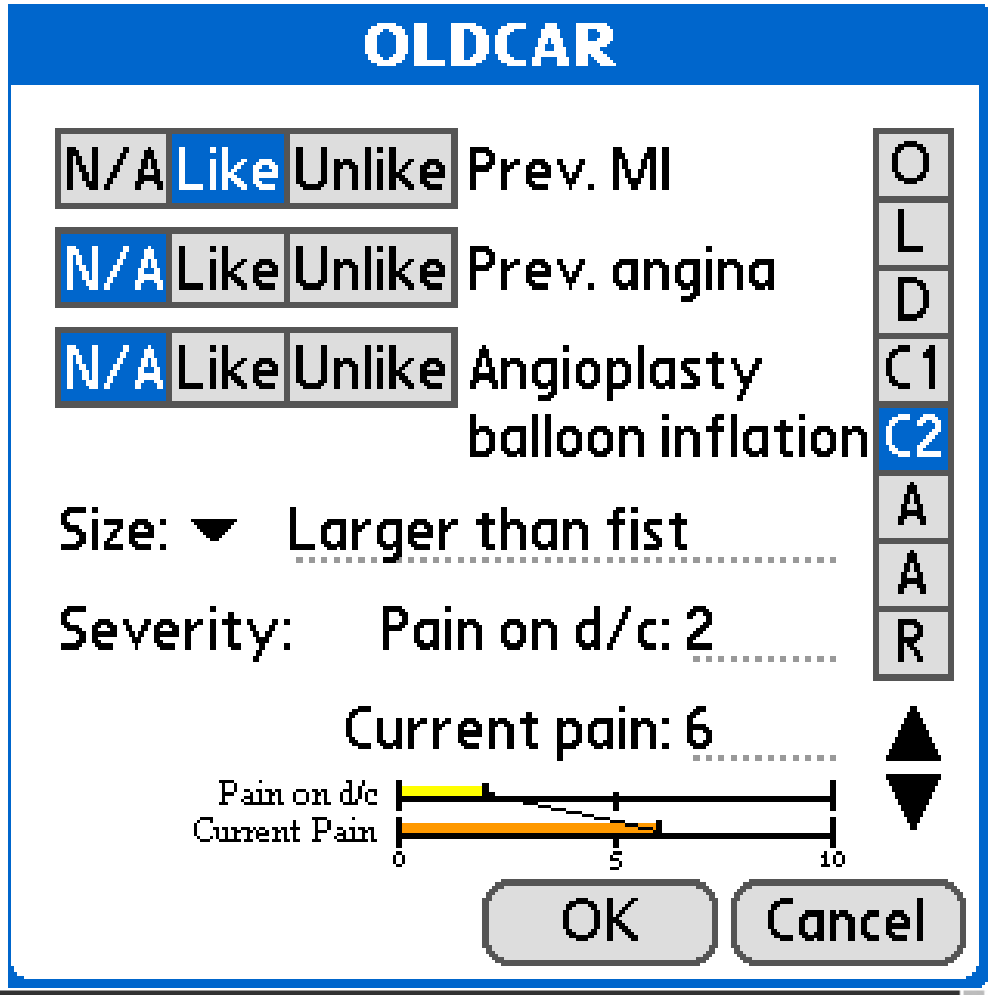
THE METHOD

Cognitive Work Analysis

Generate requirements

Develop effective decision support tools



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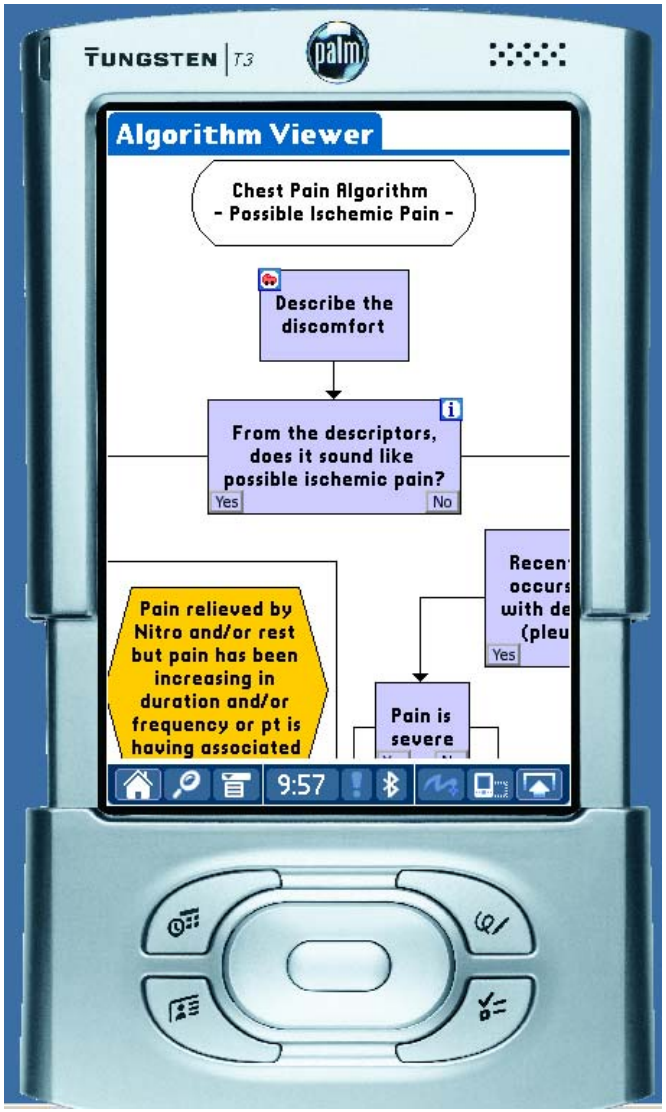
THE RESULTS

Appropriate support

Good patient response

High technology acceptance

Mobile



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THE PROJECT

Using Personal Digital Assistants and Patient Care Algorithms to Improve Access to Cardiac Care Best Practices

Talk at: GH1 1600-1730 Tuesday

The Ottawa Hospital
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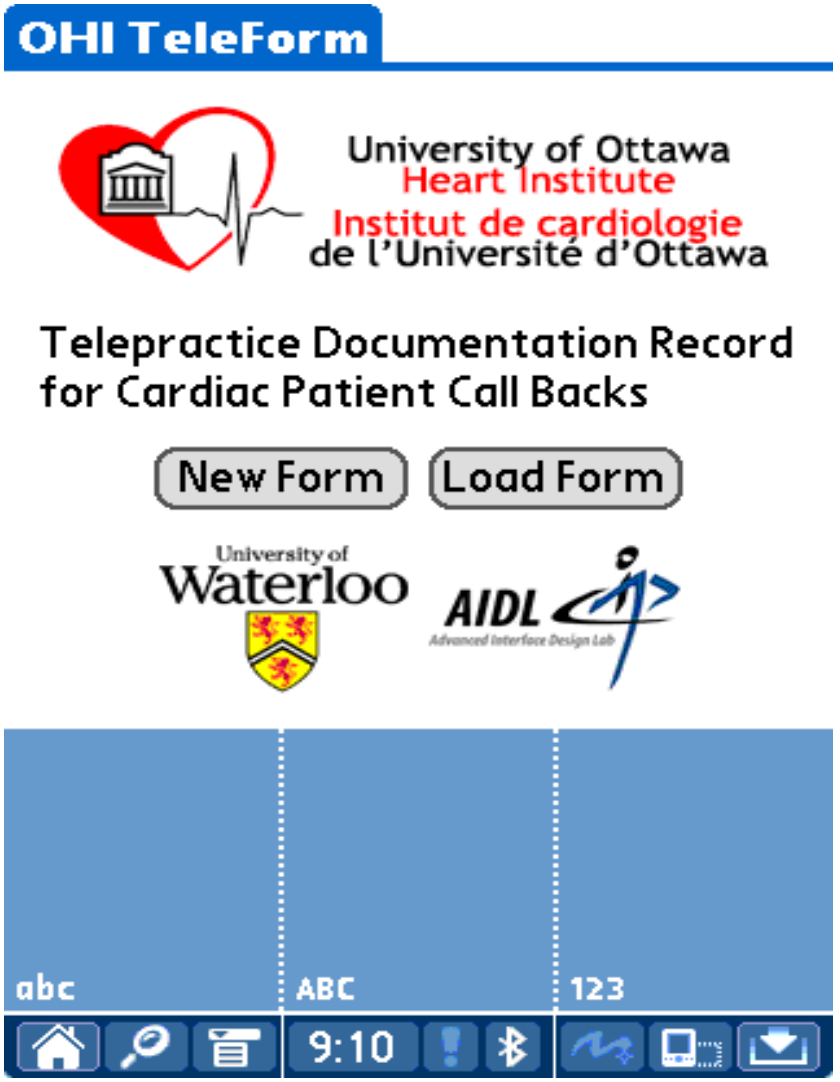
THE DEMO
See the Cardiac Care Triage Tool in the Poster Session



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OHI TeleForm

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Heart Institute
Institut de cardiologie
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Telepractice Documentation Record
for Cardiac Patient Call Backs

New Form Load Form

University of
Waterloo

AIDL
Advanced Interface Design Lab

Three Month Trial of Networked System that Improves Quality of Life of the Elderly

Kaori Fujimura, Tatsuaki Ito, Setsuko Murata, and Toshiaki Tsuboi

NTT Cyber Solutions Laboratories,

Nippon Telegraph and Telephone Co.

Introduction

Background

- It has become increasingly urgent to prevent elderly people from falling ill and eliminate the need for nursing care.
- However, we don't have enough preventative-care specialists.

Abstract

- In order to offset the shortage of these specialists, we have developed a support system that uses broadband and video-communication technologies.
- A care-prevention system aims to prevent a person from becoming bedridden due to "old-age syndrome", which frequently involves falls and broken bones, poor nutrition, incontinence, and home confinement.
- A three month trial of the system (focusing on the prevention of falls and broken bones) at a day-care center for elderly people is described.

System Structure

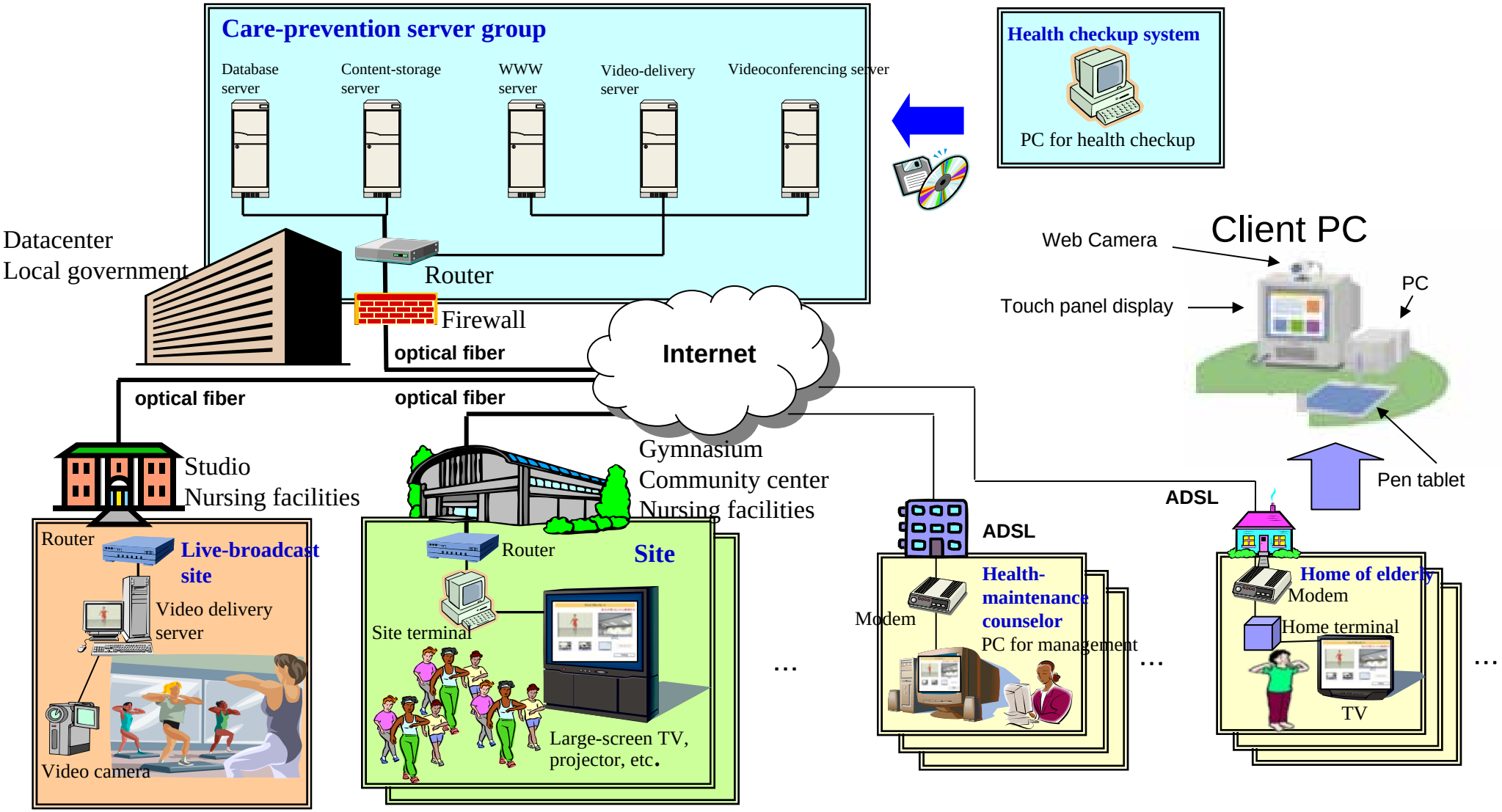
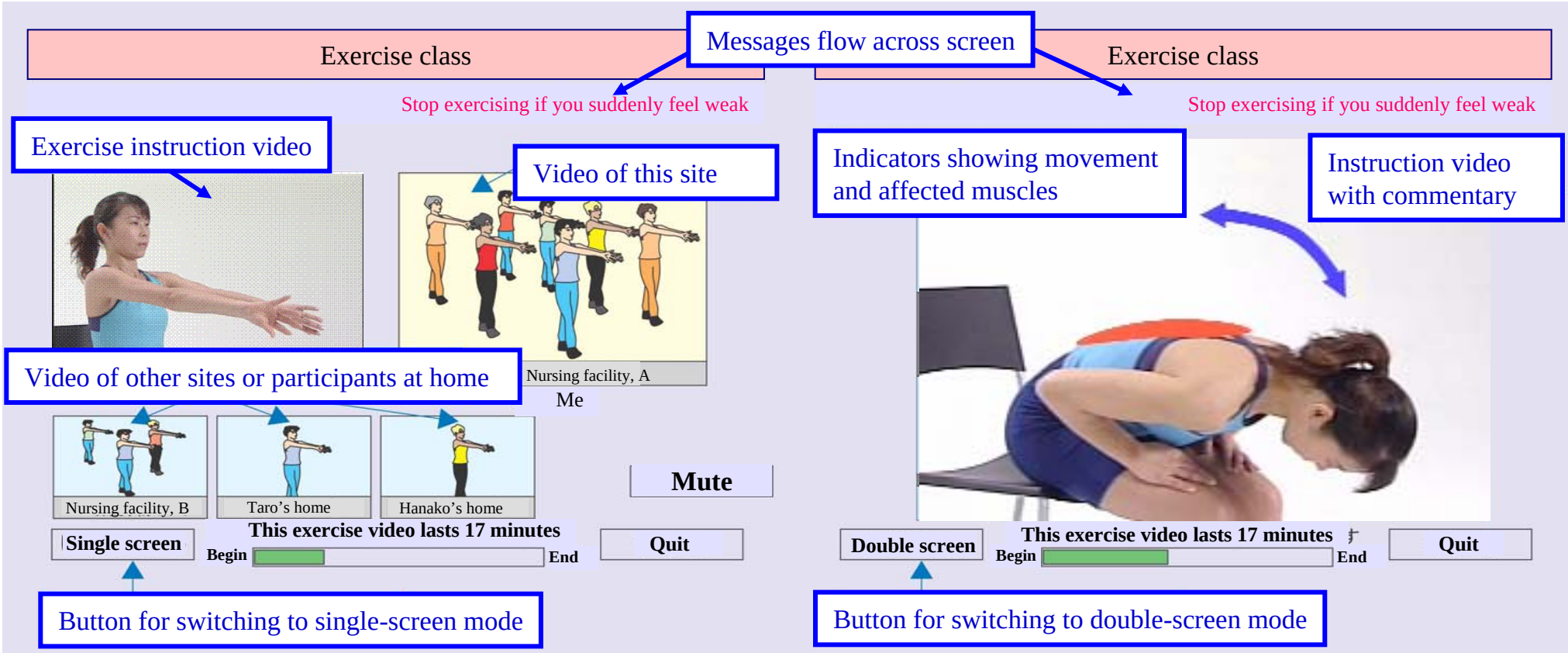


Fig. 1. Configuration of care-prevention system.

Client System



(a) Double-screen mode

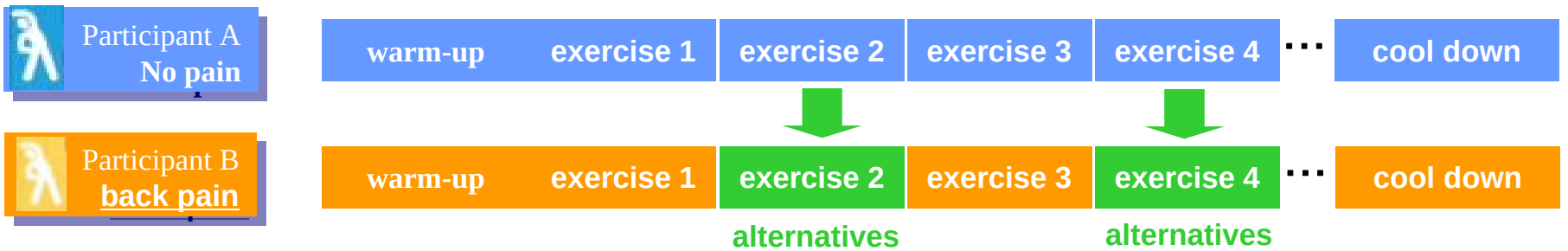
(b) Single-screen mode

Fig. 2. Screen modes for exercise classes.

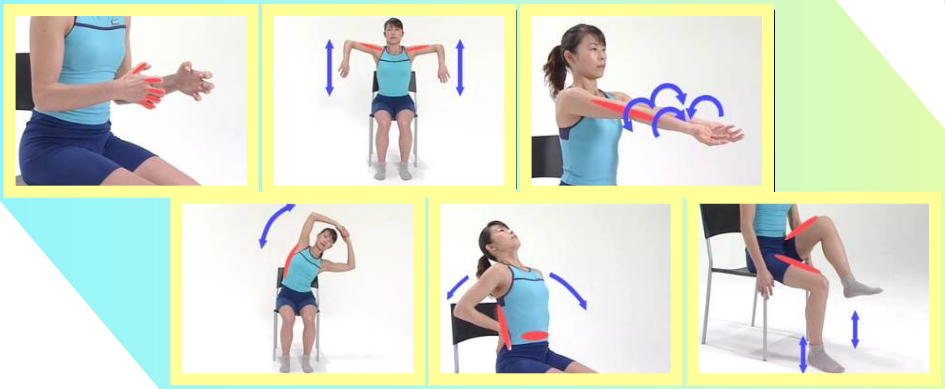
Features

- Networked System
  - Personalized program is available for people who have pain.
  - Data management is available. It makes it easy to give advice using exercise logs.
  - Having fun with exercising with people at other sites.
- Usability
  - Once client PC is powered up, the application starts automatically.
  - Most operations require only simple button pushing.

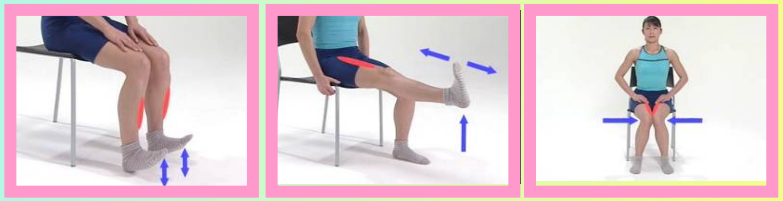
e.g.) Personalized program: Before the exercise, participants answer questions about their condition; the answer is reflected in the program.



Three Month Trial



warm-up exercises (5 min.)



strength training

cool-down (2 min.)

Trial term: 08/2005 to 11/2005
at Care-port Yahata, Telwel East Co.
Participants: 47 elderly people who need nursing care
Exercise class: 20 minutes consisting of exercises that were to be performed while sitting on a chair including exercises with rubber bands and balls

Check-up

Check-ups were held twice, before (a) and after (b) the trial.

Check-up Items:

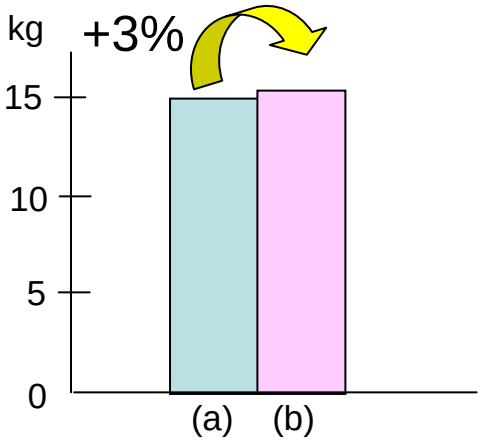
- Measurement of physical fitness
  - grip strength
  - balance on one foot (with eyes open)
  - walking speed
  - knee extension power
  - functional reach
- Interview
  - iADL (Instrumental Activities of Daily Living)

Results of Physical Fitness

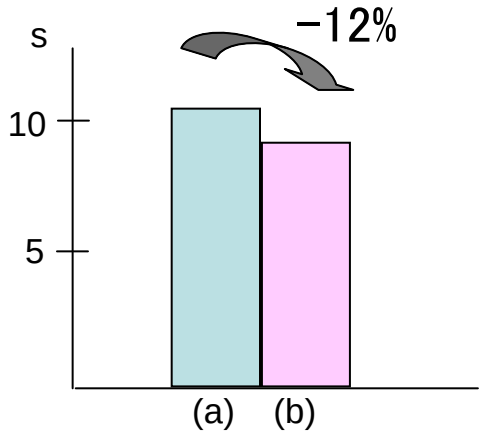
Check-up items		Mean	SD	Number	improvement rate (%)	significance probability
grip strength (kg)	(a)	14.9	6.96	47	+3	0.442
	(b)	15.3	6.56	47		
balance on one foot with eyes open (s)	(a)	10.7	10.69	29	−12	0.204
	(b)	9.4	11.43	29		
walking speed (m/s)	(a)	0.42	0.37	39	+2	0.708
	(b)	0.43	0.34	39		
knee extension power (N)	(a)	125.3	90.57	35	+30	0.010
	(b)	163.1	98.50	35		
functional reach (cm)	(a)	22.6	7.87	37	+10	0.067
	(b)	24.8	8.95	37		

Items whose average values were improved.

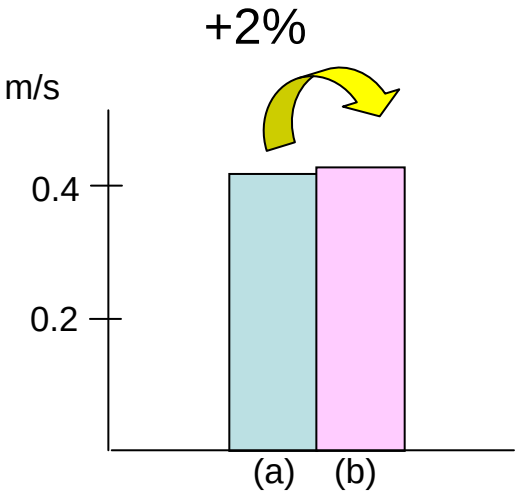
Results of Physical Fitness



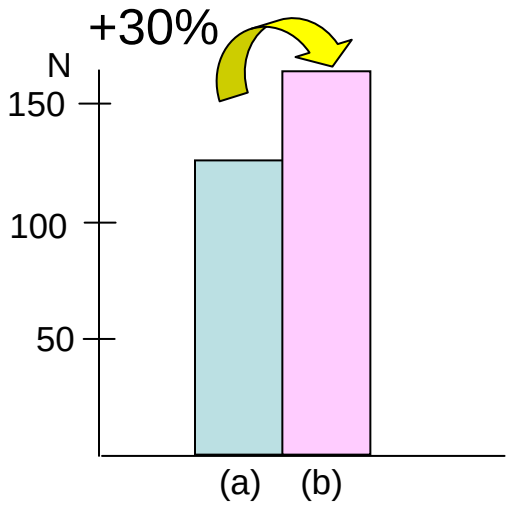
A. grip strength



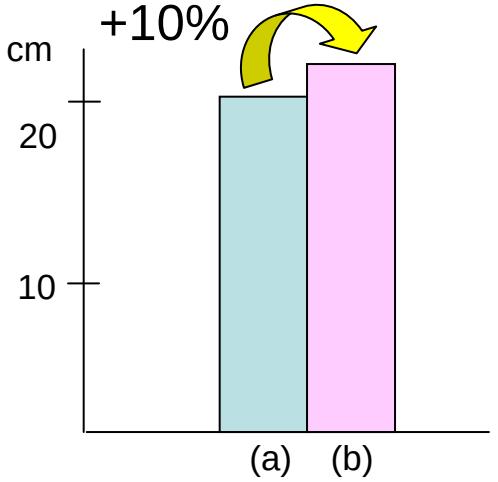
B. balance on one foot



C. walking speed

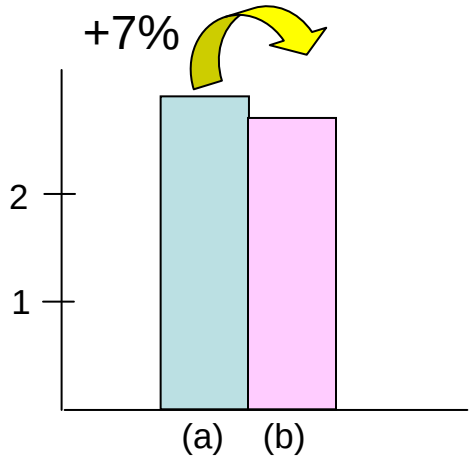


D. knee extension power

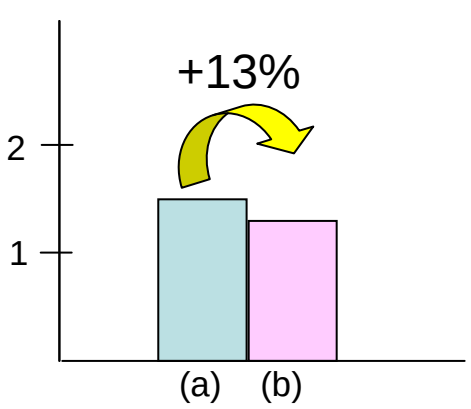


E. functional reach

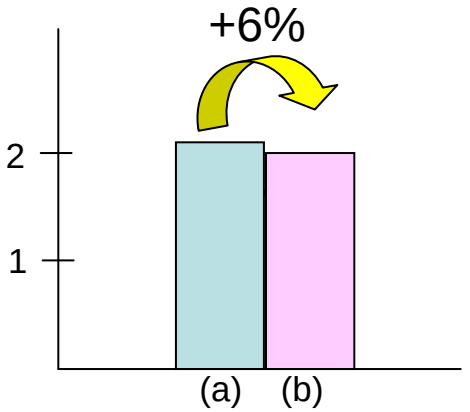
Interview Results:



A. Basic self-sufficiency



B. Intellectual Activities



C. Social Role

	A. Basic self-sufficiency		B. Intellectual Activities		C. Social Role		Total	
	(a)	(b)	(a)	(b)	(a)	(b)	(a)	(b)
mean	2.9	2.7	1.5	1.3	2.1	2.0	6.5	6.0
SD	1.9	2.0	1.1	1.1	1.3	1.4	3.5	3.9

Conclusion

While it is hard for elderly who need nursing care to maintain own strength, the results show a significant improvement in leg strength and iADL after the three month exercise.

The proposed support system has been proven to be effective for those who need nursing care. It can be expected to not only offset the shortage of preventative-care specialists, but also reduce the need for and costs of nursing care.

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  - S. Murata, T. Tsuboi, T. Ito, K. Fujimura, and H. Sato, ” Development of System for Reducing the Need for Nursing Care,” NTT Technical Review, Vol. 4, No. 2, p.60, 2006
  - Koyano W, Shibata H, Nakazato K, Haga H, Suyama Y, ”Measurement of competence: reliability and validity of the TMIG Index of Competence.” Archives of Gerontology and Geriatrics, 13: 103-116,1991

- Acknowledgments

  - We thank all the elderly people and staff members who cooperated in this trial.

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MEDINFO 2007
HISA Ltd Australia

Life Line Management System for Medical Records

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Abstract

We present in this paper a new approach to share medical information in community health networks. We propose a graphical user interface management system based on a chronological representation of medical information called Life Line. The Life Line is useful to access all medical documents represented on a temporal axis; documents can be locally created or removed from external information systems. The Life Line Management System can be adapted on any legacy systems; can push local medical data towards other information systems and the opposite.

Keywords:

user computer interface, community health network, temporal axis

Introduction

Regional health networks have been proposed last ten years. These networks gather and share medical information about patients from different care places, essentially hospitals. The most frequent architecture of such networks is based on a pointer management system that stores in a server the addresses of each medical treatment. About medical data, they are stored in the legacy systems.

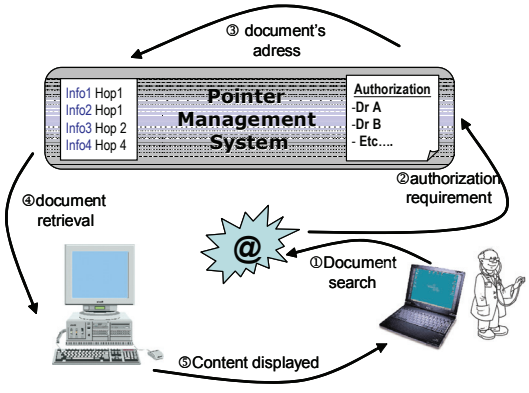

Figure 1- Network architecture

Such architecture is today very interesting to ensure data sharing in order to improve continuity of care. It will be used by the future French personal medical record called DMP.

The Life Line management system is complementary to this architecture in improving communication between general practice and hospital. It allows sending automatically data addresses to a platform called Life Line platform. It is quite similar to a semantic middleware between legacy information systems. The Life Line Management System is designed as a chronological axis on which a representation of medical documents is displayed. Such an ergonomic interface improves greatly information research and gives a synoptic view of the medical record.

The following paragraph describes the Life Line Management System according to different aspects (description, architecture, data transfer). A short paragraph concerning the related works is presented just before a conclusion.

Life Line Management System

Presentation

The Life Line Management System is both a data representation system (object types design), a graphical user interface to display data and a data exchange platform (to retrieve, display and send data).

The data representation system defines an iconic structuring (at interface level) for each parts of document (called objects) whatever their data source format in legacy systems.

The graphical interface is based on a chronological representation of the medical record on which every document (broad sense) is displayed wherever it has been created.

The data exchange platform is used to extract objects from a server, to display them on a local system and at the opposite, to send them from a local system to another legacy system. These information systems can be hospital IS or GP IS.

The Life Line Management System is associated to the Rhône-Alpes Regional Health Platform (SISRA) [1] to help the connection between GPs information systems and hospitals to share information about patients. Rhône-Alpes is the second largest administrative region in France after Ile-de-France (which includes Paris). As large as Denmark in size and with 6 million inhabitants, it is comparable to a European country. Rhône-Alpes has 300 healthcare facilities, three academic medical centers (based in the cities of

Lyon, Saint Etienne and Grenoble), one regional comprehensive cancer center, more than 20 000 physicians and over ten thousand caregivers. The concept of a universal electronic patient record (DPPR) was initiated in 2000 by health professionals from the regional comprehensive cancer center of Lyon (Centre Léon Bérard) and the ONCORA community cancer network (ONCOlogy Rhône-Alpes).

Iconic structuring

Object definition

The iconic structuring has two conceptual parts: a definition of objects according to criteria and a screen representation as icons.

The criteria chosen are: composition, communication and abstraction.

- Composition criterion: objects are classified into simple and complex object.
  - A simple object has only one type which is: text, image, number, etc.
  - A complex object is composed of simple objects and/or complex objects. As an example, an X ray is a complex object composed of two simple object (image) and a summary (text).
- Communication criterion: objects are classified according to their sharing possibilities. We define specialty objects, private objects and communicating objects.
  - A specialty object is only readable by his creator and by doctors with the same specialty (a chemotherapy guideline can be seen by the "owner" of the object and by all the oncologists that may care the patient) but not by specialists of another domain.
  - A private object is protected at the local level and never sent throughout the network. As an example, a sport medicine object is private and so not shared.
  - A communicating object is seen by all medical partners.
- Abstraction criterion: objects have a basic structure defined by experts of the medical domain. The instantiation of abstract objects produces concrete objects. This structure encapsulates an identifier, a name, a type and a iconic representation.

Object types		
Composition criterion	*Abstraction criterion*	*Communication Criterion*
Simple object	Simple abstract object	Specialty simple abstract object
		Communicating simple abstract object
		Private simple abstract object
	Simple concrete object	Specialty simple concrete object
		Communicating simple concrete object
		Private simple concrete object
Complex object	Complex abstract object	Do not exist
		Do not exist
		Do not exist
	Complex concrete object	Specialty complex concrete object
		Private complex concrete object
		Communicating complex concrete object

Figure 2 - Object types classification

Iconic interface representation

The second part of the Life Line Management System is a graphical user interface useful to identify the different objects according to shapes and colors.

Figure 3 shows the interface with icons and the chronological representation of the medical record.

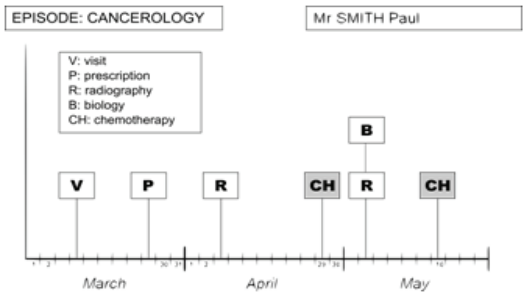

Figure 3- Graphical interface

The graphical interface has been made with different levels of granularity. A synthetic view displays all diseases on the axis and a focus on a particular episode (here Cancer) displays the objects useful to follow up the disease. In the example, the icon **CH** is a specialty object; the others are communicating objects. The difference between abstract and concrete objects is not obvious on this screen: the content of each icon is a concrete object because a click on each icon gives the content of the document. For example, a click on **R** shows the result of the X ray. The structure of

each icon corresponds to an abstract object and its content to a concrete object.

Architecture

The Life Line Management System is represented by a Life Line platform that directly connects GPs information systems to hospitals information systems (fig.4). Every server (hospital or GP) can push data on the Life Line platform and share medical information about patient. As a consequence, on a local user information system, data are displayed wherever they are created and stored.

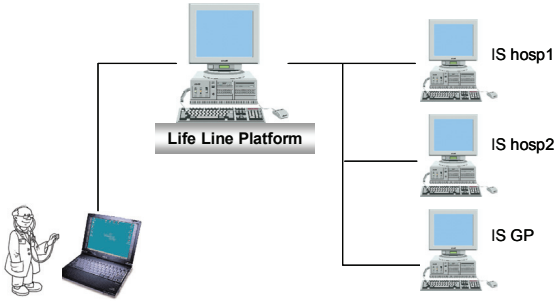

Figure4- Global architecture

A list of shared objects is sent to the platform that enhances the list of objects addresses. A click on a shared object on the Life Line interface opens directly the content of the object: in fact, the object address is automatically opened and its content displayed on the screen. When an object is not readable by a given doctor, this object does not appear on the Life Line.

Transfer of data on the network

For each object, a URL is defined. This address is automatically sent to the Life Line platform and added to the addresses list. A remote or local object is added to the patient's medical record and its content displayed as required. Fig. 5 shows how the data transfer can be done. A user request (simulated by a click on the object) send a query to the different servers and when the server which stored the object is found, an extraction is made and the content is displayed on the user's screen.

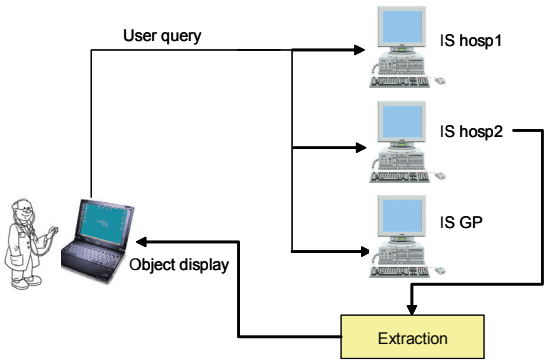

Figure 5- Extraction process

Interface

The interface is separated out in 3 parts: the first part is dedicated to the objects knowledge base. The second part is a part of abstract objects instantiation. The third part represents the chronological axis with objects (fig. 6).

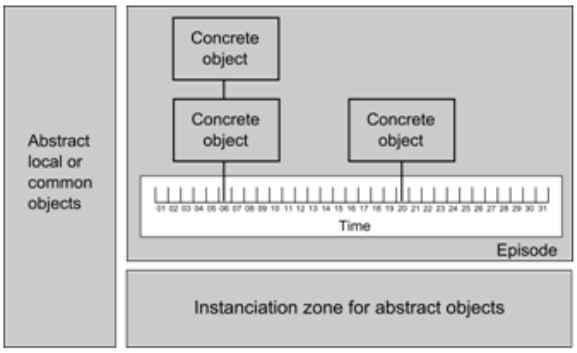

Figure 6- General architecture of the interface

The different following screens show different ways for displaying and sharing objects.

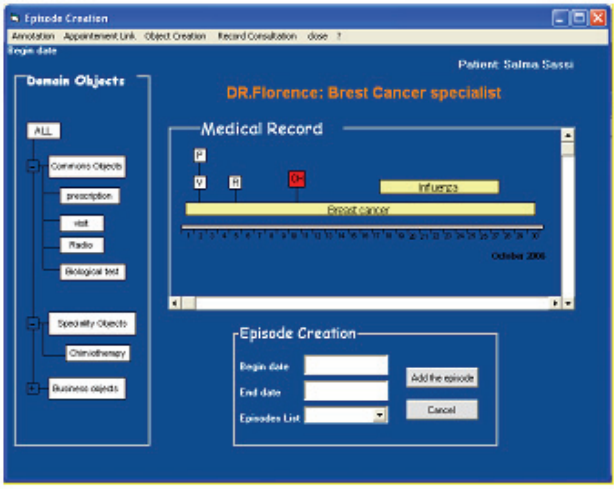

Figure 7- Concrete object instantiation

In this screen, the user creates his concrete objects concerning a disease episode. Objects are retrieved from the knowledge base and episode from a disease classification or ontology.

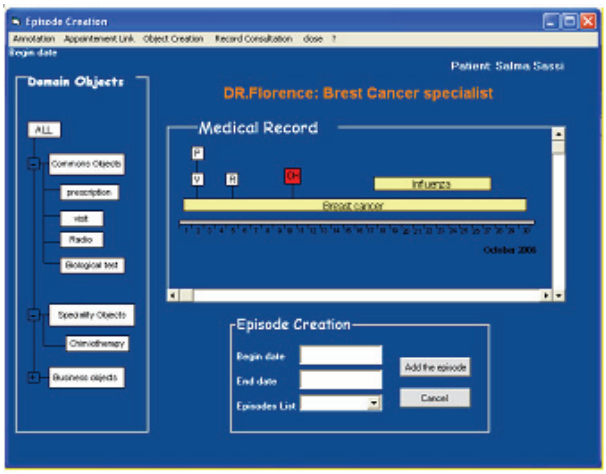

Figure 8- Interface for a specialist

In this screen, chemotherapy is a specialty object which is locally created by the oncologist. This object will be only shared by same specialists.

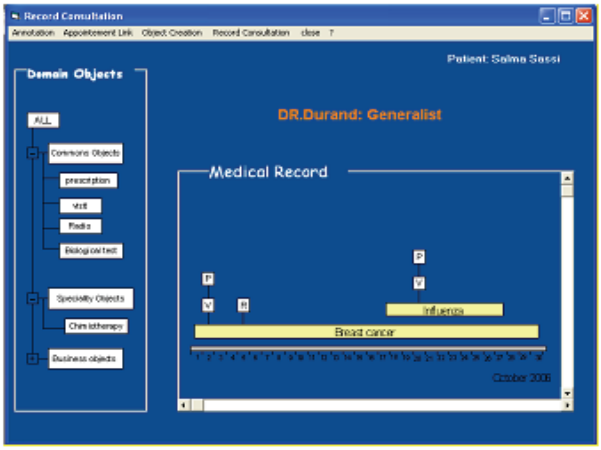

Figure 9- Interface for a GP or another specialist

In this screen, are only displayed the objects shared by everybody in the health networks.

Related works

Many groups are currently investigating medical platforms using different approaches: the first approach consists of considering the web as a useful medium to link medical data and facilitate patient follow-up. In [2], the authors describe the automation of processes between ambulance services and emergency units. The system is based on web services and workflow systems. Another interesting work addresses the transfer of information within a hospital: documents created in various formats and stored in different subsystems are made available to authorized persons for the follow-up of cardiac patients [3].

Other systems have been developed in telemedicine using standard tools. For example: Telemed [4] uses Corba [5] to connect multiple health information systems.

Other works have addressed the issue of interoperability between heterogeneous medical information systems. [6] and [7] have created Pilot, an application program interface that serves as a mediator between different information systems. [8] have proposed an upstream system which creates an exchange format at the conceptual level (use cases). Semantic integration is also a very important topic of research, with interesting studies published by [9], [10], [11].

Some approaches are more centered around the users and propose navigation tools: the project by Ouziri et al. [12] displays medical data using a concept configuration which represents a secured and semantically correct information space. This approach is based on Topic Maps and Description Logics. Users build their own data interface. Another interesting work concerns the integration of interfaces [13]. Finally, some studies have been carried out to promote evaluation in health networks [14] and [15].

Conclusion

To share medical data between heterogeneous information systems is not easy. Some platforms exist to help for data communication. We have proposed in this paper a new architecture with three different aims: a interface structure for objects, an exchange platform and a chronological representation of the medical record. This system can be used as a middleware between legacy information systems.

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MG-RBAC: Using Medical Guidelines as a Source of Contextual Information to Activate and Deactivate Roles and Permissions

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Abstract

Controlling access to information is a key concern in healthcare systems. Some form of Role-Based Access Control (RBAC) is implemented in most healthcare systems. A problem with existing RBAC models used in healthcare is their static nature which doesn't capture the dynamic needs of healthcare providers. In this paper we propose an enhanced access control model combining RBAC with the use of Medical Guidelines, MG-RBAC. Medical guidelines contain temporal and contextual information that may be used to make more informed, dynamic access control decisions.

Keywords:

access to information, computer security, privacy

Introduction

Access control is a key concern in healthcare systems. In order to ensure privacy of patient data, the systems has to provide suitable mechanisms to control access to information. Many existing healthcare systems use some form of Role-Based Access Control (RBAC) Ferraiolo D.F., Kuhn D.R., Chandramouli R., Role-Based Access Control, Artech House Publishers, 2003, ISBN 1-58053-370-1. . Access decisions are typically based on a user's role (e.g. nurse, medical doctor etc) and workplace (department, ward). A user is granted access according to his/her role's permissions for patients that are admitted the ward where he/she is working.

However, these static properties are often incapable of capturing the dynamic needs of healthcare personnel. In this paper, present a model for using Medical Guidelines (MG) as a source of information for access control decisions as a way of creating more dynamic access control for healthcare.

MGs (or clinical practice guidelines) are defined by Field M.J, Lohr K.N., Clinical Practice Guidelines: Directions for a New Program, The National Academy of Sciences, 1990. as:

"Practice guidelines are systematically developed statements to assist practitioner and patient decisions about appropriate health care for specific circumstances."

There exist several formalized notations for computer-interpretable MGs. MGs may include temporal and event information that implies information needs and therefore may be used in access control.

Computer-interpretable medical guidelines

The Asbru MG notation has been chosen as the notational example used in this paper because it contains constructs for defining periodic and event-triggered clinical tasks that suits our demonstration needs, and because Asbru MGs are encoded in XML (eXtensible Markup Langua[1]ge) which is a widely used format for exchange of data.

The Asbru Language

Asbru is a time-oriented, intention-based, skeletal plan-specification representation language [3]. A skeletal plan specified in Asbru consists of a name and a plan body and may additionally contain (optional): a set of arguments, a time annotation, preferences, intentions, conditions and effects. The plan body contains a set of plans (child plans) and information about how/in which order these plans should be executed and also conditions on which child plans must be completed in order to complete the parent plan.

An example MG in Asbru

An example of use of Asbru for encoding a guideline for treatment and observation of Gestational Diabetes Mellitus (GDM – a form of diabetes found in pregnant women) is available at [3]. Use of the guideline is initiated if a glucose tolerance test in the third trimester shows a blood sugar level between 140 and 200 mg/dl. The guideline consists of three main parts:

- Glucose monitoring: measurements performed by the patient herself and/or by the physician. Check to verify that glucose level kept below a limit of 130 mg/dl for 1-hour post meals, < 100 mg/dl fasting and preprandial.
- Nutrition: treatment is based on teaching patient a diet. The goal is to manage GDM with diet and without insulin therapy for as long as possible. Regular follow-ups (every 1-4 weeks) are recommended.

1 http://www.w3.org/XML/

- Insulin therapy: initiated if blood sugar consistently > 100 mg/dl fasting and/or one hour postprandial consistently higher that 130 mg/dl and attempts at diet modification has failed.

MG-RBAC

The Asbru guideline for GDM contains both temporal and contextual information that may be used for access control:

- Periodic information needs: visits to physician while under treatment every 1-4 weeks (specific value set for a patient). The EPR does not need to be accessible to the physician in-between visits.
- Events that trigger information needs: when blood sugar readings are too high the patient needs to visit her physician and review treatment. The EPR should be made accessible to the physician when too high readings occur.

A few UML use cases have been created to illustrate the envisioned use of medical guidelines in access control for healthcare systems.

Periodic consultations are part of the guideline for GDM. Even if the physician is regularly seeing the patient he/she does not need access to the EPR at all times. The physician might need to prepare for an appointment and enter some information after the appointment, but it should be sufficient for the EPR to be accessible e.g. two days prior to and two days past the next scheduled visit for a patient. Figure 3 - Guideline: periodic access3 illustrates how this may be done. The physician will have an assigned role that includes permissions to this patient's EPR as he has a responsibility for this patient. But this role is only activated around a scheduled visit.

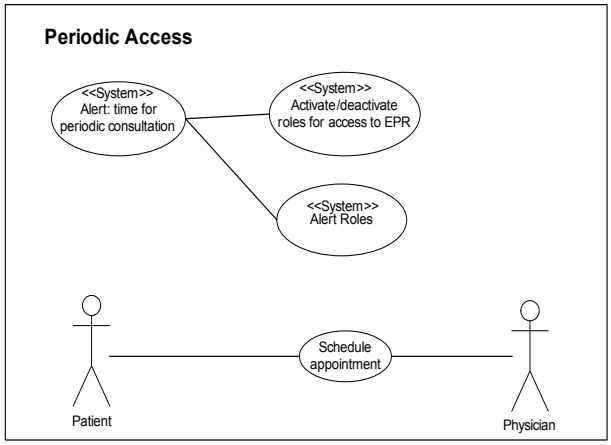

Figure 3 - Guideline: periodic access

The other example of use of guideline information for access control decisions is the occurrence of events that trigger information needs. A typical example of such an event is a measurement of some sorts, made manually or by a sensor, which triggers further actions. For the GDM example the glucose monitoring illustrates such an event. The patient is to measure her own blood sugar level 4 times a day. If the measured level is above some specified limit further action needs to be taken. To determine further actions the physician needs access to the patient's EPR. Figure 4 - Guideline: event trigger4 illustrates how roles are activated if the guideline specifies that a measure results in an action that requires access to the EPR and the relevant role (or roles) is activated.

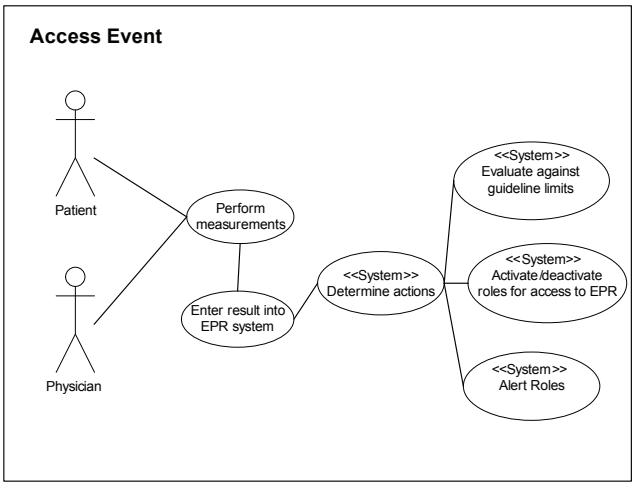

Figure 4 - Guideline: event trigger

Discussion

The model presented here for MG-RBAC is only very preliminary and serves to inform about a promising idea that requires further work.

The examples presented are based on a guideline representation in the Asbru language. Certainly for such a model to be useful it should be able to use guidelines in many different notations. One possible solution would be to integrate a guideline translation engine in the Guideline Monitor module. Work remains as to examine in details information contained in other guideline specification languages and how they may be translated.

The examples presented here only illustrate triggered and periodic events. There may be additional information contained in guidelines that could be utilized in access control, but this has not been fully explored yet.

Conclusion and future work

In this paper we have presented an idea and a preliminary model for using medical guidelines as input to access control. The idea is that guidelines contain information that can assist in creating a dynamic and context aware access control model for healthcare.

We intend to continue to explore this idea further by creating a more detailed model and developing a proof-of-concept implementation.

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A Holistic Approach for Prevention and Early diagnostics:Personal Health Management With Web-Based Personal Health Records

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Abstract

Prevention and early diagnostics are actual topics in today's healthcare. A structured and integrated approach is desired to optimize and benefit from preventive healthcare. We envision personal health records (PHRs) to be a platform for personal health services. The current PHRs, however, mainly provide services that are focussed on cost reduction and management of specific diseases. Integrated prevention and early diagnostics approach is currently not a part of PHRs, whereas an expansion with such a service is desired to create a direct value proposition for health consumers. PHR-based services thus need to focus on prevention, early diagnostics and subsequent early intervention, next to disease management. In this paper we propose a holistic approach for preventive health services via PHRs and identify the issues related to this approach.

Keywords:

personal health records, medical records, prevention, early diagnosis, personal health management

Introduction

The rising costs in healthcare are mainly due to the major burden caused by diseases for which prevention and early intervention options are gaining scientific acceptance [1, 2]. As a consequence, there seems to be an increasing consensus that prevention and early diagnostics deserve more attention. Diseases and other conditions that are recognized early, often have better treatment options and better changes of success.

The efforts to realize a more preventive healthcare are countless, ranging from over the counter diagnostic tests, to warning stickers on lifestyle consumables. The same is true for personal healthcare services via the Internet. Several population based screening programs are offered, each with its own infrastructure and analytic process. Studies on efficacy of preventive healthcare and screening methods have shown that a fragmented approach of prevention, early diagnostics, and possible subsequent early intervention, lack efficacy. Instead, an integrated approach is opted for an optimal system.

Another important disadvantage of the current lack of structure for prevention and early diagnostics is the existing gap between relevant evidence-based advances and the actual implementation of these in preventive services [2-4]. A structural approach can play a crucial role in overcoming this problem as well.

The objective of this paper is to:

1. Identify issues in personal health services via web-based personal health records (PHRs).
2. Propose a framework for a holistic approach for services targeting prevention and early diagnostics.

First, we describe how PHRs have evolved to become a potential platform for personal healthcare services. Second, we describe a holistic approach for the provision of personal health services via PHRs.

Web-based Personal Health Records:first generation

The emergent PHRs development is the results of increasing concern about extent to which decentralization of healthcare has lead to scattering of personal medical information [5, 6]. The dispersal of individual health information is the consequence of increasing mobility and freedom to seek care from different providers and on-line personal health services. Due to this trend, consumer advocates have recommended patients to adopt a more proactive attitude towards collecting and organizing their own medical information [7].

The first description of an electronic PHR was in 1978, but it was not until the recent years that a number of online applications allowed patients to enter and manage information abstracted from medical records [8-10]. Currently, an increasing number of Internet users are adopting PHRs to control and manage their health data [11].

The first generation PHRs are characterized by the fact that they were created, owned and managed by individual patients, as opposed to provider-entered records. Configured along the lines of the professional medical records, these PHRs allowed patients to directly enter health information. Some of these PHRs were stored on standalone

devices such as UBS sticks or standalone applications on personal computers, while others were web-based systems (Figure1). The web-based applications use stored information to generate records that could be reviewed or transmitted to reviewers who are authorized by the patient. The main pitfall of the first generation of web-based PHRs is that professional caregivers did not adopt these systems, mainly due to conflicting workflows and distrust of stored information [7].

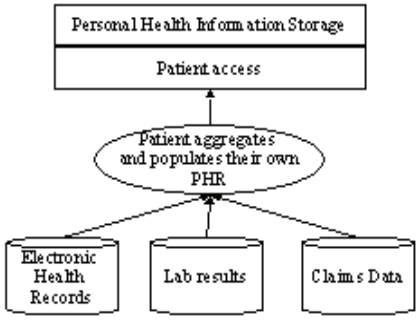

Figure 1 - Architecture of the first generation PHRs. Here the main focus was on aggregation and personal management of data from different sources in the healthcare system. Most of these systems are standalone application e.g. USB sticks, CDs, desktop application

Second generation of web-based PHR

The first generation web-based PHRs were promoted as a mean of providing patients and providers with universal access to up-to-date medical information. Evaluation shows that the primary focus on universal access resulted in limited functionalities [7].

The second generation web-based PHRs comprise longitudinal health information, sourced by both the patient and healthcare professional (Figure 2). This information typically comprises major illnesses, family history, medication, allergies, immunizations, social history, lifestyle data, diagnostic test results and sometimes home-monitored data like blood pressure and glucose levels. While first generation PHR vendors focused on users sourcing their own records, second generation PHRs are also populated by linkage with professional electronic medical or patient records and insurance claim databases. Hence, they are classified as integrated PHRs and enable additional services based on reliable data.

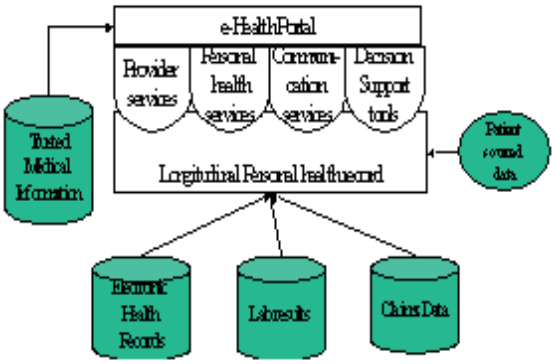

Figure 2 - Architecture of second generation PHR. Through an e-health portal, users can access trusted medical information. In addition, users can make use of different kind of services ranging from provider specific services to decision support tools. Web-based PHR integrates the patient's information from different sources

While many studies demonstrated the potential benefits of integrated PHRs [7, 12, 13], evaluation exposed concerns about lack of value proposition for the individual [7]. Most of the integrated PHRs were develop to lower healthcare expenses and not mainly to empower health consumers. As a consequence health consumers adopt the second generation PHRs very slow. As for now, vendors recognize that the value for the individual lies in the transformation of data into information that empowers individual health management [14]. As a means to this end, integrated PHRs also comprise decision support tools ranging from generating alerts and reminders to treatment comparisons.

Interactive prevention and early diagnostics services

The majority of online personal health services today are much more like the healthcare system itself. Online personal health services mainly focus on diseases or a particular health condition like diabetes and related self-management tools. Prevention and early diagnostics services seem to be in the scope of personal health services providers but they lack a holistic approach.

We spotted an opportunity to propose a holistic health management approach by incorporating an integrated tool for prevention and early diagnostics into a web-based PHR (Figure 1).

A holistic approach for prevention and early diagnostics

Healthy consumers could know their health status if PHR vendors would incorporate an integrated health risk assessment and management tool, based on a knowledge system for prevention and early diagnostics. The knowledge system itself should be based on evidence-based medicine

rules and methods, and should also be supported by the medical profession, to guarantee acceptance and for quality assurance.

Evidence-based algorithms within the knowledge system can processes data in the PHR into personal risk profiles for specific disorders. A risk profile indicates the risk of 'catching' a particular disorder, given the presence of the risk factors within a predefined time frame in the PHR. The risk profiles can than be communicated through personalized health services to educate the individuals how to reduce high-risk or maintain low-risk for a specific condition.

The personal health service could comprise a personalized health plan, that empowers individuals to be a 'co-pilot' own health by offering advise on how to adjust lifestyle variables (e.g. smoking, activity or nutritional habits) or implementing early intervention (e.g. a prescription drug). Guidance towards risk reduction could continue until the risk for a specific condition reaches a certain target, from whereon the focus shifts to low-risk maintenance. The workflow in this approach can be done simultaneously for all disorders with solid evidence-based prevention and early intervention options, creating the desired holistic approach. The PHR serves as a platform to incorporate the risk assessment, risk profile generation and health plan.

Challenges posed by the holistic approach

The proposed holistic health management approach pose some challenges that needs to be address before this can be a reality.

Data quality assurance
The first challenge that needs to be addressed is the completeness of the data in order to calculate risk profiles. As one can imagine, not all information will be stored in PHRs, not even when the PHR is linked with professional electronic medical records. As a consequence the risk profiles may not be based on complete datasets. To deal with this issue we may have to introduce a periodic health assessment check in which a minimal dataset of health variables are measured from the patient directly. The frequency of these health checks may depend on the patients' risk profiles. High-risk individuals can be advised to do a follow-up check at smaller time intervals as opposed to low-risk individuals. The check itself may consist of questionnaires to acquire or update the minimal dataset, combined with a standardized physical and laboratory examinations.

Between health assessment checks, changes that affect health status could occur. If the changes are severe, however, it may result in a reason to encounter the general practitioner or the specialist. Given the presence of integrated PHR systems, the data will automatically end up in the PHR.

The gap between health check may also be filled with sensor technology. In the past decade sensor technology build to measure and store medical signal information, such as blood pressure, have reached a stage of maturity. Depending on the disease and which variable is required, these sensors could be of value for the continuous update of the PHR content.

Compliance
Compliance of health consumers to health plans is known to be an issue in preventive medicine [7]. Patients usually comply but lose interest or fail to finish programs before predefined targets have been reached. One of the key issues here is the absence of immediate observable results for the patient. There is a need for an overall objective measure indicating one's health based on measurable health variables, e.g. a 'health index'. This measure or index could serve as a mean to help individuals observe the effect of compliance to formulated health plans. The health-index itself poses the requirement that it should be sensitive enough to generate changes between short periods of time. Technically this means that the PHR should include tools to create awareness about the effects of compliance to tailored health plans.

Recurrence of interaction
Many web-based personal health services face the problem of low recurrence of interaction rate [15]. This issue is related to the compliance. Providers, aware of this issue, engaged their subscribers by providing them e-health portal functionalities with personalized and accurate medical and health information services.

An e-health portal is a framework for integration of health information, applications and services. E-Health portals should play a key role in the housing of integrated PHR systems and the provision of different services and personalized health information (Figure 2).

Medical literacy
Even though there is a growing amount of individuals using the web for medical information, medical literacy is still an issue. Medical literacy is defined as the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions [16]. Since medical literacy is regarded as a problem to effectively consume medical information, an e-health portal should provide interpretive information. The portal should be able to adjust its content to the individual's level of understanding, i.e. educational or predefined level of understanding of the end-user.

Providers of PHRs and personal health services will face the challenge to communicate their services and information in such a way that it fits all user groups with respect to difference in level of medical literacy.

Discussion

Integrated personal health records incorporated in e-health portals could serve as a platform for the provisioning of preventive and early diagnostic services. While most preventive and early diagnostic services are scattered over a number of service provider locations, this platform provides a unique opportunity to implement a holistic approach for prevention and early diagnostics. Current PHRs and e-health portals are rather disease oriented and do not go beyond disease management. To broadly implement effective prevention, early diagnostics and subsequent early intervention, a PHR with the functionality of health risk assessments and tailored health plan generation is necessary. The proposed approach can forfill this need. Most of the components to implement this approach are already at hand.

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Web-Based Personal Health Records

A holistic approach for health management, prevention and early diagnostics

Georgio Mosis

Ersen Colkesen

Background

- A structured provision of Prevention and Early Diagnostics is needed to significantly improve healthy life years
- Empowerment of individuals in their health management is crucial in realizing prevention
- Personal Health Records can fulfill these needs

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Objective

- To identify issues in preventive health services via web-based PHRs

- To propose a framework for a holistic approach for prevention and early diagnostics via web-based Personal Health Records

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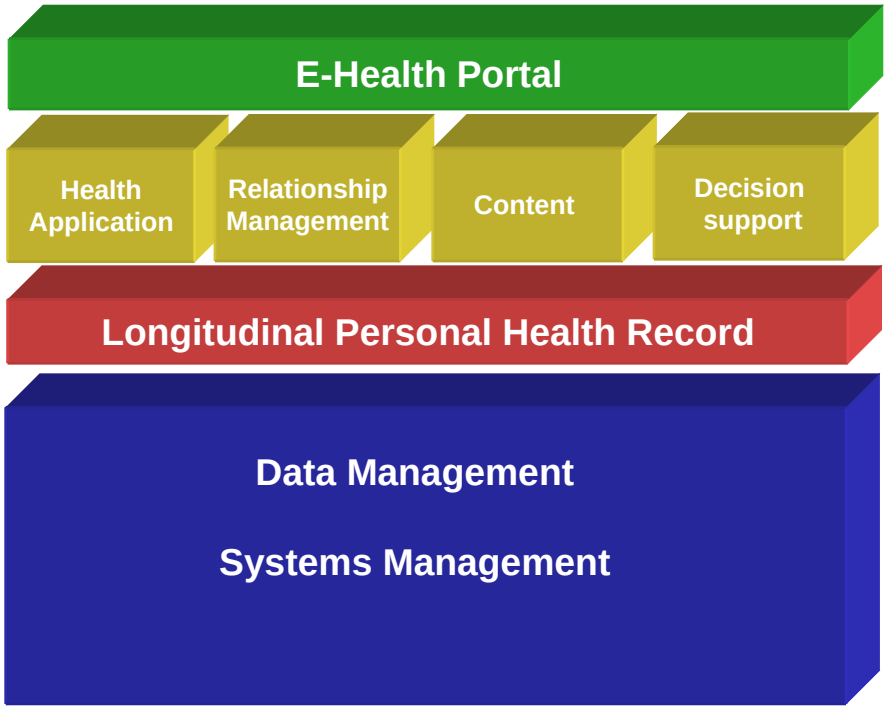
Web-based Personal Health Records

- **Web-based PHRs:**
  - **contain longitudinal health information**
  - **are sourced by both the individual as well as the health care professional**

- **Contained information comprises:**
  - **major illnesses**
  - **family and social history**
  - **medication, allergies and immunizations**
  - **lifestyle data**
  - **diagnostic test results**
  - **Home-monitored data**

→ **Web-based PHRs therefore enable additional services based on this information**



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Interactive prevention and early diagnostics services

- Current online health services mainly have a disease management focus
- Currently a holistic and structured approach for Prevention and Early Diagnostics services are lacking

→ A more prevention and early diagnostics focus is needed to improve individual health

→ A common structure is needed for provision of preventive services

→ Web-based PHRs can do just this

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Empowerment of individuals

- Web-based PHR can also provide preventive decision support for the individual, making the individual in charge of its own health

- Algorithms providing this functionality should therefore be:
  - Evidence-based and quality assured
  - Supported by healthcare providers to guarantee acceptance

- Process flow of individual decision support:
  - Knowledge system processes PHR data into personal risk profiles
  - Risk profiles are communicated to the individual
    → health education
  - Risk profiles are converted in tailored health plans
    → health improvement
  - Repeating the cycle gives insight in advances
    → health monitoring

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Discussion and conclusion

- Currently preventive and early diagnostic services are scattered and structural provision is lacking
- Web-based PHRs provide a unique opportunity to implement a holistic approach for prevention and early diagnostics
- To broadly implement effective prevention, early diagnostics and subsequent early intervention, a PHR with the functionality of health risk assessments and tailored health plan generation is necessary.

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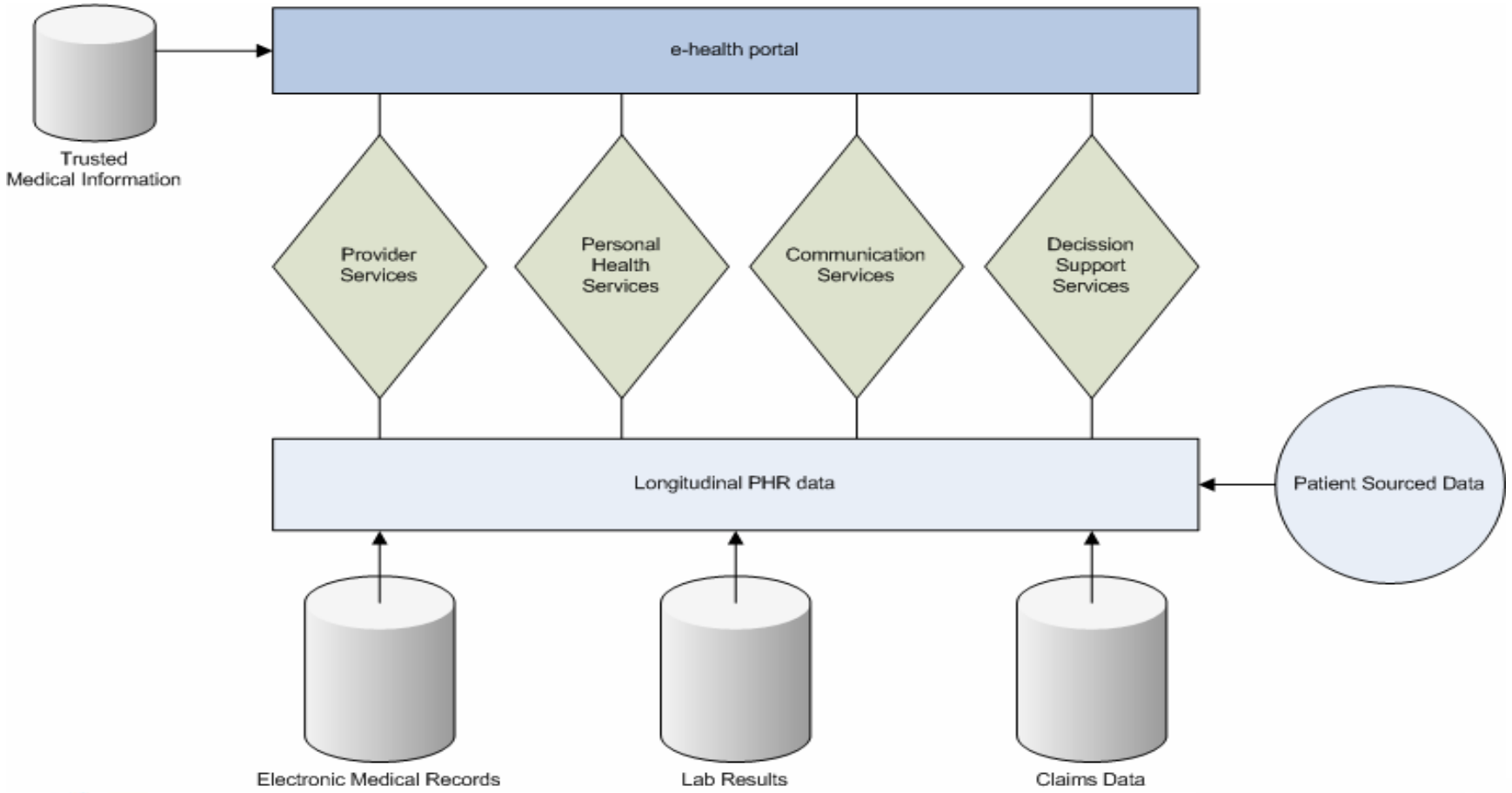
A holistic approach platform for prevention and early diagnostics



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Wireless Communication Technology to Support Rural Primary Health Care Management In South Africa

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Abstract

The aim of this study is to investigate the potential of wireless communication technology to improve in rural primary health care services. A cell-phone-based patient tracking system for use by home-based carers and a basic electronic clinic patient record system are being implemented in two sites. Summary data from the clinic patient database is transmitted wirelessly to a central database. Preliminary results indicate that electronic information systems have the potential to improve communication between clinic staff, home-based carers and sub-district managers.

Keywords:

primary health care, wireless communication technology, patient information system

Introduction

Primary health care (PHC) providers in rural clinics and those providing home-based care have difficulties in reporting and receiving feedback from management due to poor communication infrastructure and the use of manual systems to register patients' details. This study investigated the effect of implementing electronic patient record systems in two rural sites in the North West Province of South Africa (SA).

Description of the project

Two systems have been implemented: The patient tracking system (PTS) for use by home-based carers (HBCs), is cell-phone based, and the basic electronic clinic information system (CIS) is implemented on laptop computers at clinic level. A summary record of each patient clinic visit is included in the clinic database on the laptop. The data for the routine monthly report for the DHIS (district health information system) is transmitted wirelessly from the clinic to a central database via the cell-phone network, using a triband GPRS PC radio card. The PTS supports both reporting on all visits to chronically ill patients by home-based carers, and management of the home based care providers. Data from both systems is accessible via the Web to appropriate sub-district management personnel.

At initial implementation the two electronic systems operated separately, with data being consolidated in separate centralised databases. Data from the PTS and the CIS will be combined in a common database at clinic level, using the patient clinic number as the key. This will allow the clinic personnel to access full details of clinic and HBC services of patients.

The key users of the CIS at the clinics engage in diverse roles: nurse professionals can update patient data, and collate and compile data to create management reports. Data capturers transferred the details of all the patients who were registered in the manual clinic records to the electronic database on the laptop. The data capturers will be phased out as health professionals take control and operate the integrated system. HBCs enter data on patient visits on their cellphones and it is transmitted to a central database. The local sub-district information officers provide ongoing support to the system users.

Results and discussion

Ongoing monitoring of the operation and use of the electronic systems has led to significant updates of both systems. Communication costs are reasonably low. The implementation of the PTS has resulted in standardisation of the reporting on HBC visits. Experiences to date indicate that electronic information systems have the potential to improve communication between clinic staff, home-based carers and sub-district managers, and that wireless communication technologies can help to address infrastructure limitations.

Acknowledgments

The ongoing support of colleagues in the North West province and in our organisations is gratefully acknowledged.

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Extending a VEPR System Institutional Boundary

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Abstract

Information availability is a major concern when the provision of care is at stake. Physicians make their decisions based on the information at hand. Several Electronic Patient Record (EPR) systems have been developed in order to make available to physicians structured and helpful information. However most of these systems are unarticulated and usually address only the specificities of a single medical specialty. Virtual Electronic Patient Records (VEPR) such as MAID (Multi Agent system for the Integration of Data) system provide for the necessary means for intra-institutions departmental information integration. Nevertheless, patients are mobile entities, visiting multiple institutions during their life time and leaving a trail of information scattered around. In this paper is presented a mobile agent based extension to the agent based MAID system in order to enable inter-institution patient data integration.

Keywords:

mobile agents, computerized medical records systems, hospital information systems, systems integration

Introduction

Healthcare is information and knowledge driven. Good healthcare depends on taking decisions at the right time and place, according to the right patient data and applicable knowledge. Communication is of most relevance in today's healthcare settings, as health related activities, such as delivery of care, research and management, depend on information sharing. As more data on patients are now recorded than ever before [1] the economical impact of their management is high. In a single healthcare institution, information technologies usually tend to combine different modules or subsystems, resulting in a "best-of-breed" approach [2]. This leads to a great demand on creating efficient integrated electronic patient records that would facilitate the communication process. Centralized solutions are often infeasible and expensive. Thus, integration with legacy systems is a key issue in order to provide physicians with complete and reliable information. The combination of data from heterogeneous sources takes a great deal of effort because the participating systems usually differ in many respects, such as functionality, presentation, terminology, data representation and semantics [2]. Interfaces are needed in order to retrieve useful information. Taking into consideration the intra-institutional level, and departmental systems, Virtual Electronic Patient Records (VEPR) systems approach can provide for the necessary means for departmental systems integration, enabling, at the point of care, a single integrated view of all patients' clinical information existing on the institution. We could say that at the institution level local information integration could suffice to provide doctors with all the necessary information to deliver care to a given visiting patient. However, patients are mobile entities, they visit multiple institutions during their life time and leave a trail of information scattered around laboratories, primary care units and other hospitals. The patient clinical history available to the doctor should not be resumed only to the information produced locally in the institution but also to include external data. The lack of articulation observed at the institution level, in what information systems integration is concerned, is also present when looking at the inter-institution integration level. Usually data integration relies on patients carrying their paper lab reports, x-rays and other clinical documents themselves. In order to provide consistent and complete clinical data availability, solutions must be provided for bridging inter-institutional systems integration gap.

Methods

The implemented system was design for extending MAID patient data integration features [3]. MAID system was developed for patient data integration within hospital S. João, the second largest in Portugal. The MAID system was designed for gathering clinical documents such as lab results and discharge letters from several internal departments. MAID system makes use of agent paradigm in order to build an autonomous and scalable system running since 2004.

Our aim is to extend MAID enabling data integration at the inter-institutional level. In order to accomplish this, modules for external data discovery and collection need to be designed and developed. Given the error prone and instability of large networks, like the national health network, additional care must also be taken in consideration in order to enable data collection and data availability within a useful time frame.

Besides the social and autonomous behavior of agents, the system implementation makes use of their mobile capabilities. This mobility can eliminate the necessity of long running communication channels between institutions and can provide for stronger external data discovery procedures that don't lead to local communications system overloading.

Data collection activities will be trigged by surgeries, consultation appointments and other scheduled events within a health providing unit. The system is intended to be integrated not only with MAID system but also to be able to provide data search mechanisms to other existing systems. Given the widespread inexistence of international standards adoption in most of the Portuguese electronic patient record systems collection actions, at this point, will be directed only to formatted documents such as PDF files and will not retrieve data individually.

Results

Implementation

The implementation consists in three phases: Event Management, Document Discovery and Document Retrieval.

On the first phase each event corresponds to the schedulling of a new clinical episode (consultation, surgeries, etc). To each scheduled episode is associated a set of information that will be used latter for data discovery scheduling. Besides the patient identification a time interval is provided indicating the urgency of information retrieval. External systems where information is known to exist can also be added to this set.

Phase two is initiated by the event scheduler. It triggers a mobile agent for document discovery activities giving him a patient id and a set of starting locations of external systems.

Mobile agents will travel trough remote platforms asking for documents and additional locations for patient documents. In each remote platform a local broker agent will give the mobile agent a new procedure. This procedure contains all the necessary new actions for the agent to retrieve the desired information. When the procedure finishes the mobile agent will have retrieved a set of new locations and a list of remote document references and is ready to travel to a new system. When the agent is unable to move to the desired destination it will postpone the visit and continue to next available location. After a few attempts to visit a designated location the reason for failure is registered and the location is eliminated from the agent's itinerary.

After completing its itinerary the mobile agent will return to the home system and store the gathered information. This will trigger phase three were discovered documents are retrieved from remote systems by a local broker agent. After collection documents are made available within the hospital system.

The system is based on the widely used JADE multi-agent platform with the inter-platform mobility add-on.

Conclusion

Several efforts are being developed in order to make available the maximum amount of valuable health information when and where needed. Patient mobility, within a country and between countries is now more common than ever before. Health record systems should adapt to this reality and be able to cope with their patient's mobility. The implemented system is intended to enhance an existing institutional system in order to make available to care providers a more complete patient clinical history and consequently enabling patients better and faster care provision. Additional work is planned for this system regarding security and ontological issues regarding data transport and data integration respectively.

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Extending a VEPR system institutional boundary

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INTRODUCTION

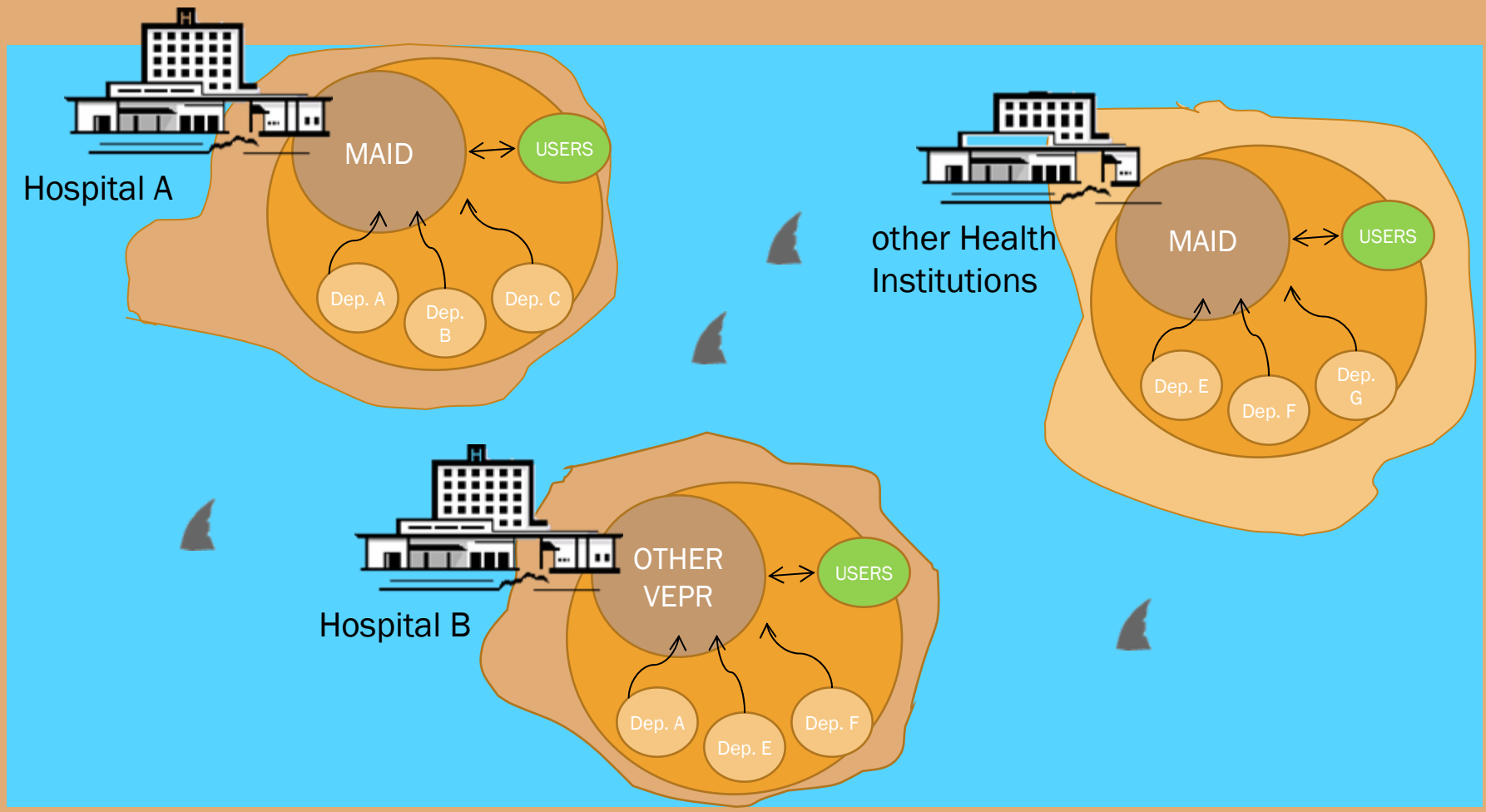
- Information availability is a major concern when the provision of care is at stake.
- Physicians make their decisions based on the information at hand.
- Most of EPR systems are unarticulated and usually address only specificities of a single medical specialty.
- Virtual Electronic Patient Record (VEPR) systems such as MAID - (Multi Agent system for the Integration of Data) provide for the necessary means for intra-institutions departmental information integration.

INTRODUCTION

- However patients are mobile entities, visiting multiple institutions during their life time and leaving a trail of information scattered around.

- In order to overcame the institutional information systems islands, a inter-institution information integration is necessary.

SCENARIO



Extending a VEPR system institutional boundary
P. Vieira-Marques et al.

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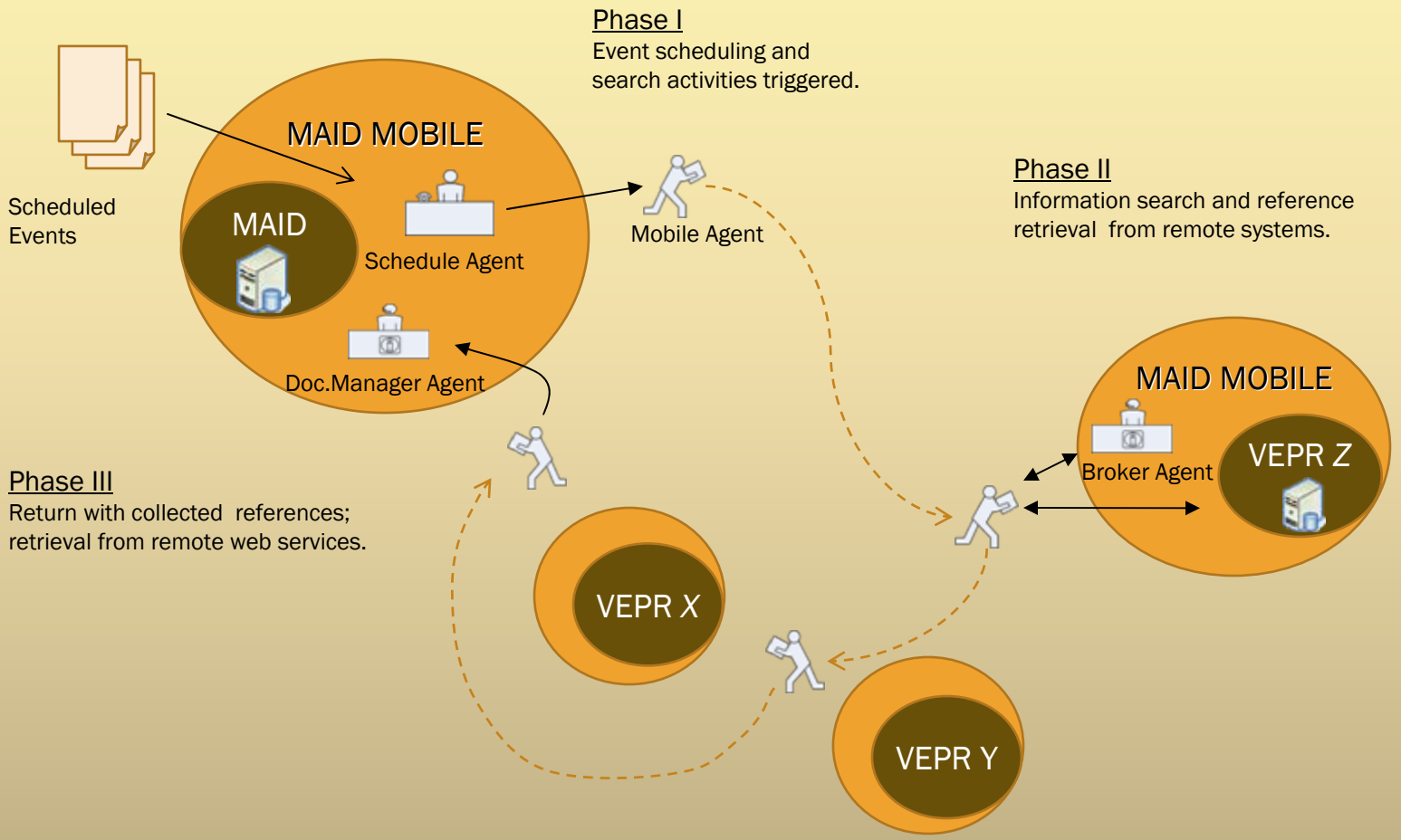
QUESTIONS

- How to bridge the institutional information systems islands?
- How to enhance the provision of up to date and, as much as possible, complete patient information?

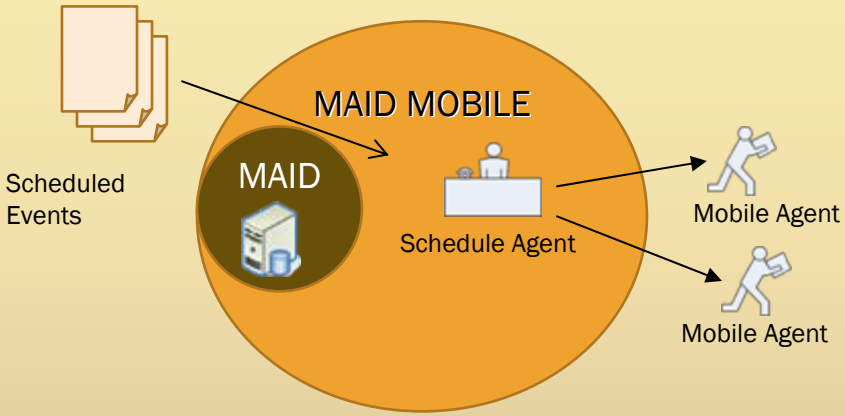
METHODS

- We start from a multiagent based VEPR system.
- Extend it with inter-institutional information search and retrieval capabilities using mobile agents.
- Test pilot system implemented using Jade multi agent platform with the inter-platform mobility add-on.

SYSTEM OVERVIEW

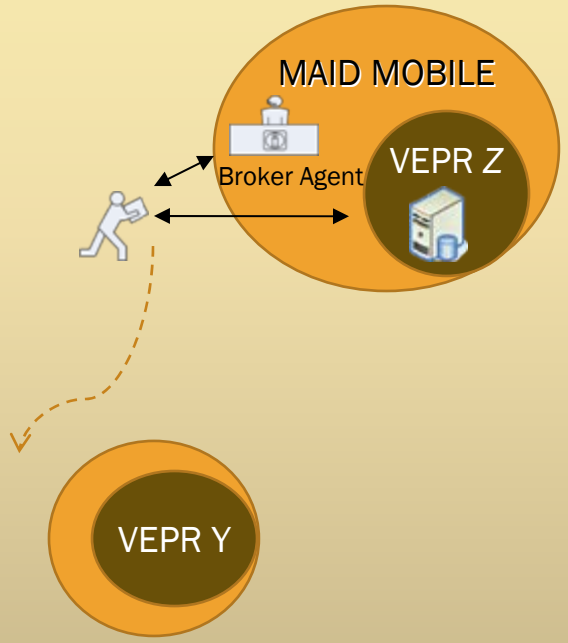


PHASE I – Event Scheduling



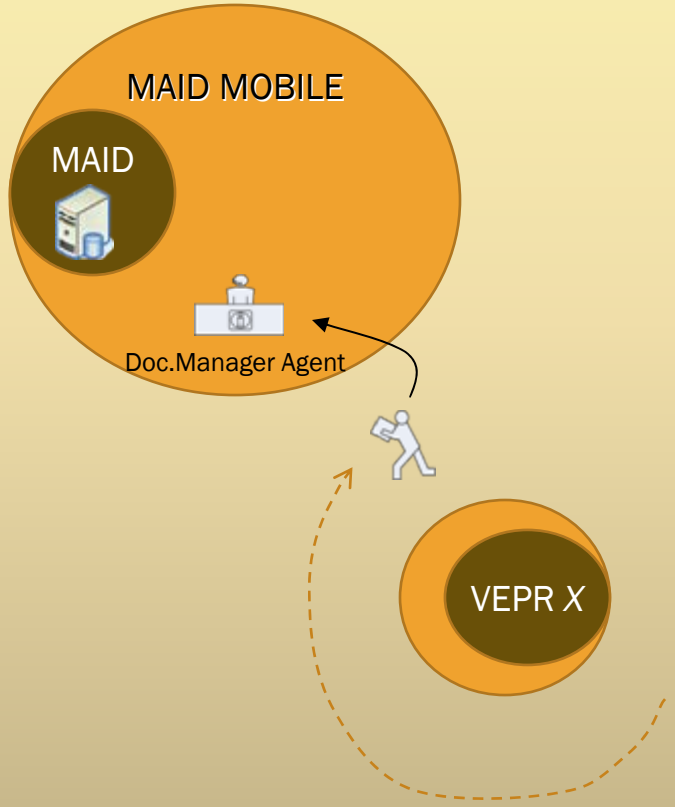
- For each patient, two mobile agents are sent looking for information.
- Along with the patient id
  - One agent receives a set of locations known to have information.
  - The other agent, the complementary set of all locations.
- New locations can be discovered along the way.

PHASE II - Retrieving references



- Mobile agent moves through a set of remote systems contacting the local broker.
- The broker agent manages incoming agents request providing the mobile agent with interfaces which enable querying the local VEPR.
- The mobile agent asks for document references from a given patient and other systems that are known to have additional patient information.
- Mobile agents stores all information adding new systems to its itinerary.
- Continues to the next system.

PHASE III – Returning results



- Document references collected are delivered to the Document Manager Agent along with a set of new contacted remote systems.
- Referenced documents are scheduled to be collected from remote webservices.
- Upon retrieval documents are made available to local users through the VEPR.

CONCLUSIONS

- The system is intended to enhance an institutional VEPR system in order to make available to care providers a more complete patient clinical history.

- The mobility behavior eliminates the need for long running communication channels between institutions and provide for stronger external data discovery procedures that don't lead to local communications system overloading.

- Additional work is planned for this system regarding security and ontological issues regarding data transport and data integration respectively.

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Understanding the Profile of Errors That Cause Duplicate Entries in a Patient Registry

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Abstract

Duplicate entries in patient registries are a significant problem facing healthcare master patient indices and public health data sources. Patterns exist in the demographic information of these records that can be used to better understand what causes duplicate entries to appear. The University of Utah contracts the Pedigree and Population Resource group at Huntsman Cancer Institute to link demographic records from its Enterprise Data Warehouse (EDW) to the Utah Population Database (UPDB). An additional benefit of this linkage is the discovery of duplicate records in the EDW. From one million EDW records, 76,922 have been identified as duplicate. A profiler was built to extract the patterns of errors from these duplicate records. Frequencies of error types found in the EDW were compared with those in existing literature.

Keywords:

record linkage, patient record management, patient registries

Introduction

Duplicate records are detrimental to the cost-effective and efficient delivery of health care.[1] Manually identifying and resolving duplicates can cost $60 per case.[2] Patterns have been found in the types of errors that occur in patient registries, suggesting that undetected duplicate records may be similar to those already identified.[3,4] The purpose of this study was to compare the frequency of error types in the University of Utah Enterprise Data Warehouse (EDW) with existing literature.

Methods

Patterns of errors in existing literature were extracted. State machine[5] templates were created for each error type as Java classes. As a potential duplicate record pair was examined, an instance of each state machine was created with one record and tested with the other record. A test resulting in an "accept" state resulted in the pair being classified as that error type.

Results

As shown in Table 1, the EDW records show some differences from published literature in patient name types.

	EDW	Friedman[4]
Extra names and titles	34.3%	36.9%
Nicknames, spelling variations	21.8%	13.9%
One letter substitutions	13.6%	13.7%
One letter added or deleted	7.6%	12.9%
Punctuation or spaces	1.9%	11.8%
Different last names for females	12.9%	7.8%
Permuted parts of names	3.2%	1.4%
Different first names	2.8%	1.4%
One letter transposed	1.9%	0.8%

Table 1 – Error types of patient names

Similar frequency discrepancies were found in error types of other demographic fields, including Social Security Number.

Discussion

Despite differences found in the frequency of error types that occur in the EDW data set from published literature, it is clear that patterns of error types do occur in duplicate records. Understanding which errors are likely to occur in a dataset can aid in the detection of duplicate records.

Acknowledgments

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Alternative Approach to Compliance of Antiepileptics and Its Clinical Meanings

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***Abstract**:*
Though compliance of antiepileptic drugs (AED) is key issue treatment of epilepsy, the only two ways to determine that are (i) interviewing patient (ii) monitoring serum level. We propose another approach by analyses the medication records of National Health Insurance Research Database (NHIRD) because it contain complete medication records of every insured person.

Keywords:

compliance, anticonvulsants, epilepsy

Method

The epileptic group are identified as diagnosed epilepsy (ICD-9CM code 345, 780.3, A-code A225, A469 in NHIRD) and receiving AED treatments.The disease duration is calculated as the period from first time diagnosis of epilepsy to the day when patient was not insured. If the patient was insured up to the final day of 2003, it is the end of duration. The drug days is calculated as total days of AED patient having during the disease duration. The times of hospitalization is also recorded. We examine the correlation between the outcome index, including hospitalization frequency, total medical payment, emergency service (ES) visiting and independent variables including age, gender, ratio respectively.

Result

The rate of epilepsy in this diseased group is 0.993%. The epileptic group is significantly older and more hospitalization than non-epileptic group. There is no difference if gender distribution between these two group. The all admission frequency increases significantly with the growing age and increasing ratio of AED days to the disease duration but oppositely with less AED days. There is the similar correlation between the total medical payment and age and ratio, but not to AED days. The ES visiting frequency is positively related to the AED days only.

Conclusion

This study suggests that NHIRD is a adequate resource in surveying compliance of specific drug in Taiwan. The result reveals that good AED compliance does not lessen frequency of hospitalization and ES visiting as expect. But the more AED taking, the less admission is noted in this study.

Alternative Approach to Compliance of Antiepileptics and Its Clinical Meanings

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Object

- Compliance is the key in controlling epilepsy
- Traditional method to estimate compliance of antiepileptic drug (AEDs)
  - Interview or questionnaire
  - Drug level test by saliva, serum, or hair sampling
- Complete medication record could be an alternative approach in estimating AEDs compliance

Materials

- In Taiwan, *National Health Insurance Research Database (NHIRD)* contain complete medication records of every insured person

- NHIRD
  - Out patient service
  - In patient service
  - Contract pharmacy

Materials

- NHIRD cohort sampling

- Population
  - 100,000 persons from 1987 to 2003
- Enrolled criteria (meet both)
  - Epilepsy diagnosis
    - ICD-9CM code 345, 780.3, A-code A225, A469
  - AED treatment

Method

- Independent variables
  - Age
  - Gender
  - Disease duration (DD)
    - Initial date : earliest date of epilepsy diagnosis
    - Final date : the end of study period or the day drop out from health insurance
  - Total AED days during disease (AD)
  - Compliance ratio (CompR) = AD /DD

Method

- Dependent variables
  - Frequency of emergency service (ES) visiting
  - Frequency of admission to hospital
  - Total medical payment
- Compare distribution of gender and age and hospitalization frequency between epileptic and non-epileptic groups
- Multiple regression model for each dependent variables
  - SAS 9.0 Reg procedure
  - Stepwise method

Result

- Study group
  - 993 observations in this diseased group (0.993%)

	Epileptic Group	Non-epileptic Group	Statistical Tests	p Value	Statistical Significance
Gender(F/M) in %	43/57	49/51	Chi-Square Test	0.055	Negative
Age	49±24	38±21	T-Test	<0.0001	Positive
Hospitalization Frequency	2.99	0.76	T-Test	<0.0001	Positive

Result

- Admission frequency = 0.57 +

  0.028 x age – 0.001 x AED days + 5.39 x CompR

  - Model R square = 0.0798

- Total medical payment = - 42142 +

  3614 x age + 496823 x CompR

  - Model R square = 0.1347

- Emergency service visits = 0.39 +

  0.0003 x AED days

  - Model R square = 0.0359

Conclusion

- Epileptic patients : older and more admission to hospital

- In epileptic patients
  - Aging more admission and more medical payment
  - More AED, less admission
  - Good AED compliance no guarantee of less hospitalization and ES visiting

Discussion

- More admission and more payment
  - = more severe and more care
  - = better compliance

- Limitation
  - Short study period in life-long disease such as epilepsy
  - Diversity of cause of admission and ES visiting

Future Application

- Correlate this compliance result with traditional drug level monitoring
- Further analysis in correlation of compliance with frequency of medication
- Study in compliance of medication for chronic diseases and correlate with outcome

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Development of a Personal Medical Recorder on Cell Phone

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Abstract

Paper medical records have effectively been used in chronic diseases without information technology. To facilitate self-control in hemodialysis and observe a patient's condition continuously, we developed a mobile phone-based personal medical recorder for patients suffering chronic renal failure. The application is based on Java2 Micro Edition and operates like a scheduler. The application stores laboratory data, such as BP, BUN, creatinine, HbA1c, etc., and other pertinent clinical comments into memory on a cell phone. The application can also customize, add or delete items (laboratory data, medications, questions, etc.). Detailed graphic displays of the data are shown. The data can also be sent to a PC with infrared communications. In a usage trial, patients were favorably receptive about this application and indicated that they wanted to continue using it.

Keywords:

cell phone, medical records, infrared transmitter

Introduction

Using a notebook-type diary, a chronically ill person can get an overview of his or her medical situation [1]. Although patients with chronic renal failure can maintain an adequate nutritional intake, they might also be able to recognize their own pathophysiological state and be aware of the settings for their own hemodialysis. Although data collection was more reliable with a palmtop computer than with paper diaries [2], there have been no reports presenting a PDA/cell phone-based clinical recorder for chronic hemodialysis other than for dietary monitoring [3]. Therefore, we developed a cell phone-based medical recorder for self-management of chronic diseases.

Materials and methods

An application on a cell phone was designed as a self-control tool for patients who are familiar with cell phone applications such as games. The application is based on a scheduler consisting of 3 canvases, a calendar, data entry and a plot canvas, and memory control and infrared modules (Figure 1). The plot canvas shows colored lines of selected clinical and laboratory data, such as BP, BUN, creatinine, HbA1c, etc.

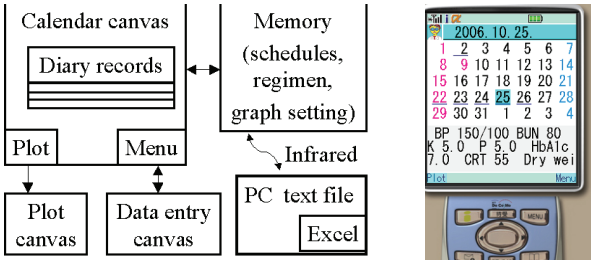

Figure 1 – An overview of the application and a calendar canvas

These data are stored in a textile format in the memory of the cell phone (maximum 200 kB). Because the record size of one schedule is estimated to be about 100 bytes, a maximum of 2000 records may be stored. An infrared module sends records in day or month units to a PC as a textile file. The records on the PC are automatically tabled and tallied on Excel with a customized VBA program.

The application was based on Java 2 Platform, Micro Edition (J2ME), and developed with an "i-appli Development Kit for DoJa-3.5" on a PC [4]. (The Doja is a version of the Java platform specially tailored to a mobile environment for NTT cell phones.) The application, a medical recorder (medData.jar 100kB), was uploaded with 2 files (medData.jam and medData.html) into our Web server. The application was then downloaded via the Internet and automatically installed into a Java-enabled cell phone in the usual way of a Java applet.

Results

For clarity, PC screens are shown in the regular order of usage rather than using photographs of cell phone screens (Figure 2). The application operates like a scheduler. Today, on the calendar, is highlighted in yellow. The selected day is highlighted in light blue and moved by operating the arrow keys. Each colored line on any day, e.g., 7th and 21st, corresponds to each clinical event or data and appears with comments and/or a graph in the lower area (Figure 2a).

Two records, pairs of the time of day and prescriptions (with laboratory data), are shown in this case (Figure 2b). Pushing the select key on a target record shows a data

entry canvas with laboratory item names and values. Numeric data are typed in by the patient. An adaptive submenu is automatically shown on the right side of the item along with a blood-flow setting for hemodialysis. All these values, including the time span, can later be edited.

Detailed graphic displays of data are sequentially shown on a plot canvas (Figure 2c). A trend graph of potassium for 1 year is shown in light blue (Figure 2d). The values in the last half of the year are higher than the target range shaded in the same color as the item in half tone. A horizontal scale of the graph is set to day, week, month or year by pushing 2, 5, 8 or 0, respectively. Graph properties of each item (vertical scale, normal range, line color, line mode and symbol) can be customized via a submenu on the calendar canvas (Figure 2e), e.g., a graph of BUN is shown in yellow bars (Figure 2f). In a selection canvas, plot items are marked with a black diamond (Figure 2g). A submenu of the calendar canvas includes functions: setting the system font, controlling infrared communications, customizing item/plot items, copying & pasting records, etc. (Figure 2h). Items (laboratory data, medications, prescriptions, questions, etc.) can be customized, added or deleted for each patient's disease.

The application was adapted for several patients in one trial. The patients were positive about this application and said that they would like to continue using it.

Discussion

Our application imposed upon the user to manually enter his or her own clinical data. The operation and graphics may deepen the patient's awareness of his or her symptoms, laboratory data, diseases, and prescriptions for self-managing therapies. The act of consciously entering and organizing data may be relevant to promoting desired behavior changes [5].

The application recognized only numeric keys where a numeric value should be entered: hour, minute, dosage, etc. Alphabetic characters are only used to enter comments. A menu is automatically shown when answers are ready. These functions do not allow any error messages that are objectionable when entering data to appear.

Graphs of clinical data are useful for awareness and self-management of chronic diseases. The system shows daily data and trend graphs of all plot items together on a calendar canvas and separately on a plot canvas. Arbitrarily selecting a horizontal term of the graph can be adapted to various data with a quick variation in minutes such as blood sugar and/or with a slow response in months for such items as glycosylated HbA1c. However, the system could be improved on the plot routines, since many daily records take about 1 second to make a graph of the data for each day of a month.

Conclusion

This personal medical recorder on a cell phone could be useful for patients requiring hemodialysis, since actively processing and managing data may improve their understanding and situational awareness. Our cell-phone application will record medical events at anytime and anywhere in a person's life.

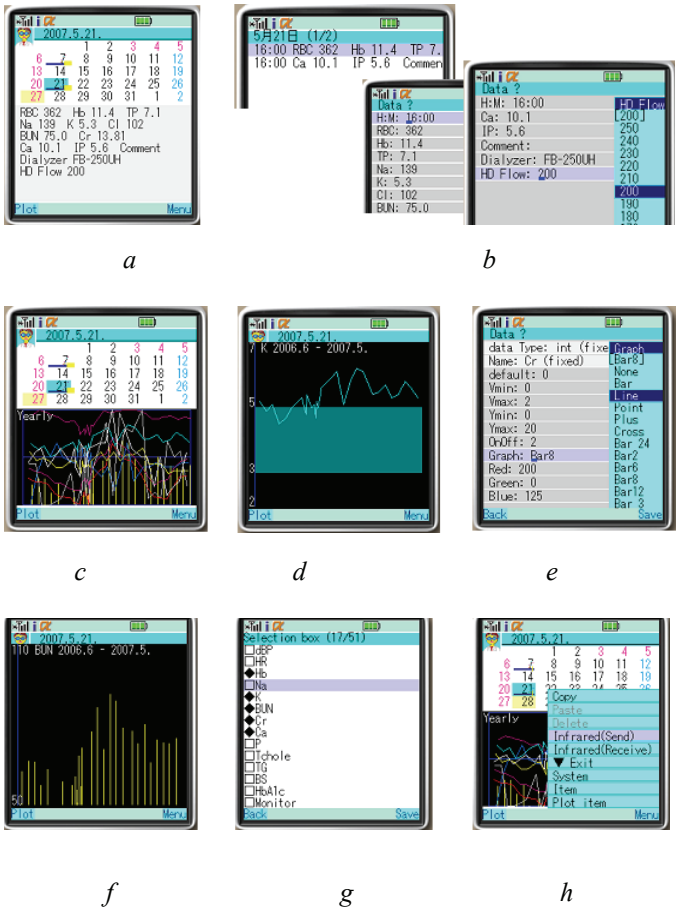

Figure 2 – Captured screen of (a) calendar canvas, (b) diary canvas and data entry canvas, (c) calendar canvas with a graph plot canvas, (d) plot canvas, (e) edit canvas to modify plot item properties, (f) a bar graph on the plot canvas, (g) selection canvas of plot items and (h) a submenu of the calendar canvas

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[1] Baert H, Gielen P, and Smet M. A health diary for the chronically ill. WHO Reg Publ Eur Ser 1992: 44: 328-31.

[2] Hyland ME, Kenyon CA, Allen R, et al. Diary keeping in asthma: comparison of written and electronic methods. *BMJ* 1993: 306: 487-9.

[3] Sevick MA, Piraino B, Sereika S, et al. A preliminary study of PDA-based dietary self-monitoring in hemodialysis patients. J Ren Nutr 2005: 15: 304-11.

[4] i-appli Development Tools for DoJa-3.5 Profile. http://www.nttdocomo.co.jp/english/service/imode/make/content/iappli/about/tool_foma2.html
[5] Tufano JT and Karras BT. Mobile eHealth interventions for obesity: a timely opportunity to leverage convergence trends. J Med Internet Res 2005: 7: e58.

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Development of a personal medical recorder on a cell phone

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[a] *Departments of Medical Informatics, School of Allied Health Sciences, Kitasato University, Japan*

[b] *Graduate School of Medical Sciences, Kitasato University, Japan*

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Abstract

Paper medical records have effectively been used in chronic diseases without information technology. To facilitate self-control in hemodialysis and observe a patient's condition continuously, we developed a mobile phone-based personal medical recorder for patients suffering chronic renal failure. The application is based on Java2 Micro Edition and operates like a scheduler. The application stores laboratory data, such as BP, BUN, creatinine, HbA1c, etc., and other pertinent clinical comments into memory on a cell phone. The application can also customize, add or delete items (laboratory data, medications, questions, etc.). Detailed graphic displays of the data are shown. The data can also be sent to a PC with infrared communications. In a usage trial, patients were favorably receptive about this application and indicated that they wanted to continue using it.

Introduction

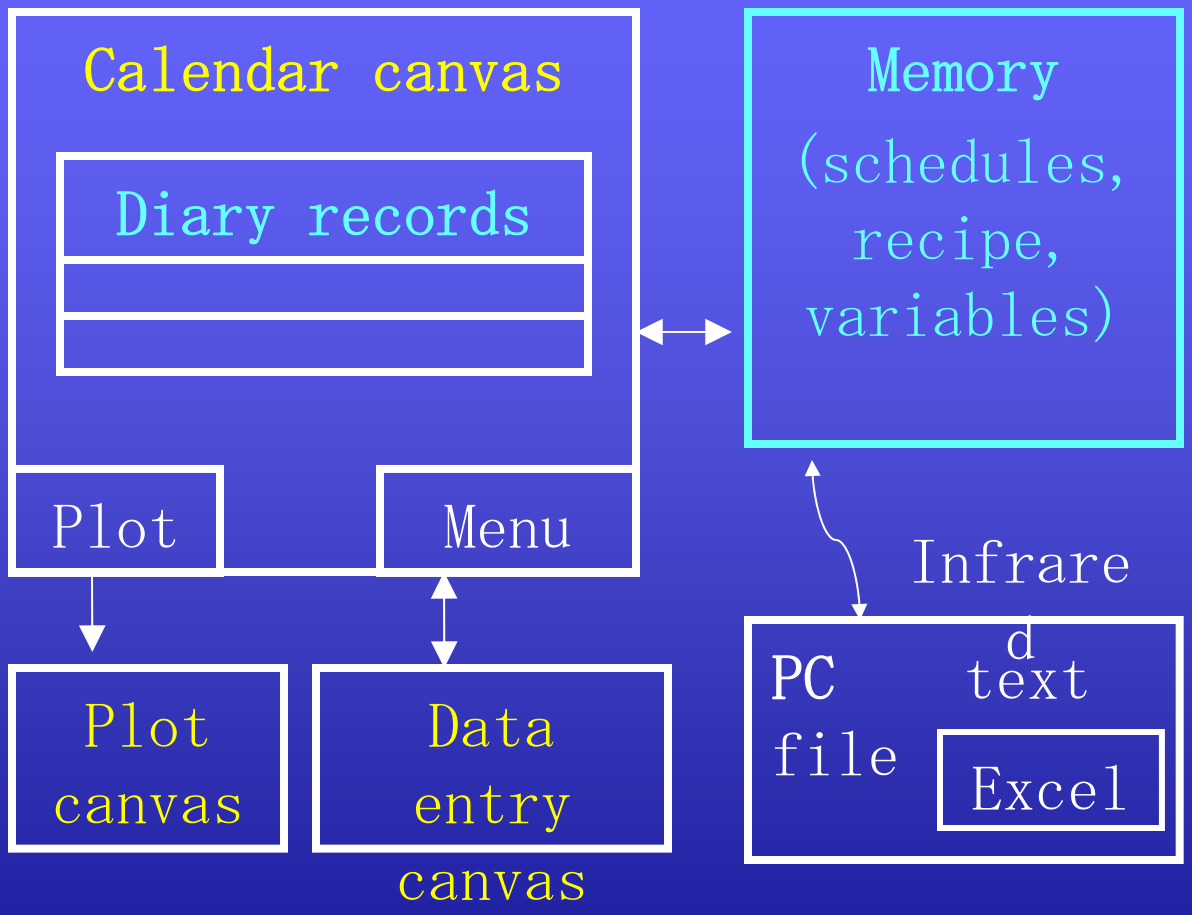
Using a notebook-type diary, a chronically ill person can get an overview of his or her medical situation [1]. Although patients with chronic renal failure can maintain an adequate daily nutritional intake, they might also be able to recognize their own pathophysiological state and be aware of the settings for their own hemodialysis. Although data collection was more reliable with a palmtop computer than with paper diaries [2], there have been no reports presenting a PDA/cell phone-based clinical recorder for chronic hemodialysis other than for dietary monitoring [3]. Therefore, we developed a cell phone-based medical recorder for self-management of chronic diseases.

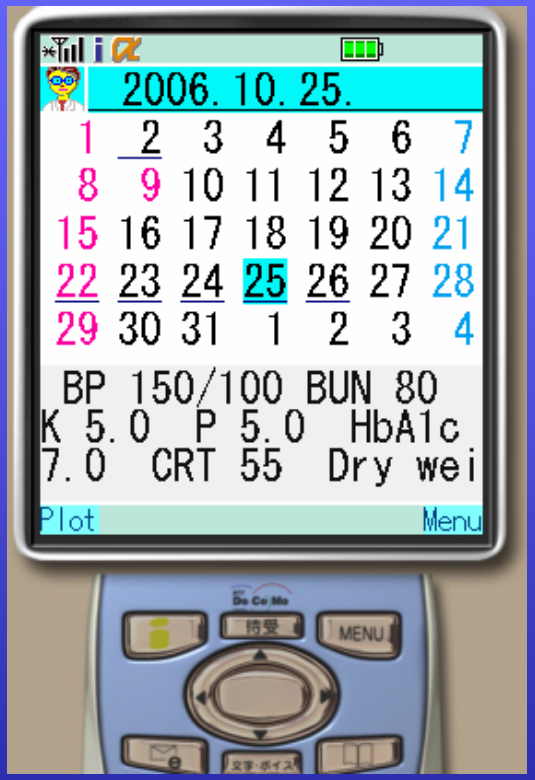
Materials and Methods

An application on a cell phone was designed as a self-control tool for patients who are familiar with cell phone applications such as games. The application is based on a scheduler consisting of 3 canvases, a calendar, data entry and a plot canvas, and memory control and infrared modules (System design p5). The plot canvas shows colored lines of selected clinical and laboratory data, such as BP, BUN, creatinine, HbA1c, etc.

These data are stored in a textile format in the memory of the cell phone (maximum 200 kB). Because the record size of one schedule is estimated to be about 100 bytes, a maximum of 2000 records may be stored. An infrared module sends records in day or month units to a PC as a textile file. The records on the PC are automatically tabled and tallied on Excel with a customized VBA program.

System design





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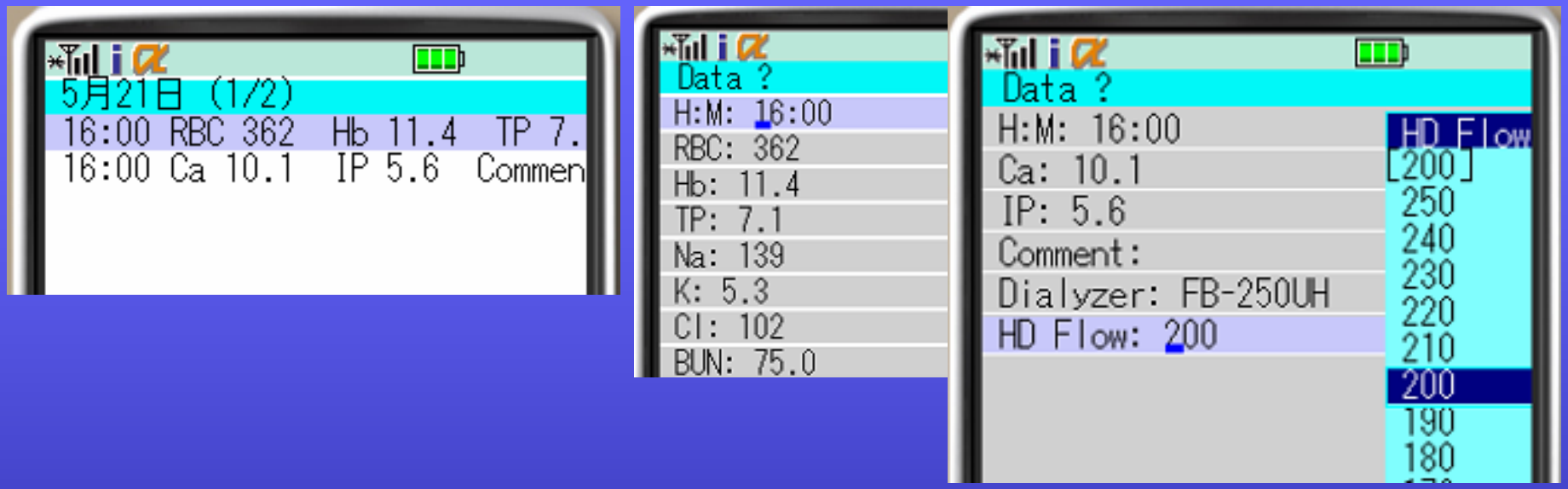
The application, a medical recorder (medData.jar 100kB), was uploaded with 2 files (medData.jam and medData.html) into our Web server. The application was then downloaded via the Internet and automatically installed into a Java-enabled cell phone in the usual way of a Java applet.

Sample runs

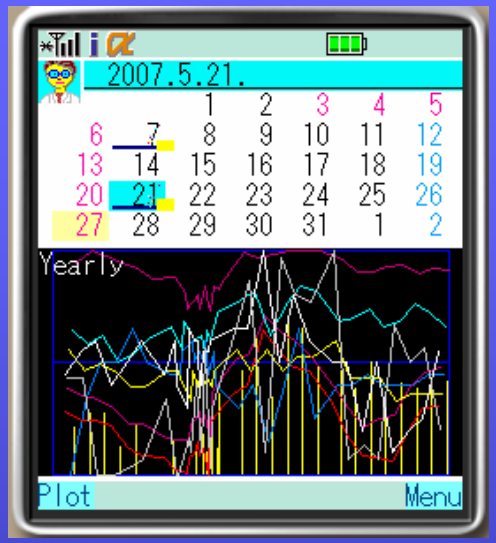
For clarity, PC screens are shown in the order of frequency of usage rather than using photographs of cell phone screens. The application operates like a scheduler. Today, on the calendar, is highlighted in yellow. The selected day is highlighted in light blue and moved by operating the arrow keys. Each colored line on any day, e.g., 7th and 21st, corresponds to each clinical event or data and appears with comments and/or a graph in the lower area.

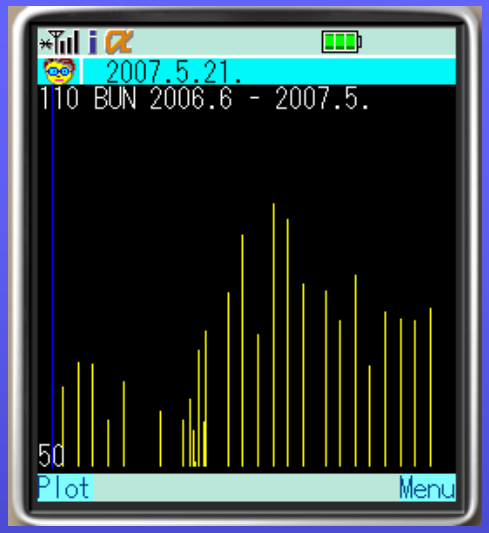
Entering/editing data



Two records, pairs of the time of day and prescriptions (with laboratory data), are shown in this case. Pushing the select key on a target record shows a data entry canvas with laboratory item names and values. Numeric data are typed in by the patient. An adaptive submenu is automatically shown on the right side of the item along with a blood-flow setting for hemodialysis and a brief comment. All these values, including the time span, can later be edited.

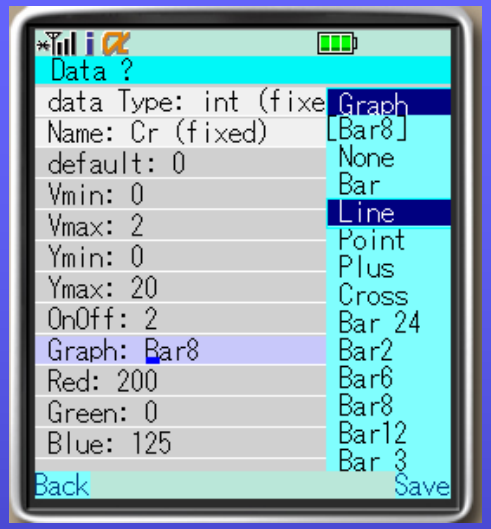
Graphics

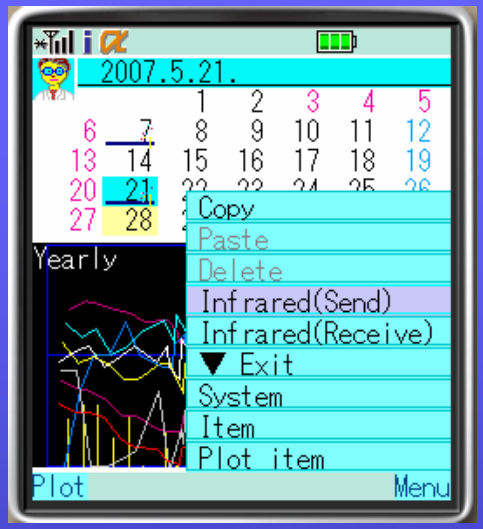




Detailed graphic displays of data are sequentially shown on a plot canvas (left). A trend gram of potassium for 1 year is shown in light blue (middle). The values in the last half of the year are higher than the target range shaded in the same color as the item in half tone. A horizontal scale of the graph is set to day, week, month or year by pushing 2, 5, 8 or 0, respectively.

Customizing





In a selection canvas, plot items are marked with a black diamond (left). Graph properties of each item can be customized via a submenu on the calendar canvas (middle), e.g., a graph of BUN is shown in yellow bars (Graphics p9, right). A submenu of the calendar canvas includes functions: setting the font, controlling infrared communications, customizing item/plot items, copying & pasting records, etc. (right). Items (laboratory data, medications, prescriptions, questions, etc.) can be customized, added or deleted for each patient's disease.

Discussion

Our application imposed upon the user to manually enter his or her own clinical data. The operation and graphics may deepen the patient's awareness of his or her own symptoms, laboratory data, diseases, and prescriptions for self-managing therapies. "The act of consciously entering and organizing data may be just as relevant to promoting the desired behavior changes" [5].

The system draws daily data on each day, and trend graphs of all plot items together on a calendar canvas and separately on a plot canvas. Selecting arbitrarily a horizontal term of the graph can be adapted to various data with a quick variation in minutes such as blood sugar and with a slow response in months for such items as glycosylated HbA1c.

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A Novel Population-Based Proband-Initial Algorithm for Family-Based Studies in Keelung Community-Based Integrated Screening: An Illustration of Hypertension

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Abstract

The family-based information is the foundation for family care and community health promotion. Based on the multiple diseases integrated screening project and the completed popultion household registry system, we developed the efficient and flexible algorithm to asscertain the family-based structure for community public health management. We use the house-hold registry system to developed family-based pedigree and degrees of relatives on the basis of two-stage procedure. The algorithm followed the rule of family case-control proband method to catch other family members, not only for specific one type of disease, but also for various types of diseases. All relationship would be changed according to the proband located. During this algorithm development, we took the case-control family-proband study of hypertension to demonstrate the application and used proportional hazard model of Cox regression to compare the onset age of hypertension. Both random sampling and optimal relationship methods were revealed well for familial aggregation study of hypertension.

Keywords:

family-based, proband, population-based, screening

Introduction

Primary care is a critical role to identify individual risk of disease, including the inherited disease. However, the primary tool for the inherit risk assessment is family history and onset age of relatives, but there are few data can be taken, hence, how to build up the database is the important issue for preventive medicine, especially for community-based and population-based application. The development of population-based and family-based data has now increasingly gained attention in studies related to population genetic epidemiology. The process of genetic epidemiology includes a spectrum of stage from descriptive epidemiology, familial aggregation, segregation analysis, linkage analysis, fine mapping, the assessment of candidate gene associations, and gene characterization. Studies on each stage call attention to the requirement of population-and family-based data. The multiple disease screening model was initiated from 1999, which combined 5 types of cancers and 3 types of chronic disease, named as Keelung Community-based Integrated Screening (KCIS) project [1]. To deal with the large and complex data management, the health information management system has built up for referral and follow-up mission [2]. To date, this project served 85956 residents for screening from 1999 to 2005. According to the contents and relative information of house-hold registration system, KCIS project offers an opportunity to spawn population-based and family-based data for a series of diseases with the potential of familial aggregation. This novel idea and development has provided the efficient practice for epidemiological research and preventive medicine.

Material and methods

Data resource and structure

To understand and to elucidate the data resource and structure are very important for this population-based and proband-initiated study. The household registration of Taiwan inherited from the governed period of Japanese. The registration system is through two major ways for household management, one is personal identification registration and another is booklet of household registration. Both were performed from 1947 and computerized from 1985. The personal identification registration not only includes unique personal identification number, name, but also gender, birthday, names of father, mother and spouse, address, marriage or devoice, adoption or not, and date of death. Every household is provided unique household number and booklet which was listed and updated all family members' personal identification information as above.

Construction algorithm of trans-generational pedigree

A prospective cohort design was adopted using the community-based multiple screening program in Keelung, the northernmost county of Taiwan. All participants were informed the associated data management. We link the

house-hold registry system to developed family-based pedigree and degrees of relatives on the basis of two-stage procedure. Since the record for each resident of population registry contains the name of parents and household number both variables enables us to identify offspring descended from the same parents. The first stage was to link probands derived from the KCIS data with population registry by identical name of father and mother to construct three-generational pedigree for proband's family. The second stage was to ascertain degrees of relatives constructed in the first stage by identical name of spouse, mother and father for maternal series, paternal series and spouse, respectively, of relatives. The KCIS data was further linked with population registry by identical name of parents to construct trans-generation pedigree (at first stage) and to ascertain degrees of relationship at the second stage (Figure 1). In our study, we developed array algorithm to change the relationship for different proband, which is usable for familial aggregation studies of various diseases, please see Figure 2. Now, the family-based data was applied to study familial aggregation of hypertension with family case-control proband sampling design and of hypertension with entire cohort.

Statistical analysis

We took the proportional hazard model of Cox regression to compare the onset age of hypertension. Cox proportional hazards model was performed to model the hazard ratios (HR) for hypertension-onset age among cases and controls of the first-degree relatives, including parents, siblings, and offspring. The previous hypertension cases were taken the onset age from self-reported questionnaire as affected duration. The age at screening attendance of new diagnosed hypertension was also too. The exact ages at screening of normal cases were collected as censoring time. All models were adjusted for independent variables, such as gender, education levels, drink, hypertension history of parents and well-known biomarkers.

Results

There were a total of 8581 families with at least two family members who attended the KCIS between 1999 and 2004. Each relationship was defined by index case of family unit. Besides the 8581 index cases, there were 4925, 1863, 2448, and 9066 of spouses, parents, children and siblings, respectively. For example by offspring, the familial aggregation HR was 3.86 after adjusted for gender, education, triglyceride and waist (Table1).

Conclusion

The health information system of KCIS is not only provided the management of workflow and data, but also supported the management and applications by family-based approach. Our study based on family-based and family-proband methods to explore the familial aggregation of hypertension by relationship ascertainment from the population-based screening data. Familial aggregation of hypertension was modeled and demonstrated by Cox regression model.

Reference

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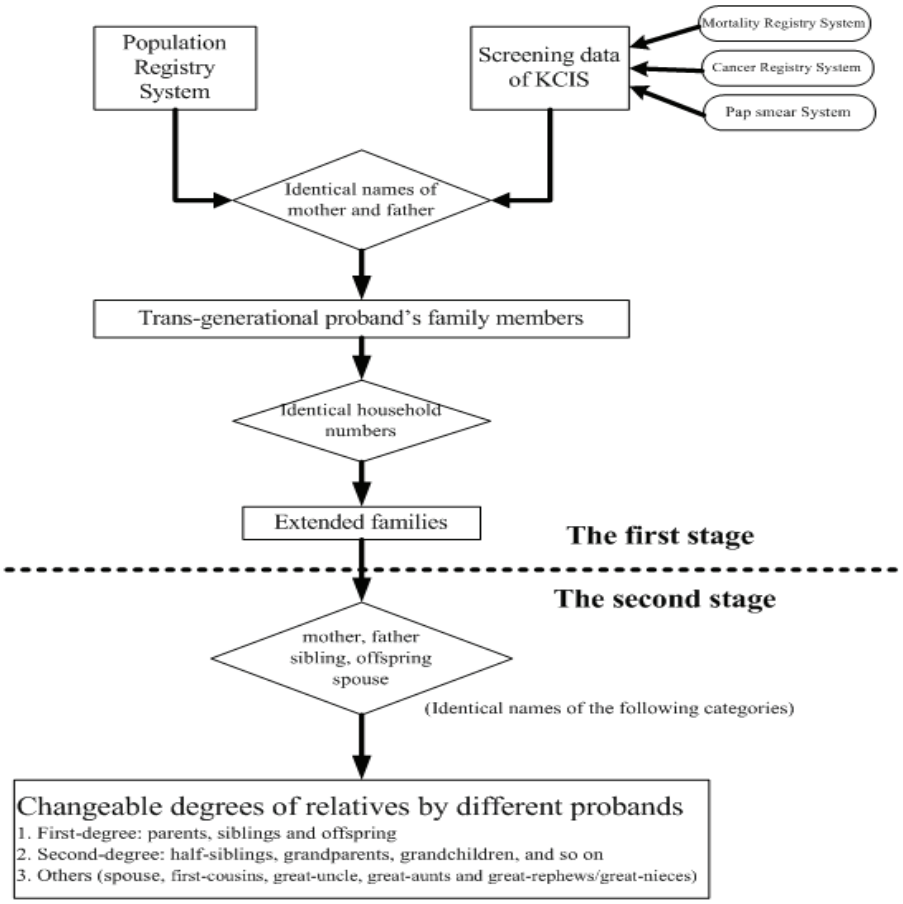
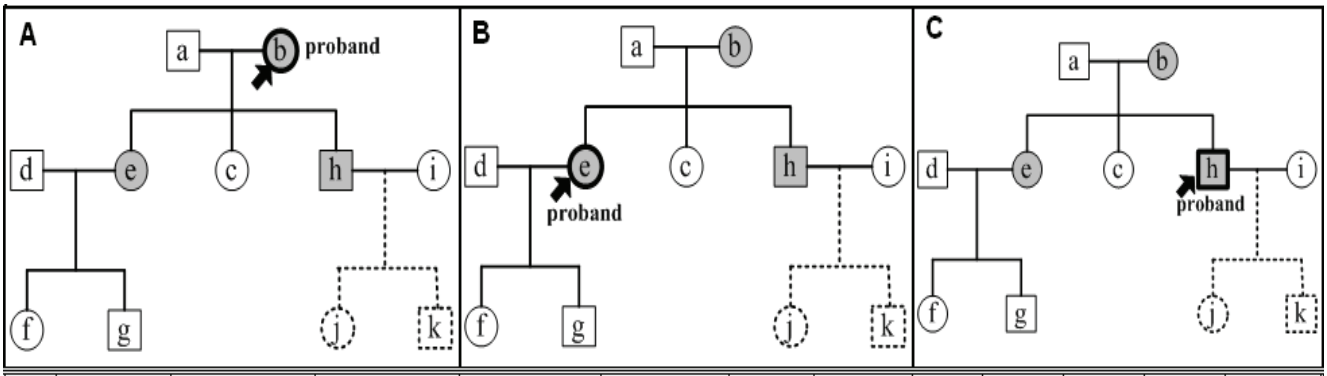


Figure 1 - Flow-chart for proband-initial construction of trans-generational pedigree



case.	Household Number	Name	Father	Mother	Spouse	Age	HTN Onset age	SBP	DBP	A	B	C
a	C2000001	Jack Wang	Jerry Wang	May Chen	Marry Fan	72		132	77	99	11	11
b	C2000001	Marry Fan	Michael Wu	Sherry Lai	Jack Wang	65	55	145	93	♦	12	12
c	C2000001	Marian Wang	Jack Wang	Marry Fan		42		130	80	14	16	16
d	C3300002	Patrick Chang	Linda Hsu	Robert Chang	Jenny Wang	44		123	75	50	99	50
e	C3300002	Jenny Wang	Jack Wang	Marry Fan	Jeffery Yen	40	40	142	95	14	♦	16
f	C3300002	Jane Chang	Patrick Chang	Jenny Wang		25		118	65	28	14	40
g	C3300002	Steven Chang	Patrick Chang	Jenny Wang		27		124	64	27	13	40
h	C4300004	Bill Wang	Jack Wang	Marry Fan	Amy Chang	42	42	138	90	13	15	♦
i	C4300004	Helen Lee	Edward Lee	Carlo Chen	Bill Wang	40		122	68	50	50	99

Figure 2 - Diagram for flexibleproband algorithm

Table 1 - Onset Age of Hypertension by Cox Model, adjusted for familial aggregation and risk factors (offspring)

variable	Class	Optimal Relationship		5000 Random Sampling	
		HR	95%CI	HR	95%CI
Familial aggregation		3.86 [c]	(2.88-5.16)	2.46	(2.03-3.06)
Gender	Male / Female	2.82 [c]	(2.02-3.92)	1.11	(0.90-1.37)
Education	Middle / High	2.32 [c]	(1.18-4.55)	2.53	(2.08-3.37)
Education	Low / High	3.94 [a]	(1.99-7.79)	3.78	(2.83-5.17)
Triglyceride	>=200 / <200	1.08	(0.74-1.57)	1.60	(1.35-1.95)
Waist	F>80cm, M>90cm	1.36	(0.98-1.88)	1.44	(1.13-1.91)
Total cholesterol	>=200 / <200	0.70 [a]	(0.51-0.96)	0.95	(0.79-1.14)

a : $0.01 \leq p < 0.05$ b : $0.0001 \leq p < 0.01$ c : $p < 0.0001$

HR: hazard ratio

“Toughclinic” – modern medical informatics under extremer conditions

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Abstract

- Care for seriously injured persons has to be guaranteed even under bad conditions.
- Paper based documentations have disadvantages.
- “TOUGHCINIC” as a solution:
  - Electronic system for emergency patients or refugees.
  - Can be set up very fast.
  - Any facts can be documented.
  - Digital photos can be added.
  - Software components are able to be adapted locally.
- Wireless linking of many individual and extremely robust notebooks without central infrastructure.
- The three principles:
  - Simple handling,
  - possibility of total configuration by non technical personnel and
  - extremely fast operational readiness as well as toughness under extreme environmental conditions without cabling.

Introduction

- Two target groups: Seriously injured persons (like victims of catastrophes) and refugees.
- On the one hand: Paper based documentation is not resistant, copies are not automatically updated, automatically analysis is not possible.
- On the other hand: Computer based documentation is not advisable. Standard hardware is under extreme environmental conditions not reliable, computer solutions often demand expert-knowledge, extra cables add logistical problems, personnel outside the base is hardly supported and available software solutions are too complex.
- With TOUGHCLINIC target groups can be cared for fast: It supports a medical and/or administrative all-embracing care.
- **A hospital information system is a “conceptual bound”, in which single appliances develop and can be integrated as an acting whole system. The system TOUGHCLINIC offers such a bound.**

Necessary equipment

- About 50 percent of all damages of notebooks go back to transport accidents.
- The expected environmental conditions like aridity clamminess and extreme temperatures let notebooks not appear as adequate equipment in areas of catastrophes or crisis.
- Special notebooks e.g. Toughbooks of Panasonic have several mechanical protections.
- Also the photo industry made progress and offers digital waterproof and sand resistant cameras like Olympus µ720SW or Pentax Optio Wpi.

Examples of equipment

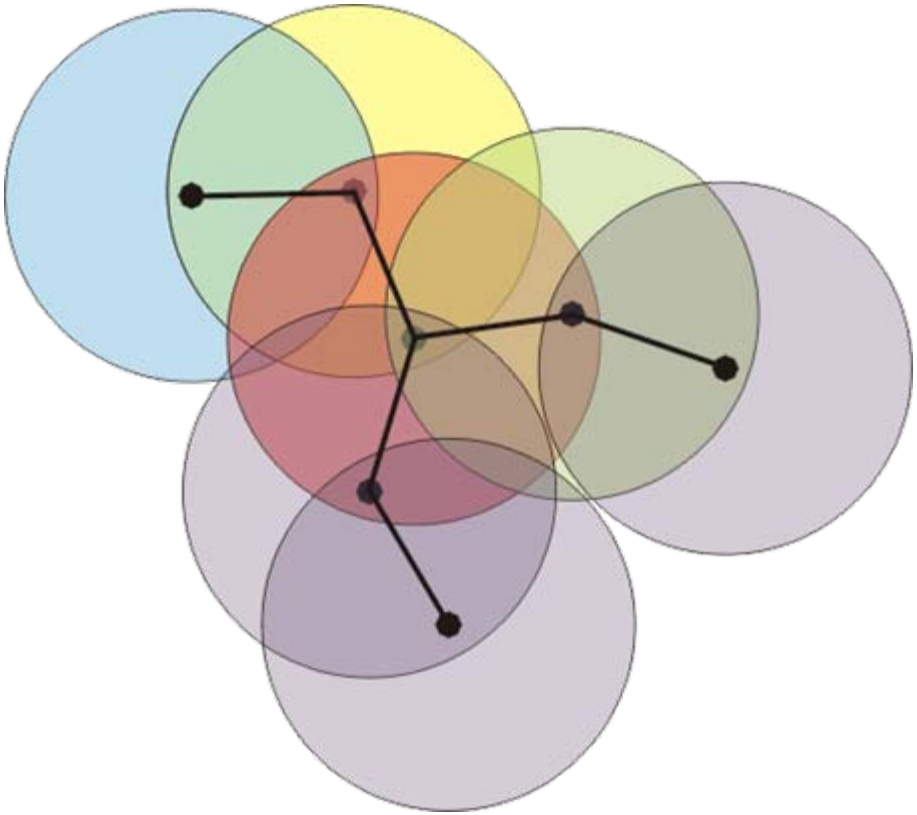
Computer language and architecture

- Modular and platform independent software concept is necessary for future flexibilty: Java with Java Runtime Environment (JRE).
- Usage of “best-practice” frameworks for easier multinational development.
- Architecture bases on a three-tier-model with data management, business logic and presentation.
- HSQLDB and Java DB as two effective Java data bank systems with support of the “embedded mode”.
- Exchange local data with every reachable co-equipment (unit, device) and to synchronize one another automatically: SyncML (Synchronization Markup Language).
- Java Foundation Classes as a comprehensive collection of GUI-components and Services.
- **Modular design leads to potential add-ons: Worldwide telemedicine or stack management.**

MANET radio communication network

- So far in a WLAN only one notebook can be connected with exactly one central router or exactly one additional notebook. → Wireless Communication is depending on central architecture and bandwidth is limited.
- Solution: Mobile ad-hoc networks (MANET).
  - Individual notebooks are nodes, which serve as a repeater for one or more other nodes.
  - The resulting network can overcome long distances, especially in uneven or challenging terrain. Furthermore MANETs are very reliable, because every node is connected with many other nodes. If a node breaks down, the surrounding nodes search for an alternative route.
  - Usage e.g. of Optimized Link State Routing Protocol (OLSR).

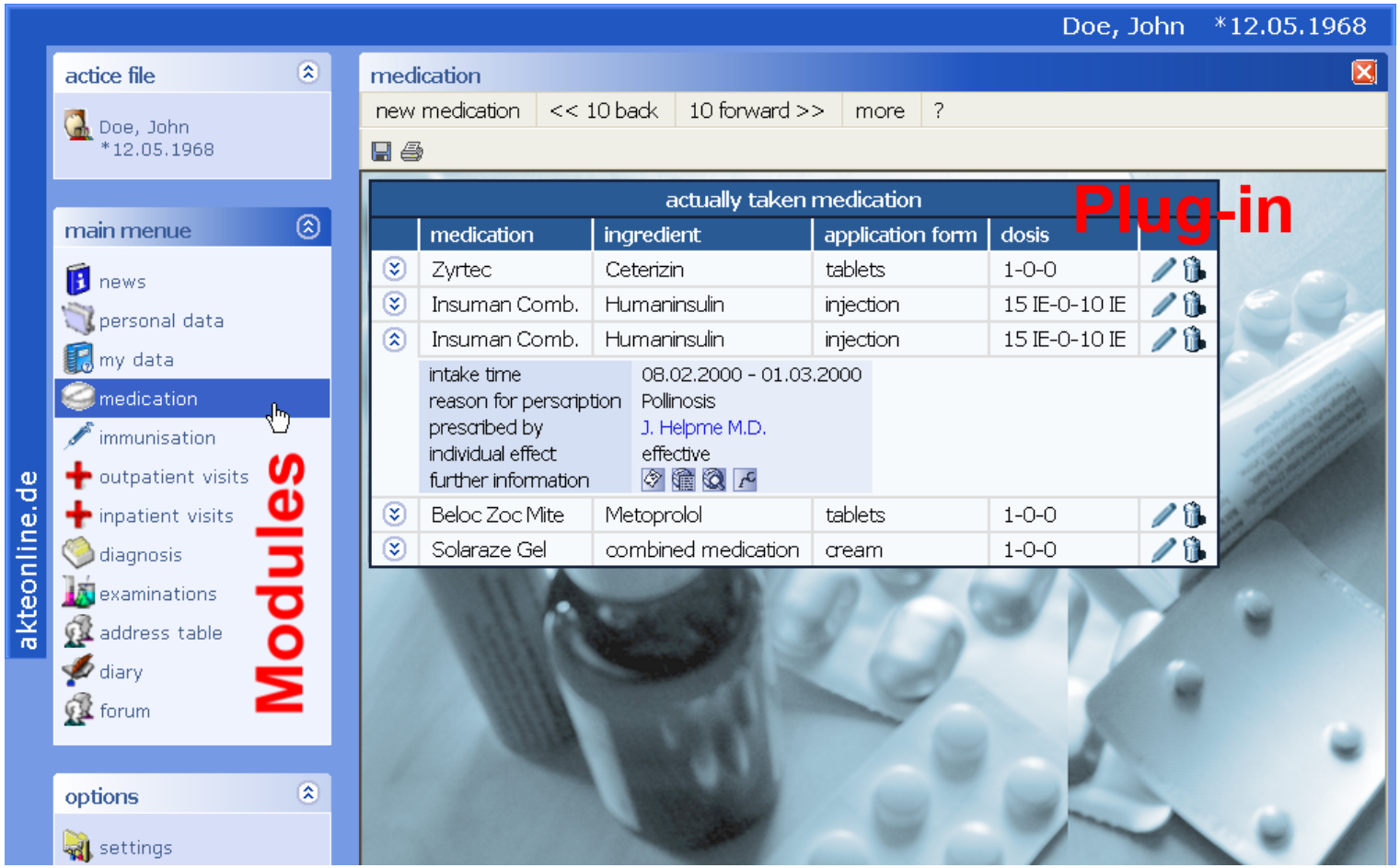
Schematic representation of a MANET wireless network



Structure of the electronic file and the form based additional documentation

- A root-appliance and a plug-in-architecture make the adding and changing of new content containers (modules and plug-ins) easily possible.
- Every installation of TOUGHCLINIC can be pre arranged with a standard set of modules and plug-ins.
- The record structure can include forms as basic modules:
  - Basic type of mask.
  - A special component enables the administration of forms.
  - Changes and add-ons can be made locally even by IT-laymen.
  - Aim: Cover as many possible intended uses, especially to cover the non-planable.
- English language and international personnel:
  - Preferably input masks should be done by selection boxes or depend on annotatable graphic illustrations of body parts.

Presentation of modules and plug-ins with an example



Results

- Many circumstances can be securely documented. Software components are adjustable for the specific intended use on-site.
- Wireless networking of individual, extremely tough computers without any infrastructure.
- Breakdown of one component does not affect others.
  - It can even be replaced immediately by another one (without bothering about manually restoring or copying of data).
- Used applications in wireless reach are synchronized automatically with the others and so they always receive an actual dataset.
  - Especially helpful for notebook usage outside the base: At return the data synchronization will be done automatically.
- No central hardware effort necessary.
- Due to encryption loosing of one of the workstation is limited to the financial loss.
- Language barriers between employees from different countries are reduced.
- Three principles are met.
- **At the actual early status of development cooperation partners for processing and use are sought-after, as well as sponsors.**

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SAS Macro Program for Lead-time Bias and Length Bias Adjustment by Stochastic Modelling

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Abstract and objective

In evaluation of cancer screening, comparison of survival between cases detected by screening and cases detected clinically was often made as the effectiveness of screening. However, this comparison is not valid due to several biases including lead-time bias, length bias, etc.. Stochastic model depicting the process from normal, preclinical phase while the cases were detected by screening, via clinical phase to cancer death can be used to obtain the mean lead-time and real survival time for screen-detected cases which is free from lead-time bias and length bias. To facilitate the application of lead-time bias and length bias adjustment for survival by stochastic modelling, a SAS macro program was developed. The program is very flexible and enables the user to specify homogeneous and non-homogeneous (i.e. Weibull distribution, log-logistic, etc.) Markov models for each transition. The program was successfully applied to an example of prostate cancer screening.

Keywords:

Stochastic model, lead-time bias, length bias, screening, survival

Introduction

In evaluation of cancer screening, comparison of survival between cases detected by screening and cases detected clinically was often made as the effectiveness of screening [1-3]. However, this comparison is not valid due to several biases including lead-time bias, length bias, etc. [4-5]. For instance, it is possible that early detection of some prostate cancers may simply advance the date of diagnosis, i.e. lead-time gain, without prolonging life, namely lead-time bias. Moreover, screen-detected cases may include a higher proportion of slowly growing cancers with a long sojourn time, which results in length bias. Due to these sources of error, the magnitude of benefit achieved from early detection estimated by comparing the survival of screen-detected cases with that of clinically detected cases is elusive.

Stochastic model depicting the process from normal, preclinical phase while the cases were detected by screening, via clinical phase to cancer death, can be used to obtain the mean lead-time and real survival time for screen-detected cases which is free from lead-time bias and length bias [1]. Nevertheless, the complexity of computer computation of the Markov model may limit the use of this method. The aim of the current study is to develop a SAS macro program to facilitate the application of lead-time bias and length bias adjustment by stochastic modelling.

Methods

Model specification

The observed survival time of screen-detected cancers consists of lead-time gain and the real survival time in absence of screening, which would be from the onset of clinical disease (without lead-time), to cancer death. In comparison of the survival of screen-detected and clinically detected cases, survival from hypothetical detection in absence of screening should be used to eliminate the lead-time bias, i.e. ensure comparability of information. However, the time when the disease would have been identified clinically is unobservable for screen-detected cases. This can be solved by applying stochastic modelling.

Furthermore, to adjust for length bias, the probability of being diagnosed with an interval cancer (typically with a short sojourn time) together with the probability of being diagnosed at screen (with a long sojourn time) was incorporated to obtain an unbiased estimate of the sojourn time. Besides, in order to further adjust for the higher proportion of slowly growing cancers at the first screen, the probability of asymptomatic cancer or normal finding at screening has to be conditional on time of surfacing to clinical phase > time to screen.

Accordingly, we defined a five-state stochastic process (figure 1) with the combination of the disease natural history model, based on screen-detected cases (long sojourn time) and interval cancer (short sojourn time), as well as disease outcome model, based on screen-detected cases

only. The details of the method for length bias adjustment have been addressed elsewhere [6].

In the model (figure 1), $I(\tau)$, $\lambda_1(\tau)$ and $\lambda_2(\tau)$ represent the pre-clinical incidence rate, the instantaneous transition rate from preclinical phase to clinical phase, and hazard of dying from cancer, respectively. The competing cause of other deaths was taken into account by λ_3. Based on the estimates of $\lambda_2(\tau)$, the cumulative survival curve after correcting lead-time and length bias can be calculated as

$$S(t) = \exp\left(\int_0^t -\lambda_2(s) ds \right).$$

Maximum likelihood approach will be applied to estimate the transition parameters and the cumulative survival adjusted for lead-time and length bias can be also obtained.

SAS Macro ADJUST

The SAS macro ADJUST which has fourteen components has been developed. The description for each components are as follows.

(1) data, the SAS data set to be analyzed; (2) dist1, dist2, and dist3, the distribution for transition from normal to preclinical detectable phase, from preclinical detectable phase to clinical phase, and from clinical phase to die from the cancer, respectively, and the choices of the distribution for each transition include exponential distribution, weibull distribution, log-logistic distribution, and gamma distribution; (3) mode, the variable name for identify the different detection mode; (4) fn, the coding of variable "mode" for normal at first screen; (5) fsd, the coding of variable "mode" for screen-detected cancer at first screen; (6) sn, the coding of variable "mode" for normal at subsequent screen; (7) ssd, the coding of variable "mode" for screen-detected cancer at subsequent screen; (8) psfun, the coding of variable "mode" for normal during post-screening follow-up; (9) ic, the coding of variable "mode" for interval cancer; (10) ocd, the coding of variable "mode" for other cause of deaths of screen-detected cases; (11) event, the coding of variable "mode" for event, i.e. dying from the disease, of screen-detected cases; (12) censor, the coding of variable "mode" for censoring of screen-detected cases; (13) init, the initial values of each relevant transition parameter; (14) upcon and lowcon, the values of upper constraints and lower constraints on each relevant transition parameters.

Example: prostate cancer screening

The Finnish population-based prostate cancer screening randomized trial was started in 1996 [7]. During 1996 to 1999, 80,458 men aged 55-67 years and resident in the metropolitan areas of Helsinki and Tampere were identified from the Population Registry of Finland as the study population. Of them, 32,000 men were randomly allocated to the screening arm and were invited to PSA screening for prostate cancer. The men were recruited and invited for the first screening round in 1996-1999, with the second screening round carried out in 2000-2003, i.e. with a 4-year screening interval. The remaining 48,458 men were assigned to the control arm and were not contacted.

Men in the screening arm with a serum PSA concentration of 4.0 ng/mL or higher were referred to diagnostic examinations, consisting of digital rectal examination (DRE), transrectal ultrasound, and prostate biopsy. Men with a PSA concentration of 3.0-3.9 ng/mL were offered a secondary screening test, which was initially (1996-98) a DRE by an urologist and since 1999 determination of the proportion of free PSA [7]. Prostate cancers diagnosed in 1996-2002 in both the screening and control arms were identified and followed up until death or until end of 2002. Causes of death were obtained from death certificates.

Example of SAS Macro ADJUST

%ADJUST(DATA=c.prostate, DIST1=weibull, DIST2=exponential, DIST3=weibull, MODE=type, FN=1, FSD=2, SN=3, SSD=4, PSFUN=5, IC=6, OCD=7, EVENT=8, CENSOR=9, INIT=0.0002 1.8 0.02 0.00001 2.3 0.02, LOWCON=0 0 0 0 0 0, UPCON=. . . . . .);

Results

The difference of survival between screen-detected cases and clinically detected cases has been heavily diminished after adjusting for lead-time bias and length bias. The unadjusted risk ratio of death for screen-detected cases against clinically detected cases was 0.17 (95% CI: 0.10-0.28). The risk ratio increased to 0.71 (95% CI: 0.51-1.00) after correcting for lead-time and length bias.

Conclusion

The program is very flexible and enables the user to specify homogeneous and non-homogeneous (i.e. Weibull distribution, log—logistic, etc.) Markov models for each transition. The program was successfully applied to an example of prostate cancer screening.

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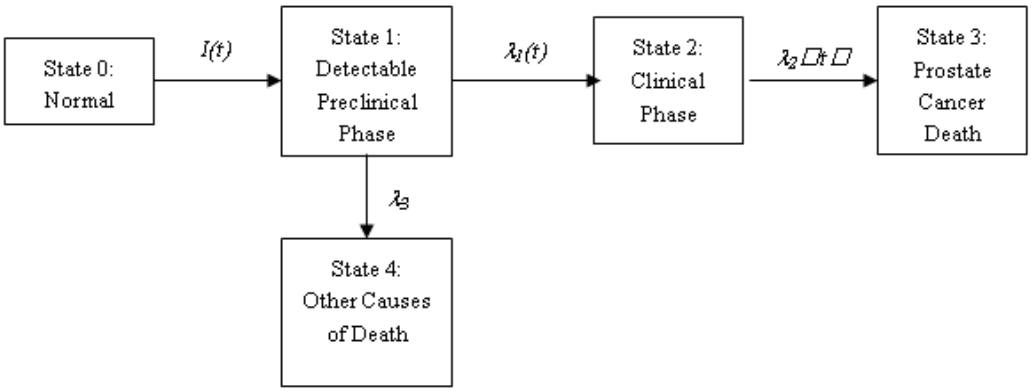

Figure 1 - Diagrams of a five-state Markov model combining the natural history and prognosis of prostate cancer from normal to death for length bias and lead-time adjustment

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Effects of Genotype Error and Sample Error on Genome-wide SNP Analysis Using Pooled DNA

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Abstract

A major obstacle in whole-genome association analysis is that the cost of individually genotyping hundreds of samples remains prohibitively expensive. One solution which addresses this is to pool genomic DNA of the cases and controls. However, pooling introduces an additional source of error, sampling error. In this study, we evaluate the effects of sampling error as well as genotyping error in pooled versus individual genotyping. Our results show that both genotype and sample error affect the significance of the results. Yet, sampling error has a larger overall effect.

Keywords:

single nucleotide polymorphism (SNP); pooled DNA; genome wide association

Introduction

In this study, we examine the feasibility of a pooling approach for genome wide association studies in the context of two types of experimental errors; genotyping error and sampling error. Genotyping error is present in both individual and pooled genotyping. Sampling error occurs in pooled genotyping when unequal amounts of genomic DNA are added to the pool, which can lead to incorrect allele frequency estimates for the pooled population.

Materials and methods

GenomeSIM simulation software was used to create a case/control population of one thousand individuals typed at ten thousand SNPs each. A three locus disease model with additive penetrance values was used. The final population consisted of 203 diseased individuals and 797 controls. Haploview was used for association testing of individuals. The Pooled DNA Analyzer (PDA) was employed for pooled association testing. Three levels of stringency were chosen with respect to the association testing chi square P-values. A low stringency cutoff (P-value <= $5E^{-2}$), a high stringency cutoff using Bonferonni correction (P-value <= $5E^{-6}$), and a middle stringency cutoff (P-value <= $5E^{-4}$).

Results and discussion

Although both genotype error and sample error had a significant effect, sampling error is much more influential. Overall, genotype error from 1% to 5% lowered the significance of P-values by a maximum of 1.6 fold across the entire range of individual or pooled genotyping. In contrast, sampling error from 1% to 5% in the pooled genotypes had a much more pronounced impact and lowered the significance of P-values by at least one order of magnitude across its range, with minimum of a 66 fold reduction in P-value significance (table 1). We conclude that if pooling is employed as a strategy for genome wide association analysis, great care must be taken to minimize the sampling error introduced while assembling the pools.

Table 1 – Association analysis of Individual and Pooled genotyping: P-values of causal SNPs

Low stringency (P-value <= $5E^{-2}$) in red / Intermediate stringency (P-value <= $5E^{-4}$) in *yellow italics* / High stringency (P-value <= $5E^{-6}$) in **green bold**

Genotype Error	individual	Pooled + sample error 1%	2%	3%	4%	5%
0%	**7.1E-10**	**2.2E-07**	*1.7E-04*	4.4E-03	2.2E-02	5.6E-02
1%	*4.4E-04*	8.8E-04	3.7E-03	1.4E-02	3.7E-02	7.2E-02
2%	*3.7E-04*	7.3E-04	3.3E-03	1.3E-02	3.4E-02	6.7E-02
3%	5.5E-04	9.9E-04	3.7E-03	1.3E-02	3.3E-02	6.6E-02
4%	*3.7E-04*	7.3E-04	3.3E-03	1.3E-02	3.4E-02	6.7E-02
5%	6.0E-04	1.1E-03	4.5E-03	1.6E-02	4.2E-02	8.0E-02

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Development of a Colon Cancer Extension for the AMANDA Microarray Management Database

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Abstract and objective

The management of information is a key aspect during microarray experiments analysis and results interpretation. The common use of this technique with clinical samples requires an adequate clinical annotation of those samples and the inclusion of that annotation into microarray information management systems. We present a module for clinical annotation of colon cancer samples for microarray experiments. This module has been developed to be integrated with a previously developed microarrays database (AMANDA). This new module stores information related with the clinical annotation of samples and patient information used during the experiments such as patient evolution, chemotherapy or surgical procedures. The module also includes information about the histological analysis of the samples used for gene expression analysis. The integration of this information into the microarray information system facilitates the processes of quality control and assessment of microarray experiments as well as further clinical interpretation of the results.

Keywords:

colonic neoplasm, microarray analysis, databases

Introduction

The recent advances in molecular biology and its techniques are being translated into medical applications and a better understanding of physio-pathological mechanisms underlying the disease states. One of those relevant techniques is microarray technologies, these techniques and their application for the study of pathological processes is becoming more and more frequent. Application of microarrays in medicine is mainly focused on the study of gene expression levels, and more specially on the correlation of those expression levels with relevant pathological states. Most of these works done with microarrays have been focused on the analysis of gene expression during cancer onset and development. Some examples of the aims pursued with these studies are the identification of relevant gene signatures for the prognosis of disease(1;2), differentiation and reclassification of disease(3) and others(1;4;5). This kind of experiments generate huge amounts of data that must be analyzed and correlated with relevant clinical data in order to facilitate their interpretation and extract the most of them. Therefore it's necessary to develop systems that can manage simultaneously both experimental data and clinical data for this purpose.

Methods

The design of the new module for the clinical annotation of samples used in microarray experiments was developed on AMANDA microarray database. AMANDA is a MIAME(6) compliant microarray database previously presented in Medinfo 2004.

The extension module has been developed in MS Access due to the familiarity of the user with this environment, continuing the philosophy of AMANDA database. This new module is composed of tables and forms in which the clinicians fill in all the selected fields.

The module was developed in collaboration with clinical oncologists who gave feed back of what information is relevant for their studies and will be required to correlate gene expression with the clinical outcomes of the disease. In the development of the extension module controlled vocabularies and terminologies as well as codes were used with the aim of standardizing the database as well as minimizing the mistyping errors during database filling processes.

The new module includes tables and forms related with:

- Patient data (AJCC defined stage group, ECOG scale level, whether the patient undergo surgery, what type of surgery, the therapies used and finally also a record for patient follow-up regarding disease state).
- Tumor data (aspects regarding tumor location in colon, Dukes' scale, metastasis degree, whether there are affected nodes and their number, and also a tumor extension scale).
- Sample Data: the data collected includes the reference to those histological preparations used for sample selection including aspects such as type of histology, % tumoral cells, % of necrosis or inflammation degree in that piece of tissue.

The forms for data input as well as some reports have been designed in order to present users with some of the most relevant data available in the database. For this purpose several queries have been especially done and formatted.

Results

A new customized version of AMANDA database has been generated by the inclusion of this new module. The use of a modular design had the benefit of using an already designed system that is compliant with microarray standards. With this new module it is possible to achieve a higher level of accuracy in the clinical annotation of samples, in a microarray environment.

During database design non standardized terminology was avoided as much as possible in order to facilitate further integration of the data with other systems. Where it was possible the use of standard terms and controlled vocabularies and codes was used. This extension module is focused on colon cancer and therefore some of the terminologies uploaded in the database are focused only on this particular disease (v.g. anatomical location), while other fields can be directly applied on any other type of cancer (v.g. metastasis degree).

The system has been developed using an user friendly interface with several forms to facilitate the user the uploading of data into the system in a environment that is well known (MS Access) for both clinicians and researchers. In this interface it's possible to find forms designed for data uploading. There are also customized reports based on queries presenting the data in the most demanded fields by the physicians as well as by the molecular biology researchers.

Conclusions

The annotation and management of all the processes undergone by the samples ensures the quality control of all these processes and it's very important in order to minimize the presence of experimental artifacts that may affect the final results of these experiments.

A remarkable aspect is that the interface must be easy to use and intuitive to ensure the participation of clinicians in filling the required fields. For this reason an MS access environment was selected, clinicians are already familiarized with this environment and they can use it immediately with few if any explanations about the system.

The use of a unified system for storage of both clinical and experimental data and information related with the microarray based analysis of clinical colon cancer samples facilitates the interpretation of these complex experiments.

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Abstract and objective

The management of information is a key aspect during microarray experiments analysis and results interpretation. The common use of this technique with clinical samples requires an adequate clinical annotation of those samples and the inclusion of that annotation into microarray information management systems. We present a module for clinical annotation of colon cancer samples for microarray experiments. This module has been developed to be integrated with a previously developed microarrays database (AMANDA). This new module stores information related with the clinical annotation of samples and patient information used during the experiments such as patient evolution, chemotherapy or surgical procedures. The module also includes information about the histological analysis of the samples used for gene expression analysis. The integration of this information into the microarray information system facilitates the processes of quality control and assessment of microarray experiments as well as further clinical interpretation of the results.

Keywords:

colonic neoplasm, microarray analysis, databases

Introduction

The recent advances in molecular biology and its techniques are being translated into medical applications and a better understanding of physio-pathological mechanisms underlying the disease states. One of those relevant techniques is microarray technologies, these techniques and their application for the study of pathological processes is becoming more and more frequent. Application of microarrays in medicine is mainly focused on the study of gene expression levels, and more specially on the correlation of those expression levels with relevant pathological states. Most of these works done with microarrays have been focused on the analysis of gene expression during cancer onset and development. Some examples of the aims pursued with these studies are the identification of relevant gene signatures for the prognosis of disease(1;2), differentiation and reclassification of disease(3) and others(1;4;5). This kind of experiments generate huge amounts of data that must be analyzed and correlated with relevant clinical data in order to facilitate their interpretation and extract the most of them. Therefore it's necessary to develop systems that can manage simultaneously both experimental data and clinical data for this purpose.

Methods

The design of the new module for the clinical annotation of samples used in microarray experiments was developed on AMANDA microarray database. AMANDA is a MIAME(6) compliant microarray database previously presented in Medinfo 2004.

The extension module has been developed in MS Access due to the familiarity of the user with this environment, continuing the philosophy of AMANDA database. This new module is composed of tables and forms in which the clinicians fill in all the selected fields.

The module was developed in collaboration with clinical oncologists who gave feed back of what information is relevant for their studies and will be required to correlate gene expression with the clinical outcomes of the disease. In the development of the extension module controlled vocabularies and terminologies as well as codes were used with the aim of standardizing the database as well as minimizing the mistyping errors during database filling processes.

The new module includes tables and forms related with:

- Patient data (AJCC defined stage group, ECOG scale level, whether the patient undergo surgery, what type of surgery, the therapies used and finally also a record for patient follow-up regarding disease state).
- Tumor data (aspects regarding tumor location in colon, Dukes' scale, metastasis degree, whether there are affected nodes and their number, and also a tumor extension scale).
- Sample Data: the data collected includes the reference to those histological preparations used for sample selection including aspects such as type of histology, % tumoral cells, % of necrosis or inflammation degree in that piece of tissue.

The forms for data input as well as some reports have been designed in order to present users with some of the most relevant data available in the database. For this purpose several queries have been especially done and formatted.

Results

A new customized version of AMANDA database has been generated by the inclusion of this new module. The use of a modular design had the benefit of using an already designed system that is compliant with microarray standards. With this new module it is possible to achieve a higher level of accuracy in the clinical annotation of samples, in a microarray environment.

During database design non standardized terminology was avoided as much as possible in order to facilitate further integration of the data with other systems. Where it was possible the use of standard terms and controlled vocabularies and codes was used. This extension module is focused on colon cancer and therefore some of the terminologies uploaded in the database are focused only on this particular disease (v.g. anatomical location), while other fields can be directly applied on any other type of cancer (v.g. metastasis degree).

The system has been developed using an user friendly interface with several forms to facilitate the user the uploading of data into the system in a environment that is well known (MS Access) for both clinicians and researchers. In this interface it's possible to find forms designed for data uploading. There are also customized reports based on queries presenting the data in the most demanded fields by the physicians as well as by the molecular biology researchers.

Conclusions

The annotation and management of all the processes undergone by the samples ensures the quality control of all these processes and it's very important in order to minimize the presence of experimental artifacts that may affect the final results of these experiments.

A remarkable aspect is that the interface must be easy to use and intuitive to ensure the participation of clinicians in filling the required fields. For this reason an MS access environment was selected, clinicians are already familiarized with this environment and they can use it immediately with few if any explanations about the system.

The use of a unified system for storage of both clinical and experimental data and information related with the microarray based analysis of clinical colon cancer samples facilitates the interpretation of these complex experiments.

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Applying Features Selection to Optimise the Cost-Benefit of Diagnostic Classifiers

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Abstract

BACKGROUND: Classification by supervised machine learning (SML) is increasingly used in clinical diagnosis. However, the benefits of feature selection (FS) prior to the construction of diagnostic classifier remain to be elucidated.

METHODS: Group B streptococcus (GBS) data were trained by SML to differentiate the invasive strains from the normal flora. Five feature ranking algorithms were used to rank the relative merits of 19 GBS features prior to classification. Areas under the ROC curve (AUC) using 10-fold cross-validation of 7 classifiers were obtained. The benefit of FS was measured by the minimum number of features (N_p) required to achieve the desired level of AUC (AUC_p).

RESULTS: For the same number of features, all classifiers achieved better AUCs under feature selection. At $AUC_{0.9}$ (90% relative to the best AUC), the median N_p achieved by FS was 4, compared to 13 using random selection and 18 under the worst scenario. The reduction of AUC from 0.724 to 0.702 was not statistically significant (p=0.21).

CONCLUSION: Feature selection algorithms have the potential to improve the cost-benefit of diagnostic classifiers through the elimination of the non-discriminatory features without compromising the overall classification performance.

Keywords:

machine learning; feature selection; diagnosis

Introduction

Individualised medicine based on genomic and proteomic data has a promising future in clinical medicine. To enable individualised medicine on a practical level, factors such as accuracy, cost, and clinical utility of the tests need to be carefully evaluated. With the current advances in biotechnology, large amount of biological data can be generated rapidly and accurately. Supervised machine learning (SML) classifiers are increasingly used in analysing complex correlations in reaching a clinical diagnosis or in predicting outcomes of various diseases [1]. The issue of cost, however, remains a potentially limitation, ranging from bench-side material to expert interpretations [2]. Excluding non-discriminatory features can lead to cost reduction and potentially faster turnover time. In addition, the inclusion of non-discriminatory features not only can increase the training burden (curse of dimensionality), it could also affect the overall classifier performance.

In this paper, the benefits of feature selection (FS) algorithms were studied by extracting a subset of discriminatory features from the original unselected dataset prior to the training of SML diagnostic classifier. Feature selection has been known to facilitate dimensionality reduction to optimise measurement, storage, and efficiency of supervised classifiers [3]. To determine the optimal subset of features, we presented a graphical method for determining the optimal cut-off.

The dataset studied in this paper was the serotypic and genotypic data of a Gram positive bacterium, group B streptococcus (GBS). GBS is an important genitourinary pathogen that frequently finds its carriage in pregnant women. It has a potential to cause serious infection in neonates including sepsis, pneumonia, and meningitis. The trained classifier aims to distinguish the invasive isolates from the normal colonising flora based on various bacterial features. The classification aims to assist clinicians in identifying the high risk patients, such that by instituting prompt antimicrobial prophylaxis, the risk of potential morbidity and mortality can be reduced.

Methods

The group B streptococcus (GBS) dataset was used to construct classifiers for predicting the virulence of bacteria based on its serotype and genotype. Eighteen genotypes were determined by multiplex PCR and reverse line blot, including molecular serotype (MS), protein genetic profile (PGP), mobile genetic elements (*GBSi1, ISSag1, ISSag2, ISSag4, IS1381, IS861,* and *IS1548*), and antibiotic-resistance genes (*tetM, int, tetO, ermB, ermTR, aph, aad, mre,* and *mef)* [4][5][6][7]. Together with the capsular serotype (CS), 19 bacterial features were selected from the database. A total of 778 GBS isolates were used for classifier training, including 590 invasive and 188 colonising isolates that were collected from clinical cultures and routine antenatal swabs.

Seven SML classifiers were used in this study, including naïve Bayes (NB), Id3 and J48 decision trees, support vector machine (SVM) trained by sequential minimal optimisation (SMO) algorithm, logistic regression (LR), and decision table (DT). The bacterial features were ranked according to their relative discriminatory power by variable ranking algorithms based on correlation criteria (symmetrical uncertainty, and Chi-squared attribute selection) or information-theoretic criteria (Information gain and gain ratio, and ReliefF). Classifiers were trained and evaluated by adding each bacterial feature incrementally in sequence as determined by each FS algorithm. The performance of classifiers was evaluated by area under the ROC curve (AUC) using 10-fold cross validation. The classification and evaluation were performed using Waikato Environment for Knowledge Analysis (WEKA) [8].

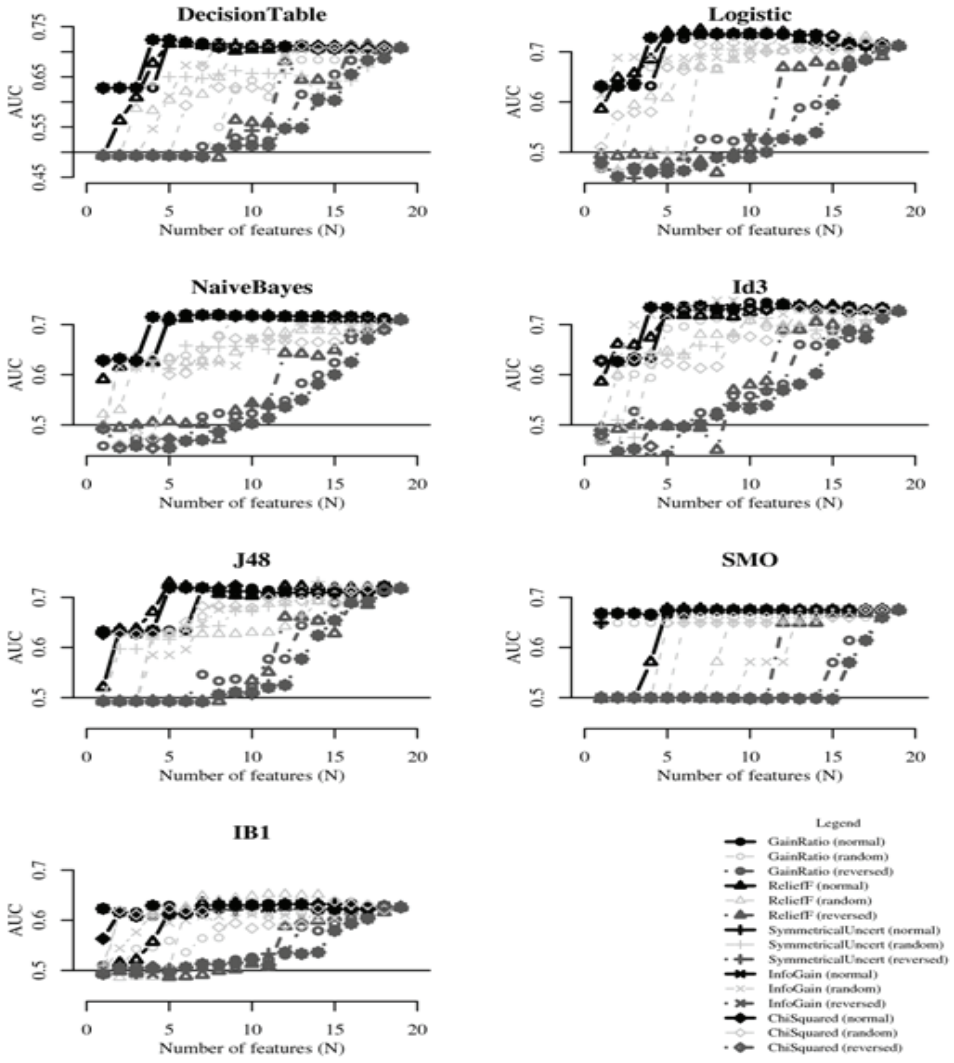

Figure 1 - AUC versus number of features (N) for 7 classifiers. (logistic: logistic regression; SMO: SVM trained by SMO algorithm; IB1: nearest-neighbour classifier)

To study the benefit conferred by the FS algorithms (normal), two extra feature selection schemes were performed. The theoretically "worst" ranking order was generated by reversing the normal rank produced by FS for each rank (reversed). In addition, the ranks were randomly shuffled to act as control, representing the

scenario where N features were selected by chance (random).

A cut-off value p (between 0.0 and 1.0) was defined to quantify the relative performance measured by AUC such that

$$AUC_p = 0.5 + p \times (AUC_{max} - 0.5)$$

In addition, N_p was defined as the minimum number of the first few features required to achieve AUC_p. The values of N_p were used to plot a cumulative gain chart for each classification scheme.

Results

The best AUC (AUC_{max}) achieved by FS using all 19 features under 10-fold classification were approximately 0.65-0.75 among the 7 classifiers (Table 1). At *N=19*, all AUC converged to the same point in all three studied ranking schemes (normal, random, and reversed). In general, the AUCs showed an increasing trend with more features involved in the classifier training. The AUCs for each classifier are shown in Figure 1.

The median N_p of the three ranking schemes across the classifiers were obtained and plotted in the cumulative gain chart as shown in Figure 2, which the ranking achieved AUC_p with less number of genes than the random and reversed set for all points. The median N_p at *p=0.90* for the 7 classifiers were 4, 13, and 18 for the normal, random, and reversed ranks respectively. The median reduction in AUC (from 0.724 to 0.702) was not considered statistically significant (p=0.21, two-tailed unpaired t-test). The top-4 features selected by FS algorithms are shown in Table 2. Features CS, PGP, *GBSil* and *ISSag2* were identified as top-4 by >50% of the selected algorithms.

Classifier	N_p			AUC	
	normal	random	reversed	AUC_{max}	$AUC_{0.9}$
DT	4	13	18	0.724	0.702
NB	4	13	18	0.721	0.699
J48	5	13	18	0.731	0.708
IB1	4	9	18	0.652	0.637
LR	4	11	18	0.745	0.721
Id3	4	10	18	0.748	0.723
SMO	2	13	18	0.677	0.659
Overall	4	13	18	0.724	0.702

Table 1 - The median of the minimum number of features (Np) to achieve relative performance p=0.90 for all 7 classifiers. (DT: decision table; NB: Naive Bayes classifier; J48: J48 decision tree; Id3: Id3 decision tree; IB1: nearest neighbour classifier; LR: logistic regression; SMO: SVM by SMO algorithm)

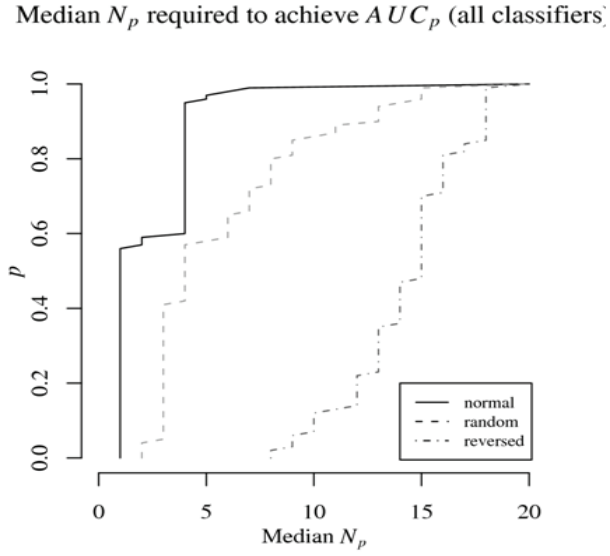

Figure 2 - Median N_p for all values of p

Rank	Feature Selection Algorithm				
#	ChiSq	SymUnc	GainRatio	InfoGain	ReliefF
1	**CS**	**CS**	**CS**	**CS**	MS
2	**PGP**	**PGP**	***GBSi1***	**PGP**	**PGP**
3	***GBSi1***	***GBSi1***	*mre*	***GBSi1***	*IS1381*
4	***ISSag2***	***ISSag2***	***ISSag2***	***ISSag2***	*int[*

Table 2 - Top-4 features as selected by feature selection algorithms. Bold font indicates the feature is identified by more than 50% of FS. (Feature selection algorithms: ChiSq: Chi-squared; SymUnc: Symmetrical Uncertainty)

Discussion

This paper evaluated the utility of feature selection algorithms in selecting a subset of features that best correlates bacterial informe random and reversed-FS ranking method for all number of features, suggesting the ability of FS algorithms in selecting the most discriminatory set of features for classification.

We used a graphical method in this paper for determining the optimal number of features to participate in the classifier training. For the desired level of AUC_p, the minimum number of features N_p can be determined by plotting a cumulative gain chart of the relative best AUC (p) that enables the visual representation of features-performance trade-off. Subsequently the corresponding N_p can be used

to select a discriminative set of features from the rank produced by FS algorithms given a desired level of classifier performance. This technique may be useful in data with larger dimensions to determine the optimal number of features, as the lengthy list generated by FS may not be immediately obvious for processing.

The benefit of FS in diagnostic classifiers can be demonstrated in Table 1 with *p=0.90*. By reducing the average number of features from 19 to 4, there was a potential reduction of over 75% on the cost of material given a <10% of relative AUC trade-off. The decrease in AUC did not represent a statistically significant decrease in performance. For our GBS classification task, the cost of the "unhelpful" PCR primers and hybridisation probes can be eliminated from the final product. According to Wilson's criteria, the cost-benefit is an important consideration in a diagnostic screening test [9]. Compared with the classifier trained with full set of features, the FS-optimised classifier potentially increased its acceptability as a screening tool, in which the cost of material was reduced through the elimination of the need non-discriminatory features where the benefits is preserved as measured by AUC.

Conclusion

Feature selection algorithms have the ability to optimise the cost-benefit of diagnostic classifiers by eliminating non-discriminatory features without compromising the overall classifier performance. This paper demonstrated that feature selection should be an integral part in the construction of machine learning-based diagnostic classifiers.

Acknowledgements

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Phenotype Analysis for Insights into Complex Inheritance Diseases: a Case Study

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Abstract

Systematic analysis of phenotypic data may provide important clues for delineating developmental mechanisms as well as functional genetic networks. In this study, 68 entries involving congenital pancreatic abnormalities were selected from OMIM. Clinical synopses data were extracted and standardized. Data mining of processed data has suggested that, anatomically, major features of syndromes involving pancreatic defects seems to congregate along the midline of the human body, which conforms to John Opitz's theorem of developmental field defects. We conclude that utilization of phenotypic data can facilitate delineation of developmental as well as genetic mechanisms underlying various types of congenital anomalies.

Keywords:

pancreas; syndrome; phenotype; data mining

Methods

Phenotypic data could be used for obtaining insights into complex diseases. Various phenotypes have usually been considered as isolated features, and studies on high-level phenotypes were rare. Cantor and Lussier (2004) had attempted to use self-organizing maps and hierarchical clustering for clinical phenotypes in order to achieve better understanding for genotypes. However, since the original categories provided in the OMIM entries were not rationalized, it is difficult to judge the usefulness of clustering results. More recently, van Driel et al. proposed an approach for measuring similarities between phenotypes, and demonstrated they are correlated with the protein sequence, protein motifs, and functional annotation. Although this result appears to be promising, meaningful patterns for a particular syndrome still cannot be obtained.

In this study, we explored using data mining techniques for analyzing clinical data derived from congenital syndromes involving pancreatic malformations. 68 pancreatic malformations entries were retrieved from OMIM (as by Nov 1st 2005). After removal of those that are non-congenital in nature, 23 entries were derived. The listed clinical synopses of these entries were converted into 55 categories manually.

The correlation between individual phenotypes among pancreatic malformations was analyzed using statistically significant association rules [3]. The results were also compared with hierarchical clustering and K-means clustering.

Results

Correlations between phenotypes were obtained, among them, kidney and liver has the strongest correlation. This result was consistent with results from hierarchical clustering and k-means clustering. Correlation of the common features among the selected syndromes seems to suggest that, developmentally, pancreas has a close relation with adjacent organs such as the kidney and the liver, whilst the overall pattern of above syndromes conforms to John M Opitz's theorem on the developmental field defect, that the midline structure of the body are most frequently involved among congenital syndromes.

Conclusion

Phenotype analysis may facilitate functional genomics and delineation of genotype ~ phenotype correlations. Data mining for a particular feature can be used for inferring closeness between genes and delineating genetic networks. Our future work will include development of a system that can automatically translate retrieved data into a comparable format, as well as utilization of laboratory experiment to validate the derived results.[1]

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Proposal of Efficient Clinical Trials by using the Genomic Information

Wataru Ohashi [a], Hiroshi Mizushima [a], Hiroshi Tanaka [a]

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Abstract

Under current clinical trials, a new drug could be authorized when a patient has no effect ("non-responder") on an existing drug. This leads to unnecessary adverse effect and high medication cost. Recently, it has become possible to change the patient's treatment depending on their genomic information, which is called "personalized medicine". It has a big benefit to patients by efficient treatment and lower cost, however, pharmaceutical companies hesitate to pursue personalized medicine, because of large development cost with very little market size, and not a matured methodology. In this paper, we will describe an efficient clinical trial, which will have a benefit to pharmaceutical companies by decreasing the cost for clinical trial, and early approval of the drug, with less adverse effect.

We will begin by describing a small size clinical trial, within a short period of study, using the patient's genomic information. We calculated the statistically required numbers of subjects and compared the cost for the current big clinical trials and the small clinical trials, excluding non-responder, by genomic information by simulation.

Keywords:

clinical trials, SNPs, personalized medicine, development cost

1. Introduction

Recently, the importance of "personalized medicine" is emphasized when a suitable treatment is selected according to the "constitution" of each patient. In the near future, it is expected that the drug and dose can be determined based on the genetic information including SNPs (single nucleotide polymorphisms) of each patient.

When personalized medicine becomes more available, unnecessary administration of drugs to non-responders can be avoided, and dose can be optimized. Also, medical expense in general can be reduced, and unexpected adverse effect can be avoided. These advantages are beneficial not only to the patients concerned, but also to the society as a whole.

However, the pharmaceutical companies are not actively engaged in the development of "personalized medicine" because they are afraid of lost revenue, and other drugs would not be prescribed to non-responders. Furthermore, the procedure for handling genetic information is not fully established yet.

The purpose of this study is to clarify the benefit and loss for the pharmaceutical companies when they adopt "personalized medicine", that is, when they take advantage of genetic information in their clinical trials. Particularly, the benefit for the pharmaceutical companies in terms of following two points will be analyzed. 1. Development cost of new drug and period of clinical trial can be reduced because a clinical trial needs less subjects, 2. The new drug can be placed on the market earlier because the development period can be shortened.

2. Methods

1) Principle of sample size estimation

Generally, the sample size of a clinical trial is calculated according to an equation as follows, for example.[1][2][3]

$$n = \frac{\left\{ Z_\alpha \sqrt{2\bar{P}(1-\bar{P})} + Z_\beta \sqrt{P_1(1-P_1)+P_2(1-P_2)} \right\}^2}{(P_1-P_2)^2}$$

$$where \quad \bar{P} = \frac{P_1+P_2}{2}$$

（In case of chi-square test for the difference in ratio between two groups）

N: Number of necessary samples

P_1: Response rate in investigational drug group

P_2: Response rate in control drug group

Z: Value calculated from significance level (generally 1.96 at 5%)

Z: Value calculated from power (generally 0.84 at 80%)

For example, when the response rate in the investigational drug group is estimated to be 70% and that in the control group is estimated to be 60%, the sample size of each group is n=356 according to above equation. Similarly, when the response rate in the investigational drug group is 90% and that in the control group is 60%, then n=32. That is, if there is a large difference in response rates, thus small sample size will be sufficient. The size is calculated based on significance level (typically =0.05) and power (typically =0.80) specified in the protocol, and estimated drug

response rate and difference between the groups. The calculation differs depending on the test method used.

3. Result

1) Enhancement of response rate using specific SNPs (Investigational drug group vs. control drug group)

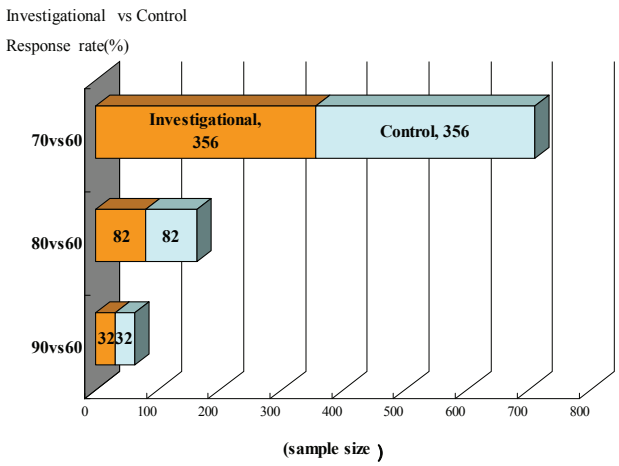

Figure 1 - Response rate and necessary sample size

By extracting and excluding non-responders based on SNPs information, the response rate of the investigational drug can be raised by 10%, e.g., from 70% to 80%. Then, the sample size of each group can be cut by 274 (356 to 82). In total, this means 548 cases will be unnecessary. This effect is more apparent when the response rate is low. Thus, this approach is highly useful in clinical trials in which only little difference in response rate is estimated between groups such as clinical trials of psychotropic drugs. In the approach above, additional cost may be necessary for a genetic testing before the clinical trial. Therefore, the total cost will be initially higher. However, if the sample size can be reduced by 548 in total, the cost as a whole will be less than the trial according to existing method. Furthermore, the cost of genetic testing is decreasing and the databases of genetic information are expanding day by day. In this circumstance, the genetic testing can be carried out at low cost in the near future.

2) Reduction of risk of adverse events

When any known adverse event (AEs) is anticipated due to causative gene, the patients concerned can be excluded from the investigational drug group. Thus, the risk of adverse events can be reduced.

Besides the safety enhanced by avoidance of an adverse event, the treatment for adverse event can be avoided. For the society in general, medical expense can be reduced, and for the pharmaceutical companies, compensation or indemnification cost can be avoided. In U.S, more than 2 million patients forced to be hospitalized because of the adverse effects in every year, hundred thousand people dies, and more than 70 billion health care cost wasted.

4. Conclusion

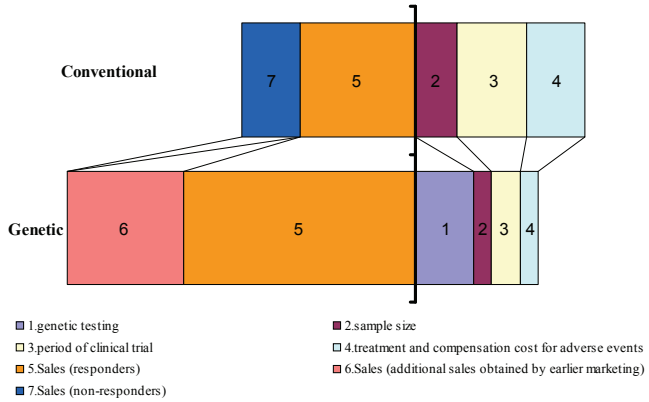

Figure 2 - Profit-cost structure in conventional clinical trial and clinical trial based on genetic information

Based on the discussion above, the profit-cost structure of a conventional clinical trial and a clinical trial based on genetic information can be estimated as Figure 2. According to our estimation, a clinical trial that takes advantage of genetic information is superior to a conventional clinical trial in terms of cost and profit. For example, the above shows, the development cost can be reduced by 5.5 million US dollar (10 thousand dollar /sample)[4]. Furthermore, the development period can be shortened by about 120 for 548 samples[4]. But, on the other hand, the sale for non-responders will be lost. However, because the drug can be marketed a120 days earlier than usual, the projected sales for the 120 days should be factored. In addition, risk of adverse events can be mitigated by screening patients based on genetic information such as SNPs. Reduction in compensation and indemnification cost, and reduction in medical expenses will be beneficial to the patients, the pharmaceutical companies, and the society as a whole. In a clinical trial using genetic information, temporary increase in process and cost may be inevitable. But, when genetic testing comes to be widely used, the cost will drop. Additionally, as the databases of genetic information are growing, it is apparent that the genetic testing will be simplified.

In view of the many benefits stated above, we expect the pharmaceutical companies to aggressively take advantage of genetic information in their clinical trials. We are now

planning profit simulation based on a clinical trial that was actually conducted.

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clinical trials, SNPs, personalized medicine, development cost

1. Introduction

Recently, the importance of "personalized medicine" is emphasized when a suitable treatment is selected according to the "constitution" of each patient. In the near future, it is expected that the drug and dose can be determined based on the genetic information including SNPs (single nucleotide polymorphisms) of each patient.

When personalized medicine becomes more available, unnecessary administration of drugs to non-responders can be avoided, and dose can be optimized. Also, medical expense in general can be reduced, and unexpected adverse effect can be avoided. These advantages are beneficial not only to the patients concerned, but also to the society as a whole.

However, the pharmaceutical companies are not actively engaged in the development of "personalized medicine" because they are afraid of lost revenue, and other drugs would not be prescribed to non-responders. Furthermore, the procedure for handling genetic information is not fully established yet.

The purpose of this study is to clarify the benefit and loss for the pharmaceutical companies when they adopt "personalized medicine", that is, when they take advantage of genetic information in their clinical trials. Particularly, the benefit for the pharmaceutical companies in terms of following two points will be analyzed. 1. Development cost of new drug and period of clinical trial can be reduced because a clinical trial needs less subjects, 2. The new drug can be placed on the market earlier because the development period can be shortened.

2. Methods

1) Principle of sample size estimation

Generally, the sample size of a clinical trial is calculated according to an equation as follows, for example.[1][2][3]

$$n = \frac{\left\{ Z_\alpha \sqrt{2\bar{P}(1-\bar{P})} + Z_\beta \sqrt{P_1(1-P_1)+P_2(1-P_2)} \right\}^2}{(P_1-P_2)^2}$$

$$where \quad \bar{P} = \frac{P_1+P_2}{2}$$

（In case of chi-square test for the difference in ratio between two groups）

N: Number of necessary samples

P_1: Response rate in investigational drug group

P_2: Response rate in control drug group

Z: Value calculated from significance level (generally 1.96 at 5%)

Z: Value calculated from power (generally 0.84 at 80%)

For example, when the response rate in the investigational drug group is estimated to be 70% and that in the control group is estimated to be 60%, the sample size of each group is n=356 according to above equation. Similarly, when the response rate in the investigational drug group is 90% and that in the control group is 60%, then n=32. That is, if there is a large difference in response rates, thus small sample size will be sufficient. The size is calculated based on significance level (typically =0.05) and power (typically =0.80) specified in the protocol, and estimated drug

response rate and difference between the groups. The calculation differs depending on the test method used.

3. Result

1) Enhancement of response rate using specific SNPs (Investigational drug group vs. control drug group)

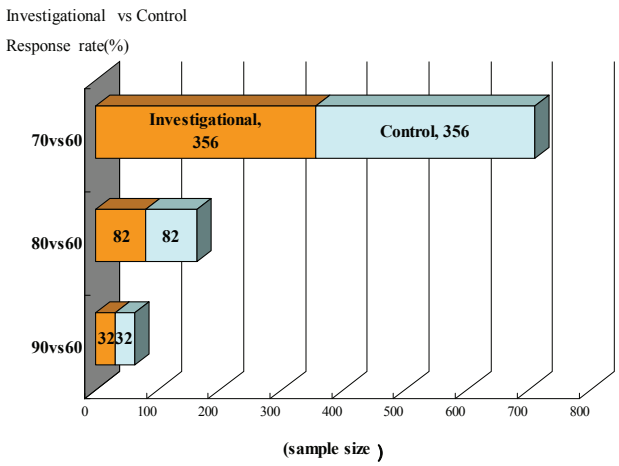

Figure 1 - Response rate and necessary sample size

By extracting and excluding non-responders based on SNPs information, the response rate of the investigational drug can be raised by 10%, e.g., from 70% to 80%. Then, the sample size of each group can be cut by 274 (356 to 82). In total, this means 548 cases will be unnecessary. This effect is more apparent when the response rate is low. Thus, this approach is highly useful in clinical trials in which only little difference in response rate is estimated between groups such as clinical trials of psychotropic drugs. In the approach above, additional cost may be necessary for a genetic testing before the clinical trial. Therefore, the total cost will be initially higher. However, if the sample size can be reduced by 548 in total, the cost as a whole will be less than the trial according to existing method. Furthermore, the cost of genetic testing is decreasing and the databases of genetic information are expanding day by day. In this circumstance, the genetic testing can be carried out at low cost in the near future.

2) Reduction of risk of adverse events

When any known adverse event (AEs) is anticipated due to causative gene, the patients concerned can be excluded from the investigational drug group. Thus, the risk of adverse events can be reduced.

Besides the safety enhanced by avoidance of an adverse event, the treatment for adverse event can be avoided. For the society in general, medical expense can be reduced, and for the pharmaceutical companies, compensation or indemnification cost can be avoided. In U.S, more than 2 million patients forced to be hospitalized because of the adverse effects in every year, hundred thousand people dies, and more than 70 billion health care cost wasted.

4. Conclusion

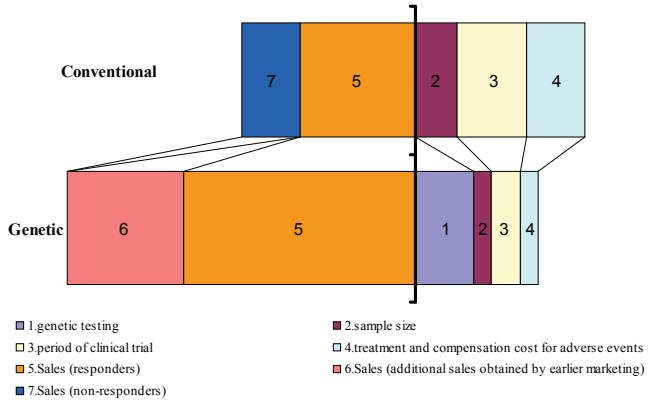

Figure 2 - Profit-cost structure in conventional clinical trial and clinical trial based on genetic information

Based on the discussion above, the profit-cost structure of a conventional clinical trial and a clinical trial based on genetic information can be estimated as Figure 2. According to our estimation, a clinical trial that takes advantage of genetic information is superior to a conventional clinical trial in terms of cost and profit. For example, the above shows, the development cost can be reduced by 5.5 million US dollar (10 thousand dollar /sample)[4]. Furthermore, the development period can be shortened by about 120 for 548 samples[4]. But, on the other hand, the sale for non-responders will be lost. However, because the drug can be marketed a120 days earlier than usual, the projected sales for the 120 days should be factored. In addition, risk of adverse events can be mitigated by screening patients based on genetic information such as SNPs. Reduction in compensation and indemnification cost, and reduction in medical expenses will be beneficial to the patients, the pharmaceutical companies, and the society as a whole. In a clinical trial using genetic information, temporary increase in process and cost may be inevitable. But, when genetic testing comes to be widely used, the cost will drop. Additionally, as the databases of genetic information are growing, it is apparent that the genetic testing will be simplified.

In view of the many benefits stated above, we expect the pharmaceutical companies to aggressively take advantage of genetic information in their clinical trials. We are now

planning profit simulation based on a clinical trial that was actually conducted.

21st Aug 2007 Medinfo

Proposal of Efficient Clinical Trials by using the Genomic Information

Wataru Ohashi [a] , Hiroshi Mizushima [a] , Hiroshi Tanaka [a]

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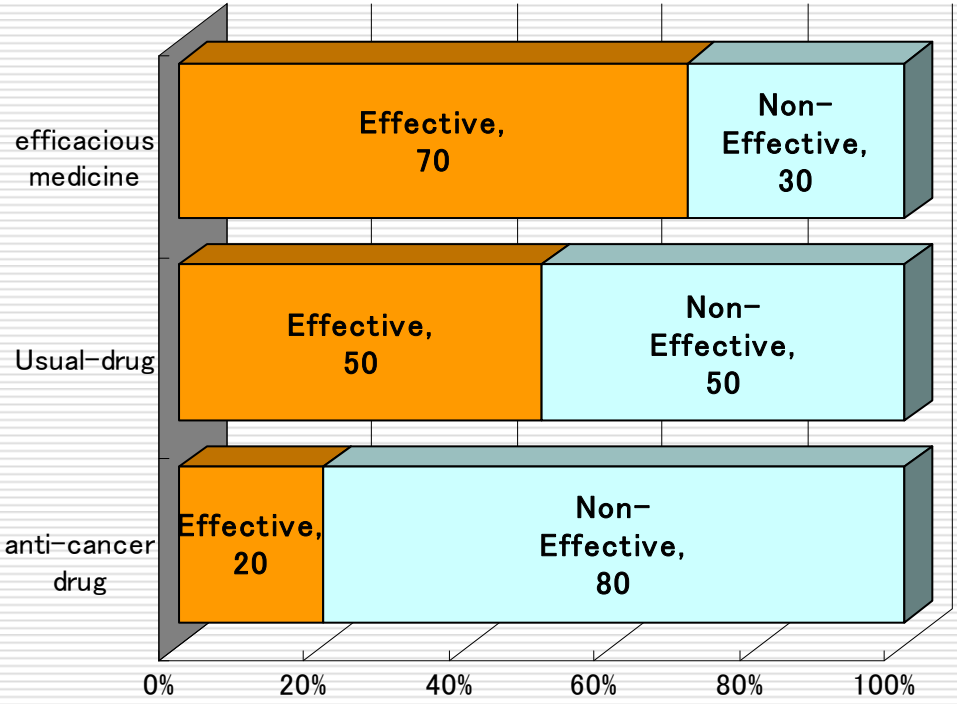
1. What does Efficacious medicine mean?



In a new drug's clinical trial, it is approved and allowed to be marketed if it can successfully show statistically significant effect compared to a placebo, a control drug (existing treatment) or a usual drug.

Even if it effects only 20% of patients like the anti-cancer drug.

The difference between responders and non-responders is often explained in terms of difference in subjects' profile. When the subjects have largely similar profiles, the difference is explained by a term called "constitution".

2. Personalized Medicine

- It is expected that the drug and dose can be determined based on the genetic information including SNPs (single nucleotide polymorphisms) of each patient.
- When personalized medicine becomes more available, unnecessary administration of drugs to non-responders can be avoided, and dose can be optimized.
- Also, medical expense in general can be reduced, and unexpected adverse effect can be avoided.

These advantages are beneficial not only to the patients concerned, but also to the society as a whole.

3.Comparison of clinical trials

Design / *Trials*	***Determination of usage and dose***	***Determination of the number and profile of subjects to be enrolled***	***Medical expenses***	***Risk of Adverse Events***
Current	Effect and adverse effect are determined based on the average.	Determined using sample size estimation equation	Rises due to unnecessary administration to non-responders	Unknown adverse event
Personalized	Can be optimized for each patient according to the patient's capacity of drug metabolizing enzyme (e.g., CYP2C29, CYP2D6)	Can be selected and response rate can be improved based on relevant genetic information	Can be cut because unnecessary administration to non-responder can be avoided	Can be minimized based on information on causative gene and minimization of drug doze.

4.Purpose

The pharmaceutical companies are not actively engaged in the development of “personalized medicine” because ･･･

1. they are afraid of lost revenue, and other drugs would not be prescribed to non-responders.
2. the procedure for handling genetic information is not fully established yet.

The purpose of this study is to clarify the benefit and loss for the pharmaceutical companies when they adopt "personalized medicine", that is, when they take advantage of genetic information in their clinical trials. Particularly, the benefit for the pharmaceutical companies in terms of following two points will be analyzed.

1. ***Development cost of new drug and period of clinical trial can be reduced because a clinical trial needs less subjects,***
2. ***The new drug can be placed on the market earlier because the development period can be shortened***

5.Methods

Generally, the sample size of a clinical trial is calculated according to an equation as follows, for example.[1][2][3]

$$n = \frac{\left\{ Z_{\alpha}\sqrt{2\bar{P}(1-\bar{P})} + Z_{\beta}\sqrt{P_1(1-P_1)+P_2(1-P_2)} \right\}^2}{(P_1 - P_2)^2}$$

$$where \quad \bar{P} = \frac{P_1 + P_2}{2}$$

(In case of chi-square test for the difference in ratio between two groups)

N: Number of necessary samples
P_1: Response rate in investigational drug group
P_2: Response rate in control drug group
Z_{α}: Value calculated from significance level (generally 1.96 at 5%)
Z_{β}: Value calculated from power (generally 0.84 at 80%)

5.Methods(2) Power Curve

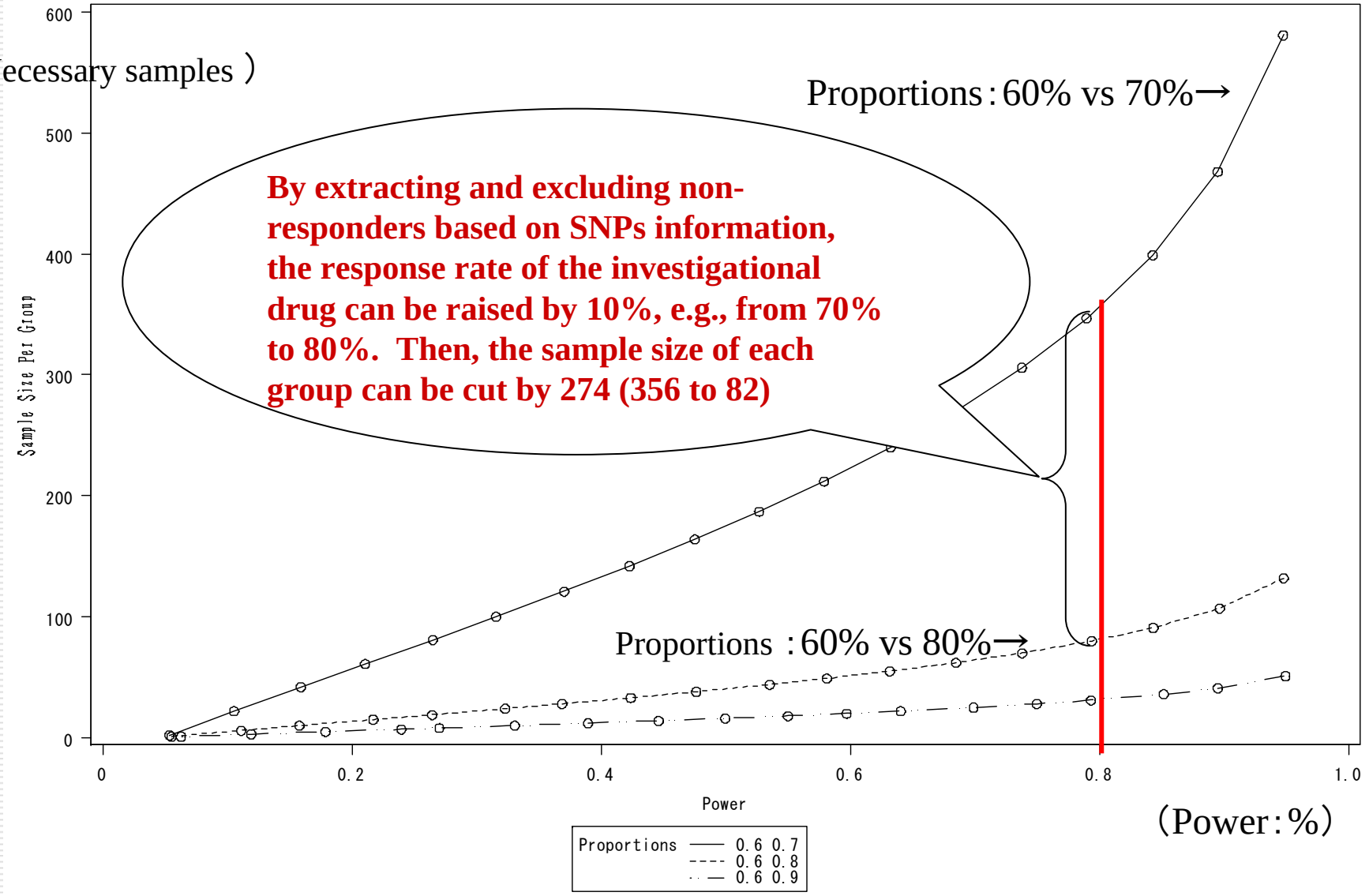


Fig. 1 Response rate and necessary sample size

6.Results

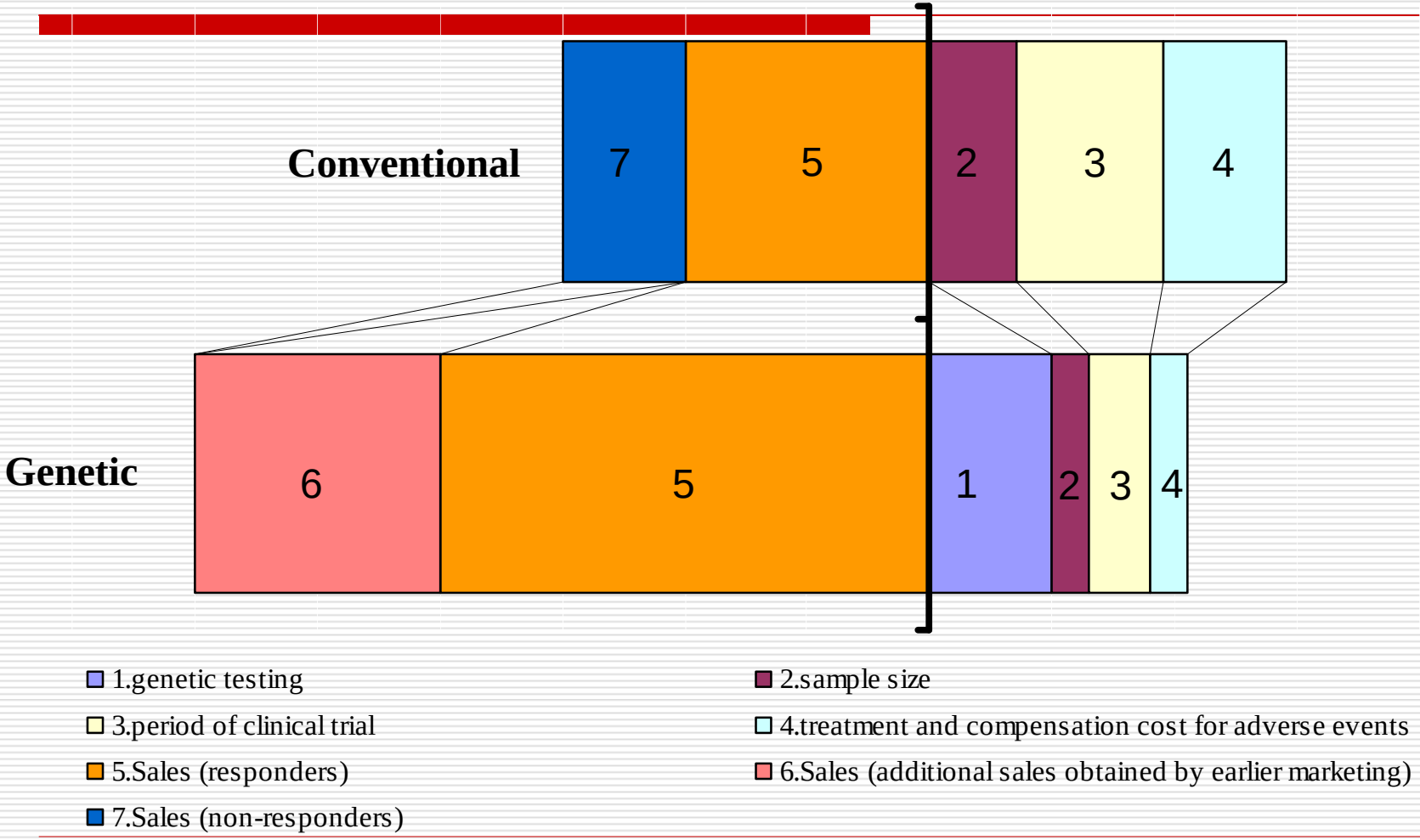
- In total, this means 548(274 per each group) cases will be unnecessary.
- This effect is more apparent when the response rate is low.
- When any known adverse event (AEs) is anticipated due to causative gene, the patients concerned can be excluded from the investigational drug group.
- Besides the safety enhanced by avoidance of an adverse event, the treatment for adverse event can be avoided.

For the society in general, medical expense can be reduced, and for the pharmaceutical companies, compensation or indemnification cost can be avoided.

(ex. In U.S, more than 2 million patients forced to be hospitalized because of the adverse effects in every year, hundred thousand people dies, and more than 70 billion health care cost wasted.)

7. Conclusion

Fig2 Profit-cost structure in conventional clinical trial and clinical trial based on genetic information



7. **Conclusion** (2)

According to our estimation, a clinical trial that takes advantage of genetic information is superior to a conventional clinical trial in terms of cost and profit.

1. **The development cost can be reduced by 5.5 million US dollar (10 thousand dollar /sample)[4].**
2. **Furthermore, the development period can be shortened by about 120 for 548 samples[4].**
3. **But, on the other hand, the sale for non-responders will be lost. However, because the drug can be marketed a120 days earlier than usual, the projected sales for the 120 days should be factored.**
4. **In addition, risk of adverse events can be mitigated by screening patients based on genetic information such as SNPs.**

7. **Conclusion** (3)

- **Reduction in compensation and indemnification cost, and reduction in medical expenses will be beneficial to the patients, the pharmaceutical companies, and the society as a whole.**
- **In a clinical trial using genetic information, temporary increase in process and cost may be inevitable. But, when genetic testing comes to be widely used, the cost will drop.**
- **Additionally, as the databases of genetic information are growing, it is apparent that the genetic testing will be simplified.**
- **We are now planning profit simulation based on a clinical trial that was actually conducted.**

Acknowledgments

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We thank Dr. Yoshiaki Uyama of Pharmaceuticals and Medical Devices Agency of Japan, and Dana Ichinotsuno of Eurus Genomics Inc. for their suggestion to this paper.

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[4] In the text, the estimation is based on the average cost of a clinical trial.

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Development of the Home-Based Multimedia System for Mental Health Management in Adolescents via Information Superhighway

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Abstract

The purpose of this study was to develop a web-based multimedia system for mental health management in adolescents using principals of user centered design. Research process includes needs assessment, needs analysis, design, development/testing, and application release. With this computerized system, adolescents can improved their mental health states. In addition, adolescents who have minor mental health problems can manage it by oneself.

Keywords:

mental health, information system, internet, adolescents

Introduction

World Health Organization's warning last year that the fastest-growing mental health problem in the world, and particularly in the developed world, was among adolescents. According to the rapid socio environmental change In Korea, many adolescents suffer from their identity confusion. Most of Korean adolescents are under pressure to study hard for an examination. The failure to examine the possible causes of rising levels of mental ill health amongst adolescents provoked much critical commentary, even from those who welcomed efforts to draw attention to the problem. One of the solutions to this problem can be a web based intervention.

Worldwide, about 4.5% of all Internet searches are for health-related information [1]. Several Internet interventions have emerged in recent years to treat mental and behavioral health problems. Computers and Internet-based programs have great potential to make psychological assessment and treatment more cost-effective [2]. In Korea, the Internet has become a most favored source to find health information. About 44.5% of all Internet searches are for health-related information [3]. Thus this project was conducted to develop a health information service system for mental health care in adolescents via internet.

Methods

This study used user-centered design model including needs assessment needs analysis, design, development/ testing, and application release.

To identify users' information needs, the investigator will conduct a descriptive study by performing surveys, interviews, and workshops in major cities in Korea. 3487 Korean adolescents participated in this study.

Investigator attempted to meet the needs of population who have various backgrounds including age, education, and knowledge in computer and mental health. The target population was identified as Korean adolescents between 13-18 years old. Minimum hardware requirements were determined to be Pentium III 1.0 GHz computer, 128mb of RAM, sound card, and a network card. Minimum software requirements were a browser capable of supporting Macromedia Flash and JavaScript; Microsoft Internet Explorer and other popular browsers support these two requirements. Task requirements were determined to be: ability to access web site, explore each intervention, read and post messages on the discussion board, enter self-assessment data, and understand tailored advice.

As we created the storyboards, we tried to make it engaging, accessible, interactive, and informative. First, we focused on the most effective and interesting way to deliver the information based on issues found through our preliminary research.

Results

The web site was released using the URL: http://www.baejy.com/youth. This system will go through individual data and will be utilized to screen those who have mental health problems. In addition, this system includes intervention programs to relieve mental health problems such as education, exercise, relaxation, visualization, music therapy, family therapy and counseling with researcher or psychiatrist. Using this system, every adolescent who has minor mental health problems can manage it by oneself.

Figure 1 - Main page

Discussion and conclusion

This research interested in the telemedicine and developing home-based multimedia system for management of the adolescent's mental health problems. Therefore, through these system adolescents can save time and cost. And it could be adequately applied to assessing mental health problems and as an intervention strategy for not only adolescents who have mental health problems but also normal adolescents. It is expected that this management system will contribute to the mental health promotion as well as community for the mental health related researchers, professionals and experts to share information on the adolescent's mental health.

We will revise this web site through these research results and through the continuous feedback that we have received from users. The second phase of this project will evaluate the effectiveness of this web intervention for further development of the program.

This research interested in the telehealth, especially information service system for more efficient psychiatric mental health care. Therefore, this system will be a new way of nursing intervention and contribute to the psychiatric mental health promotion in adolescents.

Acknowledgments

This work was supported by the Korea Research Foundation Grant funded by the Korean Government (R05-2004-000-12694-0)

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Analyzing User Satisfaction with the System in Useprior to the Implementation of a New Electronic Inpatient Record

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Abstract

This research focuses on the users' attitudes in the pre-implementation stage of a new electronic clinical information system. Contrary to most of the research in this domain, we focused on the clinical information system in use rather than on the attitudes toward the new system. The current system was analyzed as a hybrid system composed of both paper-based and electronic records. We conducted a survey with nurses and physicians in two teaching hospitals to assess user satisfaction with the current – to be replaced – hybrid system. The results showed significant differences between the two groups according to several system attributes. It highlights that a successful implementation strategy should be tailored to take into account differences among various groups of users. This approach is promising in terms of its implications for how the electronic inpatient record can be more effectively framed to facilitate user acceptance.

Keywords:

electronic patient record, clinical information system implementation, user satisfaction

Introduction

User acceptance is generally seen as a crucial factor determining the success or failure for the implementation of new information technology [1]. It is especially true in the case of the electronic inpatient record. This system is not only used as the repository for all clinical information relevant to the care of a patient but also as the main communication tool for patient-related information among clinicians. This system is thus at the core of delivery of care and is critical for teamwork productivity and quality of care. It is thus normal that the implementation of such new system monopolizes a great deal of attention. Frequently, however, little interest is left to evaluate user acceptance of the replaced system. This attitude is far from ideal given its potential impact upon the implementation strategy for the new system. Indeed the level of satisfaction or dissatisfaction with the current system affects the users' propensity to change. This oversight leaves out the first and critical stage of Lewin's field theory of organizational change that consists of three phases: (a) unfreezing old patterns, (b) moving and experimenting with new behaviors and (c) refreezing, so that new behavior becomes part of every-day business processes that are then considered normal [2]. We think that the period prior to go-live implementation is worthy of research attention because of its role in shaping users' attitudes toward the new system. Thus, similar to many models [3], this paper focuses on the users' attitudes or predispositions in the pre-implementation stage as possible significant determinants of implementation behavior. However, contrary to most of the research in this domain, we focused on the system in use rather than the attitudes toward the new system. This approach is original and promising in terms of its implications for how the electronic inpatient record can be more effectively framed to facilitate user acceptance.

Furthermore, the current patient record system is interesting to analyze because it is a hybrid system composed of both paper-based and electronic records. Although, more and more healthcare organizations are adopting electronic health records (EHRs) to overcome the weaknesses of the traditional paper-based record, we are still reproducing a dual workplace environment. We are still far from able to fully replace the paper-based record. Rather, electronic clinical documentation is usually used in addition to paper-based records. The "new" system remains a hybrid one that can be plagued with the problems of the "old" system. Earlier research suggests that the parallel use of electronic and paper-based patient records resulted in inconsistencies between the systems [4-5]. These inconsistencies can lead to significant problems for the healthcare staff in daily care. Understanding the strengths and weaknesses of the old system thus remains crucial to being able to better manage the system's transition and to ensure the successful implementation of the new system.

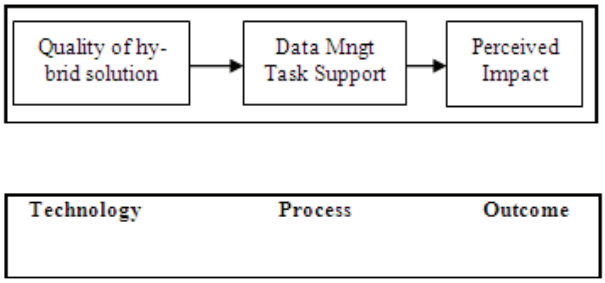

Figure 1 – Analytical framework

Within this context, our study uses a survey to pursue three objectives: (1) to assess user satisfaction with the "quality attributes" of the current – to be replaced – inpatient record system; (2) to evaluate user satisfaction with the capability of the current system to support the task of clinical data management; and (3) to measure the users' appraisal of the impact of the current system on quality of care. The sequential relationship between these 3 objectives is illustrated in Figure 1.

Materials and methods

Settings and study design

The study was conducted at the two main teaching hospitals in the province of Quebec which is the second largest healthcare jurisdiction in Canada with 7.5 million inhabitants. Both hospitals are multi-site organizations (three and five-sites), each employing approximately 10 000 employees and 1 000 physicians. The two hospitals jointly purchased the same electronic inpatient record system in 2004 and are pursuing a collaborative implementation strategy. In May 2006, a first wave of six medical and surgical services, three in each hospital, started using the new system: paediatric general surgery, internal medicine, urology/nephrology, two services of neurology and a transplantation unit.

Between November 2005 and April 2006, prior to go-live of the new inpatient record system, a cross-sectional survey with all of the nurses and physicians of these six services was conducted. At that time, the physicians and nurses had access to a complete paper-based record. However, they were also currently using electronic systems to read the results of laboratory tests and radiology exams. In two of the services, the electronic systems even allowed the ordering of lab tests and radiology exams. Electronic systems were currently used in parallel with the paper-based record by both the nurses and physicians. As shown in Table 1, the self-reported usage of electronic systems was 7.3 for nurses and 8.8 for physicians on a ten-point scale (1 indicating a low level; 10, a high level).

Three hundred and forty six (346) questionnaires were distributed to the nurses and physicians working in the six medical and surgical services. Physician questionnaires were sent out to all 150 physicians and 196 nurse questionnaires were sent out to all regular nursing personnel (24hours/7days). Questionnaires were anonymous but marked so personal reminders could be sent to those individuals who did not respond. Survey responses were confidential. The appropriate institutional review boards approved the study.

Survey instrument

The survey instrument was designed to measure users' satisfaction according to the three research objectives. The survey included the following:

- Objective 1: four "quality attributes" (ease of use, usability, data quality and record accessibility) for respectively evaluating the paper-based and electronic record systems and two additional attributes (system reliability and response-time) specifically designed for the electronic record system.
- Objective 2: approximately 20 attributes to measure the capability of the inpatient record system to supporting clinical data management. Due to task differences between nurses and physicians, two different sets of items were used: 21 items for physicians and 19 for nurses.
- Objective 3: 16 items to assess the impact of the inpatient record system in terms of quality of care.

All survey questions were answered with 10-point likert scales, rating the above-mentioned attributes of the system. With regard to objective 1, variables such as ease of use, usability, quality of information were defined in line with the DeLone & McLean Model of Information Systems success [6-7]. Table 2 shows the psychometric qualities of these measures. Their reliability (internal consistency), measured with Cronbach's alpha, indicate that all of the measures surpass the usual 0.70 threshold of statistical significance. In relation with the second objective, we used a task-oriented questionnaire developed for evaluating electronic medical record systems [8]. The questionnaire has successfully been tested in terms of criterion validity and reliability. The key feature of this evaluation tool is a list of 21 general clinical tasks that are applicable to physicians of most specialties and that covers essential parts of their information-oriented work. We have adapted the questionnaire for nurses while maintaining its structure. The nurses' questionnaire included 19 tasks related to clinical data management. Lastly, for the third objective, a 16-item scale was developed for the specific needs of this study. The scale was aimed at assessing the outcomes with positive items such as quality of care, continuity of care, accuracy of clinical decisions and negative

ones such as transcription errors and delays in patient care.

Analysis

SPSS software was used for all statistical analyses. Alpha levels of 0.01, 0.05 and 0.10 were used to test the significance of all Chi-square and t-test comparisons. Factor analyses were performed to create factors in relation to objectives 2 and 3. The variable reliability was assessed with Cronbach alpha tests.

Results

Survey response & characteristics of respondents

Questionnaires were received from 219 (63%) of 346 eligible respondents, including 123 (63%) nurses and 96 (64%) physicians.

As shown in Table 1, significant differences were observed between the nurses and physicians in terms of gender, age and experience with computers. Also, the use of the current electronic inpatient record system was significantly different between the two groups. On a ten-point scale (1 indicating a low level; 10, a high level), the nurses' use mean rating of the electronic record system was lower (7.3) than the physicians' rating (8.8). But still, both groups showed a high level of electronic systems use.

		RNs (n = 123)	MDs (n = 96)	
Gender	Male Female	12% 88%	74% 26%	$X^2 = 87.1$ (p<.000)
Age	≤ 30 31-40 41-50 51-60 61 & +	27% 23% 36% 14% 0%	10% 23% 33% 21% 13%	$X^2 = 24.1$ (p<.000)
Users' Experience with computers	A little 2 3 4 A lot	10% 32% 27% 21% 10%	2% 4% 25% 43% 26%	$X^2 = 42.7$ (p<.000)
Electronic inpatient records Use (Scale 1 – 10)	Mean (sd)	7.3 (2.3)	8.8 (1.9)	t-test p=0.000***

Table 1 – Distribution of survey respondents

User satisfaction with the inpatient record system

As shown in Table 2, the users were more satisfied with the electronic record. The global index of satisfaction for the electronic patient record reached a score of 6.8 while the paper-based record was just above the mid-point (5.7) of the 10-point scale. The electronic record system reached its highest scores for "ease of use" (7.7) and "data quality" (7.7) while the paper-based record reached its highest score for "usability" (6.3) and "ease of use" (6.2). "Data quality" was the attribute for which the electronic record showed the greatest difference (7.7 for the electronic record vs. 5.7 for the paper-based record). In both systems the least satisfactory attribute was "file accessibility" (4.2 for the paper-based record vs. 4.7 for the electronic one). The electronic record's unexpected low score was mainly attributed to the small number of PC stations available in each service.

Quality attributes of the record system	Nb of items	Cronbach Alpha	Mean	SD
Paper record				
Ease of Use	3	.93	6.2	2.2
File Access	2	.65	4.2	2.2
Usability	3	.91	6.3	2.0
Data Quality	7	.87	5.7	1.6
Total Mean	15	.91	5.7	1.5
Electronic record				
Ease of Use	3	.86	7.7	1.7
File Access	3	.87	4.7	2.3
System reliability	2	.77	6.5	2.1
Response time	1	--	6.9	2.4
Usability	2	.83	7.1	2.0
Data Quality	4	.73	7.7	1.5
Total Mean	15	.84	6.8	1.2

Table 2 – User satisfaction

Ratings of the systems' attributes varied by user group (Table 3). The nurses were more satisfied than the physicians with all attributes of the paper-based record (p=0.000) with the exception of "file accessibility" that was poorly rated by both groups. The physicians were more satisfied with the electronic record (7.2 vs. 6.5; p=0.000). Four attributes were significantly different between the 2 groups: "ease of use", "file accessibility", "usability" and "information quality".

Quality Attributes of the Record System	RNs (n=123) *Mean(sd)*	MDs (n=96) *Mean(sd)*	*t-test*
Paper Record			
Ease of Use	7.0 (1.8)	5.1 (2.3)	p=0.000***
File Accessibility	4.2 (2.2)	4.3 (2.2)	p=0.742
Usability	6.9 (1.7)	5.5 (2.1)	p=0.000***
Data Quality	6.1 (1.5)	5.3 (1.6)	p=0.000***
Total Mean	6.2 (1.3)	5.2 (1.6)	p=0.000***
Electronic Record			
Ease of Use	7.3 (1.8)	8.2 (1.4)	p=0.000***
File Accessibility	4.3 (2.3)	5.1 (2.3)	p=0.027**
System Reliability	6.4 (2.2)	6.7 (1.9)	p=0.244
Response Time	6.9 (2.6)	7.0 (2.3)	p=0.814
Usability	6.5 (2.0)	7.9 (1.7)	p=0.000***
Information Quality	7.5 (1.7)	7.9 (1.1)	p=0.068*
Total Mean	6.5 (1.3)	7.2 (1.0)	p=0.000***
*** p<.001; ** p<.05; * p<.10			

Table 3 – Comparison of User Satisfaction between Groups

Task-oriented evaluation of the Inpatient record system

The second aim of the survey was to evaluate the users' satisfaction with the capability of the record systems to support clinical data management tasks. Because it would have been difficult to distinguish the specific contribution of the paper-based record from the electronic one, their joint effect was assessed. A detailed survey instrument was developed to fulfill this objective [8].

Factor analyses[1] were conducted to be able to group the tasks together in larger domains of activities. For the physicians, the analysis of the initial 21 items generated 4 factors with eigenvalues greater than 1.0. These 4 factors were composed of 15 items that all presented loading scores greater than 0.5, a clear evidence of the discriminate validity of the measures used (Table 4). Taken together, the 4 factors explained 67% of the variance. For the nurses, the factor analysis generated 3 factors with eigenvalues greater than 1.0. The 17 items associated with these factors also presented loading scores greater than 0.5 (Table 4). Taken together, the 3 factors explained 66% of the variance. In both cases, these factors portrayed an interesting typology for identifying the main activities of clinical data management. As shown in Table 4, the composite reliability coefficients (Cronbach alpha) of all the factors were very good, varying from 0.77 to 0.96.

As shown in Table 4, the assessment scores were rather low, reaching a maximum of 6.4 on a ten-point scale (1 indicating a low level of "task usability"; 10 indicating a high level of "task usability"). The nurses rated "task usability" higher (6.4) than the physicians (5.9), a significant difference (p = 0.023). The only exception was for a similar factor, "physicians' results monitoring" and "nurses' results management" that reached a higher score of 7.8 in both groups.

Data Mngt Task Support	Nb of items	Cronbach Alpha	Mean	SD
Physician Tasks				
Medical Ordering	5	.93	5.1	2.5
Results Monitoring	4	.86	7.8	1.7
Pts' Status Monitoring	3	.79	6.3	2.0
Patient Discharge	3	.82	4.4	2.2
Summative Measure	15	.88	5.9	1.5
Factor Analysis = 67,2% explained variance				
Nurses Tasks				
Pts' Data Management	10	.96	6.2	2.1
Results Management	2	.77	7.8	1.7
Pts' Status Monitoring	5	.84	6.4	1.7
Summative Measure	17	.94	6.4	1.7
Factor Analysis = 66,4% explained variance				

Table 4 – Task-oriented evaluation

Impact evaluation of the inpatient record system

The third objective of the survey was to assess the impact of the inpatient record system. Here also, the joint effect of both the paper-based and electronic records was assessed with a ten-point scale (1 indicating a very negative impact; 10, a very positive impact).

Inpatient Record System	Nb of Items	Cronbach Alpha	Mean	SD
Impact				
Quality of care	7	.92	6.2	1.5
Data Mismanagement	5	.93	5.2	22.0
Factor Analysis = 67,5% explained variance				

Table 5 – Dimensions of impact evaluation

We also proceeded with a factor analysis[2] to identify the dimensions of impact present among our 16-item scale. The analysis generated 2 factors with eigenvalues greater than 1.0. The composite reliability coefficients (Cronbach alpha) of both factors were excellent reaching over 0.9 (Table 5). All of the 12 items associated with these variables presented loading scores greater than 0.5. Taken together, both factors explained 67.5% of the variance.

1 Principal axis factor analysis with oblimin rotation. The detail of the factor analyses is not shown here.

2 Principal axis factor analysis with oblimin rotation. The detail of the factor analyses is not shown here.

The first factor referred to positive items associated with the quality of care while the second one included negative items associated with the mismanagement of clinical data.

As shown in Table 5, the two scores were near the middle of the ten-point scale. Thus, respondents did not perceive that the record system had a negative impact on the quality of care and the occurrence of data management errors. At the same time, the contribution of the record system to the quality of care is weak. The only significant difference between the two clinician groups was with respect to the "quality of care" which received a higher rating by the nurses (6.4 vs. 6.0; p=0.054).

Inpatient Record System	RNs n=122 *Mean(sd)*	MDs n=95 *Mean(sd)*	*t-test*
Impact			
Quality of Care	6.4 (1.4)	6.0 (1.8)	p=0.054*
Data Mismanagement	5.1 (2.0)	5.3 (2.1)	p=0.423
*p<.10			

Table 6 – Comparison of Impact Evaluation between Groups

Discussion

The main results of the study are summarized in this section. A first positive result is that the electronic record was rated higher than the paper-based one. The positive ratings are congruent with other studies evaluating user satisfaction toward other electronic clinical systems [9-11]. This situation should facilitate the implementation of the electronic inpatient system. However, it is also important to note that physicians and nurses had rated the two record systems differently. The nurses rated the "quality attributes" of the paper-based record higher than the electronic system. This highlights the need to consider both perspectives when implementing a new system. This lesson is important for developing a successful implementation strategy in the domain of electronic clinical information systems. It means that the management of users' expectations should be tailored to take into account differences among various groups of users. In other words, the readiness to adopt a new system varies between user groups. In Lewin's terms, the unfreezing challenge may be different between user groups and requires different implementation strategies. It underscores the importance of specifically targeting different user groups in the implementation of a new system. The unfreezing strategy used to encourage users to give up the paper-based record should be narrowly framed according to the positive and negative attributes associated with it. We note that for the present case, "data quality" and "ease of use" were attributes showing the greatest differential in favor to the electronic record over the paper-based system. This finding is congruent with the importance given to these attributes in the research conducted with the renowned DeLone & McLean model of information system success [6-7].

Further, we also note that the presence of a hybrid record system, necessitating a joint usage of paper-based and electronic records, was poorly appraised. Indeed, the task-oriented evaluation of the hybrid record system was rather low remaining under a 6.5 level on a ten-point scale. These results are congruent with previous studies that have shown that the parallel use of electronic and paper-based patient records can result in inconsistencies between both systems that lead to significant problems for the healthcare staff in daily care [4-5]. It is thus of the utmost importance to take special care to reduce the possible impact of this conflict when implementing a new electronic clinical system. It is important to note that even if most healthcare organizations are in the process of increasing the use of electronic systems to manage their clinical data, the paper-based record is still present.

Similarly, the results also show that the impact of the hybrid record system was halfheartedly received as demonstrated by the users' ratings which remained near the mid-point of the scale. Here again, it is thus important to take supplementary efforts to conceive the means by which the new system can correct the weaknesses of the system in place.

Prior to concluding, limitations must be acknowledged. First, the response rate (63%) could have been higher even if it can be considered satisfactory in comparison with similar studies which vary between 56% and 85% [9-11]. It will also be important to replicate the study with other medical specialties and organizational contexts. We also acknowledge the usual limitations and generalizations associated with the cross-sectional nature of the study. However, we intend to use this survey as a baseline and we plan to pursue user satisfaction assessments during the new system implementation.

In conclusion, the results presented in this paper have implications for both nurse and physician information technology adoption theory development and practice. With regard to theoretical development, it would be useful to analyze in greater depth the relationship between user satisfaction with the current system, their consequent readiness to change and the latter adoption of a new system. Our results can also guide clinical information system project managers whose objectives are to further use among clinicians in their organizations. In this respect, our results suggest that users' expectations with the new system should be carefully framed in relation to their current experience with the system in place.

Acknowledgments

The authors thank all of the nurses and physicians who have taken the time to complete this survey and have made this paper possible. As well, the Canadian Institutes of Health Research and the Social Sciences and Humanities Research Council of Canada are gratefully acknowledged for providing financial support for this research project.

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Analyzing User Satisfaction with the System in Use prior to the Implementation of a New Electronic Inpatient Record

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Introduction

User acceptance is generally seen as a crucial factor determining the success or failure for the implementation of new information technology [1]. It is especially true in the case of the electronic inpatient record. This system is not only used as the repository for all clinical information relevant to the care of a patient but also as the main communication tool for patient-related information among clinicians. This system is thus at the core of delivery of care and is critical for teamwork productivity, patient safety and quality of care. It is thus normal that the implementation of such new system monopolizes a great deal of attention. Frequently, however, little interest is left to evaluate user acceptance of the replaced system. This attitude is far from ideal given its potential impact upon the implementation strategy for the new system. Indeed the level of satisfaction or dissatisfaction with the current system affects the users' propensity to change and to efficiently use the new system. This oversight leaves out the first and critical stage of Lewin's field theory of organizational change that consists of three phases: (a) unfreezing old patterns, (b) moving and experimenting with new behaviors and (c) refreezing, so that new behavior becomes part of every-day business processes that are then considered normal [2]. We think that the period prior to go-live implementation is worthy of research attention because of its role in shaping users' attitudes toward the new system. Thus, similar to many models [3], this paper focuses on the users' attitudes or predispositions in the pre-implementation stage as possible significant determinants of implementation behavior. However, contrary to most of the research in this domain, we focused on the system in use rather than the attitudes toward the new system. This approach is original and promising in terms of its implications for how the electronic inpatient record can be more effectively framed to facilitate user acceptance.

Furthermore, the current patient record system is interesting to analyze because it is a hybrid system composed of both paper-based and electronic records. Although, more and more healthcare organizations are adopting electronic health records (EHRs) to overcome the weaknesses of the traditional paper-based record, we are still reproducing a dual workplace environment. We are still far from able to fully replace the paper-based record. Rather, electronic clinical documentation is usually used in addition to paper-based records. The "new" system remains a hybrid one that can be plagued with the problems of the "old" system. Earlier research suggests that the parallel use of electronic and paper-based patient records resulted in inconsistencies between the systems [4-5]. These inconsistencies can lead to significant problems for the healthcare staff in daily care. Understanding the strengths and weaknesses of the old system thus remains crucial to being able to better manage the system's transition and to ensure the successful implementation of the new system.

Objectives

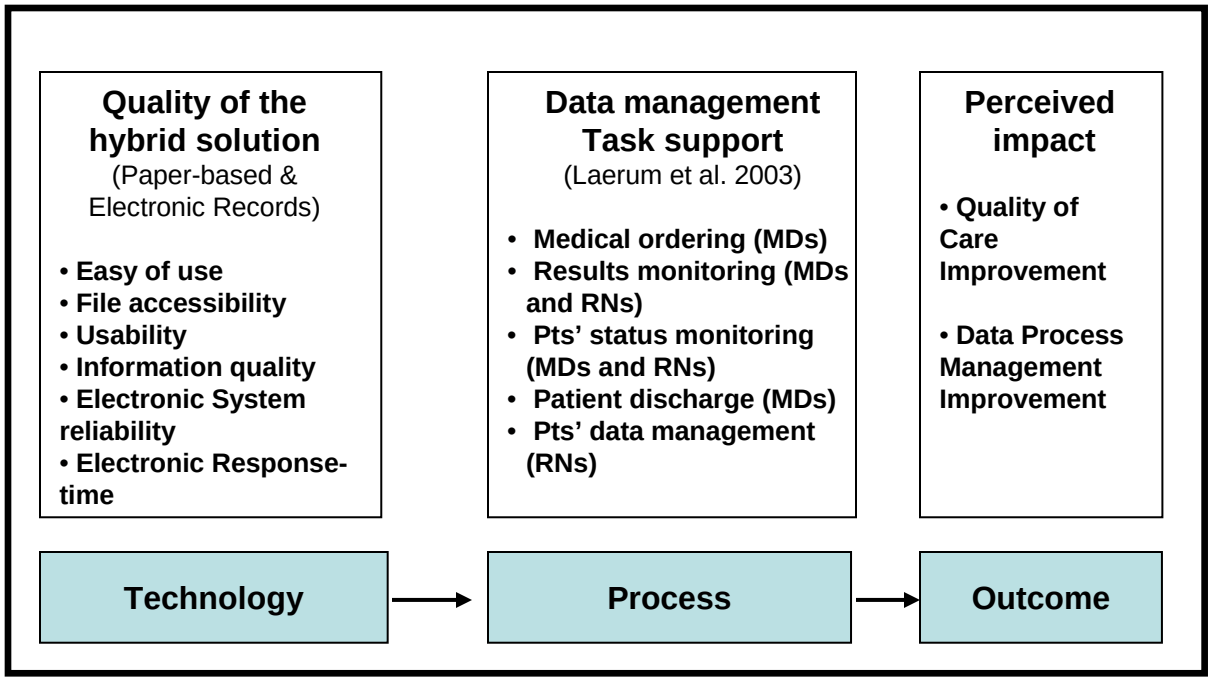
The study uses a survey to pursue three objectives:

1- to assess user satisfaction with the "quality attributes" of the current – to be replaced – inpatient record system;

2- to evaluate user satisfaction with the capability of the current system to support the task of clinical data management; and

3- to measure the users' appraisal of the impact of the current system on quality of care. The sequential relationship between these 3 objectives is illustrated in Figure 1.

Figure 1 – Analytical Framework



Methods

The study was conducted at the two main teaching hospitals in the province of Quebec which is the second largest healthcare jurisdiction in Canada with 7.5 million inhabitants. Both hospitals are multi-site organizations (three and five-sites), each employing approximately 10 000 employees and 1 000 physicians. The two hospitals jointly purchased the same electronic inpatient record system in 2004 and are pursuing a collaborative implementation strategy. In May 2006, a first wave of six medical and surgical services, three in each hospital, started using the new system: paediatric general surgery, internal medicine, urology/nephrology, two services of neurology and a transplantation unit.

Between November 2005 and April 2006, prior to go-live of the new inpatient record system, a cross-sectional survey with all of the nurses and physicians of these six services was conducted. At that time, the physicians and nurses had access to a complete paper-based record. However, they were also currently using electronic systems to read the results of laboratory tests and radiology exams and to consult PACS images. In two of the services, the electronic systems even allowed the ordering of lab tests and radiology exams. Electronic systems were currently used in parallel with the paper-based record by both the nurses and physicians. As shown in Table 1, the self-reported usage of electronic systems was 7.3 for nurses and 8.8 for physicians on a ten-point scale (1 indicating a low level; 10, a high level).

Three hundred and forty six (346) questionnaires were distributed to the nurses and physicians working in the six medical and surgical services. Physician questionnaires were sent out to all 150 physicians and 196 nurse questionnaires were sent out to all regular nursing personnel (24hours/7days). Questionnaires were anonymous but marked so personal reminders could be sent to those individuals who did not respond. Survey responses were confidential. The appropriate institutional review boards approved the study.

Survey instrument

The survey instrument was designed to measure users' satisfaction according to the three research objectives. The survey included the following:

• Objective 1**: Four "quality attributes" (ease of use, usability, data quality and record accessibility) for respectively evaluating the paper-based and electronic record systems and two additional attributes (system reliability and response-time) specifically designed for the electronic record system.**

• Objective 2: **Approximately 20 attributes to measure the capability of the inpatient record system to supporting clinical data management. Due to task differences between nurses and physicians, two different sets of items were used: 21 items for physicians and 19 for nurses.**

• Objective 3: **Seize items to assess the impact of the inpatient record system in terms of quality of care.**

All survey questions were answered with 10-point likert scales, rating the above-mentioned attributes of the system. With regard to objective 1, variables such as ease of use, usability, quality of information were defined in line with the DeLone & McLean Model of Information Systems success [6-7]. Table 2 shows the psychometric qualities of these measures. Their reliability (internal consistency), measured with Cronbach's alpha, indicate that all of the measures surpass the usual 0.70 threshold of statistical significance. In relation with the second objective, we used a task-oriented questionnaire developed for evaluating electronic medical record systems [8]. The questionnaire has successfully been tested in terms of criterion validity and reliability. The key feature of this evaluation tool is a list of 21 general clinical tasks that are applicable to physicians of most specialties and that covers essential parts of their information-oriented work. We have adapted the questionnaire for nurses while maintaining its structure. The nurses' questionnaire included 19 tasks related to clinical data management. Lastly, for the third objective, a 16-item scale was developed for the specific needs of this study. The scale was aimed at assessing the outcomes with positive items such as quality of care, continuity of care, accuracy of clinical decisions and negative ones such as transcription errors and delays in patient care.

Results

Survey Response & Characteristics of Respondents

Table 1 – Distribution of Survey Respondents

		RNs (n = 123)	**MDs** (n = 96)	
Gender	**Male** **Female**	12% 88%	74% 26%	X^2 = 87.1 (p<.000)
Age	**≤ 30** **31-40** **41-50** **51-60** **61 & +**	27% 23% 36% 14% 0%	10% 23% 33% 21% 13%	X^2 = 24.1 (p<.000)
Users' Experience with Computers	**A little** **2** **3** **4** **A lot**	10% 32% 27% 21% 10%	2% 4% 25% 43% 26%	X^2 = 42.7 (p<.000)
Electronic Inpatient Records Use (Scale 1 – 10)	**Mean** **(sd)**	7.3 (2.3)	8.8 (1.9)	t-test p=0.000***

Questionnaires were received from 219 (63%) of 346 eligible respondents, including 123 (63%) nurses and 96 (64%) physicians.

As shown in Table 1, significant differences were observed between the nurses and physicians in terms of gender, age and experience with computers. Also, the use of the current electronic inpatient record system was significantly different between the two groups. On a ten-point scale (1 indicating a low level; 10, a high level), the nurses' use mean rating of the electronic record system was lower (7.3) than the physicians' rating (8.8). But still, both groups showed a high level of electronic systems use.

Results

User satisfaction with the Inpatient System

Table 2 – User Satisfaction

Quality attributes of the record system	Nb of items	Cronbach Alpha	Mean	SD
Paper Record				
Ease of Use	3	.93	6.2	2.2
File Access	2	.65	4.2	2.2
Usability	3	91	6.3	2.0
Data Quality	7	.87	5.7	1.6
Total Mean	15	.91	5.7	1.5
Electronic Record				
Ease of Use	3	.86	7.7	1.7
File Access	3	.87	4.7	2.3
System reliability	2	.77	6.5	2.1
Response time	1	- -	6.9	2.4
Usability	2	.83	7.1	2.0
Data Quality	4	.73	7.7	1.5
Total Mean	15	.84	6.8	1.2

As shown in Table 2, the users were more satisfied with the electronic record. The global index of satisfaction for the electronic patient record reached a score of 6.8 while the paper-based record was just above the mid-point (5.7) of the 10-point scale. The electronic record system reached its highest scores for "ease of use" (7.7) and "data quality" (7.7) while the paper-based record reached its highest score for "usability" (6.3) and "ease of use" (6.2). "Data quality" was the attribute for which the electronic record showed the greatest difference (7.7 for the electronic record vs. 5.7 for the paper-based record). In both systems the least satisfactory attribute was "file accessibility" (4.2 for the paper-based record vs. 4.7 for the electronic one). The electronic record's unexpected low score was mainly attributed to the small number of PC stations available in each service.

Results

User satisfaction with the Inpatient System

Table 3 – Comparison of User Satisfaction between Groups

Quality Attributes of the Record System	RNs (n=123) *Mean(sd)*	MDs (n=96) *Mean(sd)*	*t-test*
Paper Record			
Ease of Use	7.0 (1.8)	5.1 (2.3)	p=0.000***
File Accessibility	4.2 (2.2)	4.3 (2.2)	p=0.742
Usability	6.9 (1.7)	5.5 (2.1)	p=0.000***
Data Quality	6.1 (1.5)	5.3 (1.6)	p=0.000***
Total Mean	6.2 (1.3)	5.2 (1.6)	p=0.000***
Electronic Record			
Ease of Use	7.3 (1.8)	8.2 (1.4)	p=0.000***
File Accessibility	4.3 (2.3)	5.1 (2.3)	p=0.027**
System Reliability	6.4 (2.2)	6.7 (1.9)	p=0.244
Response Time	6.9 (2.6)	7.0 (2.3)	p=0.814
Usability	6.5 (2.0)	7.9 (1.7)	p=0.000***
Information Quality	7.5 (1.7)	7.9 (1.1)	p=0.068*
Total Mean	6.5 (1.3)	7.2 (1.0)	p=0.000***

*** p<.001; ** p<.05; * p<.10

Ratings of the systems' attributes varied by user group. The nurses were more satisfied than the physicians with all attributes of the paper-based record (p=0.000) with the exception of "file accessibility" that was poorly rated by both groups. The physicians were more satisfied with the electronic record (7.2 vs. 6.5; p=0.000). Four attributes were significantly different between the two groups: "ease of use", "file accessibility", "usability" and "information quality".

Results

Task-oriented Evaluation of the Inpatient Record System

Table 4 – Task-oriented Evaluation

Data Mngt Task Support	Nb of items	Cronbach Alpha	Mean	SD
Physician Tasks				
Medical Ordering	5	.93	5.1	2.5
Results Monitoring	4	.86	7.8	1.7
Pts' Status Monitoring	3	.79	6.3	2.0
Patient Discharge	3	.82	4.4	2.2
Summative Measure	15	.88	5.9	1.5
Factor Analysis = **67,2% explained variance**. Principal axis factor analysis with oblimin rotation. The detail of the factor analyses is not shown here.				
Nurses Tasks				
Pts' Data Management	10	.96	6.2	2.1
Results Management	2	.77	7.8	1.7
Pts' Status Monitoring	5	.84	6.4	1.7
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Factor Analysis = **66,4% explained variance**. Principal axis factor analysis with oblimin rotation. The detail of the factor analyses is not shown here.				

The second aim of the survey was to evaluate the users' satisfaction with the capability of the record systems to support clinical data management tasks. Because it would have been difficult to distinguish the specific contribution of the paper-based record from the electronic one, their joint effect was assessed. A detailed survey instrument was developed to fulfill this objective [8].

Factor analyses were conducted to be able to group the tasks together in larger domains of activities. For the physicians, the analysis of the initial 21 items generated 4 factors with eigenvalues greater than 1.0. These 4 factors were composed of 15 items that all presented loading scores greater than 0.5, a clear evidence of the discriminate validity of the measures used (Table 4). Taken together, the 4 factors explained 67% of the variance.

For the nurses, the factor analysis generated 3 factors with eigenvalues greater than 1.0. The 17 items associated with these factors also presented loading scores greater than 0.5. Taken together, the 3 factors explained 66% of the variance. In both cases, these factors portrayed an interesting typology for identifying the main activities of clinical data management. The composite reliability coefficients (Cronbach alpha) of all the factors were very good, varying from 0.77 to 0.96.

The assessment scores were rather low, reaching a maximum of 6.4 on a ten-point scale (1 indicating a low level of "task usability"; 10 indicating a high level of "task usability"). The nurses rated "task usability" higher (6.4) than the physicians (5.9), a significant difference (p = 0.023). The only exception was for a similar factor, "physicians' results monitoring" and "nurses' results management" that reached a higher score of 7.8 in both groups.

Results

Impact Evaluation of the Inpatient Record System

The third objective of the survey was to assess the impact of the inpatient record system. Here also, the joint effect of both the paper-based and electronic records was assessed with a ten-point scale (1 indicating a very negative impact; 10, a very positive impact).

Table 5 – Dimensions of Impact Evaluation

Inpatient Record System	Nb of Items	Cronbach Alpha	Mean	SD
Impact				
Quality of care	7	.92	6.2	1.5
Data Mismanagement	5	.93	5.2	2.0
Factor Analysis = **67,5% explained variance.** Principal axis factor analysis with oblimin rotation. The detail of the factor analyses is not shown here.				

We also proceeded with a factor analysis to identify the dimensions of impact present among our 16-item scale. The analysis generated 2 factors with eigenvalues greater than 1.0. The composite reliability coefficients (Cronbach alpha) of both factors were excellent reaching over 0.9 (Table 5). All of the 12 items associated with these variables presented loading scores greater than 0.5. Taken together, both factors explained 67.5% of the variance. The first factor referred to positive items associated with the quality of care while the second one included negative items associated with the mismanagement of clinical data.

As shown in Table 5, the two scores were near the middle of the ten-point scale. Thus, respondents did not perceive that the record system had a negative impact on the quality of care and the occurrence of data management errors. At the same time, the contribution of the record system to the quality of care is weak. The only significant difference between the two clinician groups was with respect to the "quality of care" which received a higher rating by the nurses (6.4 vs. 6.0; p=0.054).

Table 6 – Comparison of Impact Evaluation between Groups

Inpatient Record System	**RNs** n=122 *Mean(sd)*	**MDs** n=95 *Mean(sd)*	***t-test*** * p<.10
Impact			
Quality of Care	6.4 (1.4)	6.0 (1.8)	p=0.054*
Data Mismanagement	5.1 (2.0)	5.3 (2.1)	p=0.423

Discussion and Conclusion

The main results of the study are summarized in this section. A first positive result is that the electronic record was rated higher than the paper-based one. The positive ratings are congruent with other studies evaluating user satisfaction toward other electronic clinical systems [9-11]. This situation should facilitate the implementation of the electronic inpatient system. However, it is also important to note that physicians and nurses had rated the two record systems differently. The nurses rated the "quality attributes" of the paper-based record higher than the electronic system. This highlights the need to consider both perspectives when implementing a new system. This lesson is important for developing a successful implementation strategy in the domain of electronic clinical information systems. It means that the management of users' expectations should be tailored to take into account differences among various groups of users. In other words, the readiness to adopt a new system varies between user groups. In Lewin's terms, the unfreezing challenge may be different between user groups and requires different implementation strategies. It underscores the importance of specifically targeting different user groups in the implementation of a new system. The unfreezing strategy used to encourage users to give up the paper-based record should be narrowly framed according to the positive and negative attributes associated with it. We note that for the present case, "data quality" and "ease of use" were attributes showing the greatest differential in favor to the electronic record over the paper-based system. This finding is congruent with the importance given to these attributes in the research conducted with the renowned DeLone & McLean model of information system success [6-7].

Further, we also note that the presence of a hybrid record system, necessitating a joint usage of paper-based and electronic records, was poorly appraised. Indeed, the task-oriented evaluation of the hybrid record system was rather low remaining under a 6.5 level on a ten-point scale. These results are congruent with previous studies that have shown that the parallel use of electronic and paper-based patient records can result in inconsistencies between both systems that lead to significant problems for the healthcare staff in daily care [4-5]. It is thus of the utmost importance to take special care to reduce the possible impact of this conflict when implementing a new electronic clinical system. It is important to note that even if most healthcare organizations are in the process of increasing the use of electronic systems to manage their clinical data, the paper-based record is still present.

Similarly, the results also show that the impact of the hybrid record system was halfheartedly received as demonstrated by the users' ratings which remained near the mid-point of the scale. Here again, it is thus important to take supplementary efforts to conceive the means by which the new system can correct the weaknesses of the system in place.

Prior to concluding, limitations must be acknowledged. First, the response rate (63%) could have been higher even if it can be considered satisfactory in comparison with similar studies which vary between 56% and 85% [9-11]. It will also be important to replicate the study with other medical specialties and organizational contexts. We also acknowledge the usual limitations and generalizations associated with the cross-sectional nature of the study. However, we intend to use this survey as a baseline and we plan to pursue user satisfaction assessments during the new system implementation.

In conclusion, the results presented in this paper have implications for both nurse and physician information technology adoption theory development and practice. With regard to theoretical development, it would be useful to analyze in greater depth the relationship between user satisfaction with the current system, their consequent readiness to change and the latter adoption of a new system. Our results can also guide clinical information system project managers whose objectives are to further use among clinicians in their organizations. In this respect, our results suggest that users' expectations with the new system should be carefully framed in relation to their current experience with the system in place.

Acknowledgments and References

The authors thank all of the nurses and physicians who have taken the time to complete this survey and have made this paper possible. As well, the Canadian Institutes of Health Research and the Social Sciences and Humanities Research Council of Canada are gratefully acknowledged for providing financial support for this research project.

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Information Technology for Clinical Decision Support in Primary Health Care Practices

Judith M. Engelbrecht, Inga M. Hunter, Richard J. Whiddett

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Abstract

- This study of New Zealand General Practitioner (GP) practices demonstrates that those surveyed are generally well equipped with information technology (IT), suggesting there is the potential for them to be able to utilize levels of clinical decision support (CDS) similar to each other. However,
- three commonly available technologies used by 80% or more of practices were all found to be used by fewer practices for CDS. This suggests that
- barriers other than the availability of technologies are important inhibitors to the utilization of IT for CDS.

Introduction

- International and Australasian health care organizations are seeking to improve the use of computerised clinical decision support (CDS) in health care[1;2;3].
- New Zealand's primary health care sector is now structured around not-for-profit Primary Health Organisations (PHOs)[4].
- Knowledge of IT infrastructure and its usage by PHO practices would enable their management organisations to formulate appropriate strategies to encourage better use of technologies, and the decision support capabilities they provide.
- This presentation gives preliminary results regarding the IT supporting patient care in primary care GP practices.

Study area

- Where?
  - Medium sized New Zealand Primary Health Organisations (PHOs)
    - PHO Management Services Organisations
    - Contributing General Practitioner practices
- Who?
  - PHO Management Services Organisation
    - Staff
    - Contract holders
  - Contributing General Practitioner practice
    - Doctors
    - Practice nurses
    - Practice administrators
- What?
  - What information technologies (IT) are available in the organisations
  - How the organisations use IT in the support of clinical decision making

Methodology

- A multiple case study of medium sized PHOs was undertaken, consisting of
  - a pilot case study, and
  - two other case study organisations.
- Triangulation[5] was achieved by
  - the use of face-to-face interviews,
  - a postal questionnaire survey of GP practices and
  - the collection of documentation at each case study organisation.

Results 1: Practice use of technologies

Technology	% Practices using technology
Practice Management Systems (PMS)	100
Fax. Machine	100
Printer	100
PCs	100
Healthlink[1] connection	100
Word processing software	100
The Internet/external websites or databases	90
Internal messaging system	90
Spreadsheet	90
Extranet application (e.g. ACC logging)	80
e-mail	80

[1] Secure network for health sector electronic messaging

The table shown here shows the most popular technologies identified as used in the support of patient care by the responding practices.

Results 2: Individual PHO GP practice use of technologies supporting patient care

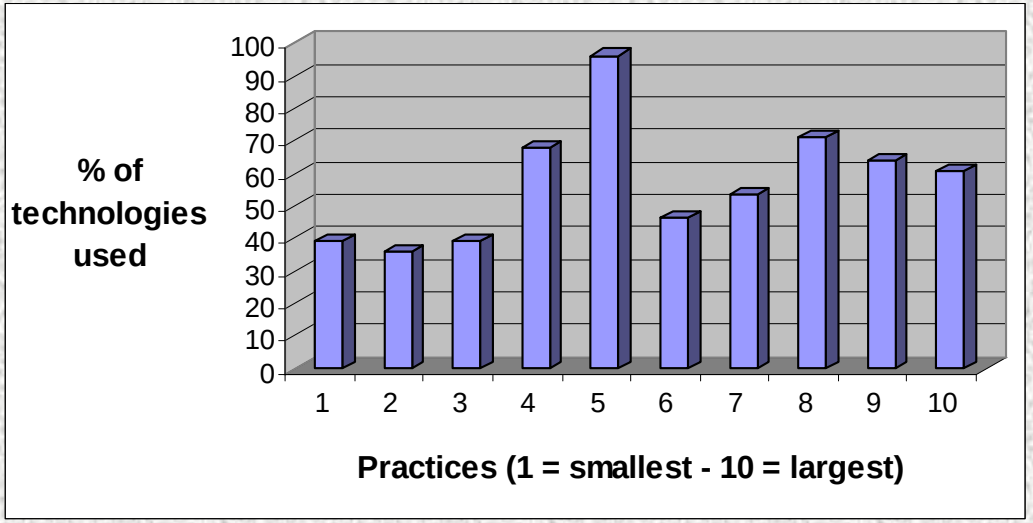

Figure 1, above, illustrates that

- individual practices used between 35.7% and 96.4% of the technologies identified as being present in similar practices belonging to their PHO, and
- all but the three smallest practices used more than 40% of the technologies, but otherwise there appeared to be little evidence that increasing practice size corresponded to increased technology infrastructure.

Results 3: Practice use of three technologies

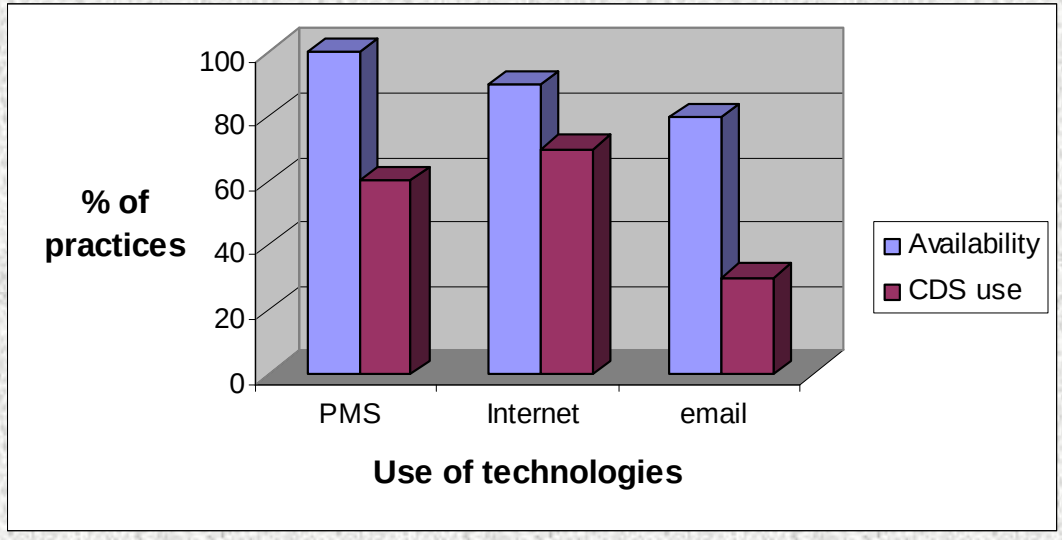

Figure 2, above, illustrates that

- practice management systems (PMSs), the Internet/external websites or databases, and e-mail were used by 100%, 90% and 80% of practices respectively. However,
- when asked about their use of the same systems in the support of clinical decision making when caring for their patients, the percentage of practices found to use the systems in that way was smaller.

Discussion

- This study shows that the respondent practices are using a wide range of available IT technologies. However,
- three of these technologies (the PMS, the Internet and e-mail) which were used by a high proportion of practices were found to be utilised by fewer practices for CDS. This suggests that
- beyond a certain point IT infrastructure ceases to have as much influence on systems use than other factors, i.e. once technology saturation is reached, other factors become responsible as barriers to adopting the technology for CDS.
- Such additional barriers may include resource and clinical issues such as time, cost, training, credibility, and skills in using CDS programmes, and less importantly, technical and systems considerations[6;7;8].
- These findings are re-enforced by this study which also illustrates that
- actually having access to popular technologies within an organisation or even within one practice does not necessarily guarantee either their general use, or use for CDS.

Conclusions

- The results demonstrate that within one organisation, GP practices can have similarly high levels of IT in some areas which should enable them to achieve similar levels of CDS to each other, by utilising available technologies. However, there is evidence to the contrary.
- In order for primary health care managers and practices to improve CDS a detailed knowledge of practice IT infrastructure and how it is used, together with a clarification of barriers to the use of available technologies for CDS, would be beneficial.

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Acknowledgements and Contact Details

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  - the Tertiary Education Commission for the support provided by a Bright Future Top Achiever Doctoral Scholarship, and
  - the Health and Disability Ethics Committee for approval for the research (reference: CEN/05/08/053).

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Abstract

This study of New Zealand General Practitioner (GP) practices demonstrates that those surveyed are generally well equipped with information technology (IT), suggesting there is the potential for them to be able to utilise levels of clinical decision support (CDS) similar to each other. However, three commonly available technologies used by 80% or more of practices were all found to be used by fewer practices for CDS. This suggests that barriers other than the availability of technologies are important inhibitors to the utilisation of IT for CDS.

Keywords:

primary health care; primary health organisation (PHO); Information Systems (IS); Information Technology (IT); General Practitioner (GP); Clinical Decision Support (CDS); case study

Introduction

International and Australasian health care organisations are seeking to improve the use of computerised clinical decision support (CDS) in health care [1;2;3]. New Zealand's primary health care sector is now structured around not-for-profit Primary Health Organisations (PHOs) [4]. Knowledge of IT infrastructure and its usage by PHO practices would enable their management organisations to formulate appropriate strategies to encourage better use of technologies, and the decision support capabilities they provide. This paper presents preliminary results regarding the IT supporting patient care in primary care General Practitioner (GP) practices.

Methods

A multiple case study of medium sized PHOs, consisting of a pilot and two other case study organisations, was undertaken. Triangulation [5] was achieved by the use of face-to-face interviews, a postal questionnaire survey of GP practices and the collection of documentation at each case study organisation.

Results

A response rate of 43.5% was received from 10 completed questionnaires. Table 1 shows the most popular technologies identified as used in the support of patient care by the responding practices.

Figure 1 illustrates that individual practices used between 35.7% and 96.4% of the technologies identified as being present in similar practices belonging to their PHO. All but the three smallest practices used more than 40% of the technologies, but otherwise there appeared to be little evidence that increasing practice size corresponded to increased technology infrastructure. Figure 2 shows that PMSs, the Internet/external websites or databases, and e-mail were used by 100%, 90% and 80% of practices respectively. However, when asked about their use of the same systems in the support of clinical decision making when caring for their patients, the percentage of practices found to use the systems in that way was smaller.

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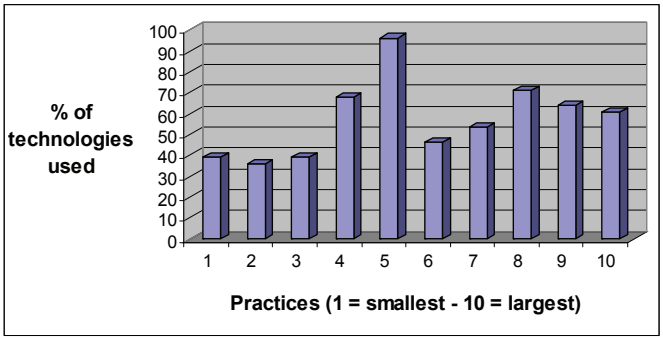

Figure 1- Individual PHO GP practice use of technologies supporting patient care

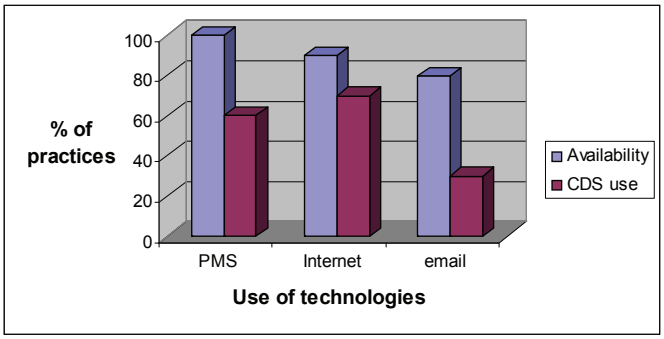

Figure 2- Practice use of three technologies

Discussion

This study shows that the respondent practices are using a wide range of available IT technologies. However, three of these technologies (the PMS, the Internet and e-mail) which were used by a high proportion of practices were found to be utilised by fewer practices for CDS. This suggests that beyond a certain point IT infrastructure ceases to have as much influence on systems use than other factors, i.e. once technology saturation is reached, other factors become responsible as barriers to adopting the technology for CDS. Such additional barriers may include resource and clinical issues such as time, cost, training, credibility, and skills in using CDS programmes, and less importantly, technical and systems considerations [6; 7; 8]. These findings are re-enforced by this study which also illustrates that actually having access to popular technologies within an organisation or even within one practice does not necessarily guarantee either their general use, or use for CDS.

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Attitudes PEP HIV/AIDS Health Care Workers' (HCW) for Implementation of Electronic Health Record: A study at AIIMS, New Delhi, INDIA

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Introduction

India is having 3.97 million people living with HIV/AIDS, which is 2nd height in the world next to South Africa. The first case of HIV in India was detected in Tamil Nadu in 1986. Over 38% of those living with HIV in India in 2006 are women, most from regular partners who were infected during paid sex and blood transfusion. For treating HIV/ AIDS patients, health care worker (HCW) need protection and management. So there is a lot of health worker has got infected during treatment or care to the patients. PEP means Post-exposer prophylaxis means taking antiviral medications as soon as possible after exposure to HIV so that the exposure will not result in HIV infection. These medications are only available with a prescription. PEP should begin within as soon as possible after exposure to HIV but certainly within 72 hours. Treatment with 2 or 3 antiviral drugs should continue for 4 weeks, if tolerated. To analysis the information that in what time and place and what type of health worker are getting infected. Occupational exposures to HIV should be considered urgent medical concerns to ensure timely post exposure management and administration. To keep their record of these Health Care Workers and monitoring them regular whether they got infected or not and further their treatment and management it requires a proper EHR (Electronic Health Record).

Keywards:

PEP, EHR, Health Care Worker (HCW)

Objective

To identify the attitude of i. Health Care Worker' (HCW) interested to keep their health record electronically or not. ii the attitudes among Health worker (Doctors, Nurses, Paramedical staff) to use of computers in their clinical information/Investigation of their health and other health worker. iii. Is their electronic record to be monitor by other physician without permission from the health workers? iv. Is their health will be monitored by management or not.

Methods

A self-completed, 35 questions questionnaire were distributed to 750 randomly selected Health Care Workers (HCW). The questionnaire focused on details of the Health Care Workers (HCW) practice; actual computerization of or intention to computerize clinical and administrative functions of Health Care Workers; attitudes towards computerization; self-perceived computer ability and knowledge; and demographic information of HCW. The attitude statements were grouped under four themes according to a factor analysis. HCW Electronic Health Record (EHR) to be monitor by other physician without permission from the health worker. Can their EHR to be used for the administrative Purpose.

Results

The survey was completed by 750 physicians. Only 24% physicians, 2 % Para-medical staff and 12% Nurse were interested for computerisation of HCW EHR. 87 % HCW are in interested to share their record with their friends and colleagues. Only 27 % are interested to use their EHR for administrative purpose. If you will consider age group above 50 years, 34 % physician are interested to share their EHR with their colleagues. Those 54% physician less then 50 years of age interested to share their EHR with their colleagues. The 26% less 25 years old nurses are interested in favor of HCW EHR. Non-clinical users were older and had fewer specialist qualifications. Although there was strong support for the attitude statements among both groups with regard to the benefit of computerization (EHR) to HCW, there was much less support from medical records personnel. Non-clinical users were concerned about the potentially negative impact of computerization on the clinical encounter for HCW.

Discussion

1. The attitudes among current clinical users and non-users (HCW) were substantially different. They need proper training and exposer to the technology.

2.It needs proper policy in the hospital administration level that the HCW's data to be stored and shareable with the following community

3 Policy to be framed to start this type of program.

4. Govt and NGOs should be involved.

5. Motivate the people for the technology

6.Continuous training to be continued and be in touch with people

7.Continuous monitor is required for each hospital

8. This type of program to be introduced at the time of education/course. If attitude of HCW change then EHR for HCW can be implemented in thoroughly.

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Cost-Effectiveness Analysis of Tele-ophthalmology for Screening for Diabetic Retinopathy in Remote Communities

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Abstract

Application of tele-ophthalmology to community-based screening for diabetic retinopathy with one-stage or two-stage design in remote area has been hardly addressed. Digital image data underpinning this architecture were transferred for sending images to a retinal specialist for diagnosis. The clinical burden of diagnosis and confirmatory should be taken into account even though applying the tele-ophthalmology screening in rural area. In this circumstance, one needs to screen general population on the basis of predictive model to ascertain high-risk subjects that in turn receive confirmatory diagnosis at second stage. The balance between cost and effectiveness for different screen regimes was worthy of being investigated. A Monte Carlo computer simulation approach has been employed to simulate the disease natural history of diabetic retinopathy for a hypothetical population. The model generates a hypothetical population with the make-up of demographic features identical to that of Matsu population in 2004. Economic evaluation of different screening regimes was performed by TreeAge. All strategies dominated over no screening according to incremental cost-utility ratios. The incremental C/U ratio for two-stage design versus no screening (US 218) was not substantially different from that for tele-ophthalmology (US 220). The optimal inter-screening interval was two years for tele-ophthalmology and two-stage design.Time-dependent predictive model was developed for two-stage design with tele-ophthalmology. Economic evaluation found biennial screen regime dominates over other screening regimes because it elicits less cost but more benefit.

Keyword:

tele-ophthalmology, retinopathy screening, cost-effectiveness analysis

Introduction

The application of teleophthalmology to population-based screening for eye-related diseases in remote areas with scare ophthalmologists has been developed through a population-based multiple disease screening for ocular diseases among residents aged 40 years or older in Tungyin, one of townships in Matsu, Taiwan. Digital image data underpinning this architecture were transferred to a conventional personal computer via the Internet[1].

Data from clinical trials have shown that timely intervention with retinal photocoagulation prevents vision loss due to diabetic retinopathy. Because the condition is often asymptomatic in its early phase, regular evaluation is critical to clinical management of diabetic retinopathy. Numerous studies have demonstrated an overall cost effectiveness of retinopathy detection for type 2 diabetic patients. Although tele-ophthalmology has been recognized as a tool in providing health care for rural community[1], the clinical effectiveness and economic value of telemedicine has been poorly understood. From the viewpoint of evidence-based medicine, decision on whether such a diabetic retinopathy screening is worthwhile is dependent on a series of factors, including screen tools, disease natural history, cost, effectiveness of screening and inter-screening, interval. The balance between cost and effectiveness was worthy of being investigated. The aim of this study is to perform economic evaluation for the assessment of tele-ophthalmology and screening regime for diabetic retinopathy.

Methods

Participants would then be consecutively imaged using a store-and-forward telemedicine system. Digital 350 color fundus images were obtained with the non-mydriatic digital fundus camera. Two-field dilated digital images would be taken per eye. As screening for DR with direct method and fundus image check in general population may be costly two-stage design was therefore proposal to identify high-risk group for further referral to undergo examinations. To ascertain high-risk group, one may require predictive model on the basis of inexpensive and routine biochemical variables, time-dependent Cox regression model was proposed to build up adequate predictive model.

The five-state Markov model was used to model the disease natural history of diabetic retinopathy following the proliferative pathway to blindness was delineated follows NDR->BDR->PPDR->PDR->blindness. Through screening, asymptomatic stages were detected and received intervention in order to reduce blindness. Markov decision

tree was applied as the basis of the decision on policy of screening for diabetic retinopathy regarding tele-ophthalmology.

The base-case parameters estimated including probability of disease progress, sensitivity, specificity, attendant rate, utilization value and discount rate. The costs for tele-ophthalmology include direct costs for devices, training, and overhead expenses. The cost without tele-ophthalmology for screening and treatment were based on current health insurance programme for an ophthalmology visit with a dilated eye examination. A Monte Carlo computer simulation approach has been applied to simulating the disease natural history of colorectal cancer for a hypothetical population with the make-up of demographic features identical to that of Matsu population. Micro-simulation using Tree-Age software was performed to calculate cost in dollars, effectiveness expressed by the remaining vision after 50 years of follow-up of subjects who are screened from 30 years of age

Results

Average baseline values were also used to derive average QALYs for each strategy. Base-case analyses resulted in 18.39 of average QALYs with the tele-ophthalmology strategy , 18.35 of average QALYs using two-stage design and 18.28 of average QALYs with no screening strategy. The average cost effectiveness ratio was US 220 per QALY for the tele-ophthalmology , US 218 for two-stage design, and NTD 262 for no screening strategy. Again, all strategies dominate over no screening. The incremental C/E ratio for two-stage design was not substantially different from that for tele-ophthalmology. Incremental cost for reducing one unit of QALY was UD 1,595 for tele-ophthalmology against two-stage design. The optimal inter-screening interval was two years for tele-ophthalmology and two-stage design for sensitivity-analysis.

Discussion

Two screening decisions, including tele-ophthalmology, and tele-ophthalmology with two-stage design, opposed to no screening were considered in the current study. It is very interesting to note that tele-ophthalmology elicits more cost but also more effectiveness in reducing blindness. On the other hand, two-stage tele-ophthalmology may reduce cost but lead to smaller benefit because of false negative cases compared to tele-ophthalmology. This suggests that one may make use of two-stage design with the application rather than the administration of tele-ophthalmology to the entire population. As far as inter-screening interval, biennial screen regime dominates over other screening regimes.

In conclusion, tele-ophthalmology with or without two-stage design was demonstrated to be feasible in community-based screening for DR in remote area. Economic evaluation found two-stage tele-ophthalmology with time-dependent model almost as cost-effective as the application of tele-ophthalmology to the whole population.

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Cost-Effectiveness Analysis of Tele-ophthalmology for screening for Diabetic Retinopathy in Remote Communities

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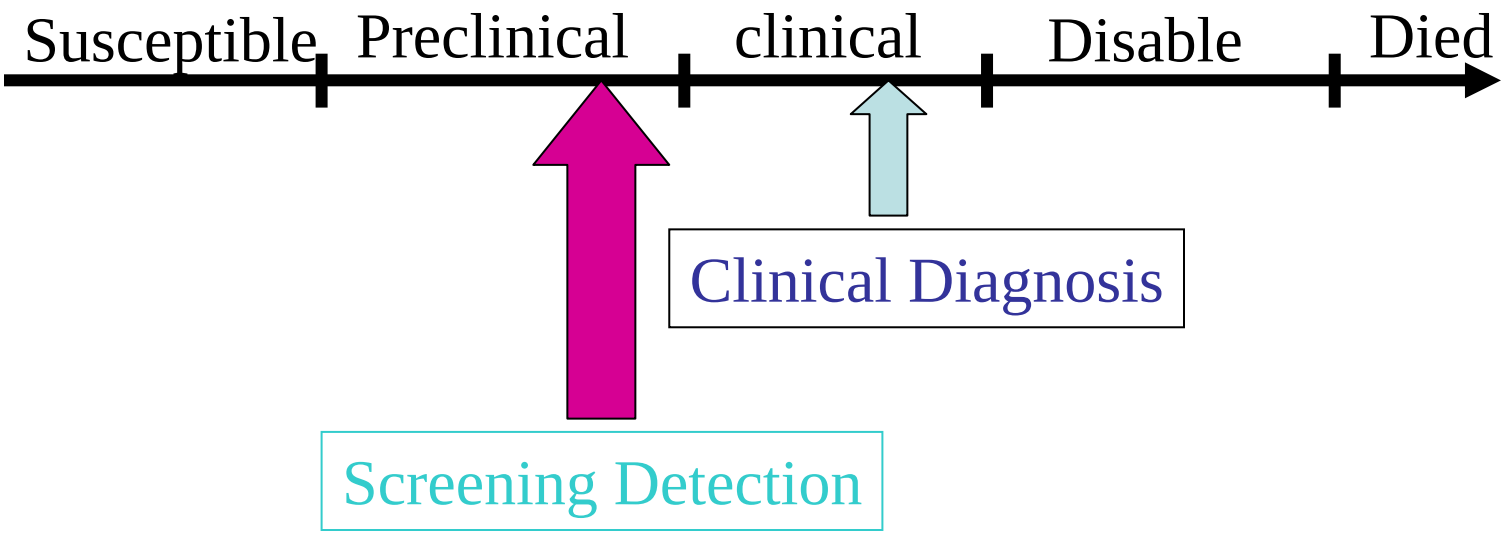
Why Tele-ophthalmology

- Scarce resource in Ophthalmologist in remote area
- Visual loss problem
  - Between 2000 and 2020, the prevalence of blindness is expected to double
  - Major causes of low vision and blindness
    - diabetic retinopathy, macular degeneration, cataracts, and glaucoma
- Diabetic retinopathy incidence increase
  - Diabetes is expected to increase worldwide from 135 million to 300 million people between 1995 and 2025(Mokdad ,2000)
- Tele-ophthalmology has been recognized as a tool in providing health care for rural community (Chen et al. 2004)



The disease natural history of diabetic retinopathy

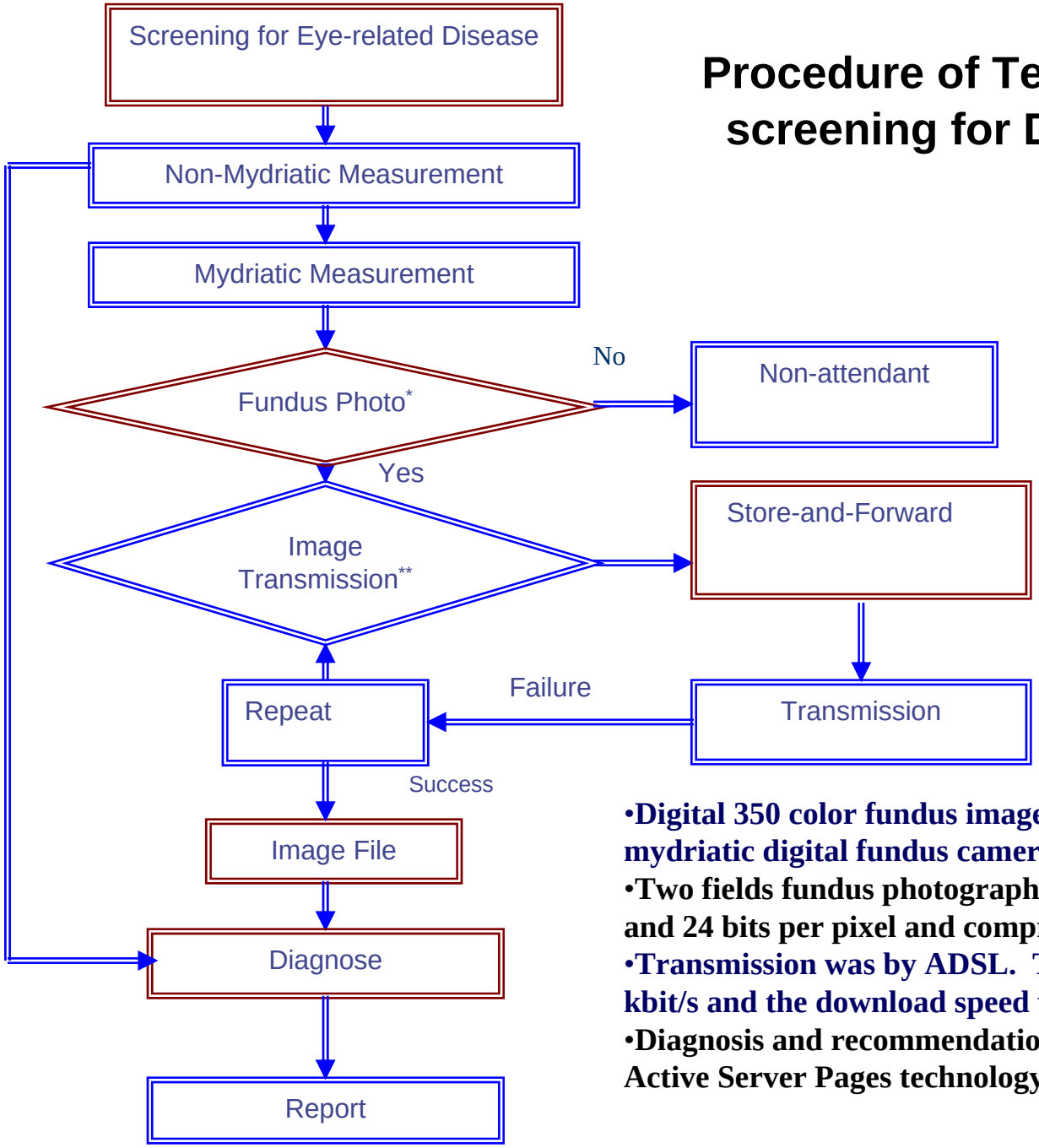
NDR (1) $\xrightarrow{\lambda_1}$ BDR (2) $\xrightarrow{\lambda_2}$ PPDR (3) $\xrightarrow{\lambda_3}$ PDR (4) $\xrightarrow{\lambda_4}$ Blindness (5)

Annual transition rates

λ_1 (NDR→BDR):	0.11	λ_2 (BDR→PPDR):	0.07
λ_3 (PPDR→PDR)	0.24	λ_4 (PDR→Blindness) :	0.20

NDR: No diabetic retinopathy BDR: Background diabetic retinopathy
PPDR: Preproliferative diabetic retinopathy PDR: Proliferative diabetic retinopathy

Procedure of Tele-ophthalmology for screening for Diabetic Retinopathy



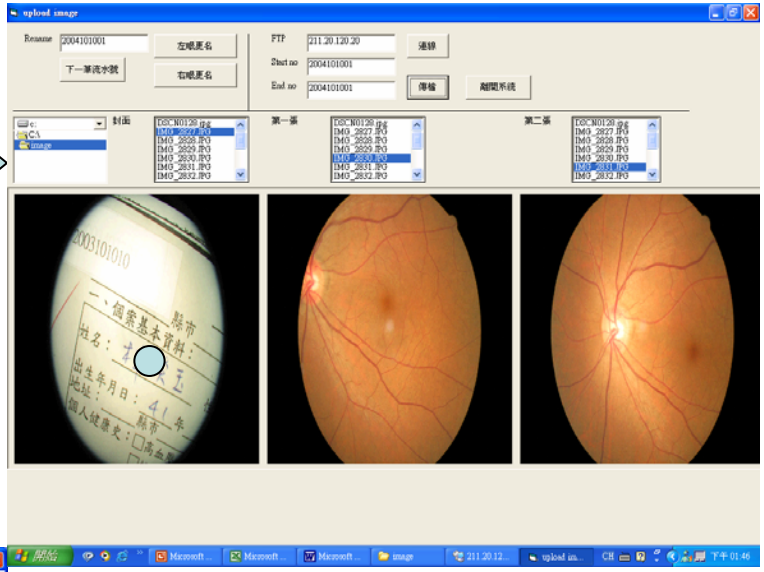
- **Digital 350 color fundus images were obtained with a non-mydriatic digital fundus camera**
- **Two fields fundus photographs consisted of 2048 x 1360 pixels and 24 bits per pixel and compressed to 1:20 before sending**
- **Transmission was by ADSL. The lowest upload speed was 64 kbit/s and the download speed was 512 kbit/s**
- **Diagnosis and recommendations in a server was based on the Active Server Pages technology and SQL-SERVER database**

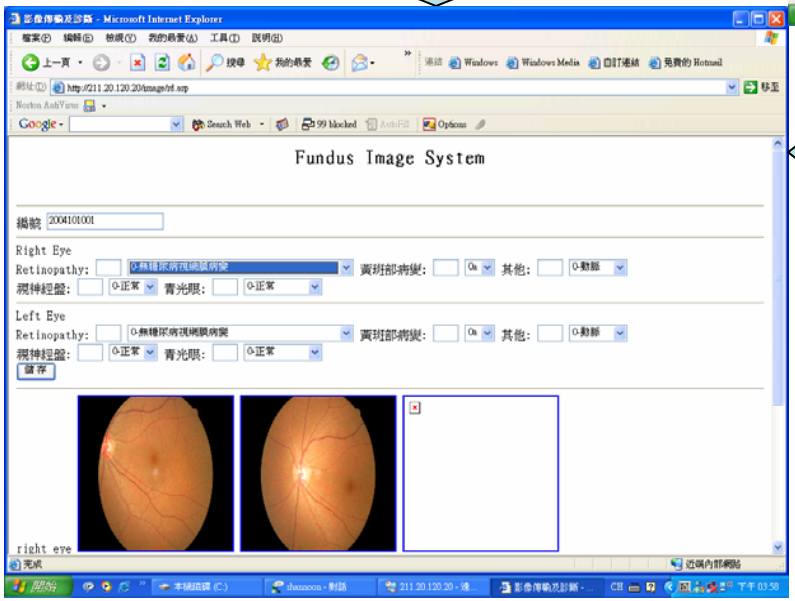
Tele-ophthalmology in DR Diagnosis

Fundus

Image Rename/ Transfer

Diagnosis

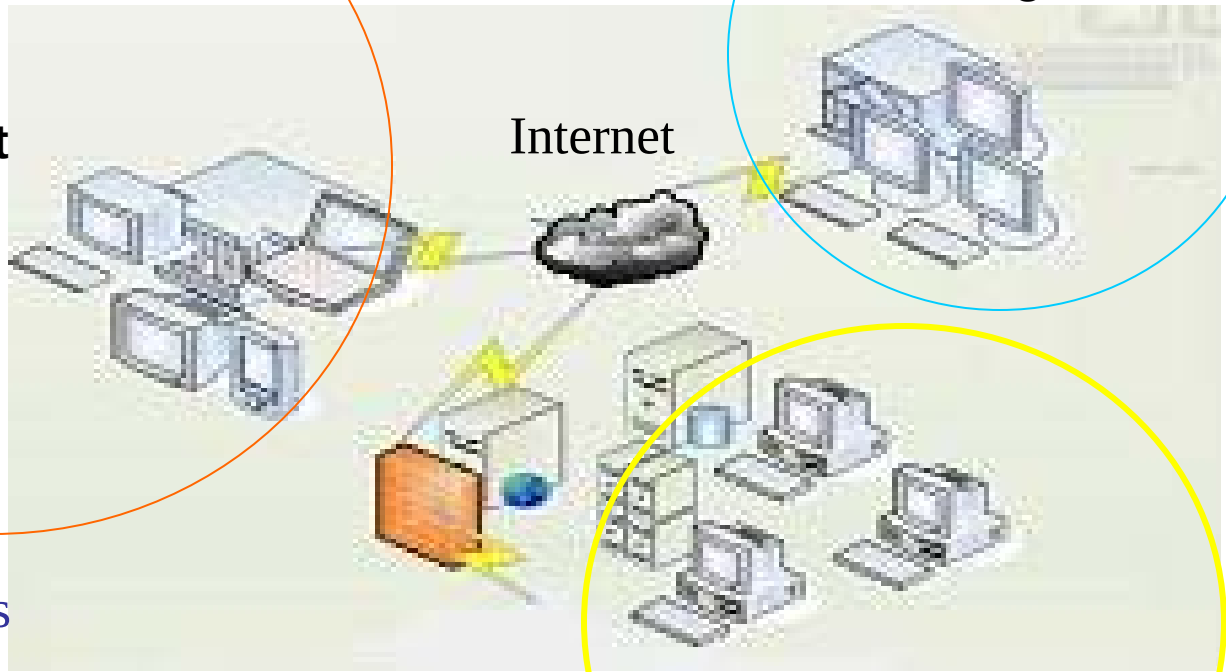




2 fields fundus images
2048 x 1360 pixels
24 bits per pixel
compressed to 1:20

Ophthalmologist

Community DR Screening



Active Server Pages technology

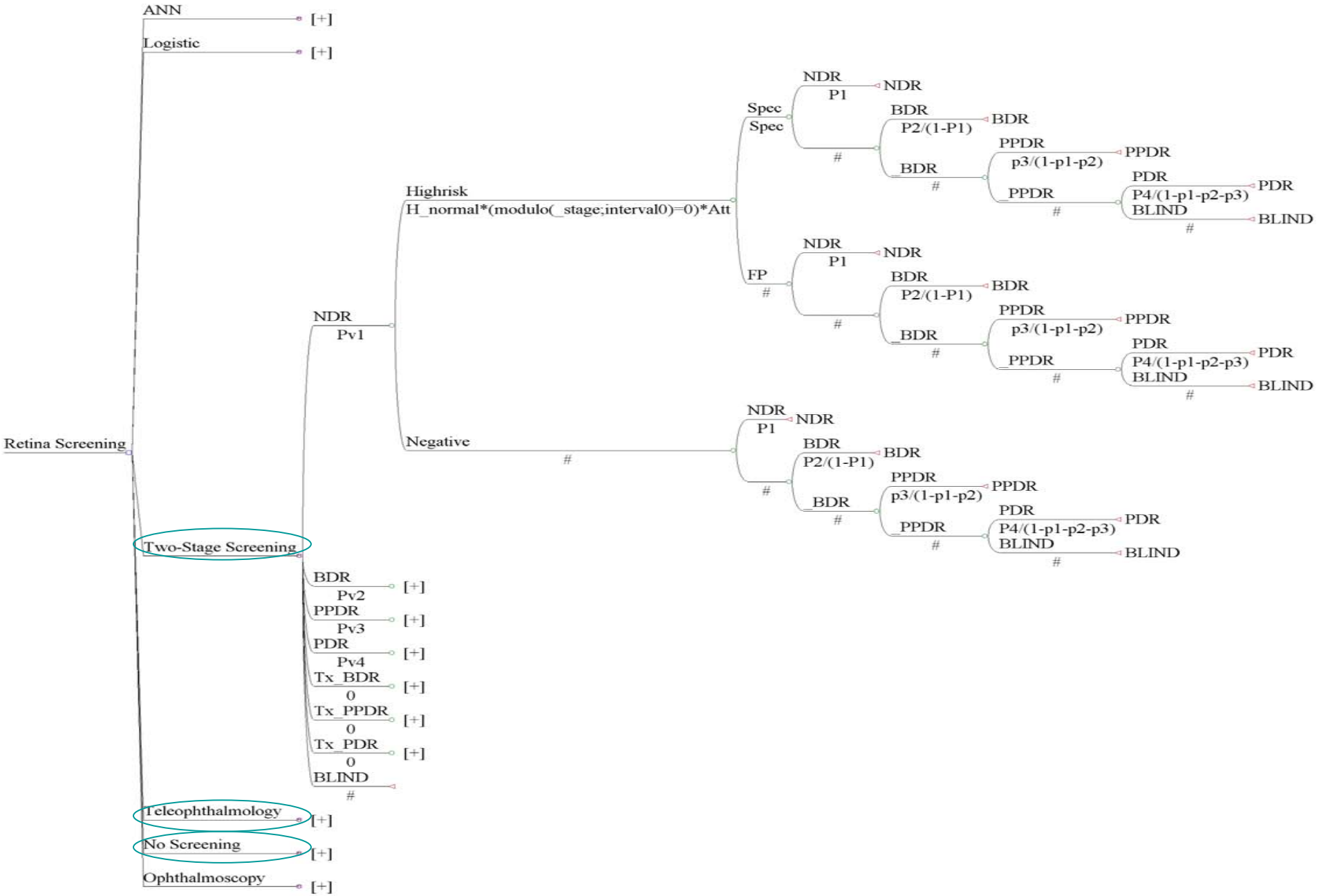
Server)

SQL-SERVER database

Rationale

- Natural History Model of Diabetic Retinopathy
- Markov Decision Analysis
- Data source and base-case probability
- Utility measurement
- Cost data
- Monte Carlo Computer Simulation
- Implementation of computer simulation
- TreeAge 4.0 used

Decision Tree for diabetic retinopathy screening



Base-Case Estimates

- Annual transition rates
  - NDR to BDR 0.11
  - BDR to PPDR 0.07
  - PPDR to PDR 0.24
  - PDR to Blindness 0.20

(Liu et al , Diabet Med, 2003)

- Screening test characteristics
  - Ophthalmoscopy
    - Sensitivity% 0.75(0.33-0.86)
    - Specificity% 0.86(0.75-0.99)
  - Teleophthalmology
    - Sensitivity% 0.88(0.72-0.98)
    - Specificity% 0.9(0.75-1)

Base-Case Estimates

- Attendance rate 0.5(0.25-0.7)
- Attendance rate on site 0.9(0.5-0.95)
- Utilization Value 0.92(0.91-0.93)
- Discount rate % 5%
- Year of repeat screening 4(2~8)

Cost Estimated

- Teleophthalmology
  - Fundus photograph evaluation — US:5
  - Initial Cost — US:20000
- Nonteleophthalmology
  - Examination Cost — US:6
  - Transportation — US:90
- Confirmatory Cost
  - Fluorescein angiography — US:30
  - Transportation — US:90
- Cost of treatment
  - Clinic visit — US. 120
  - Transportation Fee — US. 300
  - Operation Fee — US. 400
  - Transportation Fee — US. 160
- Cost of Blindness care
  - Age < 65 years — US. 2000
  - Age ≥ 65 years — US. 30

Blindness Incidence Case-55 years follow up

- No screening strategy : 265 blindness
- Teleophthalmology strategy: 218 blindness
  - Compare no screening: 15.7% blindness reduction
- Two-stage Design strategy: 236 blindness
  - Compare no screening: 9.5% blindness reduction

Cost-Utility for each screening regime

Two-stage Design v.s No Screening

ICUR: $\frac{3{,}992 - 4{,}781}{18.350 - 18.276} = (10{,}658)$ dominate

Tele-ophthalmology v.s No Screening

ICUR: $\frac{4{,}051 - 4{,}781}{18.387 - 18.276} = (6{,}573)$ dominate

Cost-Utility for each screening regime

Two-stage Design v.s Tele-ophthalmology

ICUR: $\dfrac{3{,}992 - 4{,}051}{18.387 - 18.350} = 1{,}595$

Screening interval for each screening regime

	Screening interval	Two-stage Design	Tele-ophthalmology
Cost		3,773	3,581
Qalys	2	18.43	18.51
C/E		204.7	193.4
Cost		3,992	4,051
Qalys	4	18.35	18.39
C/E		217.5	220.3
Cost		4,025	4,112
Qalys	6	18.32	18.35
C/E		219.6	224.1
Cost		4,032	4,125
Qalys	8	18.31	18.33
C/E		220.2	225.1

Economic Evaluation

- Tele-ophthalmology elicits more cost but also more effectiveness in reducing blindness
- Two-stage tele-ophthalmology may reduce cost but lead to smaller benefit because of false negative cases compared to tele-ophthalmology
- Cost per one Qalys gained was US 1,595
- Biennial screen regime dominates over other screening regimes because it elicits less cost but more benefit

Conclusion

- Tele-ophthalmology with or without two-stage design was demonstrated to be feasible in community-based screening for DR in remote area
- Cost per one Qalys gained was US 1,595

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Pharmaceutical Safety Reporting System on UMIN

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Abstract and objective

The number of pharmaceutical safety reports from medical institutions to the government is about 5,000 annually and only one fifth comparing to industry in Japan. In order to facilitate such reporting, and enhance early detection or prevention of adverse drug reactions (ADRs), we have developed a pharmaceutical safety reporting system on University hospital Medical Information Network (UMIN). UMIN is the largest and most versatile academic network information center for biomedical sciences in the world, and considered as indispensable information infrastructure for the Japanese medical community.

The major benefits of this system are as follows; user-friendly interface to make reports, easy management of reports, and immediate sharing information on suspect ADRs among medical institutions. In the future, it will be more beneficial for reporters if the government accepts pharmaceutical safety reports directly through UMIN.

Keywords:

adverse drug reaction reporting systems, internet, safety management

Introduction

Based upon national or international agreements, rules, and regulations, individual case safety reports (ICSR) of ADRs need to be transmitted. The International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use (ICH) is a project that brings together the regulatory authorities of Europe, Japan and the United States and experts from the pharmaceutical industry in the three regions to discuss scientific and technical aspects of medicinal products. E2b is one of the expert working groups (EWG) in ICH for harmonization of Data Elements for Transmission of ICSRs. This group published E2b guideline in 1997. Due to the advantage of information technology, the Specification for the electronic message of ICSR was released in 2001 by ICH M2. M2 is a Multi-disciplinary Group 2 EWG in ICH and discusses Electronic Standards for the Transfer of Regulatory Information (ESTRI) that will meet the requirements of the pharmaceutical companies and regulatory authorities. After this development of specification, each region implemented electronic ICSR system. Since October 2003, electronic ICSRs have been accepted for industry by the Ministry of Health, Labor and Welfare (MHLW). However, most medical institutions need to report ICSRs to the government as paper form. The number of ICSRs from medical institutions to the government is currently about 5,000 annually and only one fifth comparing to industry in Japan.

In order to facilitate such reporting from medical institutions to the government, and enhance early detection or prevention of ADRs, we have developed a pharmaceutical safety reporting system on University hospital Medical Information Network (UMIN). UMIN is the largest and most versatile academic network information center for biomedical sciences in the world, and considered as indispensable information infrastructure for the Japanese medical community.

Methods

The system was designed as web-based in Japanese. Although the form is based upon paper which is currently used for safety reporting from medical institutions to the government, each element reflects the global standard which ICH E2b/M2 produced. There are two steps to create a report. The form 1 is designed as the first step for capturing minimum data which should include at least one identifiable patient, one identifiable reporter, one reaction/event, and one suspect drug. If any of such data is missing or wrong, a reporter can't register it. The form 2 is the second step appearing as the next page to the form 1 and designed for entering other detailed information as optional. These optional data are for example, relevant medical history and concurrent conditions, and results of laboratory tests, etc. Our system also provides the function to search a drug by product name or substance name.

There are three classes for users; administrator, responsible user, and reporter. An administrator is usually a representative of a medical institution. This administrator assigns a responsible user in the same institution who has right to approve reports to be open to outside or not. A reporter is a person creating a report and usually a health professional.

There are three repository statuses of reporting, “temporary saving”, “waiting for approval”, and “approved reports”. The reports which are temporary saving or waiting for approval, are reviewable only within the same institution. The approved reports are open to outside the institution, but privacy information such as reporter’s name or patient’s name is anonymous. A reporter can receive a question via e-mail from an identifiable reviewer, and this reporter can answer anonymously.

Results

The system has been developed successfully. The first page of ICSR system has two parts; the upper section is for reporting, the lower section is for the administrative function. A reporter is likely to belong to two or more institutions. Therefore a reporter should define at which institution an ADR occurred.

The reporting function has three sections mainly; the first is for creating or amending reports, the second is for reviewing reports, and the third is for setting up reporter’s information. For the first time to use this system, a report needs to fill out reporter’s information. Once a reporter has completed this section, it is not required to fill out any more.

In order to create a new ICSR, a reporter is required to enter patient’s age and select gender. After that, identification number is assigned to each case automatically. Then the form 1 appears. The top section is to enter an adverse event. A reporter can enter several events. Then, the next column is for a suspect drug. There are two ways; one is to enter a substance name, and the other is to enter a product name. If you enter some characters for either of them, applicable drug names appear. Then a reporter can select intended drug name. There is also descriptive section about details of adverse reactions or events. After clicking the button “next” and no missing data on the form 1, the page can move to the form2. If there is any missing data, this system indicates which information is missing.

In the top section of the form 2, patient’s gender and age are placed automatically. A reporter can enter more information regarding a patient such as height, weight, pregnancy, if needed. As the next section, a reporter can enter relevant medical history and concurrent conditions. Also, there are some sections to capture some information, such as smoking, alcohol consumption, allergy, etc. The next section is for adverse reactions/events, and the major adverse reaction/event which was entered in the form 1 is placed in the top. And if necessary, a reporter can add more reactions/events. Also a reporter can enter the outcomes about ADRs, such as recovered, not recovered, fatal, etc. Also a reporter can enter the information about severity and concomitant drugs. And the next to them, a reporter can put results of laboratory tests. Also a reporter can enter descriptive information regarding ADRs. A reporter can stop the process any time and the entered data can be stored temporary and restart anytime.

Discussion

The two-step data entering prioritizes the information according to its importance, and contributes user-friendly interface. Archiving reports by three statuses helps to count how many ADRs occurred inside/outside the institution. Therefore, the system brings us easy management of reports. If lots of reports are stored, we can apply data mining to detect a signal of a real ADR. Furthermore, the numbers of suspect ADRs inside one institution is limited. Our system has the function to know the similar suspect ADRs outside and contact the reporter by e-mail to get the detail information immediately. This is helpful to evaluate ADRs and prevent more cases.

Since the government hasn’t approved our system yet, reporters need to print out and send ICSRs by surface mail or fax to the government. If the government accepts reports directly through UMIN, it is actually more beneficial for them. Created report can be exported as a Microsoft Word format, this format is acceptable through e-government portal gateway. Therefore our system is useful to adapt a report to this e-government. However, in order to send a report through this e-government portal gateway, a reporter should get an electronic certification from any certificate authority. This process of obtaining an electronic certification is difficult and complicated. If UMIN can take a role of a certificate authority; a reporter would not need to obtain an electronic certification from any other certificate authority.

The Pharmaceuticals and Medical Devices Agency (PMDA) was established in 2004 based on the law for the incorporated administrative agency. This agency started to open ICSRs which were submitted from pharmaceutical companies to the government. But there is about one-year time lag from reporting to disclosure because of evaluation process. Our system on UMIN has no such time lag. In addition, our system has a detail searching function which PMDA doesn’t provide.

Another benefit of our system is that it can be useful for data mining. FDA and WHO have already started to use data mining methods to detect suspect ADRs. These methods are probably applied to our system.

The strong proof of feasibility is necessary to get permission from the government. There is a plan to carry out a feasibility test of it in the near future.

Conclusion

In order to facilitate pharmaceutical safety reporting from medical institutions, and enhance early detection or prevention of ADRs, we have developed a system on UMIN successfully. The major benefits of this system are user-friendly interface, easy management of reports, and immediate sharing information on suspect ADRs among medical institutions. The feasibility test of it is necessary in the near future.

Pharmaceutical Safety Reporting System on UMIN

Daisuke Koide[a], Hisako Matsuba[b], Hiroyuki Furukawa[c], Kiyoshi Kubota[a], Takahiro Kiuchi[d]

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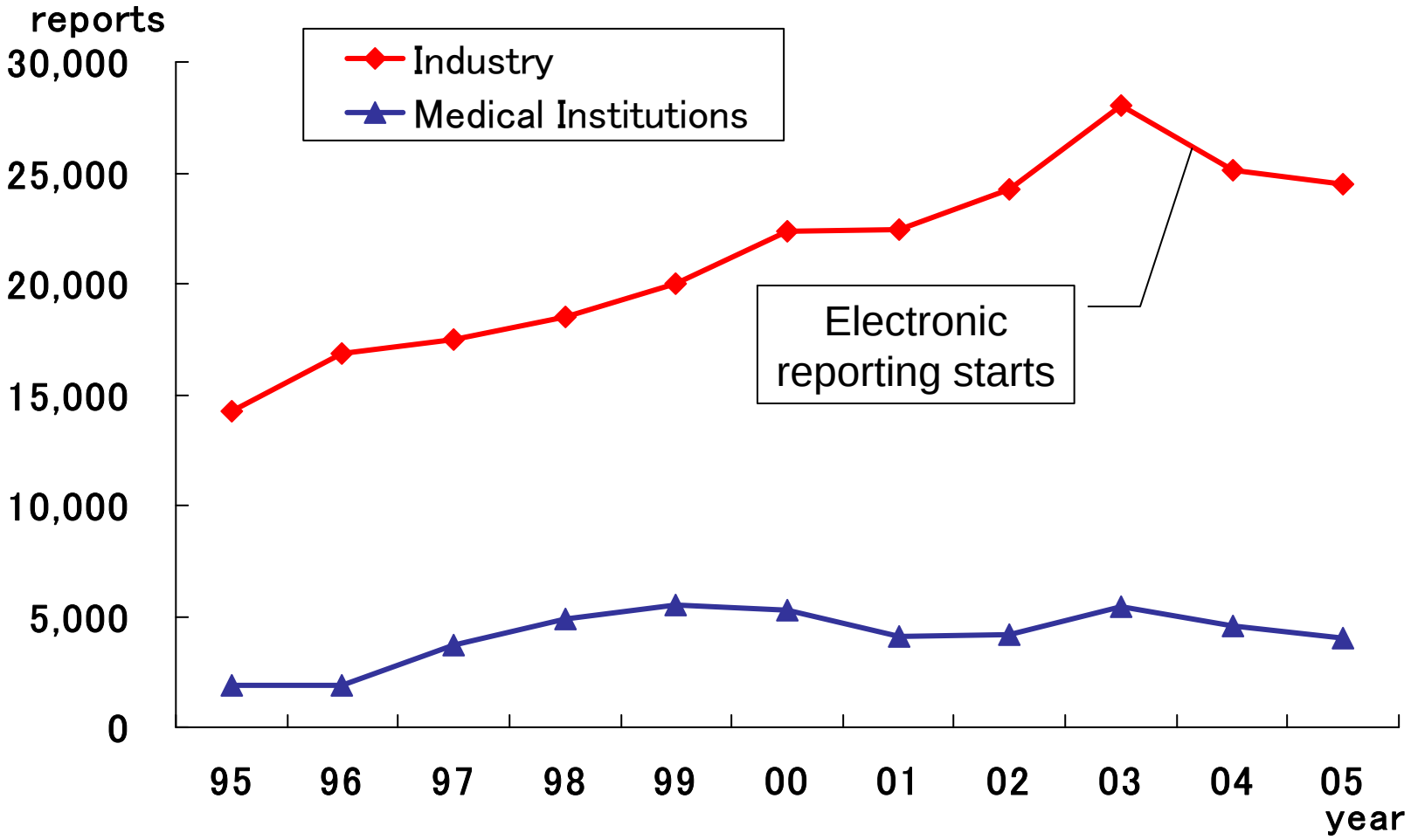
[d] University hospital Medical Information Network (UMIN) Center, The University of Tokyo Hospital, Japan

Introduction

- ICSRs of ADRs need to be transmitted nationally and Internationally.
- ICH E2b/M2 guidelines provide standardized data elements for transmission of ICSRs.
- Since Oct. 2003, electronic ICSRs have been accepted for industry by MHLW in Japan.
- However, most medical institutions still need to report ICSRs to the government as paper form.

ICSR : Individual Case Safety Report / ADR : Adverse Drug Reaction
ICH : International Conference on Harmonization of Technical Requirements for Registration of Pharmaceuticals for Human Use

The number of pharmaceutical safety reports to the government in Japan



Purpose

- Facilitate pharmaceutical safety reporting from medical institutions to the government.
- Enhance early detection or prevention of ADRs.

A pharmaceutical safety reporting system should be developed on UMIN

UMIN : University hospital Medical Information Network in Japan

Methods 1 cont.

- Web system based on paper form.
- Each element reflects the ICH E2b/M2 guideline.
- Two-step creation
  - Form 1:minimum data (mandatory)
    - identifiable patient, identifiable reporter, reaction/event, and suspect drug.
  - Form 2:detail data (optional)
    - relevant medical history and concurrent conditions, and results of laboratory tests, etc.

Methods 2

- User class
  - Administrator
    - Representative of a medical institution
  - Responsible user
    - An administrator assigns a responsible user who has right to approve reports to be open or not.
  - Reporter
    - Health professional
- Repository status
  - Temporary saving
  - Waiting for approval

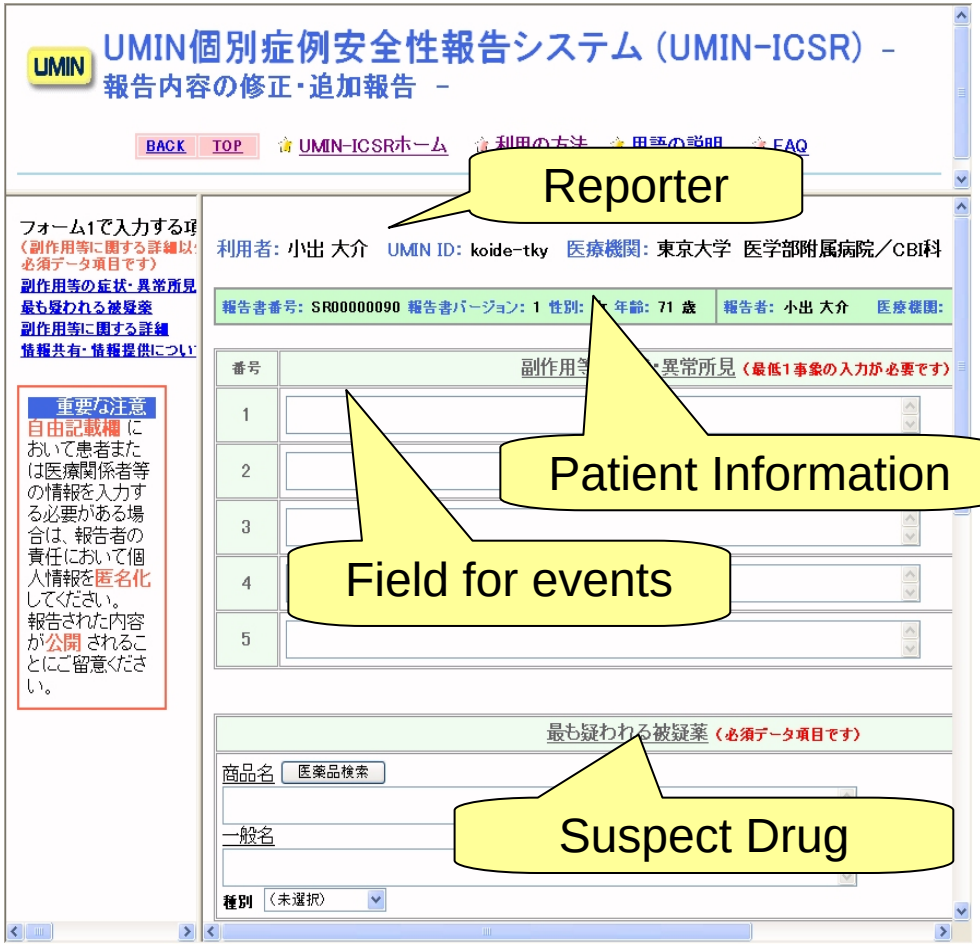
  } Reviewable only within the same institution.
  - Approved report— Open to outside a institution

Results 1 cont.

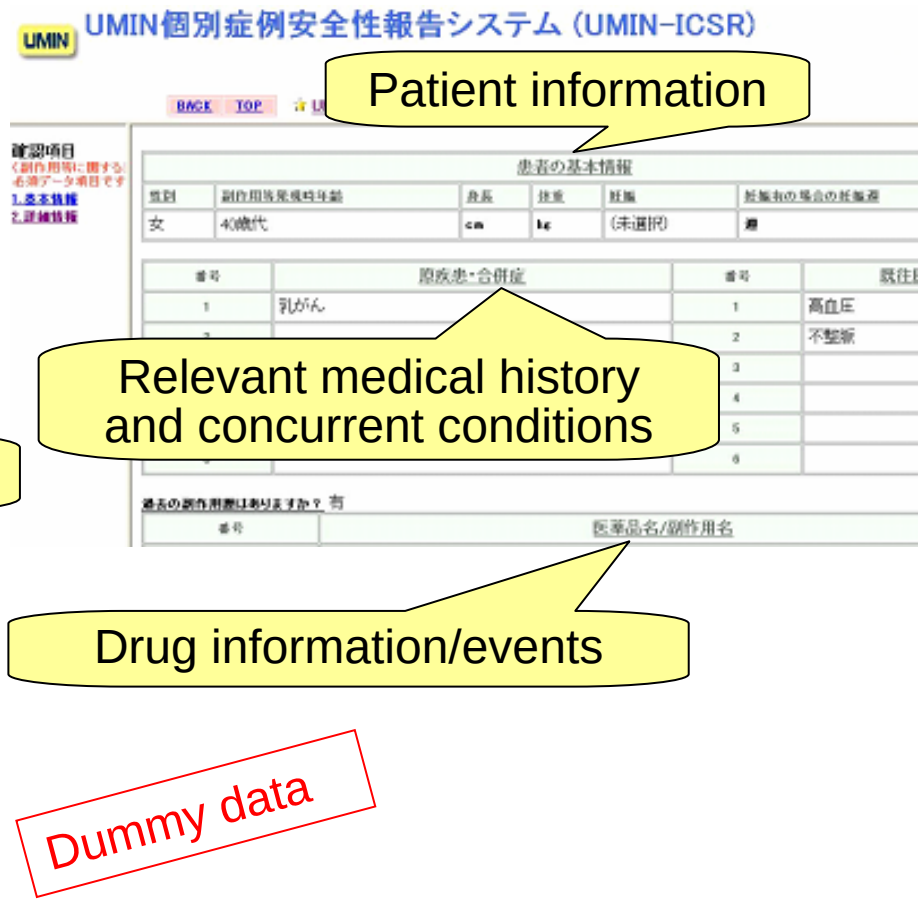
- The system has been developed successfully.
- The right figure is the top page of this system.

Results 2 cont.

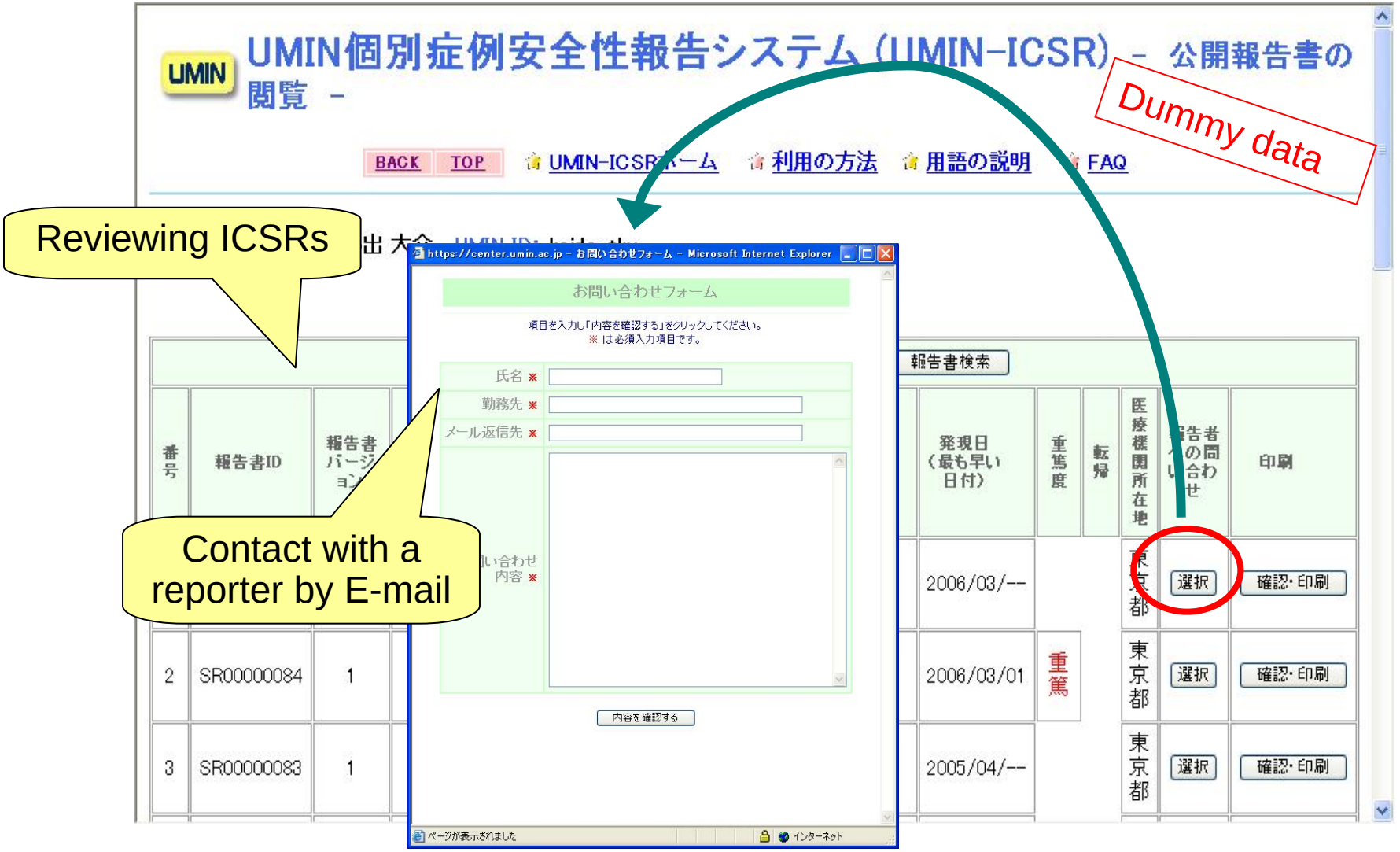
Form1



Form2



Results 3


UMIN
UMIN個別症例安全性報告システム（UMIN-ICSR） - 公開報告書の閲覧 -
BACK TOP
UMIN-ICSRホーム
利用の方法
用語の説明
FAQ
Dummy data
Reviewing ICSRs
Contact with a reporter by E-mail
https://center.umin.ac.jp - お問い合わせフォーム - Microsoft Internet Explorer
お問い合わせフォーム
項目を入力し「内容を確認する」をクリックしてください。
※ は必須入力項目です。
氏名 ※
勤務先 ※
メール返信先 ※
問い合わせ内容 ※
内容を確認する
ページが表示されました
インターネット
報告書検索
番号
報告書ID
報告書バージョン
発現日（最も早い日付）
重篤度
転帰
医療機関所在地
報告者への問い合わせ
印刷
2006/03/--
選択
確認・印刷
2
SR00000084
1
2006/03/01
重篤
東京都
3
SR00000083
2005/04/--

Discussion

- The two-step data entering prioritizes the information according to its importance.
  - This contributes user-friendly interface.
- Archiving reports by three statuses helps to count how many ADRs occurred inside/outside the institution.
  - The system enables easy management of reports.
- If lots of reports are stored, data mining can be applicable to detect signals of ADRs.

Conclusion

- The pharmaceutical safety reporting system has been developed successfully on UMIN.
- The major benefits of this system are;
  - user-friendly interface,
  - easy management of reports,
  - immediate sharing information on suspect ADRs among medical institutions.
- The feasibility test is necessary.

Ref., Ack & Contact details

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- Acknowledgments

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Understandable Logical Design Specifications for HL7 CDA Interoperability

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[b]DataSel, Ankara, Turkey,
[c]Birim Bilgi Tek. Tic. A.S., Izmir, Turkey,
[d]Middle East Technical University, Ankara, Turkey

Abstract

This paper describes the approach adopted by the Turkish National Health Information System to build a national Data Warehouse, covering more than 50 Data Sets, specified by the Ministry of Health, and an EHR for each citizen.

The messages are first specified using a UML logical design model, which is understandable to all stakeholders. These specifications are then mapped to HL7 CDA Release 2 to produce the wire format specifications, xsd's and java classes.

Each message is assembled from stand-alone Data Sets, which populate the Data Warehouse, and Sections which are used to create the EHR.

Keywords:

systems integration, computerized medical record, logical design specification

Introduction

The Turkish National Health Information System is to provide a national Data Warehouse, based on more than 50 Data Sets, and an EHR for each member of the population of almost 80 million people. Data is submitted by hospital clinics and family physicians.

The project is being implemented by a consortium, which includes Datasel, Birim and Sun Microsystems. Interoperability uses HL7 V3 CDA Release 2, with nationally-defined coding schemes and identifiers.

The challenges include the development and implementation of a large number of messages, involving multiple suppliers in a short period, as well as reconciling the central requirements of the Ministry for data analysis and the users expectation of having a useful EHR.

Method

The messages have been designed using a common structure, shown in Figure 1 as a UML diagram. Each Message includes a Header and one or more Data Sets. Each Data Set contains one or more Sections and each Section contains may contain various Data Elements. The Header, Data Sets and Sections include default Context data. This maps to HL7 CDA Release 2 [1] in a straightforward way.

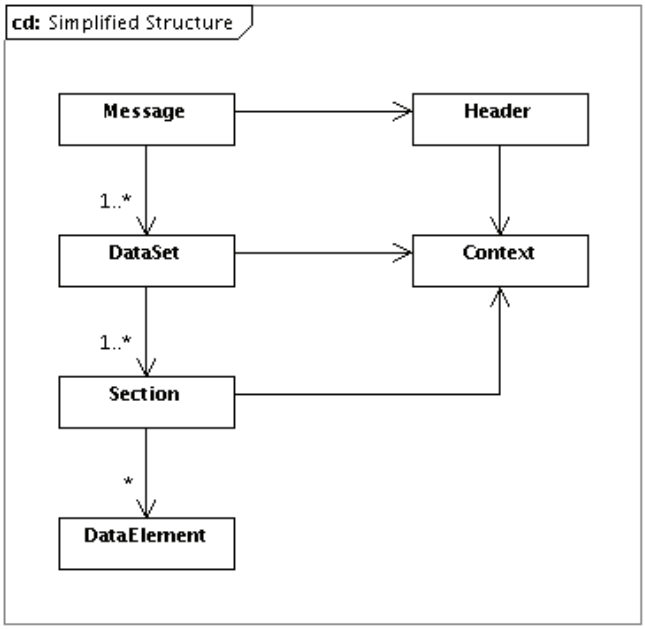

Figure 1 - Simplified logical design of messages

Context data

Each Message concerns one patient (who about), has a specific date (when), a single location (where) and author (who by). This is referred to as Context data and provides the default values of patient ID, date, location, clinic type (e,g, Cardiology) and user (health care party), which apply to all parts of the message, unless more specific data is provided.

Header

In addition to Context data, the Header for each message contains standard metadata, such as unique identifier, time of creation (to the nearest second), name, type and version of the message, realm (e.g Turkey), processing status (e.g. live or test) and confidentiality level.

Data set

The main body of the message contains one or more Data Sets, specified by the Ministry of Health. Examples of Data Sets include patient referrals, discharges, births and deaths. Each Data Set has its own unique identifier and specific version identifier (template ID) and includes Context data. Each Data Set is composed from a number of Sections.

Section

A Section is a standalone data object, which is reusable in different Data Sets. For example the Diagnosis Section (figure 2) may occur in several Data Sets. Other examples include procedure, medication and allergies. Each Section contains a unique identifier, type code, version (template ID) and a human readable free text statement of what it contains (text). It also includes default Context data, as well as its own data elements. Note that some Sections may only contain text and as a result have no additional data elements.

These Sections correspond to HL7 CDA Sections. In CDA the sharing of default Context in Data Sets and Sections is achieved by setting a Context Conduction Indicator to "true".

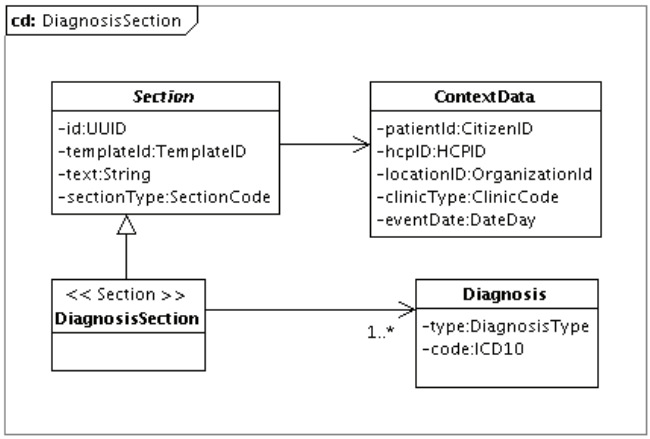

Figure 2 - An example of a section - diagnosis section

Design method

The number of Data Sets and their content will evolve over time, while the header, context and Section definitions are likely to be much more stable.

The data content used throughout the whole system is specified in a single UML model. Each message, Data Set and Section is one view into the model. This provides a comprehensive and consistent specification, written at the logical level, which understood by both users and developers [2]. The UML model is also computer-readable, generating an XML output (XMI).

It is straightforward to map the logical design specifications to HL7 CDA R2 as well as to the applications software used at both the sending and receiving ends. Each Section is mapped to build a library of HL7 templates, CMETs, xsd and Java classes, which can be assembled to build, check and process Data Sets and complete messages, just like putting Lego bricks together.

This method could be used to build a new set of tools, which may simplify development of CDA R2 based messaging solutions. HL7 already has tools for various purposes, but the method employed in this project is simple, flexible and powerful. Such a tool, based on the Eclipse platform, has the potential to boost adoption of HL7 CDA R2 by simplifying the production of stringent HL7 CDA specifications and interfaces.

System architecture

Messages are generated in hospitals, clinics and general practices and then sent to the Ministry of Health. On receipt and after validation, the information is directed as follows:

(a) Data Sets, in an anonymous form, are sent to the Data Warehouse as a resource for management and research.

(b) Sections are submitted to the EHR portal. Persons with a need to know may submit searches to the EHR portal to retrieve views into each patients record according to date (when), clinic (where), author (who) and the type of information required (what); this might be all data or a subset such as medications, allergies, diagnoses etc. The EHR portal returns the appropriate sections, and the human-readable text may be displayed on a web-browser.

The overall system is SOA-based and uses a layered approach, whereby each separate layer only interacts with the layer below the current step, and the lower layer not in any way interacting with the upper one, maintaining system changeability and extensibility, resulting in the layers having distributed responsibility.

Discussion

Some aspects of this project are comparable with the approach recently adopted by the NHS National Programme for IT in England with two main differences. First, the architecture (and scope) is much simpler and, secondly, a logical design specification is used to specify exactly what is required.

The UML-based logical design specification has been invaluable at all stages of the project. It has allowed discussions to focus on the critical issues of what is to be done, rather than on the constraints of representing this using HL7 artefacts. It has greatly facilitated communication between all members of the project, analysts, message

architects, software developers, managers and user representatives, who could not understand detailed HL7 specifications.

References

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Address for correspondence

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Opportunities for Error in CPOE Alert Responses

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Ways Alerts Could Promote Error

- Erroneous Overrides [1]
  - Drug safety alerts override rates: 49-96%
  - May be due to alert fatigue, incorrect information, or clinician time shortage
- Errors of Commission [2]
  - Alert instructions may be followed contrary to clinical knowledge due to unwarranted trust in computer authority
- Errors of Distraction [3]
  - High cognitive complexity in CPOE systems can lead to missed steps when responding to alerts

Overall Alert Categorization

- Types
  - **Informational:** give timely information that may change patient care
  - **System Data Request:** collect information needed by electronic medical record and CPOE systems
  - **Critique:** detect a possible error in an order and request the clinician to change or confirm the order
  - **Suggestion:** anticipate an order and attempt to streamline the order process and/or ensure order correctness
- Features
  - Interruptive / Non-interruptive
  - Synchronous / Asynchronous
  - Enforced / Not Enforced
  - Triggered by Order Entry / Data Entry / User Interface

Current focus: Critique Alerts

- Usually Interruptive
  - Must break into clinical workflow
- Synchronous
  - Logic trigger = Display trigger
- Triggered by order entry
- Often Enforced
  - To continue with workflow, clinician must satisfy alert condition

Solution: "Offered Choices" [4]

- Selectable items from the alert which enable the clinician to specify their desired response
- Preconfigured to include most probable clinical choices
- Common options include
  - Write a new order (specified by alert)
  - Override the alert
  - Defer warning for later
  - Cancel pre-existing or current order
  - Edit pre-existing or current order

Possible Advantages of *Offered Choices*

- Rapid selection of desired alert response
  - → less clinician time pressure
  - → fewer incorrect alert overrides
- Explicit display of *Offered Choices*
  - → less perception of alert as decision maker
  - → fewer errors of commission
- Decreased cognitive load for alert responses
  - → fewer errors of distraction

Clinical Example with *Offered Choices*

Dr. Bright has decided to order paroxetine.

An alert notifies her that the patient is already receiving fluoxetine, which is the same class of drug as paroxetine.

Dr. Bright decides to cancel the previous order of fluoxetine and continue her current order for paroxetine.

Task Analysis With *Offered Choices*

1. Using *Offered Choices*, Dr. Bright selects “Cancel pre-existing order” and continues with her work.

Task Analysis Without *Offered Choices*

Option 1

Select “Go Back”

Save constructed but unsubmitted order for paroxetine

Find pre-existing order for fluoxetine in long list of current orders

Cancel fluoxetine order

Recall saved order for paroxetine

Submit order for paroxetine

Option 2

Select “Proceed”

Submit new order for paroxetine

Find pre-existing order for fluoxetine in long list of current orders

Cancel fluoxetine order

Task Analysis Comparison

- With *Offered Choices*
  - 1-step process
  - Less clinician time consumption
  - Less cognitive complexity
  - Explicit choices available
- Without *Offered Choices*
  - Either 4-step or 6-step process
  - Increased clinician time consumption
  - Increased cognitive complexity renders alert responses vulnerable to Error of Distraction
    - “Proceed” path → both drugs received
    - “Go Back” path → neither drug received

Further Advantages of *Offered Choices*

- Without *Offered Choices*, override rates are difficult to measure
  - "Go Back" vs. "Proceed" selection insufficient to determine whether alert advice was followed
  - Must laboriously examine order sets following alert triggering
- With *Offered Choices*, explicit selection allows clear determination whether alert advice was followed

Conclusions

Several types of errors are associated with clinical alerts, as demonstrated by our analysis of critique alerts.

Offered Choices, as a feature of critique alerts, provide significant theoretical potential for decreasing alert-related errors.

Further study is needed to evaluate improvements in alert efficacy and usability after implementation of *Offered Choices*.

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Opportunities for Error in CPOE Alert Responses

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Abstract

The default alert response options in a commercial Computerized Physician Order Entry (CPOE) system are markedly different from the clinical cognitive model. This difference can contribute to alert fatigue, incorrect alert overrides, and increased errors in patient treatment. By examining an interruptive, overridable alert from the perspective of both cognitive and workflow analyses, this paper presents insights into potential errors and proposes a novel testable model for alert conflict resolution.

Keywords:

CPOE, user computer interface

Introduction

CPOE systems have been shown to both prevent errors and open opportunities for new types of errors. Overriding alerts is a serious and common problem, with 49-96% of all alerts being overridden.(1) Many alerts are interruptive. They stop the clinician's workflow until the alert receives a response. When encountering this type of alert, clinicians are more likely to respond, rather than automatically overriding it, if they are provided with a reasonable set of alternative actions.(2)

Clinical cognitive model vs. workflow constraints

Consider the scenario in which the clinician is presented with an alert of the form "Item A conflicts with Item B". There are three possible responses to this alert form: delete or modify Item A; delete or modify Item B, or override the alert. The specific implementations vary depending on what A and B are. Drugs can be canceled or modified. Allergies can be marked as inaccurate, or narrowed in scope, if the patient had tolerated a related substance. Lab values could be marked as unreliable.

In a currently implemented commercial system, the two response options for this type of alert are *Go Back* and *Proceed,* as in Figure 1. Pre-existing orders (Item A) cannot be modified until the new orders are submitted or cancelled.

Opportunities for error

Tracking Errors: (a) The alert is logged as cancelled, but the user did change their orders. (b) The alert is logged as overridden, but user changed orders in a separate session.

Patient Care Errors: Without the ability to immediately modify Item A, the user is forced to recall the conflict state for later correction. This imposes an unnecessary cognitive workload which is vulnerable to interruption and error.

Hypothesis and implications for future studies

We hypothesize that the ability to change both preexisting and new items when responding to alerts is both desired by clinicians and necessary to reduce errors. To confirm this, alerts of the form "A conflicts with B" will be presented to clinicians who will be asked about their possible responses. Then they will be asked to respond to these alerts while unable to modify any pre-existing items in the same order session.

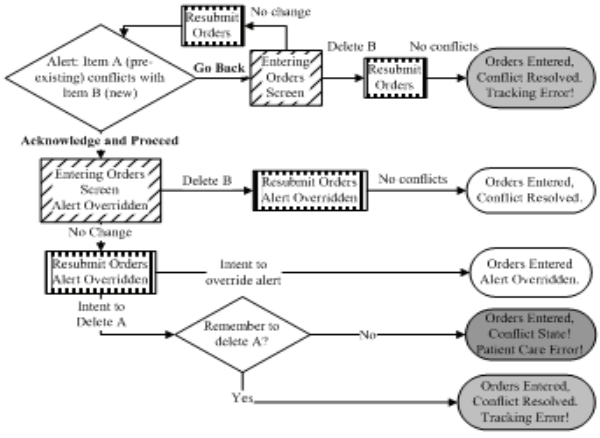

Figure 1 – Alert response task flow

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Acknowledgements

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Elements of CPOE Style: A Guide to Formatting Text for Clinician Users

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Abstract

We present our methodology for formatting the text of medical information to clinicians in the context of computerized physician/provider order entry (CPOE). Well-formatted text improves usability, and ease of use is not just a nicety: systems that are easy to use will be adopted more readily and, more importantly, will be used more accurately and thus more safely. In our experience of CPOE implementation, text formatting can be most helpful for two key goals: helping the user find the desired information, and adding meaning beyond the literal words. Specific principles are presented here verbally, and visual examples of better and worse text formatting are shown on the poster.

Keywords:

Medical Order Entry Systems, CPOE, Usability

Introduction

Computerized Physician/Provider Order Entry (CPOE) systems have the audacious job of presenting vast amounts of material to clinicians, most of whom experience the volatile combination of being both very busy and under high pressure to perform well and almost all of whom express a desire for more simplicity (e.g. fewer clicks, fewer words). In our experience of CPOE implementation, we have encountered both a general under-appreciation of the importance of carefully crafting the on-screen text encountered by clinician users and a demand for an easy-to-follow style guide for clinical content creation. Here we lay out several design principles which have evolved and proven helpful throughout our CPOE implementation – in all levels of content, from individual orderable items to ordersets to complicated pop-up advisors – and on the poster we display several examples of formatting, both better and worse.

Principles of text formatting in CPOE

Help users find their target

Focus on keyword(s) – Starting each item's name with the key concept maximizes visibility for the scanning user and gives similar items parallel structure.

- BEFORE

  VENTILATOR
  8. pc/ps mechanical ventilation
  + emergency (fio2 100%) backup mechanical ventilation
  9. qam compliance study by rt

  AFTER

  VENTILATOR
  8. mechanical ventilation: pc/ps mode
  + mechanical ventilation: emergency (fio2 100%) backup
  9. compliance study by rt qam

- BEFORE

  Complicated Urinary Tract Infection (Peds)

  AFTER

  Urinary Tract Infection: Complicated (Peds)

- Use standard English conventions and familiar (or at least logical) abbreviations – The need to convey the most meaning in the most concise fashion developed in the paper-based world, but it is arguably even *more* important in the digital one. Ideally, present an abbreviated version to the prescriber (input) but a more explicit version for the nurse (output).

- BEFORE

  6. nurse: complete diabetic flowsheet with each glucose measurement
  + nurse: teach patient and family to check blood sugars, draw insulin, and give insulin
  + teach family signs & symptoms of hypoglycemia, and treatment of hypoglycemia
  + nurse: teach family how to administer intramuscular injection (glucagon prn)

  AFTER

  6. record each glucose measurement on diabetic flowsheet
  + teach checking glucose & giving subq insulin
  + teach s/sx & tx of hypoglycemia & giving im glucagon

- BEFORE

  17. nursing: collect aliquot (10-20 ml) of each void and label with time. if frank hematuria is present, notify h.o.

  AFTER

  17. collect & label aliquot each void; notify if hematuria

- Organize text with concise headers and assure the visual alignment reflects logical hierarchy – Subdivide long lists into logical groups so users can go straight for what they want and be less intimidated along the way. Do not let line-wrapping interfere. Concise use of ALL CAPS helps draw the eyes to important categories.

- BEFORE

Nitrates
17. nitroglycerin 2% oint [nitro-bid] topical ntg x28 days off from midnight to 0600
18. nitroglycerin infusion (100mg/250ml) iv cont now x5 days
-titrate
up until chest pain relieved or systolic bp <100 mmhg; requires stepdown status
19. nitroglycerin sublingual [nitrostat] 0.4 mg subling q5mprn prn x28 d for chest pain per chest pain protocol
20. all formulary nitrates »
Beta-blockers

AFTER

NITRATES
17. nitroglycerin 2% oint [nitro-bid] topical ntg x28 days off from
18. nitroglycerin infusion (100mg/250ml) iv cont now x5 days
19. nitroglycerin sublingual 0.4 mg sl q5min x3 prn chest pain per
20. all formulary nitrates >>
BETA-BLOCKERS

Increase meaning using visual relationships

- Consistency of format – In some ways, it is more important than the format itself… but "proper" formatting (eliminating typos and adhering to conventions of spelling and grammar) creates the professional appearance clinicians expect and engenders trust in the accuracy of the clinical contents. Note that difference of structure implies difference of meaning, even when there is no such difference.

- BEFORE

RADIOLOGY
(if fluctuant) ultrasound of affected area
(if history of trauma) plain radiograph

AFTER

RADIOLOGY
(if fluctuant) ultrasound
(if history of trauma) plain radiograph

- BEFORE

23. expressed breast milk (no adds) po
24. expressed breast milk (with additives)

AFTER

23. expressed breast milk (no additives)
24. expressed breast milk (with additives)

- Align common text to highlight the differences. Watch for redundant phrases that can be either aligned or extracted.

- BEFORE

1. peds hem-onc admission (if not already done) >>
2. peds line draw (if not already done)
3. enter bsa (if not already done)
4. enter dosing weight (if not already done)

AFTER

1. (if not already done) peds hem-onc admission >>
2. (if not already done) peds line draw
3. (if not already done) enter bsa
4. (if not already done) enter dosing weight

- BEFORE

3. weight: obtain on admission (in kg)
4. weight (kg): estimate only & defer measurement

AFTER

3. weight (kg): obtain on admission
4. weight (kg): estimate only & defer measurement

- Structure conveys relationships with less text – Emphasize similar meaning by using similar structure; conversely, when meaning is different, be sure the structure does not imply nonexistent similarity.

- BEFORE

Consider Pediatric Infectious Diseases consult if:
Immunocompromised patient, alternative antibiotics needed for allergies, comorbid conditions, clinical failure after 48 hrs of treatment
17. pediatric infectious disease consult
Consider Pediatric General Surgery consult if:
Parapneumonic effusion, necrotizing pneumonia, abcess
18. pediatric general surgery consult

AFTER

CONSULTS
If immunocompromised, allergic & needing alternative antibiotics, comorbid conditions, clinical treatment failure after 48 hrs:
17. pediatric infectious disease consult
If parapneumonic effusion, necrotizing pneumonia, abscess:
18. pediatric general surgery consult

Conclusion

The human eye and mind are remarkably facile at recognizing patterns and inferring meaning from them; in the never-ending quest to make CPOE both faster and safer, optimal formatting of text can help guide them to their targets. Meaning occurs in layers beyond the literal words themselves: how the words are formatted can say as much as the words themselves. The central challenge is balancing the need for clarity (for the sake of quality and accuracy) against the demand for conciseness (for the sake of speed and efficiency); achieving the optimal balance requires an understanding of the information-processing needs of clinicians. Conveying the same information with fewer words (or symbols) improves the signal-to-noise ratio and is thus favorable in almost all cases. Good text formatting can go a long way toward increasing usability, which is a necessary (but not sufficient) step toward craft-

ing information systems than can help meet the many challenges faced by our struggling healthcare system.

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Elements of CPOE Style: A Guide to Formatting Text for Clinician Users

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Setting & Challenge

- CPOE becoming more common → rapidly-increasing prescriber “face-time” with computers
- Increasing recognition of unintended consequences of CPOE (Ash, 2007)
  - More or new work for prescribers
  - Workflow mismatches
  - New kinds of errors
- We believe well-formatted text can → improve usability & ease-of-use

  → improve adoption

  → accuracy → safety

Under-Appreciation of Formatting

- Pressure to install CPOE
  - Basic performance (e.g. software, hardware) & functionality given higher priority
- CPOE often installed/configured by non-prescribers
  → Less familiar with prescribers' mental processes
  - Filtering of information (What needs to be shown? What does NOT need to be shown?)
  - Language / jargon
  - Time pressure / urgency to find information
    - High value of fewer words, fewer clicks
- Lack of style guide

Goals & Principles

- Lofty goals: extra care in text formatting can actually…
  1. Help user find desired information
  2. Add meaning beyond literal words
- Design principles
  - Applicable to all levels of text in CPOE
    - From individual orderables
    - To complicated pop-up advisors
  - Evolved and proven helpful throughout our CPOE experience (Duke Univ. Hospital, North Carolina, USA)

Help User Find Desired Information

- Focus on keywords
  - Favor bringing keyword to the margin
  - Creates natural organization

BEFORE	AFTER
VENTILATOR 8. pc/ps mechanical ventilation + emergency (fio2 100%) backup mechanical ventilation 9. qam compliance study by rt	VENTILATOR 8. mechanical ventilation: pc/ps mode + mechanical ventilation: emergency (fio2 100%) backup 9. compliance study by rt qam
Complicated Urinary Tract Infection (Peds)	Urinary Tract Infection: Complicated (Peds)

Help User Find Desired Information (Cont'd)

- Take advantage of conventions & abbrev'ns
  - Ideal if prescriber can select abbrev'ed version (input) but nurse receives more explicit version (output)
  - As used profusely in written charts (for good reasons, mostly)
  - Choose standard English conventions: avoid IT jargon
  - Choose familiar (or at least logical) abbrev'ns

BEFORE	AFTER
6. nurse: complete diabetic flowsheet with each glucose measurement + nurse: teach patient and family to check blood sugars, draw insulin, and give insulin + teach family signs & symptoms of hypoglycemia, and treatment of hypoglycemia + nurse: teach family how to administer intramuscular injection (glucagon prn)	6. record each glucose measurement on diabetic flowsheet + teach checking glucose & giving subq insulin + teach s/sx & tx of hypoglycemia & giving im glucagon
17. nursing: collect aliquot (10-20 ml) of each void and label with time. if frank hematuria is present, notify h.o.	17. collect & label aliquot each void; notify if hematuria

Help User Find Desired Information (Cont'd)

- Visual alignment must reflect hierarchy of info
  - Essential for quick navigation to information sought
  - Beware line wrapping
  - Assume user looking for visual patterns more than reading literal text
- Organize text with brief headers
  - Concise use of ALL CAPS can help navigation

BEFORE

Nitrates
17. nitroglycerin 2% oint [nitro-bid] topical ntg x28 days off from midnight to 0600
18. nitroglycerin infusion (100mg/250ml) iv cont now x5 days
-titrate
up until chest pain relieved or systolic bp <100 mmhg; requires stepdown status
19. nitroglycerin sublingual [nitrostat] 0.4 mg subling q5mprn prn x28 d for chest pain per chest pain protocol
20. all formulary nitrates »
Beta-blockers

AFTER

NITRATES
17. nitroglycerin 2% oint [nitro-bid] topical ntg x28 days off from
18. nitroglycerin infusion (100mg/250ml) iv cont now x5 days
19. nitroglycerin sublingual 0.4 mg sl q5min x3 prn chest pain per
20. all formulary nitrates >>
BETA-BLOCKERS

Add Meaning Beyond Literal Words

- Consistency of format
  - Different format implies different meaning (even when not true)
  - Internal/local (especially within field of vision) consistency more important than

BEFORE	AFTER
Non-cardiac: 17. cefuroxime inj [zinacef] 50 mg/kg/dose iv q8h x2d + gentamicin inj [garamycin] 3.5 mg/kg/dose iv q24h x99d Cardiac closed chest: 18. cefuroxime inj [zinacef] 50 mg/kg/dose iv q8h x 2 days	Non-cardiac: 17. cefuroxime inj [zinacef] 50 mg/kg/dose iv q8h x2d + gentamicin inj [garamycin] 3.5 mg/kg/dose iv q24h x99d Cardiac closed chest: 18. cefuroxime inj [zinacef] 50 mg/kg/dose iv q8h x2d
RADIOLOGY (if fluctuant) ultrasound of affected area (if history of trauma) plain radiograph	RADIOLOGY (if fluctuant) ultrasound (if history of trauma) plain radiograph
23. expressed breast milk (no adds) po 24. expressed breast milk (with additives)	23. expressed breast milk (no additives) 24. expressed breast milk (with additives)

Add Meaning Beyond Literal Words (Cont'd)

- Structure conveys relationships
  - Similar structure implies similar meaning (thus words are not needed to state the relationship)

BEFORE	AFTER
Consider Pediatric Infectious Diseases consult if: **Immunocompromised patient, alternative antibiotics needed for allergies, comorbid conditions, clinical failure after 48 hrs of treatment** **17. pediatric infectious disease consult** **Consider Pediatric General Surgery consult if:** **Parapneumonic effusion, necrotizing pneumonia, abcess** **18. pediatric general surgery consult**	**CONSULTS** **If immunocompromised, allergic & needing alternative antibiotics, comorbid conditions, clinical treatment failure after 48 hrs:** **17. pediatric infectious disease consult** **If parapneumonic effusion, necrotizing pneumonia, abscess:** **18. pediatric general surgery consult**

Add Meaning Beyond Literal Words (Cont'd)

- Align common text
  - Highlights differences
  - Natural pattern recognition brings the choices into focus

BEFORE	AFTER
1. peds hem-onc admission (if not already done) >> 2. peds line draw (if not already done) 3. enter bsa (if not already done) 4. enter dosing weight (if not already done)	1. (if not already done) peds hem-onc admission >> 2. (if not already done) peds line draw 3. (if not already done) enter bsa 4. (if not already done) enter dosing weight
3. weight: obtain on admission (in kg) 4. weight (kg): estimate only & defer measurement	3. weight (kg): obtain on admission 4. weight (kg): estimate only & defer measurement
43. nutrition consult for evaluation of intake 44. nutrition education consult 45. nutrition evaluation consult	43. nutrition consult: evaluation of intake 44. nutrition consult: education 45. nutrition consult: evaluation

Conclusion

- The human eye and mind can recognize (& infer meaning from) patterns readily. Take advantage of that.
- Present information in the way that it is expected → Less interpretation → Less cognitive load → More safety & satisfaction
- Saying the same thing with fewer words improves signal-to-noise ratio.
- Well-formatted text can make a difference.

- Reference:
  - Ash et al, 2007. Unintended Consequences Related to CPOE. *JAMIA* 14(4): 415-23.

- Acknowledgements:
  - Mentors: James Tcheng MD & Michael Russell MD
  - Tremendous work by entire Duke CPOE team

- Contact:

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Design of Health Information Management System Interfaces Using Human-Centered Decision Principals

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[2]Escuela de Medicina, Instituto Technológico y de Estudios Superiores de Monterrey, NL, México

The University of Texas
Health Science Center at Houston
School of Health Information Sciences

Objective

Describe how we applied the **Human-Centered Distributed Information Design Methodology** (HCDID) to develop a series of interfaces for a particular user's interactions with a Health Information Management System

- **Analyze** the interviewer's interactions with the system
- **Develop** a series of user interfaces based on HCDID methodology
- **Evaluate** and **improve** the prototype

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Background

- **User Interface Engineering (UIE)** is the process of designing the interfaces for the interactions of a human (user) and a machine
- UIE focuses on the way the user inputs and retrieves information, and efficiently navigates the system
- This is the foundation of HCDID
- **Health information management** was a challenge during the **relief efforts** of U.S. hurricanes Katrina and Rita
- Multiple systems, both electronic and paper, were implemented in an effort to collect, distribute and share information about the victims

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Background

- The integration of these systems was impossible due to the lack of standards and inconsistencies in the data
- In response to the information challenges, The UT-School of Health Information Sciences developed a web-based system to assist during major Disaster's Relief Efforts: **HIMS-DRE**
- HIMS-DRE allows the creation and use of web-based forms
- An interviewer is the HIMS-DRE user who utilizes such forms to enter data into the system

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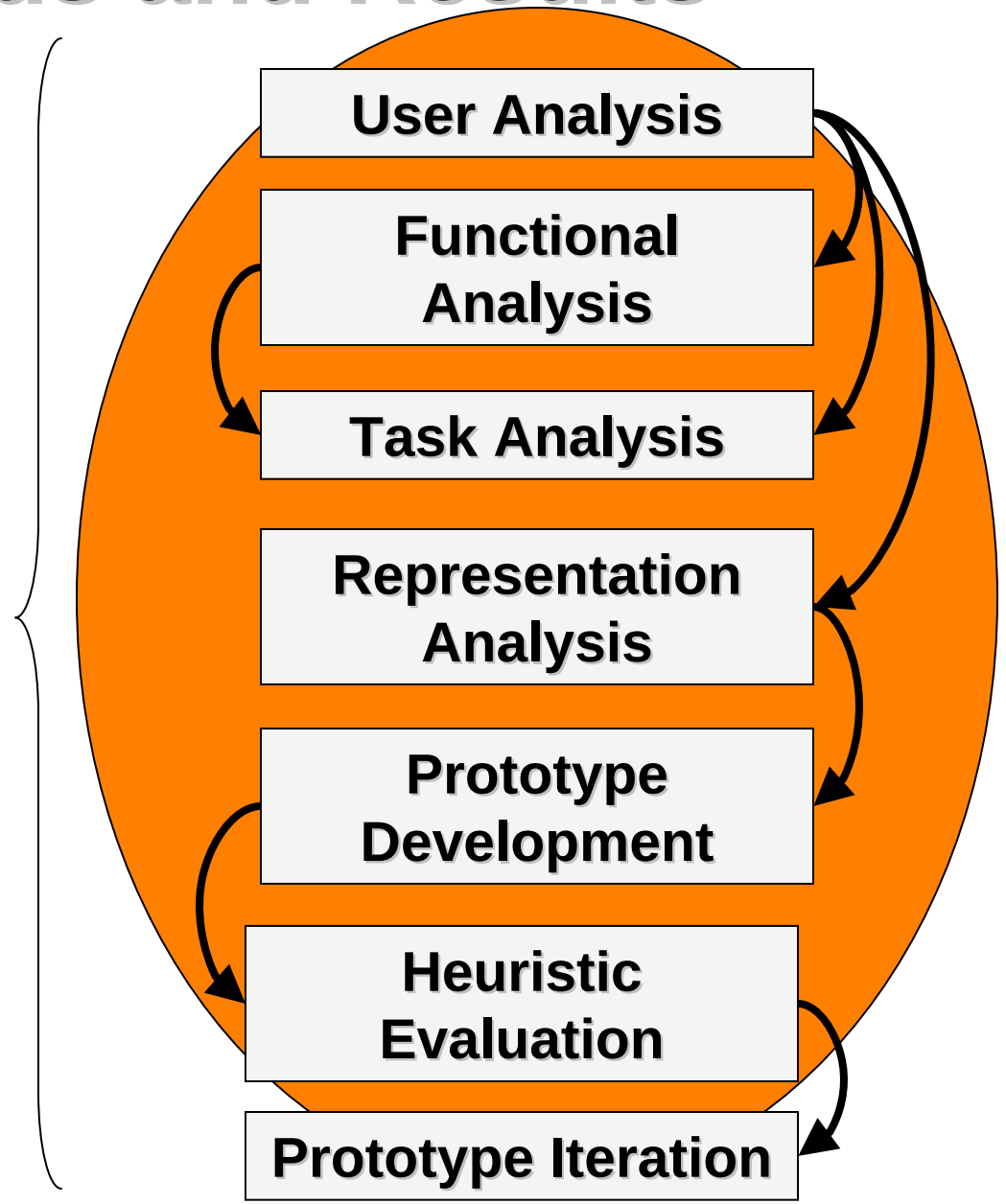
School of Health Information Sciences

Methods and Results

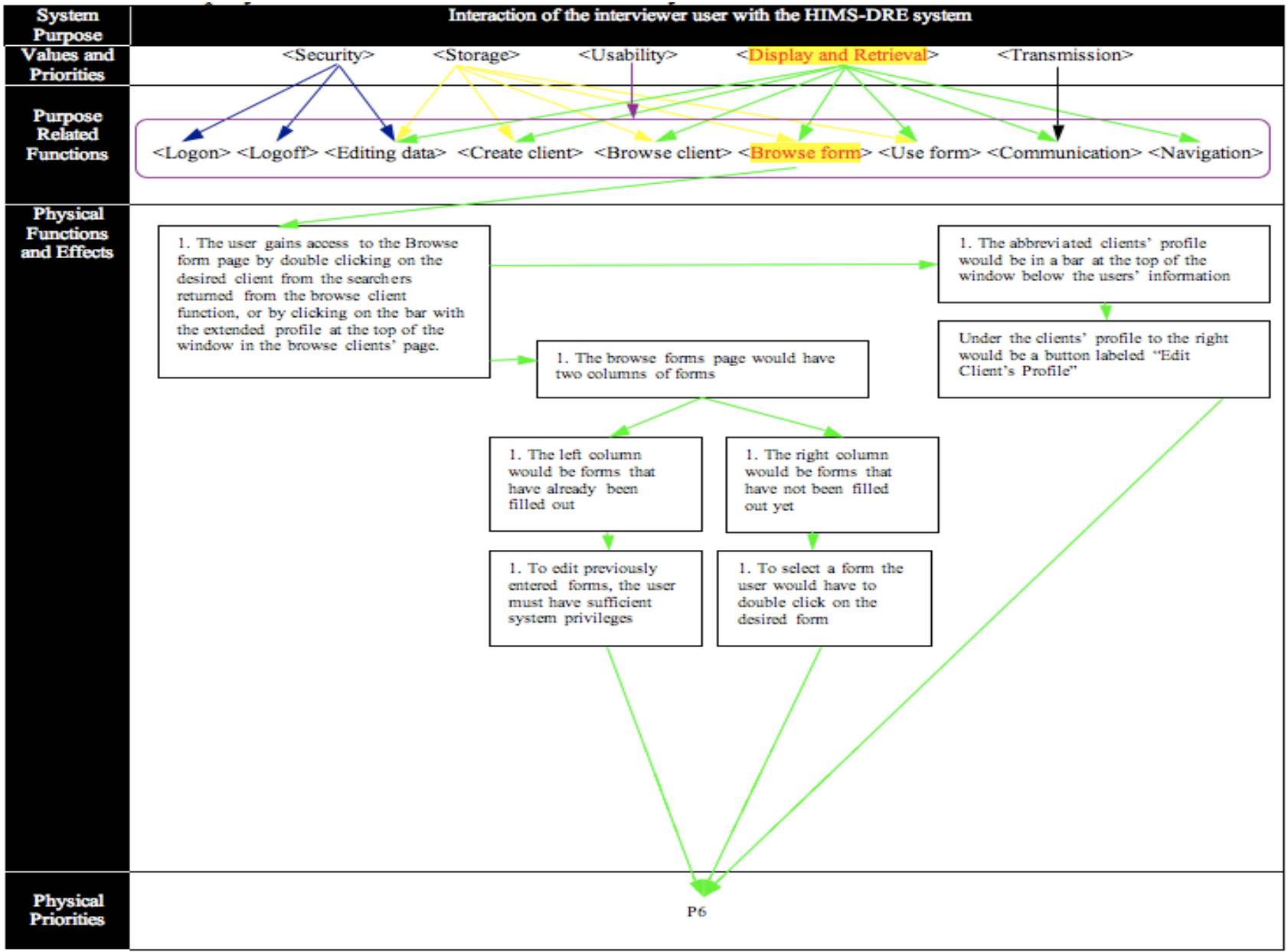
HCDID
Multiple Levels of Analysis



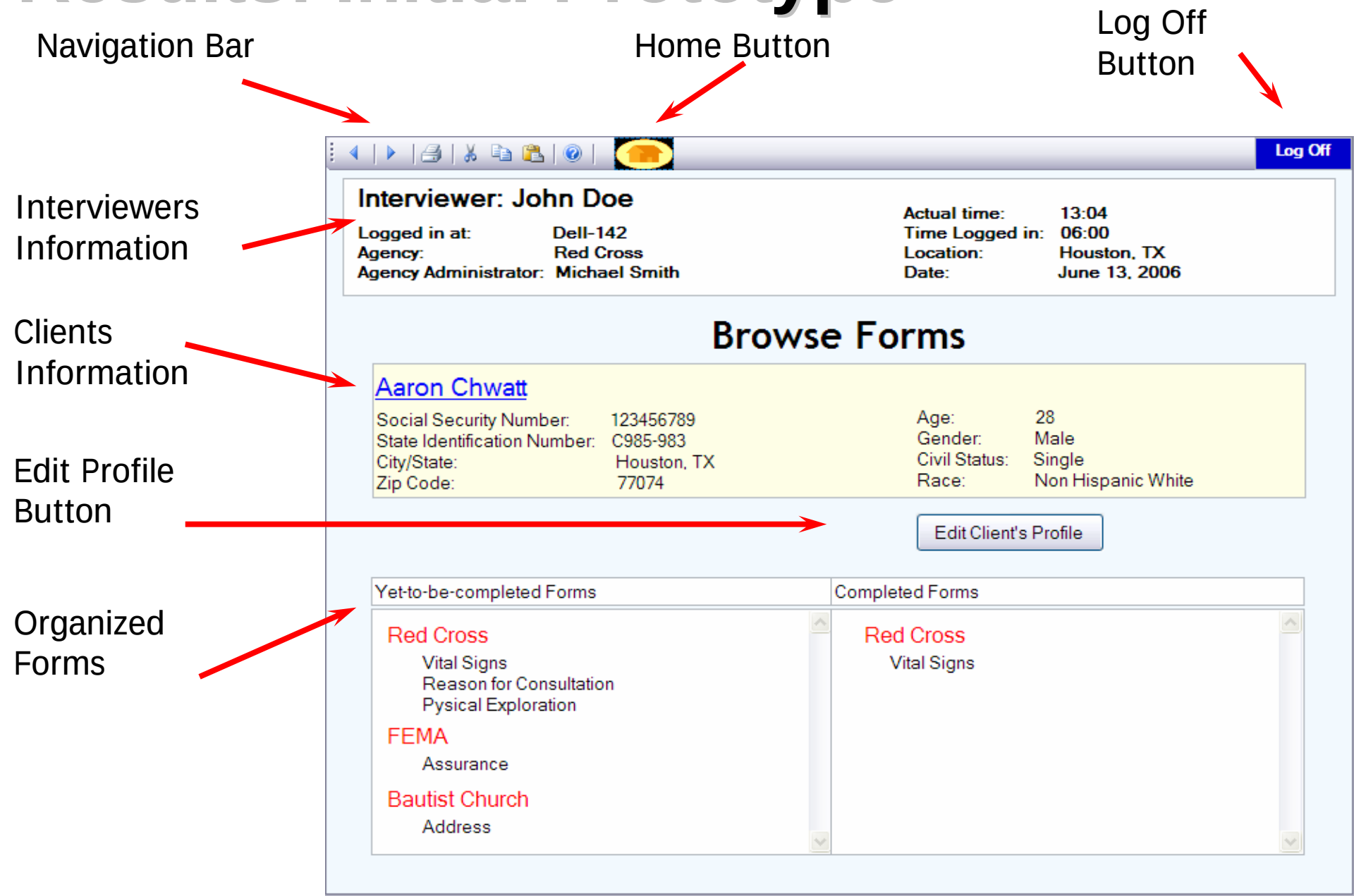
Results: User Analysis

User	Location Profession Life Style	Education	Gender	Expertise	Age	Skills	Physical Abilities
Interviewer	Any	High School at minimum	Either	Basic Word Processing	18 Until not physically able	Interview	Motor control
							Speech
							Vision
						Able to work under pressure	Not depend on medications
							Cognitive awareness
				Basic Web Browsing		Language	Mobility
							Extended time outdoors

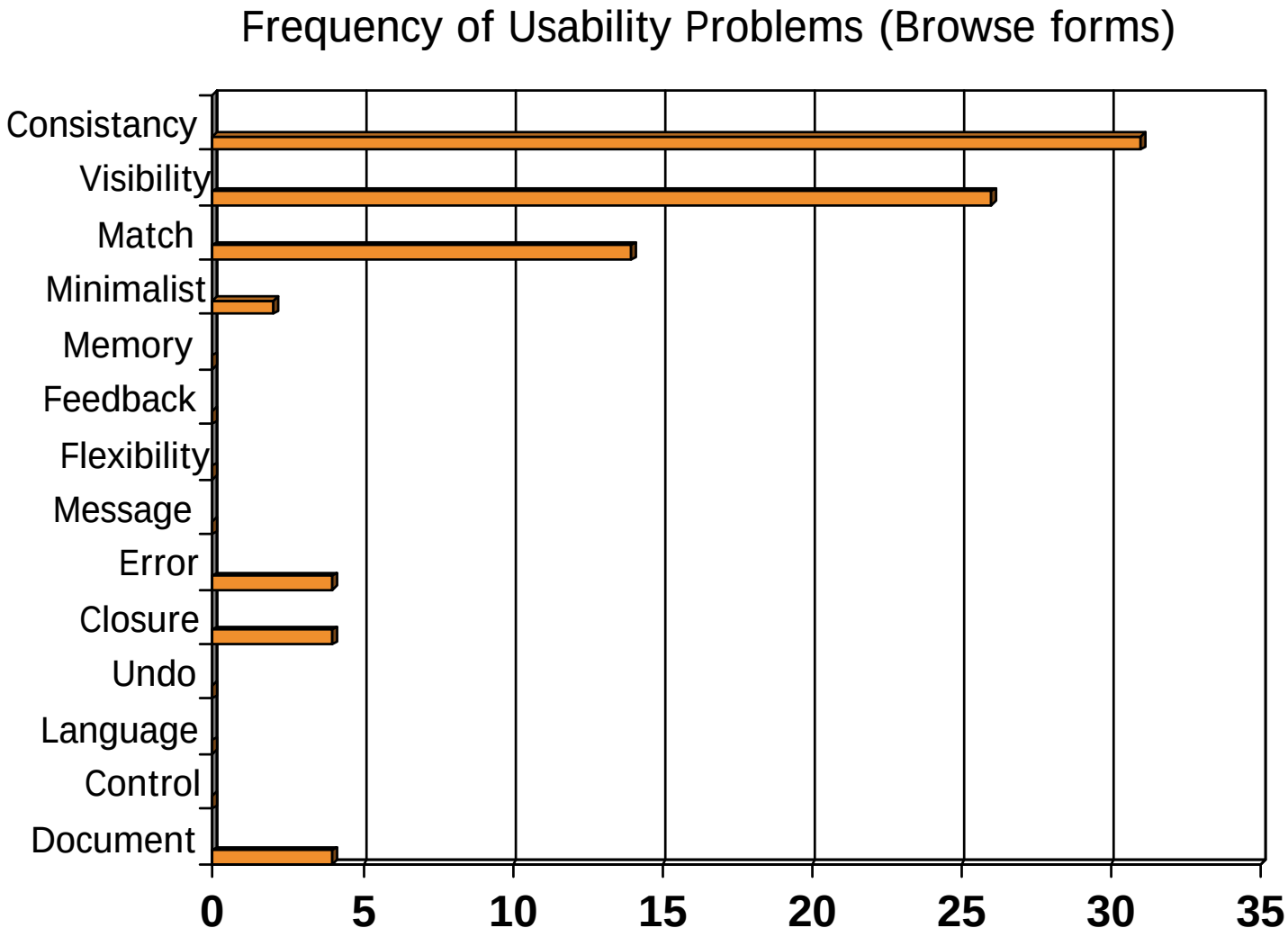
Results: Functional/Task Analysis



Results: Initial Prototype



Results: Usability Violations



Results: Improved Prototype

Notification of Entry to System

Event Name

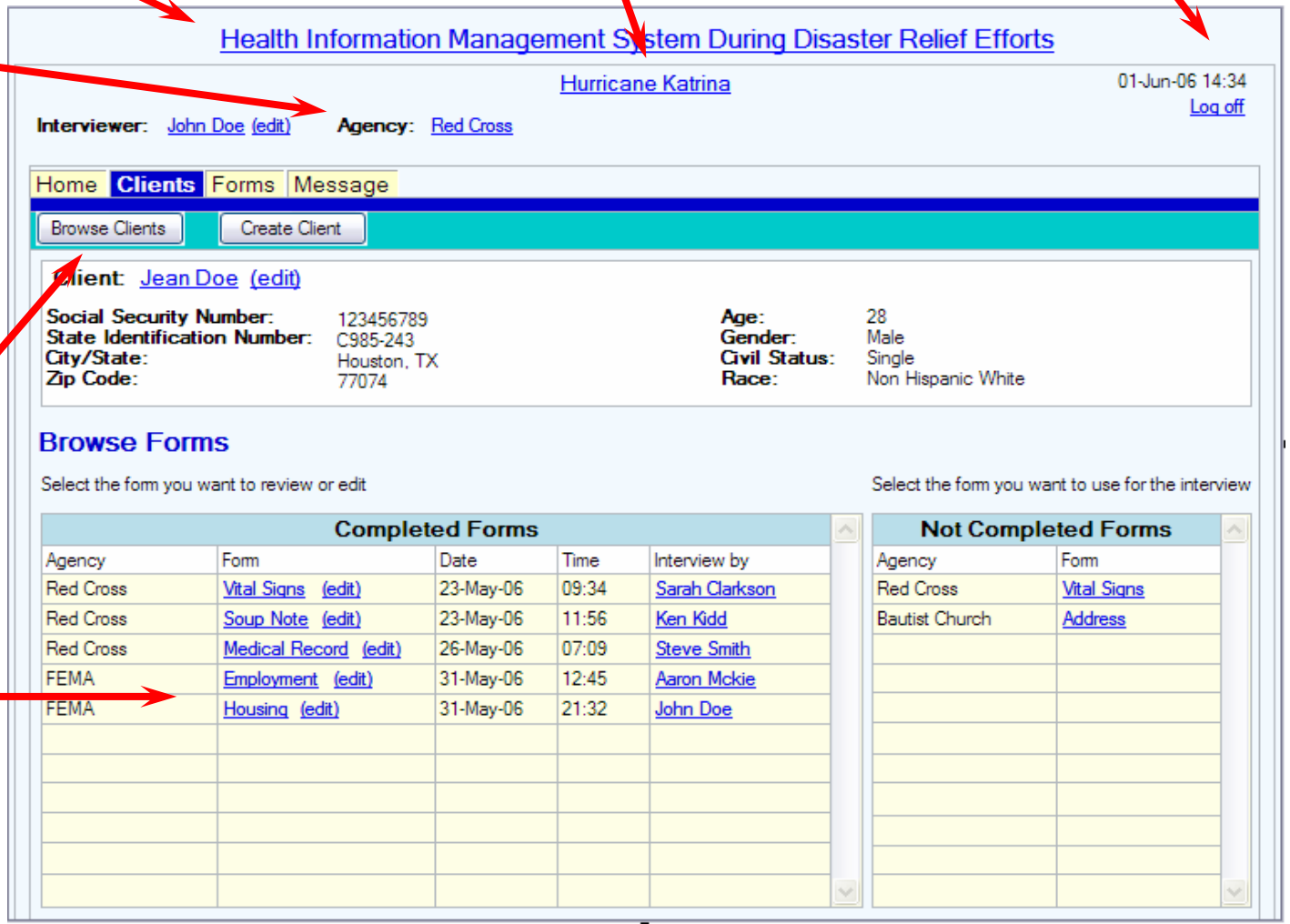
Standardized Dates

Agency Name

Tabbed Browsing

Buttons for Functions

Links for Navigation



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Conclusions

- HCDID was a useful methodology in determining the structure of our user analyses and to construct a framework for our interface development.
- WDA greatly assisted in the interface design process. It helped identify the purpose, priorities, values, functions, and it drew connections between them that facilitated the graphical representation of our interface.
- Heuristics evaluation was an effective and time-efficient method of evaluating user interface prototypes.
- During every step of the design it was important to focus on the users' needs rather than on the system's developers so that the final product would be based on the users.

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References

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Design of Health Information Management System Interfaces Using Human-Centered Design Principles

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Abstract and objective

This project used the Human-Centered Distributed Information Design Methodology (HCDID) to develop a series of interfaces for a Health Information Management System. HCDID employs several levels of analysis including an analysis of the user, a functional and task analysis, a representational analysis, then prototype development, a heuristic evaluation, and finally prototype iteration. Based on the user, functional, task and representational analyses, an initial prototype was developed and then evaluated using a heuristics worksheet. Using the information from the heuristic evaluation, an improved prototype was created that addressed the problems of the original prototype. HCDID was an effective methodology for analysis of interfaces of a Health Information Management System. During the design phase, the focus was on the users' needs rather than the system's developers so that the final product would meet the users' requirements.

Keywords:

User interface engineering, health information management, heuristics, work domain analysis

Introduction

This project used the Human-Centered Distributed Information Design Methodology (HCDID) to develop a series of interfaces for a Health Information Management System. HCDID is based on User Interface Engineering (UIE), a process of designing interfaces for human interactions between a human (user) and a machine focusing on the way the user inputs and retrieves information, and how effectively users navigate the system.

Health information management was a challenge during the relief efforts of last year's U.S. Gulf Coast hurricanes Katrina and Rita. Multiple systems, both electronic and paper, were implemented in an effort to collect, distribute and share information about the victims. The integration of these systems failed due to the lack of standards and inconsistencies in data.

In response to the information challenges during the gulf coast disasters, The UT-School of Health Information Sciences developed a web-based system to assist during major disaster's relief efforts, the Health Information Management System -Disaster Relief Efforts. (HIMS-DRE) This HIMS-DRE allows the creation and use of web-based forms by an interviewer, who utilizes them to enter data into the system.

Methods

HCDID employs several levels of analysis including an analysis of the user, a functional and task analysis, a representational analysis, then prototype development, a heuristic evaluation, and finally prototype iteration. [1]

User analysis

User analysis is a method that allowed us to identify and classify the most important attributes of potential users that will directly affect how the user interacts with the system. The information about the users of the system was acquired by performing interviews, site visits, surveys, and a review of the literature. The user's own definition of their role was also an important factor to consider when designing the system.

Functional analysis

We used functional analysis to describe the main user's goals, and task analysis to identify the information, processes, and expected outcomes needed to achieve those goals. We used Work Domain Analysis (WDA) to identify the functional properties of the system.

Representational analysis

We constructed Abstraction Decomposition Maps (ADM) to graphically represent the WDA. The representational analysis consists of a graphical analysis of the interaction between a system and its user, taking into account the previously completed user analysis and the functional and task analysis. Representational analysis also utilizes several design principles including layout, type face, color, language, and structure.

Heuristic evalution

Heuristic Evaluation is a type of usability inspection method in which evaluators examine an interface for usability issues. In our case, three independent users evaluated the user interface using heuristics to identify usability problems, grade the severity of the problems, and propose solutions. There were 14 heuristics in the evalua-

tion including the following: consistency and standards, visibility of system state, match between system and world, minimalist, good error messages, prevent errors, clear closure, and help and documentation.

Results

User analysis

Based on techniques such as job description and interviews with the system's designers we designed a basic profile for the interviewer user. The focus was on several aspects of the interviewer that are flexible and several that have more rigid requirements. The more flexible characteristics of the interviewer user include the user's location, profession, lifestyle, and gender, because these characteristics would have less influence on the user's interaction with the system. Other aspects were less flexible and had more requirements. For example, the education level of the user, a minimum of high school, would have to include basic reading and writing skills. The user's technical expertise would have to consist of at least basic computer use (e.g. word processor and internet browser use) because the interface would have similar features to these programs. The minimum age of the user would be 18 years old age, because some agencies involved in the aftermath of hurricane Katrina, preferred to have volunteers that were older. The upper age limit is not definite because it would depend on the physical and mental abilities needed to complete the tasks required. Being physically and mentally competent means the ability to talk freely without impediment, have no trouble seeing or reading, have motor control of the hands, have the ability to hear without aid, have medications that do not require refrigeration, to work outdoors, and have cognitive awareness. These are all basic factors needed to be able to conduct an interview and interact with the system's interface. It is possible that the user could be of limited mobility, and still be able to perform the tasks, as long as the location allowed the user access. The user would have to possess certain skills, for example, the ability to perform an interview, to work in stressful situations, and be proficient in the victims' language. These skills are important because the user must be able to work in crisis situations. The user would also be required to have affiliation with an organization granted access to the system. These conditions should be considered when looking for qualified users.

Functional/task analysis

We identified several high-level interviewer functions and interaction with the system. Based on the WDA that was conducted, security, storage, display and retrieval, transmission, and usability were priorities because these values were important and they encapsulated all of the tasks that the interviewer-user would perform. These values also influence all of the user's interactions with the system. The purpose-related functions that related to security included logon, logoff, and editing already entered data. These functions would allow structured access and interaction with the system as well as provide a safe environment for both the user and the information that is being stored, displayed, retrieved, and transmitted. The values of storage, display and retrieval share relations with many of the same purpose related functions including browse clients, edit already entered data, create clients, browse forms, and use forms for interview. These functions are the ones that will have the greater impact on how the user interacts with the system. In addition, the display and retrieval values also include the navigation function and shares the communication function with the transmission value. These last two functions are important to the user because they are the functions that provide routing through the system and support for the user when it is needed.

Heuristic analysis and prototype development

Based on the user, functional, task and representational analyses, we developed an initial prototype and then evaluated it using a heuristics worksheet. In just one prototype screen, there were 75 heuristics violations. 14 were minor (0-2 on the rating chart) and 61 were rated as major violations (3-4). We catalogued all of the heuristics evaluations along with information about the description of the problem, the heuristic that was being evaluated, the severity of the problem, and the recommended solution. Using the information gathered, we created an improved prototype that addressed the problems of the original prototype.

Conclusion

We used HCDID based on UIE to develop interfaces of the HIMS-DRE. WDA greatly assisted us in the interface design process. It helped us identify the purpose, priorities, values, functions, and draw connections that facilitated the graphical representation of our interface. Heuristics evaluation was an effective and time-efficient method of evaluating user interface prototypes. During the design phase, we focused on the users' needs rather than the system's developers so that the final product would meet the users' requirements.

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Evolving a Second Opinion Software to Web 2.0

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Abstract

This article describes the evolution needs of a second opinion software (HealthNet), which uses Java language with Web pages. The HealthNet was deployed in April 2004 and only a few clinical cases were started since then. In conclusion, besides the barriers to acquire technology in a poor region of an under development country, cultural barriers have to be undertaken by health professionals and a whole new set of functionalities has to be developed to achieve full potential of the HealthNet. This facts and the approach of the Web 2.0 made a second version necessary using new concepts such as communication and facilitating community.

Keywords:

telemedicine, family practice, medical second opinion

Introduction

HealthNet is a web based information system designed to support the evaluation of clinical cases, family practice professionals and reduce referrals to the Clinics Hospital (HC), of the Federal University of Pernambuco (UFPE), which admits around 1,000 inpatients and provides assistance to 13,000 outpatients per month [1], leading to faster and better care of high complexity level medical cases. Through the HealthNet, health professionals that are located in health basic assistance units can ask for support in diagnosis and therapeutically conducts to health professionals from Reference Centers.

The idea of constructing a Telehealth system occurred in 1999 within the ATM (Asynchronous Transfer Mode) Recife Network Project. From this period until nowadays, some prototypes were developed. Based on these experiences, a review from literature and meetings with health professionals from primary care, the initial requirements of a health information system to support the Family Health Program (FHP, a national program implementing family practice, started in 1994 [2]) in the state of Pernambuco were established and implemented. The first version of HealthNet system was constructed and implanted in Pernambuco Telehealh Network, in Recife city and its metropolitan area, in April 2004.

Despite of the good appearance evaluation made by the users themselves [3], the usability (easiness, errors and flaws) is the worse thing found in the current version of the system, and lacks of a better way of using.

Now, it is possible to improve the use of the HealthNet by making advantage of the Web 2.0 concept and its keywords such as: freeing of data, building of virtual applications, user participative, work for the user, modular, sharing, communication and facilitating community, remix, smart [4].

Materials and methods

HealthNet was constructed with Java language, using Servltes technology and structured in layers. Due to its design, HealthNet can be expanded to support the most of medical specialties. It uses a database server (MySQL), a Web and application server (Tomcat).

After development of the system, Health Units and professionals were recorded. A main telehealth center (NUTES-HC) coordinates the telehealth network maintaining the users' registers (solicitant and consultant), the Health Units and their relationship.

The pilot health areas considered were medical clinic, pediatrics, cardiology and nursing. There were training in the HC with nurses and doctors from this hospital as well as technicians from FHP units that are participating in this project. The technicians are trained in Loco, the doctors and nurses from their localities. After training process, the system was putted under utilization.

Based on a store-and-forward concept the users can type the information in almost any Web browser and it is planned to don't need a broadband connection – it is possible to have good use even with a dial-up connection.

Results

There was observed a low rate of utilization. Since its deployment there were submitted twenty eight clinical cases to be evaluated by specialists. Some factors are highlighted as contributions to this low usage: (i) Health professionals from primary care are not used to electronic information system, this fact can induce resistance to its

usage. Many of them think information systems can overload their already busy work routine. (ii) The nearness of the basic health units and Reference Centers motivate to a non alteration of the leading processes already established for many years. (iii) Fragility of telecommunication infrastructure between FHP units and specialized center. Besides, as part of the evaluation process of the system, there were pointed some functionalities and technological limitation.

Discussion and conclusion

Because of the problems found, planning to overcome the difficulties is to be adopted in a second version. About technological and functionality points, new requirements were identified and the system was redesigned. For the Web 2.0 interface it is intended to permit the development of a wide health cooperation network bringing notorious resources found in communication's software such as Windows Live Messenger [5]. Below are listed some highlights: synchronous (on-line) and asynchronous (off-line) communication; multimedia communication (text, sound and image) allowing users wish association; handling free use of its desktop, dragging components/ services; modular components/services allowing future evolutions without program code need.

The second version of Healthnet is already under development.

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Evolving a Second Opinion Software to Web 2.0

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Based on a store-and-forward concept the users can type the information in almost any Web browser and it is supposed to work even with a dial-up connection.

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There were trainings at the university hospital with nurses and doctors from this hospital as well as technicians from FHP units that are participating in this project. The technicians are trained in Loco, the doctors and nurses from their localities.

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"To tell or not to tell?" :Incorporating Disclosure and Privacy Requirements In Web Portal Design for Malaysian Cancer Patients

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Abstract

Cancer patients need to disclose their health information to their disclosure network: a group of people who patients disclose sensitive health information. The disclosure process can be done using oral as well as communication technologies like telephone and the Internet. In this paper, I propose a research agenda to get requirements from cancer patients and their disclosure network to build a web portal for cancer information management. A web portal is conceptualized as a website set up by healthcare providers whereby patients have the ability to import necessary information (monitored and verified by healthcare providers) from their electronic medical record to disclose information to their disclosure network. Patients need to make active decision who and when to disclose as well the depth and level of information to share with others. This paper will outline the importance of the research, the methodology and expected outcomes from this research.

Keywords:

Web Portal, Disclosure, Privacy, Cancer Information

Introduction: health disclosure

Self-disclosure is defined as "any message about self that one communicates to another" [6]. In this paper, I will use the term self-disclosure and disclosure interchangbly. The topic has attracted scholars from diverse fields – communications, information studies, social psychology, sociology, and psychology. Northouse and Northouse (1998) presented five variables in health communication, where disclosure is one of the central variables that determine the effectiveness of communication. The authors discussed disclosure as a variable since the presence (or absence) of disclosure facilitates (or impedes) effective health communication among patients and medical teams.

Numerous studies have examined disclosure of health information. These studies looked at the content, frequency and consequences of self-disclosure in different medical situations and raised different issues of disclosure, but frequently ignored the balance between disclosure and privacy issues (Cozby, 1973; 17]. Wiener et al. (1996) explored the process of disclosure and consequences among HIV patients and their support network. It examined the caregiver-patient dyad it did not discriminate between the different roles of caregivers during the coping period, thus we are unable to conclude what specific roles are crucial for effective communication with the dyad. Another study [1] explored how family and caregivers cope with cerebral palsy, and found that support network members were dissatisfied with the information disclosure activities. That study also determined that factors such as the age of the child, the timing of diagnosis and the severity of physical disability influenced information disclosure. At the end, the study suggested "best practice" guidelines for disclosing the diagnosis of an illness to the support network. Contro et al. (2002) showed that some family members such as siblings were often not included during the information disclosure process; this in turn caused the siblings to feel "left out" of the coping process.

A few studies pointed out the lack of empirical work in understanding self-disclosure among medical teams and family in chronic illness situations [2, 5]. Families also made it clear that they wanted more information from the medical teams in order to be able to provide the appropriate support for the patient [2,9]. Other recent research on self-disclosure in healthcare examined different situations, contexts and issues as well as the nature of relationships. Topics examined include the process of disclosure (e.g. content and frequency) and its consequences [9], the dyad relationship during disclosure[14,22], practices for disclosing illness [1], disclosure of chronic illnesses [2,5] functional perspectives on health disclosure [7], privacy and disclosure [21], and the influence of illness, relationship and information-seeking on disclosure [4]. Recently, self-disclosure research in healthcare has begun to pay attention to the larger group of people involved in patient care – friends, employers, spiritual groups and self-help groups. Petronio and her colleagues (2004) explored the role of these "informal advocates" by examining the self-disclosure behavior of family and friends when they were present during a patient's visits with the physician and/or medical team.

All the empirical work mentioned above informs the question of self-disclosure in various medical situations. However, it is clear that little work has been done on the disclosure of health information using Information and Communication Technology (ICT) , specifically using web portal. Thus it is a good candidate for exploration using grounded theory, when little is known about a topic.

ICT for health disclosure

There are numerous of health websites resided in the World Wide Web today. Most of them provide health information on specific illness, treatment, drugs and rehabilitation. Websites like WEBMD(http://www.webmd.com/) and Ask Dr. Greene (http://www.drgreene.com/) are moderated by healthcare professionals and they are endorsed as one of the most reliable and trustworthy health websites. There are also many social support type websites that provide emotional support and information sharing among patients and family members. In addition, there are also new research developments for health web portal. There are many different elements that go into the web portal. For an example, a group of researcher designed and developed a diabetes web portal where patients are able to import "diabetes care plan" from their electronic medical record. Patients were able to use this information from the portal to make decisions on their own diabetes care management [8].

The focus of this research is to explore the possibility of using health web portal for health communication. The web portal has to have the ability to import medical record so that patients can use the technology to disclose information to others. The uniqueness of this research is to explore the disclosure and privacy requirements for the web portal design.

The Malaysian Government, under the Multimedia Supercorridor (MSC), has invested billions in ICT infrastructure to support Telehealth(http://www.telehealth.com.my/portals/myhealth/) projects around of the country. One of the main projects is to develop a website called Telehealth to provide credible and trustworthy health information in Malaysia context. The mission of the web portal is to enhance the quality of health among Malaysians. However, there is no cancer-specific web portal has been developed for patient communication. Thus, the outcome of this research can merge with the existing initiatives in MSC.

Methods

There are two stages for this research; the first one is to get the requirements on disclosure and privacy from patients. The technique proposed in this stage is using face to face interviews and grounded theory analysis. In the second stage, I propose to conduct software prototyping to evaluate the usability of such portal. This involves the development of desired prototype and a think aloud technique to capture user satisfaction on using the prototype.

Stage 1: interview with patients

An interview is defined as a construction of knowledge [10] or as a "purposeful conversation, usually between two people but sometimes involving more" [13, page 93]. "Purposeful conversation" here means that interviewers have chosen a specific topic that both interviewer and interviewee can explore and discuss at length. An interview is a tool with which to elicit information from a participant, to find out his or her perceptions, meanings and construct of reality [16]; its purpose is to gather what people say about their perceptions, feelings and behaviors.; its purpose is to gather what people say about their perceptions, feelings and behaviors.

As part of my preparation, I reviewed literature pertaining to conducting interviews. From several previous research projects, I had prior experience conducting interviews with patients, family members and medical personnel in a hospital setting as well as with undergraduate students and these experiences enhanced my confidence in my ability to conduct interview-based research.

This study employed face-to-face semi-structured interviews. Interviews will be conducted wherever the subject feels comfortable. With the subject's permission, I will record the interview session using an audiotape recorder. If respondent refuse to be taped, I will take notes during the interview.

Interview protocol

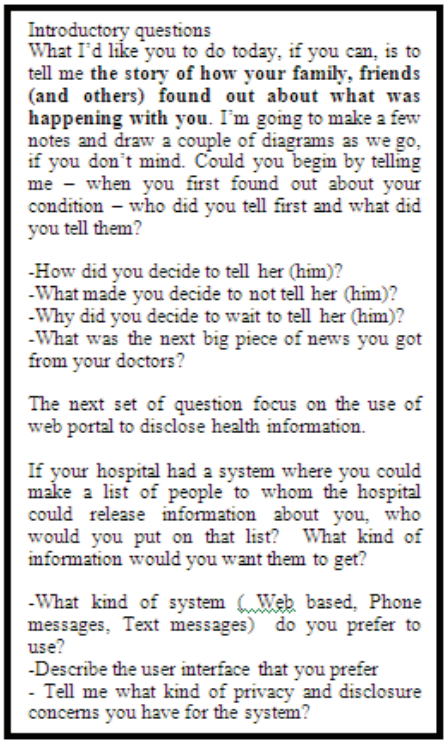
I have developed an interview protocol to start up interviews with cancer patients. I designed a protocol with a background question that asks patient's disclosure behavior when dealing with cancer. Then, I created some questions to elicit the requirements for the future web portal (Figure 1). These questions will be modified based on the feedback by the subjects.

Sampling

Research subjects comprised of medical patients in Malaysia. I will select patient with any types of cancer illness. I chose cancer illness because it is one of the leading illness in Malaysia [11]. The annual incidence of cancer was 30,000 in the year of 2000. Cancer illness has a predictable prognosis where patients have some flexibility in planning either their treatment, recovery or facing end of life situations. With this existing factual in Malaysia, it is appropriate to explore how to build a cancer specific web portal for cancer patients and their disclosure network.

Research subjects will be selected using a convenient snowball-sampling technique. The technique is convenient in the sense that respondents are recruited based on whoever who meet the criteria and was available for the interview. Using the snowball sampling technique, I will identify research volunteers based on others' recommendations [3]. Many patients who would have been reluctant to discuss their illness with a stranger were more open and willing to talk when approached by someone with whom they were comfortable. A snowball-sampling technique

takes advantage of the natural human tendency to extend trust through social relationships, since the interviewer is implicitly endorsed as trustworthy by the participant who provides the referral.



Introductory questions
What I'd like you to do today, if you can, is to tell me **the story of how your family, friends (and others) found out about what was happening with you**. I'm going to make a few notes and draw a couple of diagrams as we go, if you don't mind. Could you begin by telling me – when you first found out about your condition – who did you tell first and what did you tell them?

-How did you decide to tell her (him)?
-What made you decide to not tell her (him)?
-Why did you decide to wait to tell her (him)?
-What was the next big piece of news you got from your doctors?

The next set of question focus on the use of web portal to disclose health information.

If your hospital had a system where you could make a list of people to whom the hospital could release information about you, who would you put on that list? What kind of information would you want them to get?

-What kind of system (Web based, Phone messages, Text messages) do you prefer to use?
-Describe the user interface that you prefer
- Tell me what kind of privacy and disclosure concerns you have for the system?

Figure 1 - Interview protocol

Data analysis

Grounded Theory is a qualitative data analysis technique that serves several purposes [20, page 24]: immersion in the real world situation to gain a deeper understanding of the research phenomena, formation of a theoretical framework that arises from the data itself, and comprehension of the process of change in real situations.

Analysis and coding will begin as soon as the first interview ends and continues until the last interview is completed and coded. Grounded theory recommends that data analysis take place in parallel with data collection [12] so that the researcher is able to make ongoing adjustments to the existing data collection process. For example, analysis of subjects' responses in the first few interviews may suggest new dimensions and directions for subsequent interviews. Ongoing data analysis in parallel with data collection also encourages the early discovery of new insights rather than waiting until the end of the entire data collection process.

Stage 2 study

In the second phase, the main research goal is to expose users to a web portal prototype and to evaluate user acceptance. The focus will be on user interface for the portal where I will explore factors that influence patient to use web portal to disclose sensitive information. Since there is no specific web portal exists yet for patient to communicate and disclose sensitive information with their disclosure network, I would like to employ a socio-engineering approach. With this approach, I will develop a software prototype and refine the design iteratively by incorporating end user needs at every stage. An adaptation of a software engineering approach called rapid software prototyping [19] will be applied to my socio-engineering nature of work.

In creating a "universal" web portal that could be used by patients all over the world, no single theory that can inform the best web portal design for disclosure activities. This is because there are many technological, human, situational and institutional factors that could influence the final product. It is a very complex design and development process to create a "one for all" system, thus a qualitative combined with rapid software prototyping approach seem to be most suitable way to proceed. In this optimization approach, researcher will try to maximize the user acceptance into system design and development. The end goal of this research is to develop an appropriate ICT innovation that could enhance social interaction among cancer patients and their disclosure network. This ICT innovation could also be incorporated in the existing telehealth system in Malaysia.

Using the rapid software prototyping approach, the main research activity is to create an artifact based on a rough approximation. The artifact will be tested and refined according to user feedback. For my research problem, I will develop the first version of the web portal using the effective web design guide. In each stage or version, I will carefully observe and document users' perception on multiple outcome variables like sense of privacy, usefulness and ease of use of the web portal. One possible way to capture users' perceptions is by using a "think aloud" technique. We can also use a technique called "aggregation" to quantify the system outcome. After each data collection, I will incorporate the users' suggestions and make necessary changes in next version of the program. I will then repeat the data collection process with end users until I find their suggestions reach saturation. I will need to observe all the outcome variables over time. The proposed duration of this prototyping process is between six to nine months. The key of this methodology is the iterative refinement process based on users' needs when they want to disclose sensitive health information over the web portal.

Expected outcomes

This research will be conducted over the duration of 24 months beginning of January 2007. It is fully funded by the Malaysia Cancer Council (MAKNA) as part of its annual cancer research award. The expected outcomes are the following:

1. a list of requirements addressing the disclosure and privacy concerns on cancer-specific web portal.
2. a web portal prototyping processes with user feed-back.
3. a well developed web portal prototype.

Acknowledgement

This research work is funded by Malaysia Cancer Council (MAKNA) to facilitate the understanding of health communication through the use web portal among cancer patients and their network in Malaysia. I would also like to acknowledge Dr. Jeffrey Stanton from School of Information Studies, Syracuse University for his guidance in Information Privacy issues in health care setting.

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Using An Electronic Prescribing Tool As a System for Chronic Disease Management

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Abstract

Electronic prescribing tools are gaining popularity because they promote best prescribing practices. We have previously shown that the MOXXI electronic prescribing solution is used frequently to help manage patients with complex medication problems. We have now begun to investigate the utility of using the MOXXI system to improve management of asthma in the primary care setting. If a decision support system targeted at improving chronic disease management is to be effective, it must be used often. In addition to traditional clinician user feedback we discovered that the analysis of system audit trails yielded information useful in modeling physicians' behaviours and contributed to improved software design. We have implemented these improvements and await observational data.

Keywords:

electronic prescribing, medical informatics applications, computer assisted decision-making, disease management

Introduction

Clinical software that is well designed and integrated into the clinical workflow along with providing relevant recommendations has the best chance of being frequently used. The Medical Office of the XXIst century (MOXXI) project is an electronic prescribing solution that was developed for use by primary care physicians in community-based practice. In previous work [1] we showed that this system is preferentially used by busy clinicians to manage their complex cases. Our group has now focused on asthma management since it is a chronic condition with substantial morbidity, involves significant healthcare costs, and has effective therapeutic options that can reduce those costs if disease management is optimized. Our objectives were to determine if computerized decision-support and timely home-monitoring of asthma severity that are integrated into the MOXXI system can improve asthma management and treatment outcomes for those patients.

Methods

A new custom-designed module was integrated into the MOXXI system to provide recommendations and action plans to optimize care for patients older than 5-years with asthma. Clinical content was based on the Canadian Asthma management guidelines. Information relevant to asthma control were presented and treatment options were directly integrated into the electronic prescription tool. During the iteration of the module design we analyzed the system audit trails and discovered that certain fields or screens were avoided. This information, along with feedback from test physicians resulted in a greatly improved module design that is now deployed among 85 family physicians in Montreal and Quebec City.

Conclusion

Consistent use of information technologies in primary care leads to an opportunity to assist in the optimal management of chronic diseases. We are exploring the utility of using an electronic prescribing solution to improve management of asthma in primary care. Future candidate conditions include: hypertension, diabetes, and cardiovascular diseases. The eventual addition of lab results management to this system would create a 'light' electronic medical record, with perhaps similar impacts on quality of care improvements as hospital-based clinical information systems.

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Tracking Children for the Newborn Hearing Screening in Northern Germany

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Abstract and objective

The Newborn Hearing Screening (NHS) in Schleswig-Holstein (northern Germany) covers about 23,000 newborns a year. In Germany NHS has not yet become "universal" for the state but has voluntary activities in many of its federal countries, predominately based on private sponsorship. In Schleswig-Holstein, a multidisciplinary screening program ("UNHS-SH") was started in December of 2003 involving the departments of pediatric audiology, otolaryngology, pediatrics, obstretrics, social medicine, education, medical informatics, and a quality management group supported by the Schleswig-Holstein-division of the German Medical Association. We aimed to fulfil all claims of the international consensus in regard of screening procedures, quality management, tracking, follow-up, and timing. All of the 28 birth hospitals participate in the screening. In 2005, the mean participation rate was 81.6 %, while seven hospitals reached over 90 %. Lost to follow-up was 1.5% and 16 hard hearing newborns (of the statistically expected 23) were discovered by the UNHS-SH. UNHS-SH shows that an internet tracking with intensive feedback to screeners and parents is a candidate to overcome the potential drawbacks of a voluntary screening.

Keywords:

tracking, newborn hearing screening, hardness of Hearing

Introduction

As a voluntary approach, an Universal Newborn Hearing Screening was started in Schleswig-Holstein (northern Germany) in December 2003 ("UNHS-SH"). The multidisciplinary screening program is arranged in a highly multidisciplinary fashion including the departments of pediatric audiology, otolaryngology, pediatrics, social medicine, or medical informatics. Currently UNHS-SH serves for approximately 23,000 newborns a year in Schleswig-Holstein, further federal countries are joining.

Methods

Healthy newborns are screened bilaterally with a two-step-screening (otoacoustic emissions; OAE) and newborns at risk bilaterally with a one-step-screening (automated auditory brainstem response; AABR). If necessary, an immediate follow-up is performed in the university hospitals (Fig. 1).

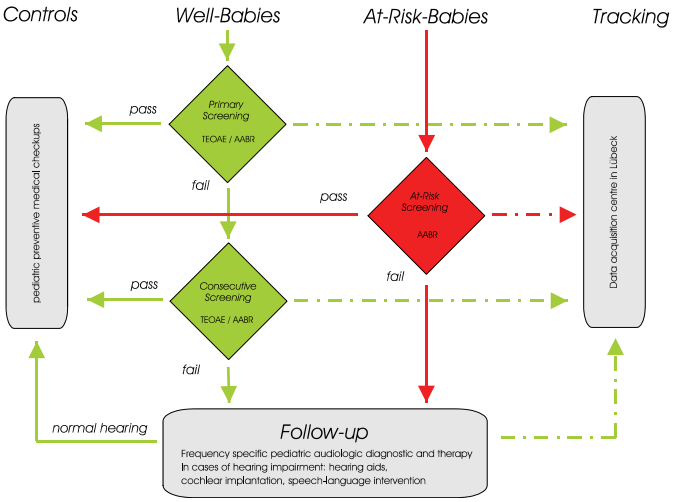

Figure 1 - Timing chart of the UNHS-SH: At-Risk-Babies are obligatory screened using AABR technique. Well-Babies undergo a primary screening (mostly by OAE) and if necessary a consecutive screening.

Results are noted in paediatric development protocol and also send to the data acquisition centre in Lübeck via the internet or email-attachment using special software for data acquisition (Fig. 2).

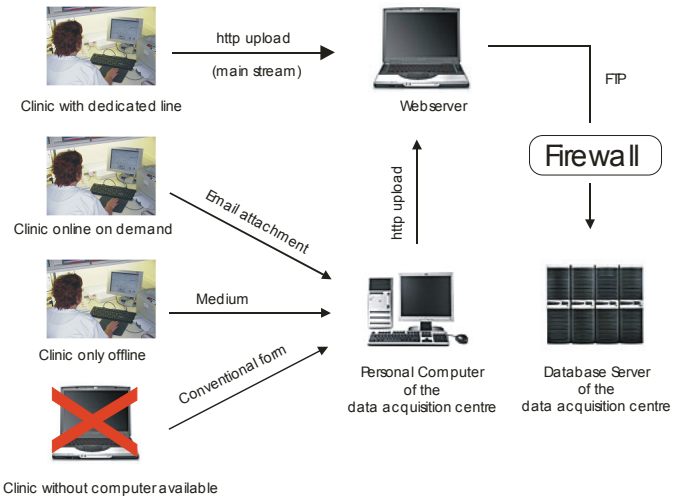

Figure 2 - Data flow of the UNHS-SH: Data are mainly transferred using http upload but some nurses have no access to the internet

Needs for 2nd step screenings or a follow-up are automatically recognized by the software in the data acquisition centre in Lübeck. Parents are then informed by automatically generated letters (up to three times if necessary, afterwards telephone call). If they changed their addresses, local authorities are involved to find them. The tracking software used supports the above mentioned activities by providing to-do lists (Fig. 3).

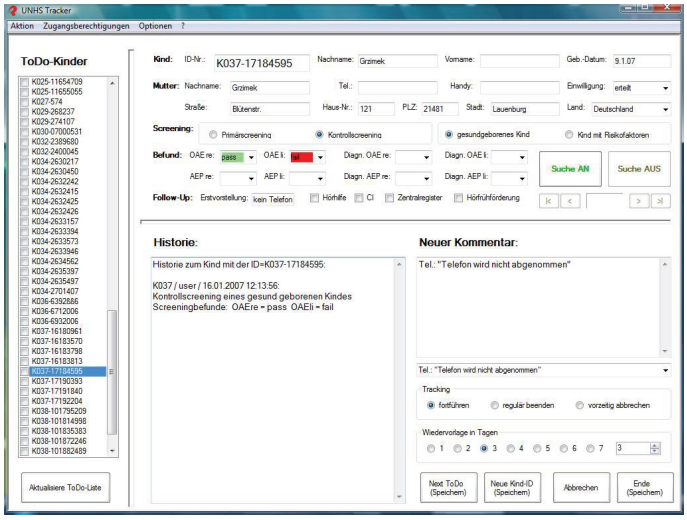

Figure 3 - Screenshot of the tracking software. Picking a child of the to-do list on the left hand side displays all corresponding information like address data or history. Dummy patient

Moreover, the tracking software provides statistics as a feedback to the institutions involved. The statistics comprise rates as demonstrated in Tab. 1.

Rate	Meaning
Acquisition rate	Ratio of registered babies relating to total number of newborns
Screening rate	How many % of the registered babies have been screened in hospital?
Consent rate	How many % of the parents have given their consent for tracking?
Fail rate	How many % of the screened babies have been considered „fail“?

Table 1 - Some of the statistics provided by the tracking software of the UNHS-SH

Results

All of the 28 birth hospitals participate in the screening, while the biggest 25 hospitals participate in the tracking and three smaller ones are prepared to join soon. In 2005, the mean rate was 81.6 %, while seven hospitals reached over 90 %. All hospitals and practitioners are periodically informed about their statistics compared to the other in order to keep their motivation. In case of a rate below 60 %, a mobile service gives an on-site training session. In 2005, lost to follow-up was 1.5 % and 16 hard hearing newborns (of the statistically expected 23) were discovered by the UNHS-SH and fitted with hearing aids beyond the age of nine months (six months desired, of course).

Discussion and conclusion

In Germany, a voluntary screening instead of an obligate is going to be installed nationwide. Thus, acquisition rates and lost-to-follow up rates are problematic issues. The UNHS in northern Germany shows that a far-reaching automatic internet tracking with intensive feedback to screeners and parents is a candidate to overcome the potential drawbacks of a voluntary screening. Thus the UNHS-SH approach might be suited for other countries building up a NHS of their own.

Tracking Children for the Newborn Hearing Screening in Northern Germany

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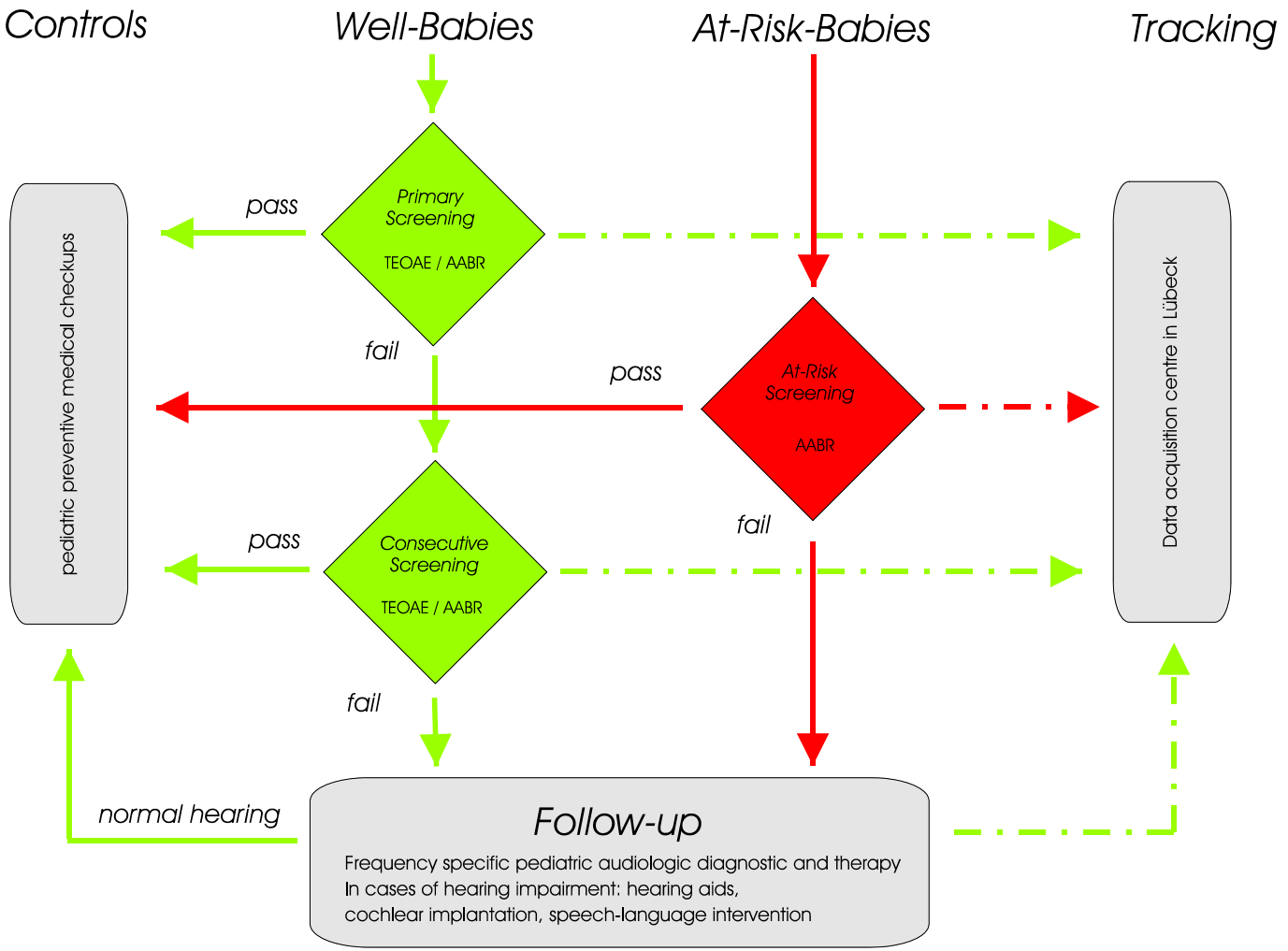
Timing chart of the UNHS-SH



Data Flow of the UNHS-SH

Clinic with dedicated line

http upload

(main stream)

Webserver

FTP

Firewall

Clinic online on demand

Email attachment

http upload

Clinic only offline

Medium

Clinic without computer available

Conventional form

Personal Computer
of the
data acquisition centre

Database Server
of the
data acquisition centre

Software solutions – an overview

Name of program	User	Application
UNHS.exe	clinics, practices	Data acquisition
UNHS-FTP.exe	IT	FTP-transfer from internet server to the intranet server of the tracking center
UNHS-Collector.exe	IT	Decoding and entering of data into an MS ACCESS database of the tracking center
Tracker.exe	Tracking center	Tracking of babies not confirmed as „pass“ on either side. Feedback to clinicis by providing statistics.
Letters.exe	Tracking center	Automatic generation of letters to parents and clinics
CSV-Converter.exe	Tracking center	Conversion of CSV-Dateien into the UNHS data format
UNHS-DBConverter.exe	clinics	Decoding of local data for intern analysis

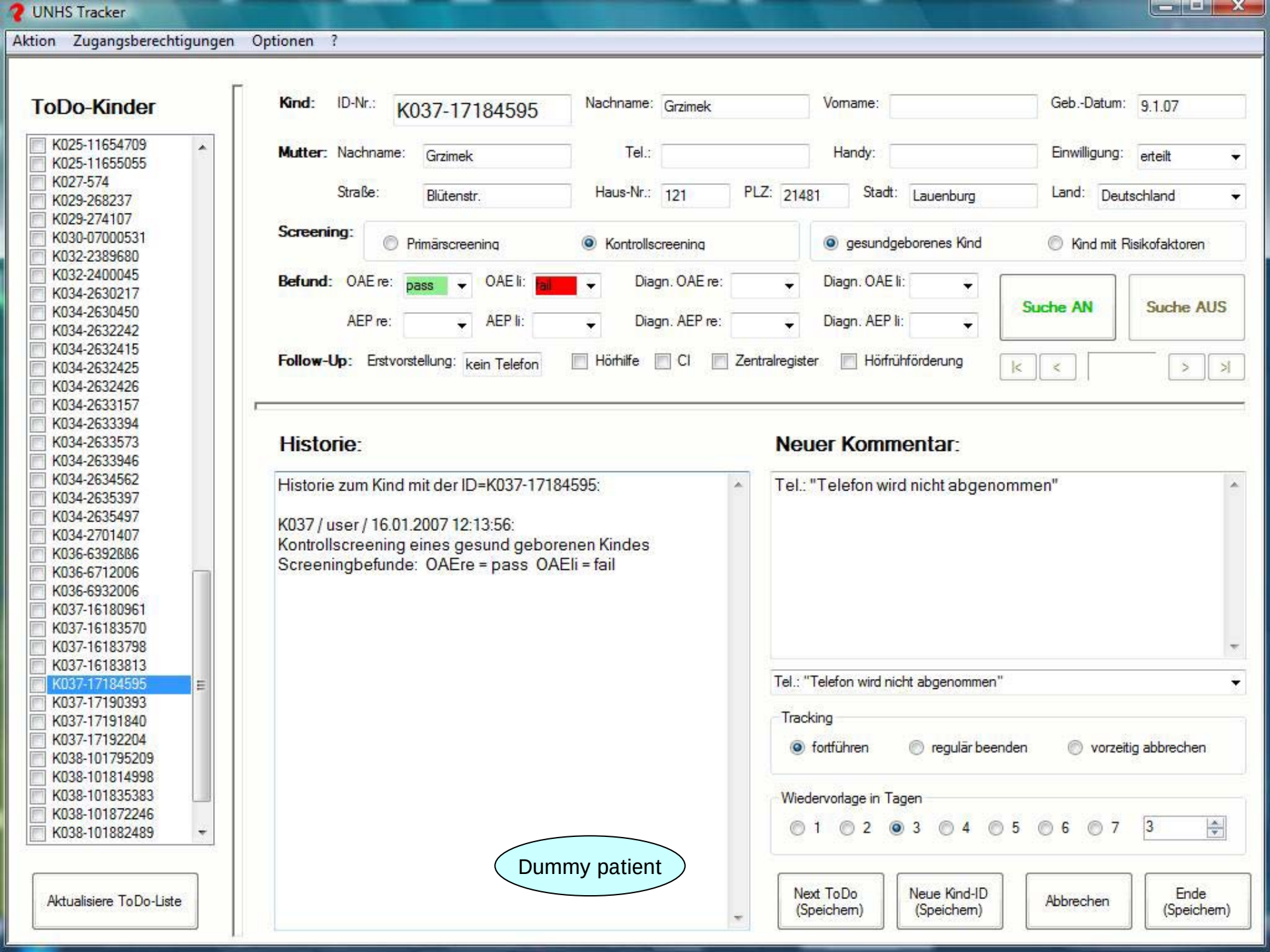
UNHS Tracker

Aktion Zugangsberechtigungen Optionen ?

Benutzername: admin

Kennwort: ********

Anmelden


UNHS Tracker
Aktion
Zugangsberechtigungen
Optionen
?
ToDo-Kinder
K025-11654709
K025-11655055
K027-574
K029-268237
K029-274107
K030-07000531
K032-2389680
K032-2400045
K034-2630217
K034-2630450
K034-2632242
K034-2632415
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K037-16183570
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K037-17184595
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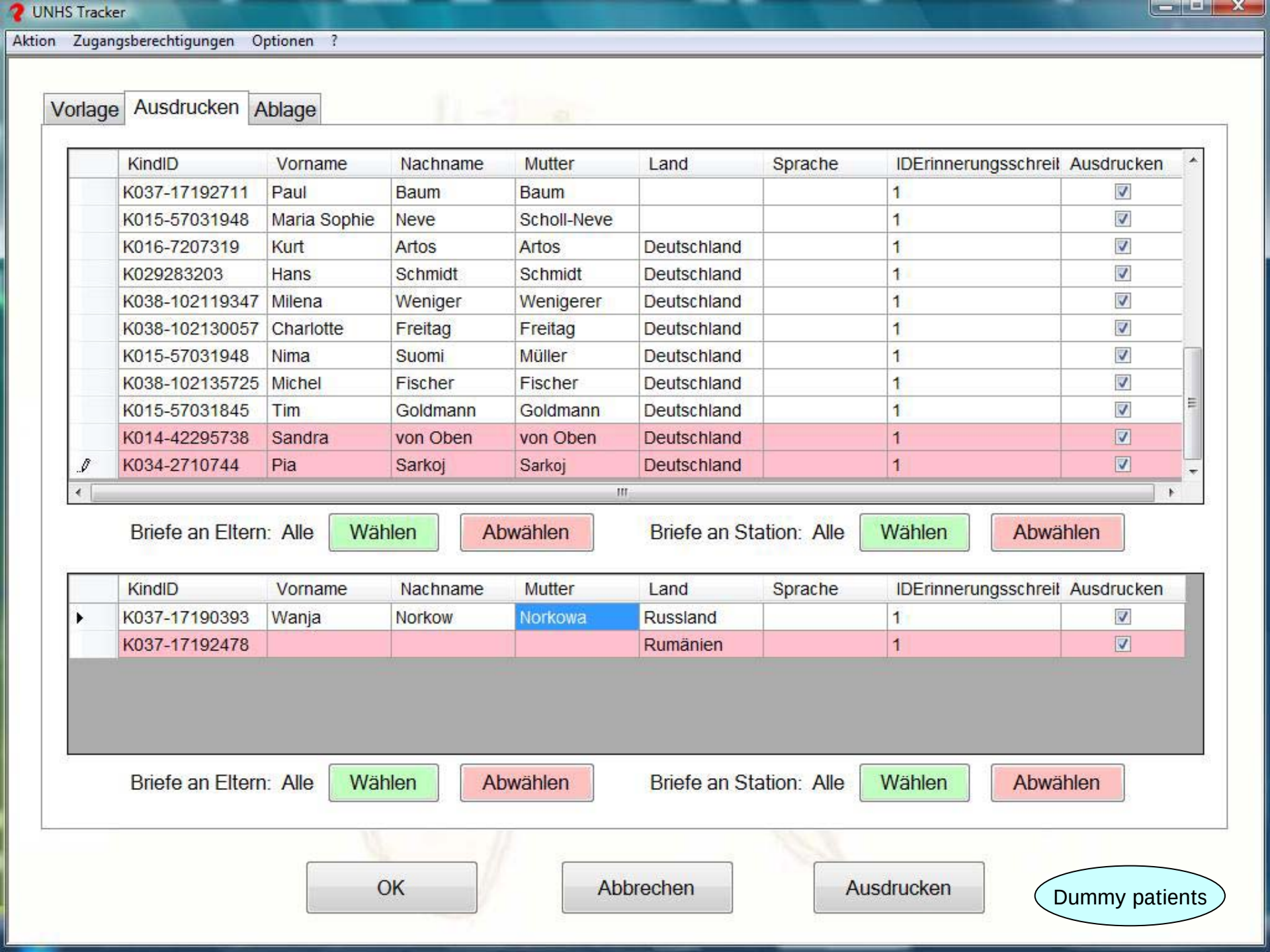
K037-17191840
K037-17192204
K038-101795209
K038-101814998
K038-101835383
K038-101872246
K038-101882489
Aktualisiere ToDo-Liste
Kind:
ID-Nr.:
K037-17184595
Nachname:
Grzimek
Vorname:
Geb.-Datum:
9.1.07
Mutter:
Nachname:
Grzimek
Tel.:
Handy:
Einwilligung:
erteilt
Straße:
Blütenstr.
Haus-Nr.:
121
PLZ:
21481
Stadt:
Lauenburg
Land:
Deutschland
Screening:
Primärscreening
Kontrollscreening
gesundgeborenes Kind
Kind mit Risikofaktoren
Befund:
OAE re:
pass
OAE li:
fail
Diagn. OAE re:
Diagn. OAE li:
AEP re:
AEP li:
Diagn. AEP re:
Diagn. AEP li:
Suche AN
Suche AUS
Follow-Up:
Erstvorstellung:
kein Telefon
Hörhilfe
CI
Zentralregister
Hörfrühförderung
Historie:
Historie zum Kind mit der ID=K037-17184595:
K037 / user / 16.01.2007 12:13:56:
Kontrollscreening eines gesund geborenen Kindes
Screeningbefunde: OAEre = pass OAEli = fail
Dummy patient
Neuer Kommentar:
Tel.: "Telefon wird nicht abgenommen"
Tel.: "Telefon wird nicht abgenommen"
Tracking
fortführen
regulär beenden
vorzeitig abbrechen
Wiedervorlage in Tagen
1
2
3
4
5
6
7
3
Next ToDo (Speichern)
Neue Kind-ID (Speichern)
Abbrechen
Ende (Speichern)


UNHS Tracker
Aktion Zugangsberechtigungen Optionen ?
Vorlage Ausdrucken Ablage
KindID Vorname Nachname Mutter Land Sprache IDErinnerungsschreil Ausdrucken
K037-17192711 Paul Baum Baum 1
K015-57031948 Maria Sophie Neve Scholl-Neve 1
K016-7207319 Kurt Artos Artos Deutschland 1
K029283203 Hans Schmidt Schmidt Deutschland 1
K038-102119347 Milena Weniger Wenigerer Deutschland 1
K038-102130057 Charlotte Freitag Freitag Deutschland 1
K015-57031948 Nima Suomi Müller Deutschland 1
K038-102135725 Michel Fischer Fischer Deutschland 1
K015-57031845 Tim Goldmann Goldmann Deutschland 1
K014-42295738 Sandra von Oben von Oben Deutschland 1
K034-2710744 Pia Sarkoj Sarkoj Deutschland 1
Briefe an Eltern: Alle Wählen Abwählen
Briefe an Station: Alle Wählen Abwählen
KindID Vorname Nachname Mutter Land Sprache IDErinnerungsschreil Ausdrucken
K037-17190393 Wanja Norkow Norkowa Russland 1
K037-17192478 Rumänien 1
Briefe an Eltern: Alle Wählen Abwählen
Briefe an Station: Alle Wählen Abwählen
OK
Abbrechen
Ausdrucken
Dummy patients

UNHS Tracker

Aktion Zugangsberechtigungen Optionen ?

Statistiken

betrachten

erstellen

Quartal: 2005 / Q2

Alle Alle

K001	P032	K001	P032
K003		K003	
K011		K011	
K012		K012	
K013		K013	
K014		K014	
K015		K015	

Zurück zur Statistikauswahl

Statistiken schließen

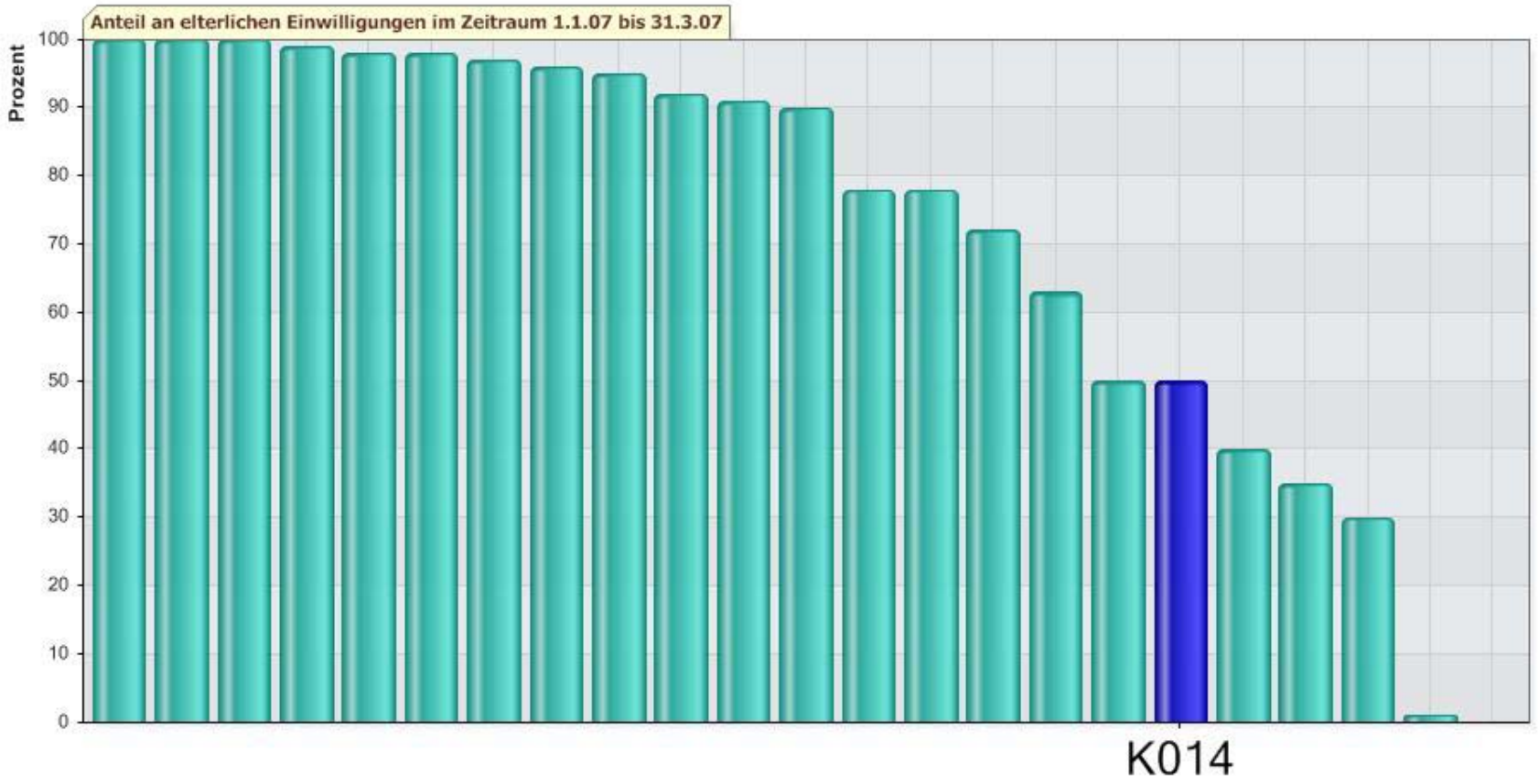
What statistics will be provided?

The subsequent statistics are provided as well in an **across-the-clinics** manner as well as in a **clinic-specific** form each spanning four quarters:

Acquisition rate:	Ratio of registered babies relating to total number of newborns
Screening rate:	How many % of the registered babies have been screened in hospital?
Consent rate:	How many % of the parents have given their consent for tracking?
Fail rate:	How many % of the screened babies have been considered „fail“?

UNHS Tracker

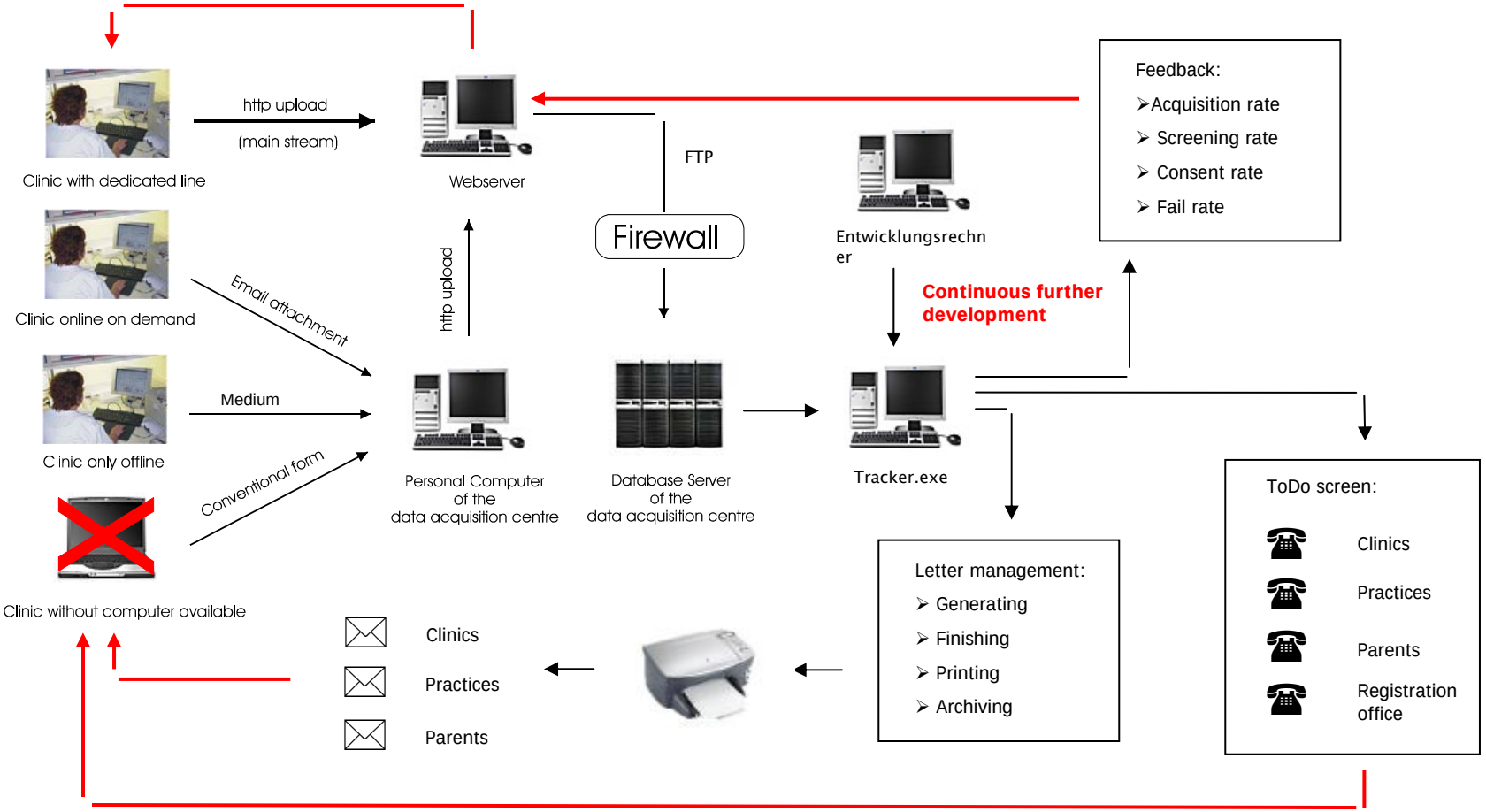
Aktion Zugangsberechtigungen Optionen ?



Zurück zur Statistikauswahl

Statistiken schließen

Feedback loops



The end

Thank you very much
for your attention!

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UI Improvement Plan by Analyzing User Requirements at NICU for OCS in Korea - Focused on Laboratory Information System at Asan Medical Center in Seoul

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Abstract and objective

This study examines a way to improve UI by analyzing on-the-spot user's requirements, By making surveys and interviews with medical staffs at NICU and by my personal experience learned from using the Laboratory Information System while working at NICU for A general hospital Asan Medical Center in Korea. This study analyzes user's requirements on Laboratory Information System and seeks to improve UI of Laboratory Information System. Accordingly, this study aims for the current NICU users to perform NICU businesses easy and convenient, by redesigning display screen and procedure on Laboratory Information System of OCS. In addition, this study will further help achieve improvements of work environments for medical staffs and improvements of OCS efficiency.

Keywords:

OCS, user interface, LIS, NICU

Methods

User interface (UI) improvement plan is made reflecting user's requirements at NICU in a hospital, centered on Laboratory information system, in designing the actual display screen of OCS. This study examines a way to improve UI by analyzing on-the-spot user's requirements, By making surveys and interviews with medical staffs at NICU and by my personal experience learned from using the Laboratory Information System while working at NICU for A general hospital Asan Medical Center in Korea.

Results

This study re-composed a next generation OCS User Interface plan based on NICU (Neonatal Intensive Care Unit) User' s requirements From investigation results analysis on Laboratory Information System and improved User Interface of Laboratory Information System

Conclusion

Laboratory Information System from Order Communication System (OCS) is a computer system that is built for laboratory information processing. Laboratory Information System exists as a sub system of hospital information system or exists as an independent system. However, although it exists under the sub system of hospital information system, it has a high rate of use and has the largest volume of information in a hospital, except for image information.

However, according to the previous studies, database construction and studies on OCS medication information are done and made, But database construction and studies on Laboratory Information System are rare. In fact, Laboratory Information System is built based on clinical pathologic tests. However, it is believed that necessary measures need to be taken to reduce nurse's jobs according to doctor's order from a variety of actual clinical tests such as cranial nerve center test, radiation test, digestive organ center test, cardiac center test, nuclear medicine test, and respirator lab test.

This study analyzes user's requirements on Laboratory Information System and seeks to improve UI of Laboratory Information System. Accordingly, this study aims for the current NICU users to perform NICU businesses easy and convenient, by redesigning display screen and procedure on Laboratory Information System of OCS. In addition, this study will further help achieve improvements of work environments for medical staffs and improvements of OCS efficiency.

Acknowledgement

This research was supported by the Seoul R&BD Program (10608), Korea

UI Improvement Plan by Analyzing User Requirements at NICU for OCS in Korea - Focused on Laboratory Information System at Asan Medical Center in Seoul-

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Abstract

This study examines a way to improve UI by analyzing on-the-spot user's requirements, By making surveys and interviews with medical staffs at NICU and by my personal experience learned from using the Laboratory Information System while working at NICU for A general hospital Asan Medical Center in Korea.

This study analyzes user's requirements on Laboratory Information System and seeks to improve UI of Laboratory Information System. Accordingly, this study aims for the current NICU users to perform NICU businesses easy and convenient, by redesigning display screen and procedure on Laboratory Information System of OCS.

In addition, this study will further help achieve improvements of work environments for medical staffs and improvements of OCS efficiency.

Keywords[1]: OCS, User Interface, LIS, NICU

Introduction - (1)

Laboratory Information System from Order Communication System (OCS) is a computer system that is built for laboratory information processing.

Laboratory Information System exists as a sub system of hospital information system or exists as an independent system.

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Introduction – (2)

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In fact, Laboratory Information System is built based on clinical pathologic tests. However, it is believed that necessary measures need to be taken to reduce nurse's jobs according to doctor's order from a variety of actual clinical tests such as cranial nerve center test, radiation test, digestive organ center test, cardiac center test, nuclear medicine test, and respirator lab test.

Methods

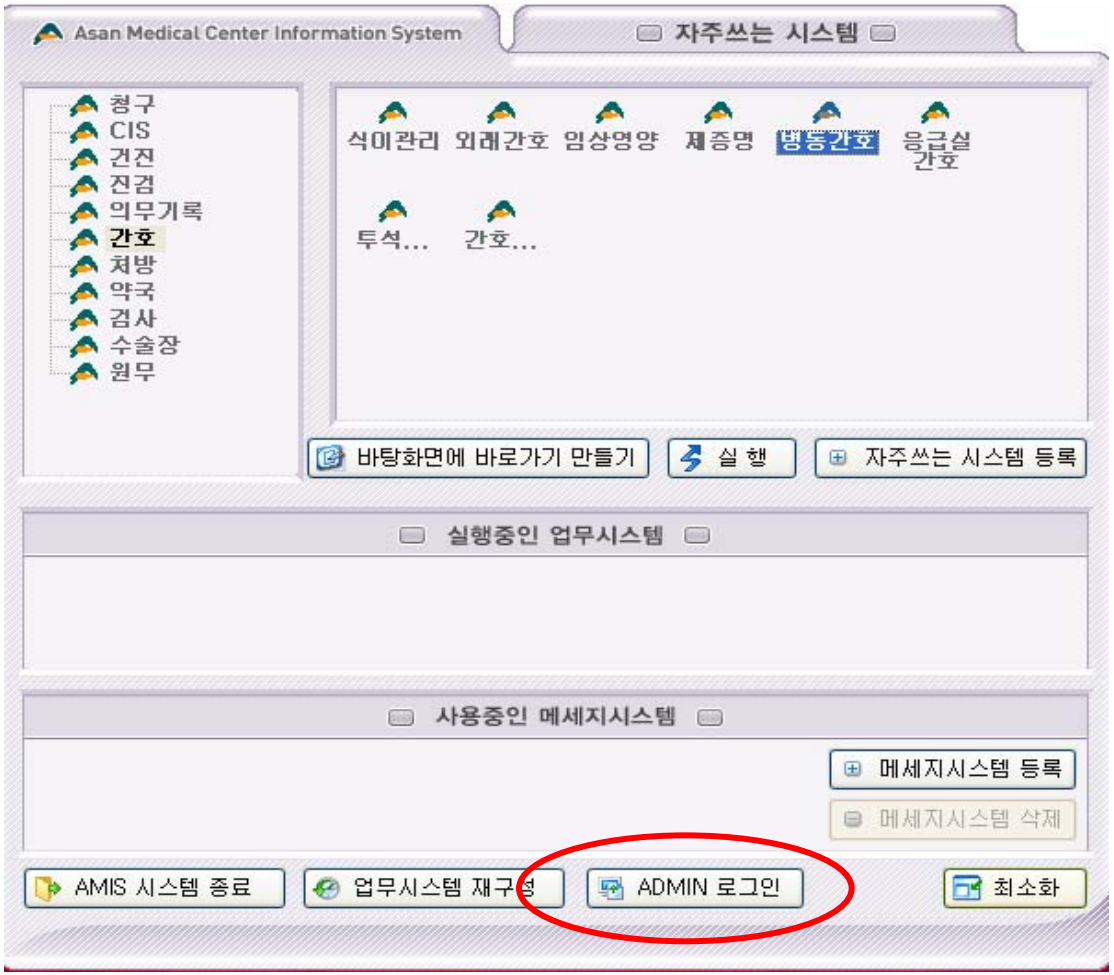
User Interface (UI) improvement plan is made reflecting user's requirements at NICU in a hospital, centered on Laboratory information system, in designing the actual display screen of OCS.

This study examines a way to improve UI by analyzing on-the-spot user's requirements, By making surveys and interviews with medical staffs at NICU and by my personal experience learned from using the Laboratory Information System while working at NICU for A general hospital Asan Medical Center in Korea.

Results - (1)

This study re-composed a next generation OCS User Interface plan based on NICU (Neonatal Intensive Care Unit) User' s requirements From investigation results analysis on Laboratory Information System and improved User Interface of Laboratory Information System

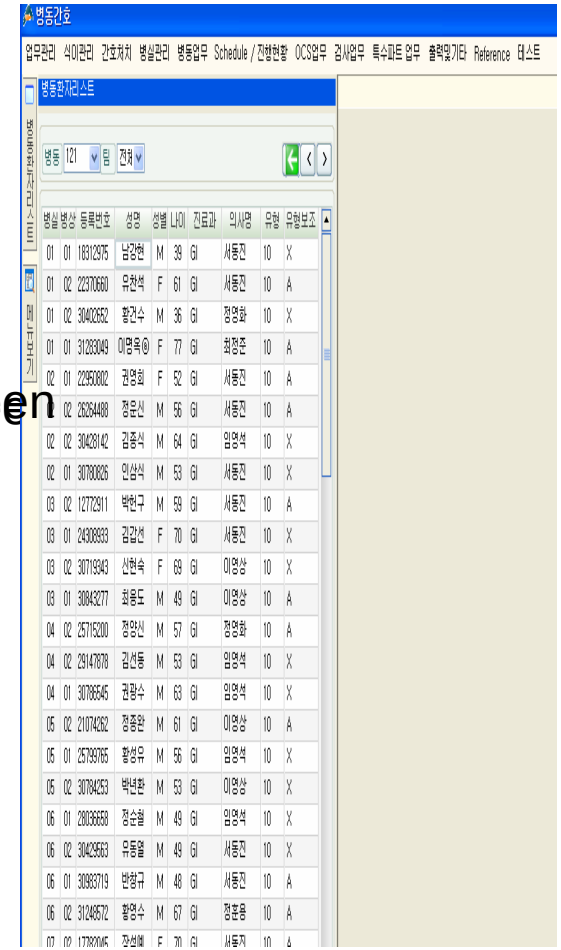
Results - (2)



The next generation OCS program which is 2005 May opened project of the Seoul subject matter A general hospital the user to existing login did in multi branch program and it did information confirmation, but from next generation OCS all programs at one login to integrate the screen which it does at one and to the program which the user in that writes frequently and [to seem system registration which it writes frequently] to register only necessary program in order to come, it planned.

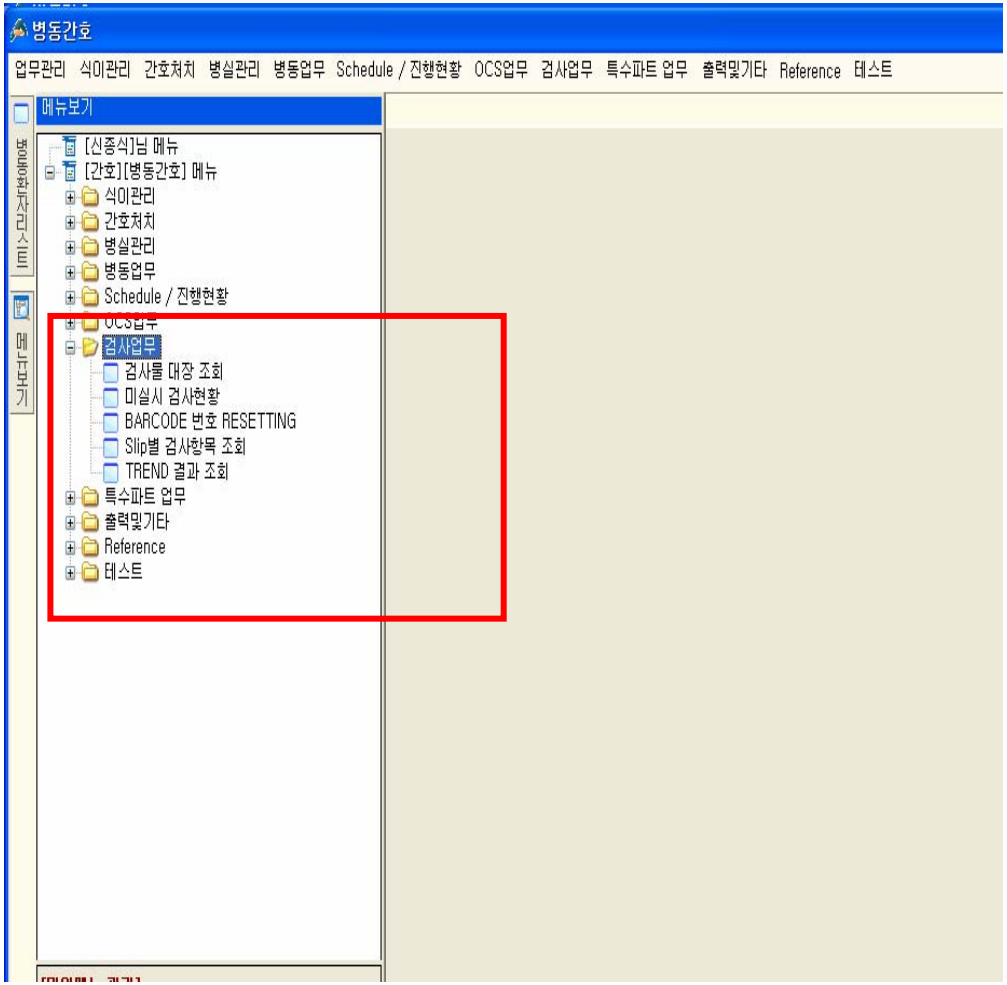
Results - (3)

Click the screen magnification



From the interface position of User Interface the ward patient list comes to seem has the Sub menu from existing OCS program to do, it is not and to do it is inconvenient, from next generation OCS in the left side the ward patient list is fixed in Tab height type and menu and click it appears and to do it disappears. When click it does and the patient list is expanded and there is a possibility of seeing information which is detailed against the patient. From program of existing registration number of the hazard patient who sees different information tie Ping there is a day when it does by the hand but it means like that day will lose from next generation OCS program.

Results - (4)

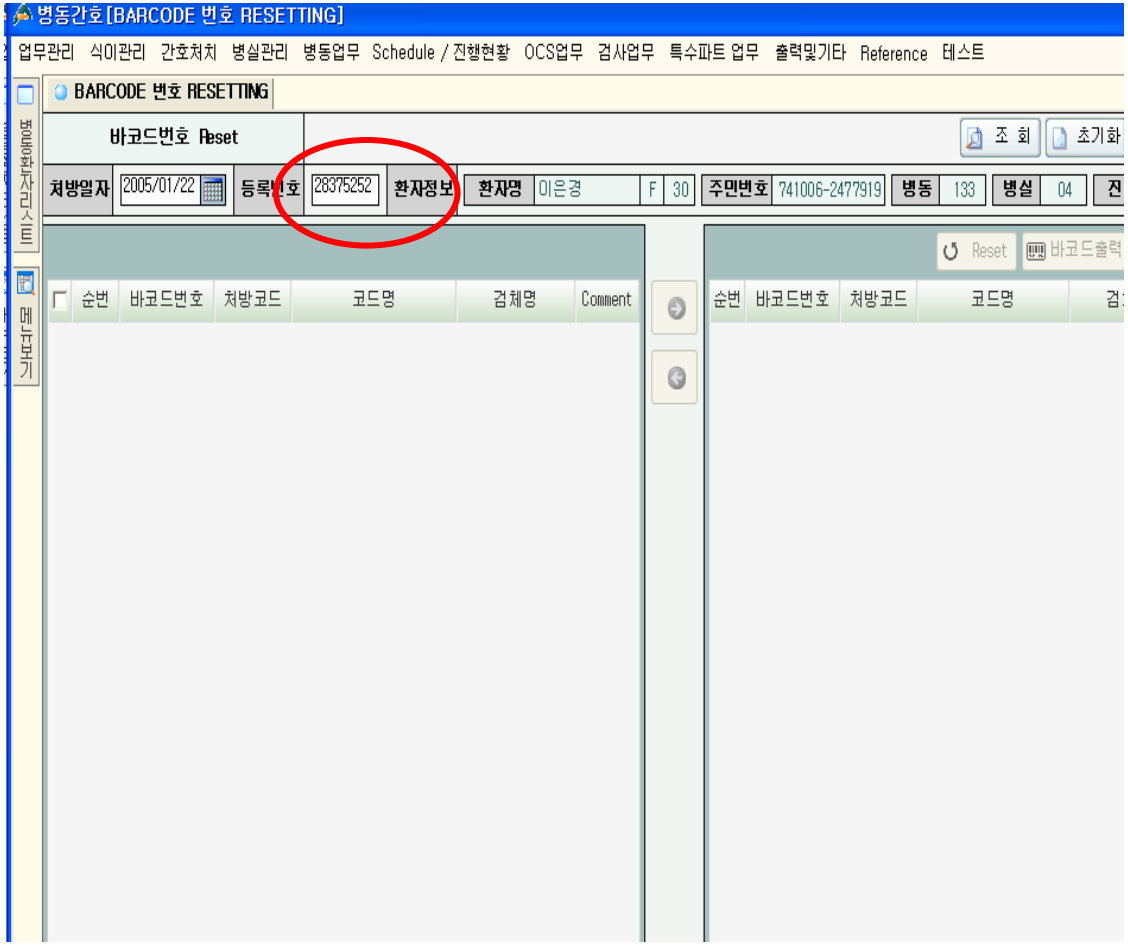


It considers that interface of User, the menu of Tab type it sees in that interface concept and the left side of User of width portion, it established, design it did that interface of User of length concept. User it will be able to select the interface which is convenient from that position in order, the menu which menu control chart oneself to do writes plentifully selection it will be able to manage in order.

Results - (5)

From laboratory Information System at the diagnosis test is named frequently with the L30, L32 , the possibility of seeing all items from more in order to be, Slip test item inquiry it planned the screen

Results - (6)



With program of existing differently by the hand tie Ping or it copied a patient registration number from the different place and it attached and a patient license number without and rightly percentage necessity ward patient list after click it had the possibility of coming in order to be, it planned.

Discussion and Conclusion

This study analyzes user's requirements on Laboratory Information System and seeks to improve UI of Laboratory Information System. Accordingly, this study aims for the current NICU users to perform NICU businesses easy and convenient, by redesigning display screen and procedure on Laboratory Information System of OCS. In addition, this study will further help achieve improvements of work environments for medical staffs and improvements of OCS efficiency.

Acknowledgement

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Open Source Patient Data Management System for Intensive Care

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Abstract and objective

In Intensive Care Units, the amount of data to be processed for patients care, the turn over of the patients, the necessity for reliability and for review processes indicate the use of Patient Data Management System (PDMS). To respond to the needs of a Surgical Intensive Care Unit, we developed a PDMS based on open source software and components.

The software was designed as a client–server architecture running on the Linux operating system and powered by the PostgreSQl data base system. The client software was developed in C. The application offers the following functions: medical notes captures, observations and treatments, nursing charts with administration of medications and scoring systems functionalities. The PDMS was used to care more than two thousands patients with the expected reliability and functionalities.

Key words:

database management system, software, intensive care

Introduction

Patient Data Management Systems are mandatory in Intensive Care Unit in response to the amount of data to be processed, the turn over of the patients and the necessity for reliability and review processes. Open Source Software (OSS) by publishing source code allows sharing of software resources and experience. To respond to the needs of our unit and benefit of resources from OSS we developed a PDMS based on open source software and components.

Methods

The software was designed as a client-server architecture running on the Linux operating system (SUSE Linux Enterprise Server 8.0). It uses the PostgreSQL relational database (v 7.2). The client software was developed in C using the GTK interface library. Remote access from remote PCs is implemented by virtual network connections (VNC) : the use of VNC servers on linux servers and VNC viewers on Windows PCs.

The hardware consists in two Intel x86 servers with uninterrupted power supply, one master and one slave to assure the integrity of the database by replication, 14 medical grade panel PCs (Advantek PPC-153m) connected via RS232 medical bus to the patient's monitoring devices and to the servers via dedicated local Intranet network. The master server runs the postgreSQL database, the client-software and the VNC servers. The slave server is used for replication of the database by drdb (Distributed Replicated Block Device). The 14 medical grade panel PCs run the client software at the bedsides and acquire data from the monitoring devices.

The software, developed in C on the Linux platform, offers the following functions:

1. Medical notes captures with patient's history, observations and treatments,
2. Nursing charts for vital signs, IN-OUT balance, ventilation parameters and settings,
3. Functionalities for administration of medications,
4. Scoring system possibilities for patient's classification. (APACHE II, SAPS II, SOFA scores).
5. Reporting at the end of hospitalization in Intensive Care.

Interoperability between these modules is realized through access to the PostgreSQL database and not the use of local memory in the interface. The software was developed to be open source in all its components and is interfaced with Open Office for reporting..

Results

The PDMS was used in our unit from February 2004 for the care of more than two thousands patients. The system is accessible at every bed through panel PCs and at desks or offices through VNC viewers on windows PCs. Its design allowed an access to the database's functionalities with a high availability level (less than 5 hours of interruption over one year).

The use of open source resources was effective to customize the solution to ICU's request and contributed to the acceptability of the software. The use of the C language permitted to obtain small response times but limits the portability of the system and complicated the debugging process in this critical environment. For that reason, Valgrind software was used to systematically track runtimes errors. As pointed before, the system was well accepted locally, but was harder to interface with the information system of the hospital. The PostgreSQL data base largely

contributed to the overall efficacy and robustness of the system.

Discussion

We developed the present software to respond to the needs of our surgical unit, with the hope that this will enhance quality in our unit. In a review of Clinical Informatics in Critical Care, G. Daniel Martich describes several reasons to implement information system in intensive care.[1] The first one is that information systems could reduce medical errors and first of all medications errors. The second reason is that information overload is present at point of care in intensive care units. Clinical informatics at the bedside can help to better manage this load. Other reasons are described like necessity to achieve and assess compliance to guidelines and accreditation rules.

We decided to base our development work on OSS for tree main reasons, first to benefit of the large OSS library and resources, second to avoid to be locked into proprietary software and third to be able to adapt the software to the manual procedures preexisting in our unit. Economical reasons were also present. These reasons are similar to that described by Douglas Carnal. That author described in 2000 that open collaboration over the internet is changing development methods and that OSS will be a significant part of the Medical Software's Future. [2]

Intensive care environments require systems with high availability. The system described here was able to respond to these requirements by the use of dedicated and duplicated servers and the use of dedicated local network for communication between bedside Panel PCs and servers.

Software development and testing for Intensive Care need to achieve high reliability. The C language used to develop the software is unfortunately not by itself a safe language. For that reason, we systematically tested the software with Valgrind, a suite of simulation based debugging and profiling tools, to track run-time errors. The uses of static analysis of the C code with tools like Splint [3] early in the development process and before compilation, or the use of safer languages like Ada or SparkAda [4] are however a better solutions and are used to develop secure systems.

The lack of module specifically designed to communicate with other medical software and applications is a limitation of the system. Development of a communication module with ProGen/HL7 library (an implementation of HL7 in C++) or with Mirth (implemented in java 1.5) would greatly facilitate the integration of the PDMS with other medical software and the hospital's information system.

Conclusion

PDMS based on open source software components are effective and able to respond to the needs of the ICU environment, with a high availability level. The use of OSS allowed us to customize the software to the preexisting organization of the unit and contributed to the acceptability of the whole system. Better integration in the hospital's information system necessitates development of a module specifically designed to communicate with other medical software and applications.

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Development of Case-based Medication Alerting and Recommender System:A New Approach to Prevention for Medication Error

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Abstract

The purpose of this study was to develop a new alerting and recommender system for preventing medication errors. In recent years, alerting systems have been widely implemented, but because these systems apply a same static threshold for all patients in all cases, they produce excessive alerts and subject physicians to "alert fatigue". We believe that the most commonly-written prescription for a patient's status is the safest one. From this standpoint, we developed a real-time case-based medication alerting and recommender system linked to a database of past prescriptions. When a physician issues his or her prescription, our system dynamically compares it with past ones for similar patients in the database. An analysis of the 10 most frequently-used drugs in the University of Tokyo Hospital revealed that our system reduced the number of false alerts compared to the traditional static alert method. Our system contributes to the creation of alerts that are appropriate for patients' clinical conditions and based on physicians' empirical discretion.

Keywords:

case-based alerting; decision support systems, clinical; medical order entry systems; medication errors; prescriptions, drug

Background

In recent years, computerized physician order entry (CPOE) systems have been introduced to health care institutions worldwide [1, 2]. In Japan, the use of CPOE systems for medication has become widespread [3], and their implementation rate in hospitals with 500 or more beds was 70% as of 2005 [4]. The use of CPOE system is expected to contribute to efficient health care delivery and reduce physicians' time costs [1, 3, 5].

CPOE systems also contribute to improvements in health care quality, particularly in regard to safety [6–8]. To decrease errors in medical treatments, several systems with real-time data input checks have been developed, for example, to detect inappropriate dosages or drug combinations. In these systems, as soon as a physician clicks the "issue prescription" button, the system compares input data on dose regimen and concomitant drugs to data on dosage limitations and contraindicated drugs stored in a master table file. If the prescription contains inappropriate data, the system displays an alert. Alert systems that use static threshold data stored in a master table file are called *static alert systems.*

Although static alert systems are generally useful, excessive alerts can be produced because the systems check off patient status and treatment policies. Excessive alerts cause physicians to pay less attention to the alerts [9], which then lose their effectiveness. In other words, the few important alerts are overlooked amid a lot of meaningless ones. Peterson et al. described physicians in this situation as being in a state of "alert fatigue" [7, 10]. Particularly in university hospitals, where doctors treat many patients whose cases run counter to standard treatment, the risk of overlooking alerts cannot be ignored.

Physicians need to receive appropriate alerts. In this paper, the term *appropriate alert* refers not to an alert generated based on whether the data match standards determined by drug notes, but rather to an alert generated based on whether the present treatment differs greatly from actual treatment records. Our purpose in this paper is to suggest a new approach for generating appropriate prescription alerts. We believe that most commonly written prescription is the safest one, and we considered past records stored in HIS as the gold standard. From this standpoint, we developed a real-time case-based system that alerts physicians when their prescription deviates from this gold standard.

System design

System structure

The overview of our system is shown in Figure 1. The system consists of existing HIS and a database of past prescription records, as well as an alert engine. MySQL version 5.0 was chosen as the database for our system. All prescription data from the University of Tokyo Hospital (UTH) for 2000 through 2005 were extracted from HIS and stored in the database. For the alert engine, both Perl version 5.8, PHP version 5.1, and Apache version 2.0 were used.

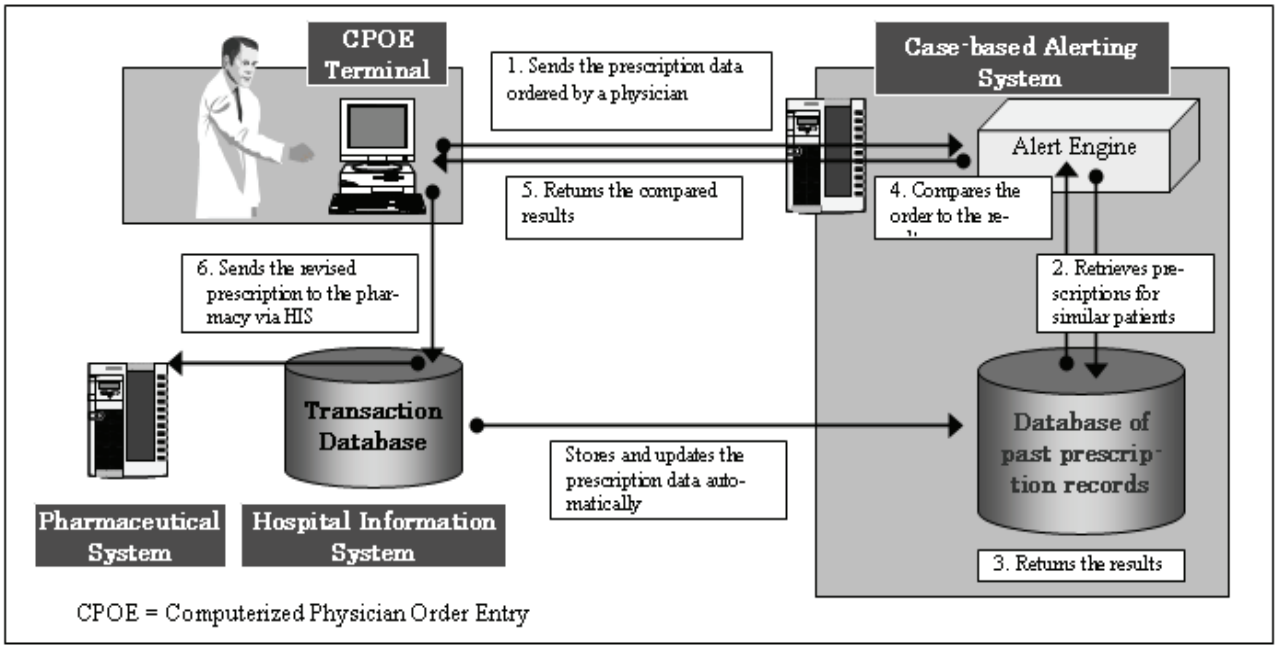

Figure 1- The structure and workflow of the case-based alert system

System feature

Our system has two major functions: alert function and decision support.

Alert function

The alert engine receives the prescription data entered by a physician before sending them to the pharmaceutical system. The alert engine compares these data to the statistical data for that same drug, compiled from past records in the database. If the alert engine finds that the entered data exceed the threshold described below, it sends an on-screen alert to the physician. Figure 2 presents an example of such a prescription alert. At present, the items that can trigger an alert are dosage, dose regimen, duration of drug administration, and concomitant drugs.

Figure 2 - A pop-up alert on the computerized physician's order entry terminal

Statistical data on past prescriptions (such as 95th percentile and standard deviation) serve as the alert threshold. Prescription data in the database are also linked to the patient in question and to his or her diseases. Therefore, the alert thresholds classified according to clinical department (specialty), disease, sex, and age can be also used.

Decision support function

The recommendation function shown in Figure 3 is used when a physician wants to know the appropriate dosage and duration of drug administration. This function pro-

vides the most frequently used value by analyzing a distribution of values of past records. The physician can reexamine his or her prescription with these recommendations in mind. As in the case of the alert function, the recommendation function takes the patient's attributes into consideration.

Interim system evaluation

The final evaluation of our system should be done by physicians who actually use it. The present system, however, is still in the prototype phase. Therefore, we here clarify some interesting aspects of our method by comparing it to traditional static alert systems. We used data on dosage for the evaluation.

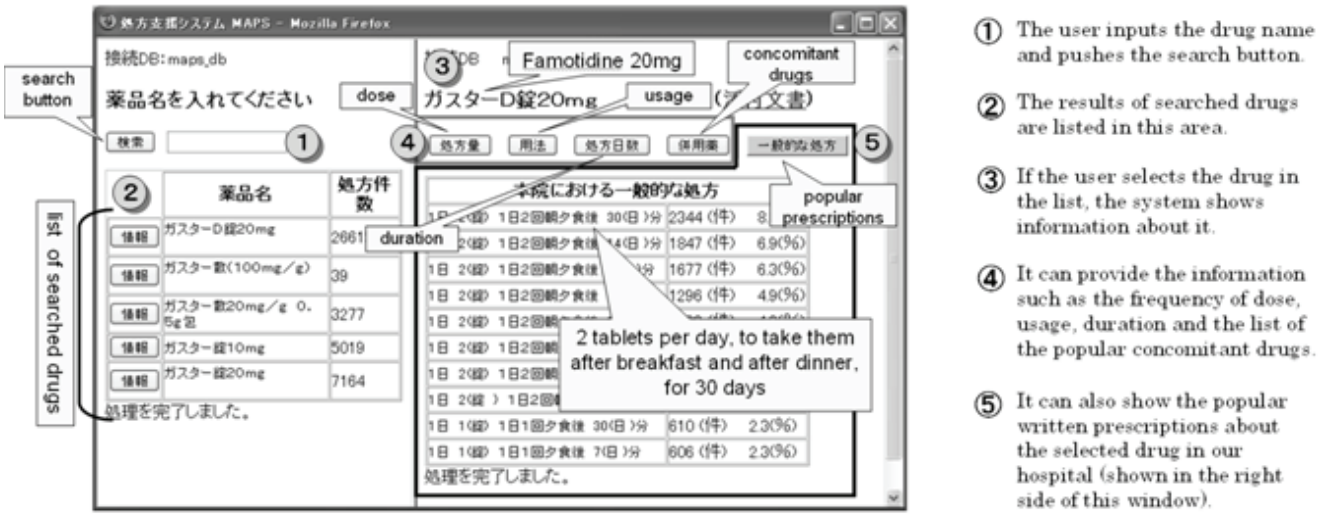

Figure 3 - The window of the recommendation function

Evaluation method

We used the September 2006 the UTH prescription records for the system evaluation. We compared cases using our method to those using information about dosage limitation provided by drug notes. The alert function of our system used two thresholds. One was the 95th percentile threshold of each drug, and the other was the mean + 2. We analyzed the 10 most frequently prescribed drugs at the UTH.

Evaluation results

Results are shown in Table 1. Under both the mean + 2 and the 95th percentile thresholds, we found that the number of alerts declined for nearly one-third of the drugs compared to the existing static alert method. However, because the value of the mean + 2 for prednisolone is lower than the value described in the drug note, the number of alerts increased. The reason is that the range of prescribed dosages of prednisolone is broad (i.e., the maximum prescribed dosage was up to 120 mg, whereas the values of prescribed dosages were concentrated around 5 and 10 mg). Thus, our research showed that our system, based on physicians' empirical discretion, set different thresholds than the existing static alert methods.

Discussion

System evaluation

One advantage of our method is that the number of alerts distinctly decreased from that produced by traditional static alert methods because unlike these traditional methods, our thresholds have upper values (e.g., for drugs with high variance of dosage). Loxoprofen sodium and amlodipine are good examples. In the case of prednisolone and aspirin, the mean + 2 thresholds were lower than those described in the drug notes, which caused the increase in alerts. It is critical to warn physicians when they are about to prescribe drug dosages that they do not often prescribe, even if that dosage is within the normal range described in a drug note. This is another advantage of our case-based method. It is one of our key future tasks to determine which threshold to use: mean + 2 or 95th percentile.

Another advantage of our method is that it can issue alerts differently for each clinical department. Prednisolone, whose dosage varies greatly among departments, is a good example. Applying a threshold across the board as traditional methods do results in the production of unnecessary alerts in certain departments. Our system, however, avoids

this issue by issuing alerts based on department features, and on values such as disease, sex, and age, even for one drug. This ensures that alerts are appropriate for each patient's clinical conditions.

Although our system is in the prototype stage at present, we will start actual operation in 2007 and survey physicians' prescribing behavior and degree of satisfaction.

Availability of case-based approach

Master table maintenance is unnecessary

The traditional method, which keeps static descriptions of dosage limit and contraindicated drugs in master tables, requires a huge amount of work to maintain these tables. Our system, however, requires less maintenance because information on dosage limit and contraindicated drugs is dynamically created using already stored data. In addition, our method keeps up with medical advances. When dose regimens change, our method automatically updates the alert thresholds and consequently can issue alerts based on the current prescription trends.

Oriented to physicians' experiences

Our system promises to clarify various dose regimens in a way that is consistent with physicians' empirical discretion. By using past records, our system can alert physicians to drug combinations not empirically prescribed, even if the drugs are not described in drug notes as being contraindicated. In addition, our system can present information about recommended concomitant drugs, similar to the way interns receive advice from supervisors.

Drug	Total number of orders	Threshold from drug note	# of alerts	$M + 2\sigma$*	# of alerts	95th percentile*	# of alerts
Teprenone	3424	150 mg	14	202.3 mg	0	150 mg	14
Loxoprofen Sodium	2623	180 mg	27	244.8 mg	5	240 mg	5
Brotizolam	2666	0.25 mg	460	0.485 mg	447	0.5 mg	1
Famotidine	2238	40 mg	3	51.2 mg	3	40 mg	3
Prednisolone	2110	60 mg	32	41.9 mg	77	40 mg	77
Rebamipide	2094	300 mg	12	398 mg	12	300 mg	12
Amlodipine	1915	5 mg	392	10.2 mg	2	10 mg	2
Aspirin	1950	300 mg	0	125 mg	24	100 mg	24
Sennoside A·B	1820	48 mg	26	47.2 mg	154	48 mg	26
Mecobalamin	1849	1500 μg	1	1815 μg	1	1500 μg	1

*The system issues an alert when the dosage is greater than this value.

Table 1 - Results of interim evaluation

Possibility of graded alert

Our method provides distributions of various parameters such as dosage and dose period. As a result, our system can present graded alerts, such as 1: attention, 2: warning, and 3: prohibited. Gradings of how extensively prescription data diverge from past records enable the physician to quickly decide whether he or she should heed the message.

Limitations of our system

One limitation of our system is that it does not function well with an insufficient amount of past data. For drugs on which a hospital has few or no past records, it is necessary to combine our method with other existing techniques. Small hospitals that do not have a sufficient number of past records must import prescription data from authorized large-scale hospitals. Using data from other hospitals is equivalent to asking "In your hospital, how is this drug commonly used?"

Future direction

The alert and recommendation function can also be applied to laboratory test and radiological records. We are now considering how to make the system available for other medical practices.

Conclusions

We developed a real-time case-based medication alert system that alerts physicians when a prescription deviates from similar commonly written prescriptions in a database of stored records. We set past records stored in HIS as the gold standard. An analysis of the 10 most frequently prescribed drugs at the UTH revealed that our system reduced the number of unnecessary alerts compared to the traditional static alert method. Our easy-to-maintain system

creates alerts appropriate for patients' clinical conditions and alerts based on physicians' empirical discretion. In addition, it can provide more appropriate alerts than traditional methods, and as a result, will contribute to the prevention of errors in medical treatments.

Acknowledgments

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Developing A Paper-Based Surviving Sepsis Campaign Guidelines Compliance Support and Outcome Predicted System

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Abstract

In 2003, 11 international organizations had a consensus committee created and published an evidence-based guidelines - Surviving Sepsis Campaign (SSC) guidelines- for the management of severe sepsis and septic shock.

Keywords:

sepsis, outcome, artificial neural network, intensive care Uuit, decision support system

Introduction

In 2003, 11 international organizations had a consensus committee created and published an evidence-based guidelines -Surviving Sepsis Campaign (SSC) guidelines- for the management of severe sepsis and septic shock. SSC had provided tools and website to help interested hospital and teams to improve to meet the standard care outlined in the guidelines. Meanwhile the product of computer industry, such like IBM® CDI (clinical decision intelligence) system, had tried to provide different solution. These methods are not fitted to every situation, either cost too much time (to audit whole care procedure) or too much money (to integrate the whole hospital computer system) and they also lacked for outcome (mortality) prediction system. Trying to resolve above problems, we have developed a Surviving Sepsis Campaign Guidelines Compliance Support and Outcome Predicted System especially for an Intensive Care Units (ICU) that has basic bedside monitoring machines but lacked for integrated clinical information system (CIS) and still paper-based working.

Method

A 22 beds surgical ICU, lacking for integrated clinical information system, still uses paper-based method to collect patient data. First step we transformed Surviving Sepsis Campaign guidelines into one-page document. There are checkboxes on this document represented the data we want to collect for helping treating the sepsis patient. This document will be scanned later in our OMR (Optical Mark Recognition) system. In second step we developed OMR system included three primary modules which are "Document Positioning Generator (DPG)", "Guideline Document Recognition Engine (GDRE)", and "Correction and Statistic Tools (CST)". The output of our system is in XML-format which makes the data easily transferable to customize designed SCC guidelines rule engine based decision support system. In the same time, XML-format data would be randomly allocated to either the training or validation set for constructing and validating artificial neural network (ANN) using a back-propagation algorithm which will be used to predict patient's outcome. (Figure 1 demonstrated our system architecture)

Results

Our results can be divided into three parts. First part is about error rate of document recognition. The error rate in preliminary study is 0.19% (1 error in 531 scanned checkboxes), after changing automatic scan documents to scan document one by one, the error rate can be reduced to 0.057%(1 error in 1754 scanned checkboxes). Second part is the raise of the rate that adherence to guideline-based care, from 25% to 54% (immediate adherence rate). The third part is mortality prediction. After collecting enough case number (near 200 cases), the prediction result will gain soon.

For the cost issue, the whole system hardware cost less than 6,000 US dollars. Compared to build integrated clinical information system in studied ICU, it cost more than 600,000 US dollars.

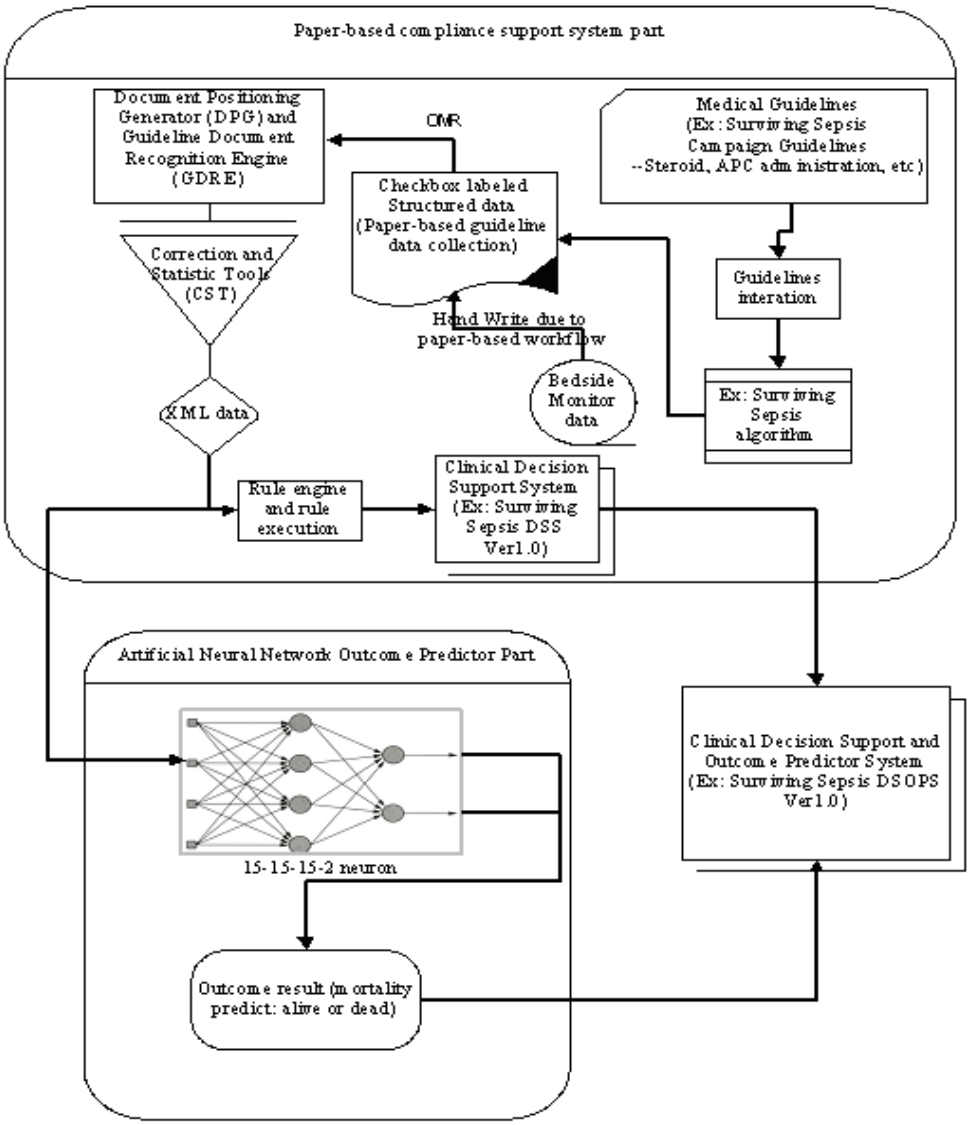

Figure 1 - System architecture

Conclusion

Not only the ICU owning the advanced and integrated CIS could take the advantage of guideline implementation and quality improvement, we proved that using our system has the chance to do the same thing; especially in the ICU that still using paper-based method to collect patient data and the cost of whole system could be minimized.

Developing A Paper-based Surviving Sepsis Campaign Guidelines Compliance Support and Outcome Predicted System

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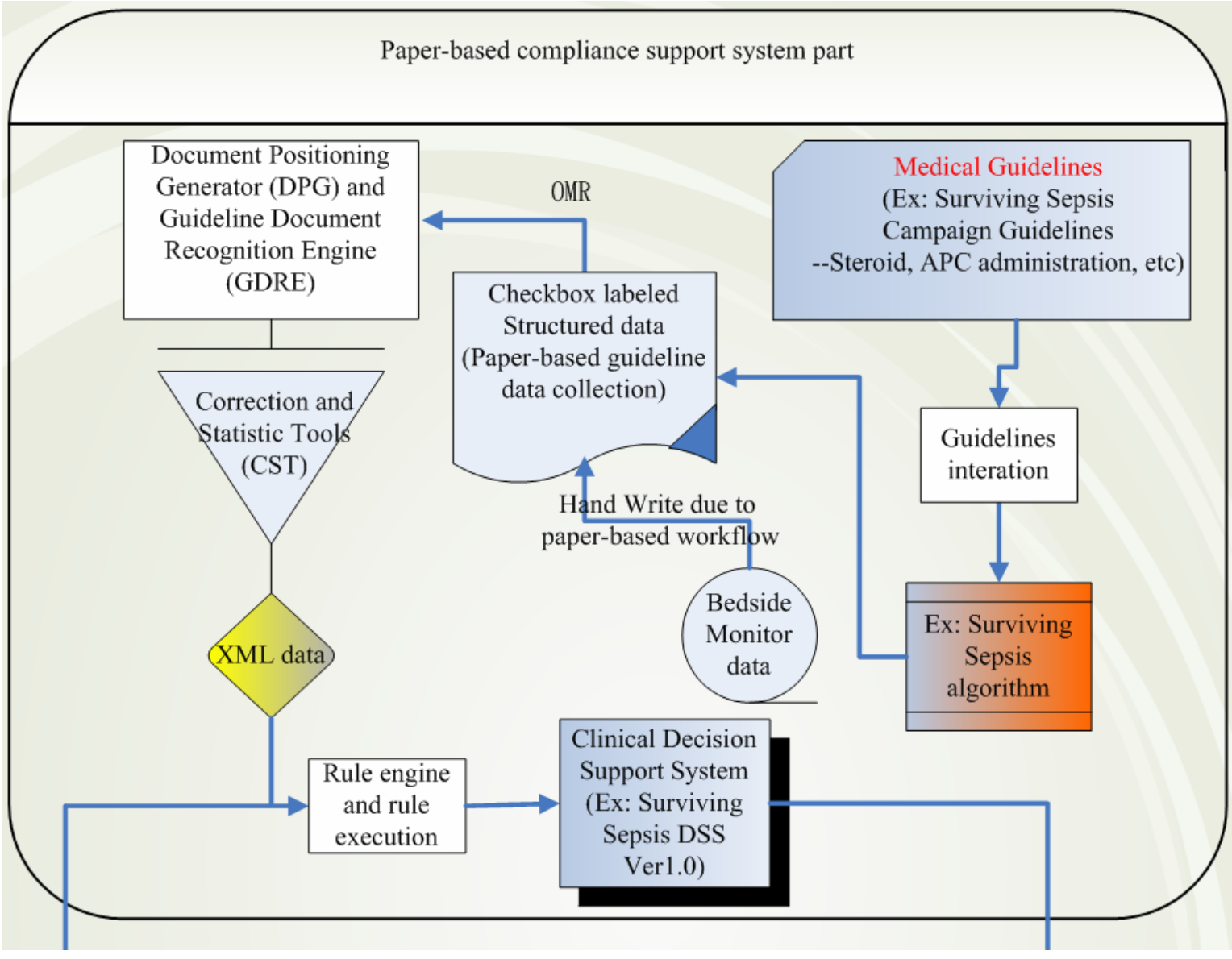
Background (1)

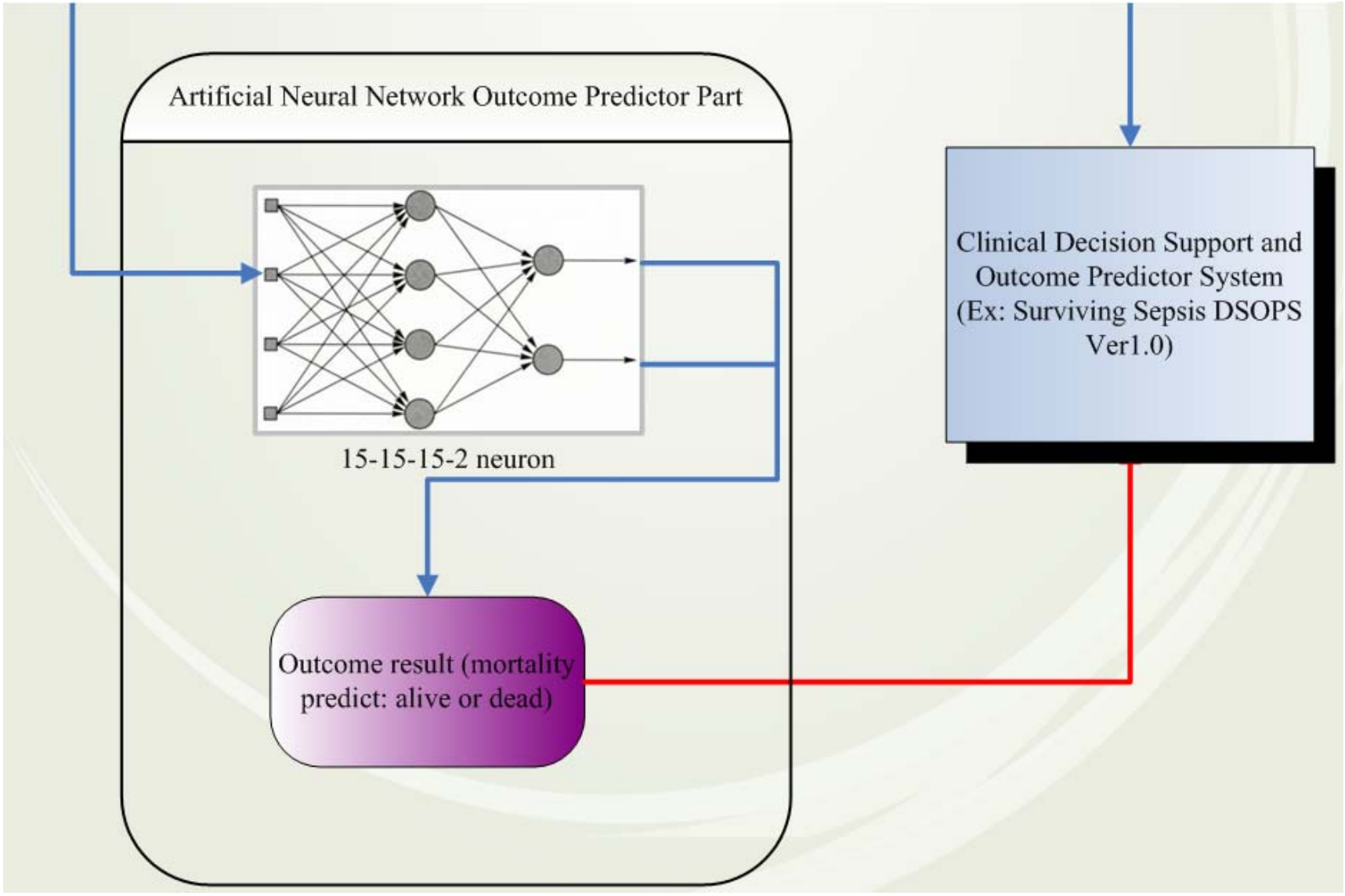
- Severe sepsis mortality rate still high[1]
- 2003 Surviving Sepsis Campaign (SSC) guidelines
- What Clinical Decision Support System (CDS) can do ?[2]

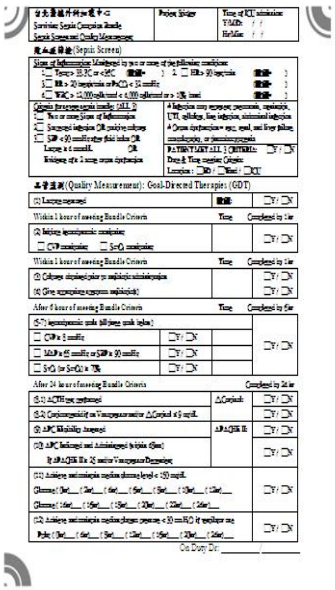
Background (2)

- Computer Industry (such as IBM CDI) try to provide a solution
- Should consider cost effectiveness
- Lack for outcome (mortality) prediction system
- Hard to implement to the organization that still paper-based working

System Architecture[3]




Artificial Neural Network Outcome Predictor Part
15-15-15-2 neuron
Outcome result (mortality predict: alive or dead)
Clinical Decision Support and Outcome Predictor System (Ex: Surviving Sepsis DSOPS Ver1.0)



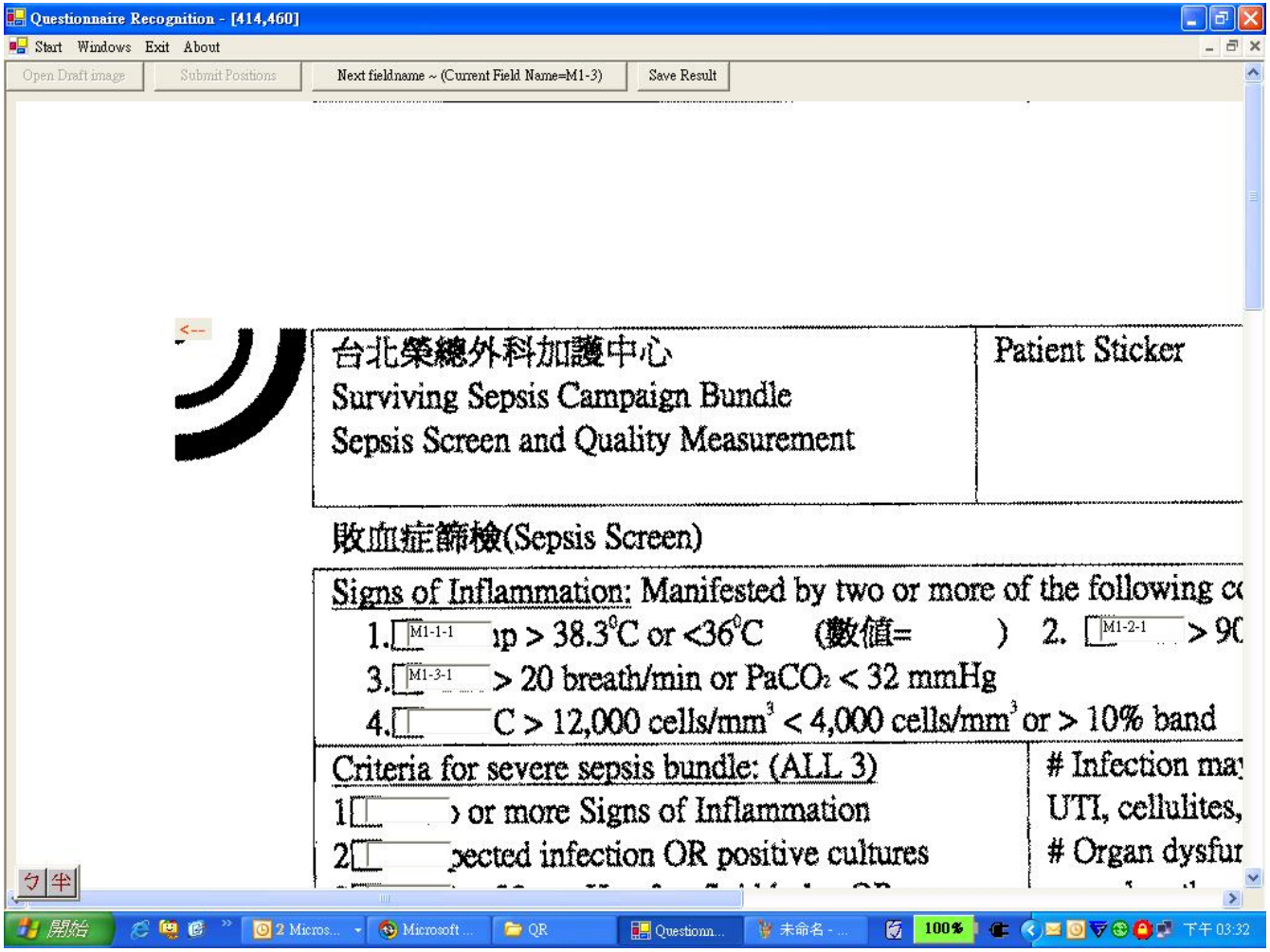
Paper-based guideline data collection

Scanner scan the paper

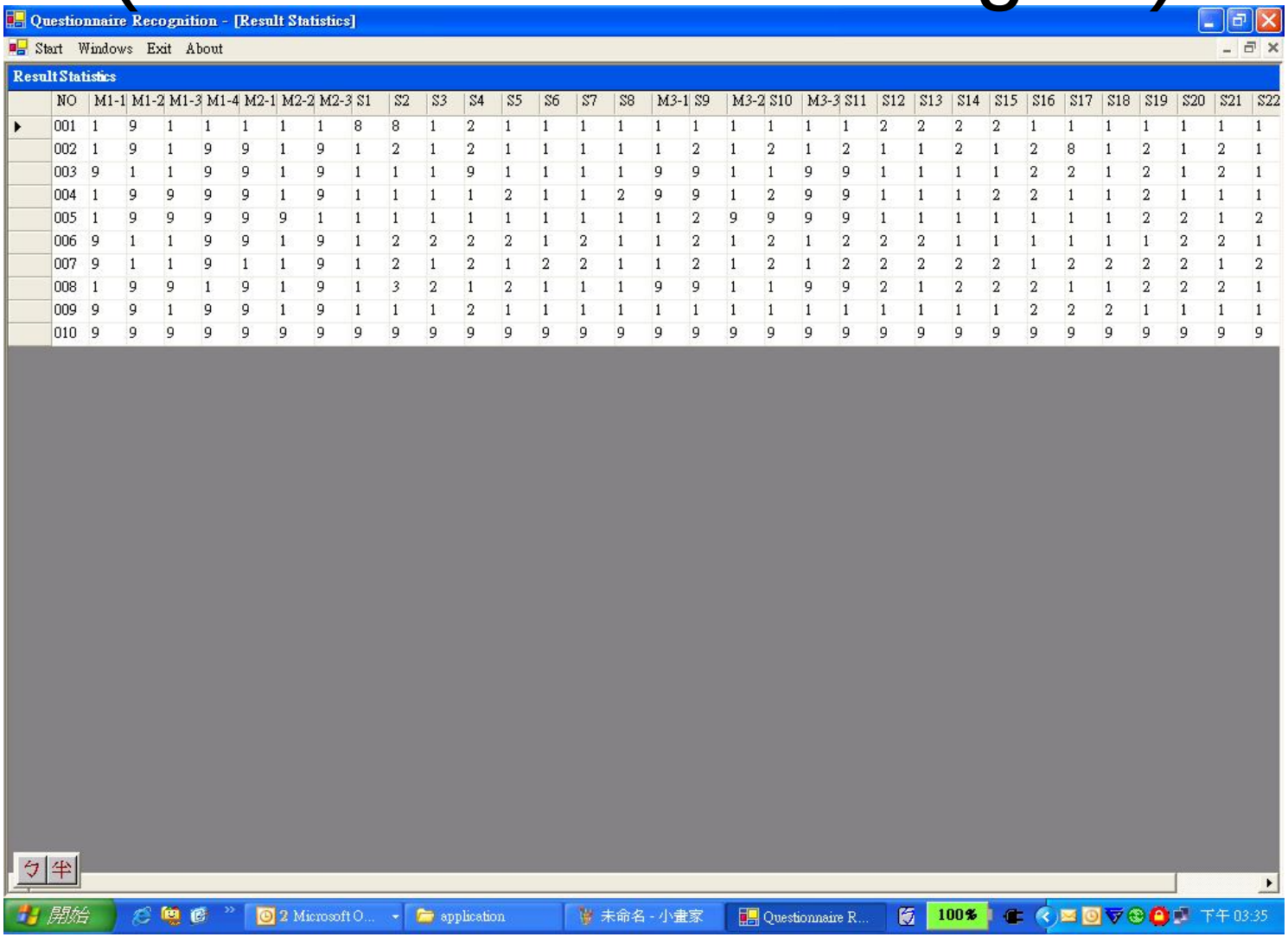
OMR system processing

Software designed for sepsis treatment decision support and ANN

Checkboxes Scanned

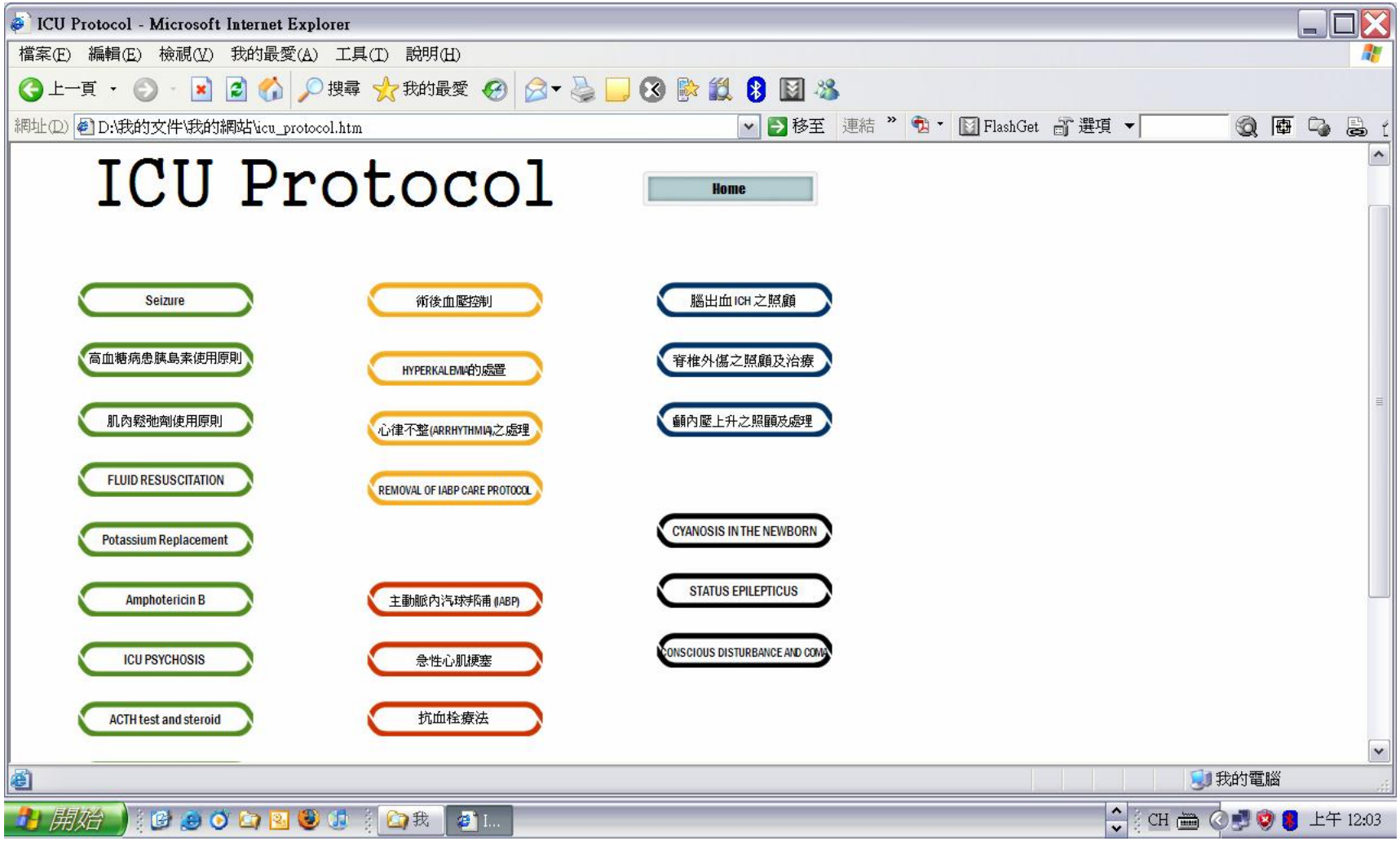


Scanned Results
(XML data for rule engine)



NO	M1-1	M1-2	M1-3	M1-4	M2-1	M2-2	M2-3	S1	S2	S3	S4	S5	S6	S7	S8	M3-1	S9	M3-2	S10	M3-3	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20	S21	S22
001	1	9	1	1	1	1	1	8	8	1	2	1	1	1	1	1	1	1	1	1	1	2	2	2	2	1	1	1	1	1	1	1
002	1	9	1	9	9	1	9	1	2	1	2	1	1	1	1	1	2	1	2	1	2	1	1	2	1	2	8	1	2	1	2	1
003	9	1	1	9	9	1	9	1	1	1	9	1	1	1	1	9	9	1	1	9	9	1	1	1	1	2	2	1	2	1	2	1
004	1	9	9	9	9	1	9	1	1	1	1	2	1	1	2	9	9	1	2	9	9	1	1	1	2	2	1	1	2	1	1	1
005	1	9	9	9	9	9	1	1	1	1	1	1	1	1	1	1	2	9	9	9	9	1	1	1	1	1	1	1	2	2	1	2
006	9	1	1	9	9	1	9	1	2	2	2	2	1	2	1	1	2	1	2	1	2	2	2	1	1	1	1	1	1	2	2	1
007	9	1	1	9	1	1	9	1	2	1	2	1	2	2	1	1	2	1	2	1	2	2	2	2	2	1	2	2	2	2	1	2
008	1	9	9	1	9	1	9	1	3	2	1	2	1	1	1	9	9	1	1	9	9	2	1	2	2	2	1	1	2	2	2	1
009	9	9	1	9	9	1	9	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	1	2	2	2	1	1	1	1
010	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9

Embedded Rule Engine CDS



Results

- Error rate of document recognition: 0.19%
  - If scan document one by one, the error rate can be reduced to 0.057%
- Raise of the rate that adherence to guideline-based care: from 25% to 54%
- Mortality prediction: Need more data collection

Conclusion

- Cost saving : 6,000 us dollars versus 600,000 us dollars to setup CDS
- Organization that still paper-based working can take advantage of this CDS to improve guideline-based care

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Identifying a Rare Mortal Risk Factor Using Full Text Search of an EMR

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Abstract objective

Hippus, a rare physical exam finding, is a prominent, repetitive oscillation of the pupils. Through a full-text search of our electronic medical record, we identified hippus cases and matched controls. Hippus was associated with a 3-fold increase risk of 30-day mortality.

Keywords:

electronic medical records, text searching, clinical research, mortality

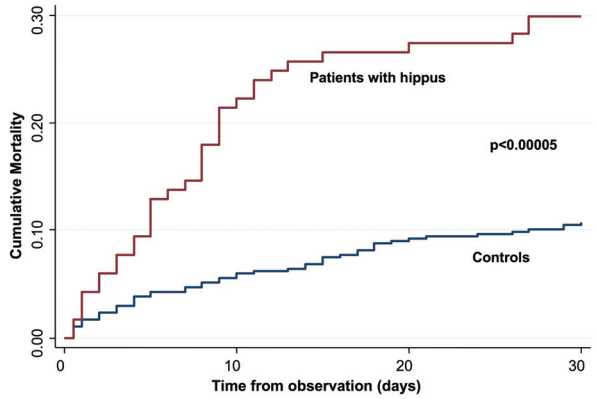

Figure 1 - Cumulative mortality of patients with hippus versus

We conducted a retrospective cohort study of hospitalized patients demonstrating hippus prominent enough to be noted in their electronic medical record (EMR). To identify cases of hippus, we did a full text search of greater than 60 million electronic records representing 1.3 million patients between 1995 and 2005 at one academic medical center. To mitigate observer bias, we used hospital billing records to select four controls for each case: two adjacent admissions by the same attending physician before and after each index case. We compared patients by past medical history, medications, and mental status. Chart abstraction was performed by two physicians, using a concept identifier to assist mapping this free text to standard terms[3]. Cases and controls were assessed for risk and mortality by univariable and multivariable logistic regression and Kaplan-Meier survival analysis.

Results

We found 147 cases of hippus in our search; 117 of these were inpatients. We identified 468 controls. There were no demographic differences between cases and controls. Patients with hippus were more likely to die within 30 days of observation ($p<0.00005$, see Figure). Independent risk factors for death by 30 days were altered mental status (OR 4.11; 95% CI 2.05 – 8.25, $p<0.001$), hippus (OR 2.99; 95% CI 1.46 – 6.11, $p=0.003$), renal disease ($p=0.054$), and cirrhosis ($p=0.029$); angiotensin-system inhibitors were protective ($p=0.012$). The presence of hippus on exam was associated with altered mental status (OR 11.23; 95% CI 6.27 – 20.09, $p<0.001$), a history of trauma (OR 3.76; 95% CI 1.65 – 8.59, $p=0.002$), cirrhosis ($p=0.038$), renal disease ($p=0.051$), and the use of iron ($p=0.016$).

Conclusions

Recognition of hippus in hospitalized patients is a clinically important predictor of early mortality. Hippus is associated with altered mental status, trauma, and cirrhosis. Full-text searching of a comprehensive EMR allowed fast identification of a large cohort demonstrating a rare finding and discovery of new clinical knowledge.

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Artificial Neural Networks to Predict Patient's Length of Stay

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Abstract

Hospitals determine the anticipated length of stay (LOS) based on the national benchmarks data. Those benchmarks are based on admitting diagnosis, Diagnostic Related Groups (DRGs), patients' age, sex, and other comorbidities. Providers are reimbursed based on these LOS calculations, since patients with similar DRGs/LOS are supposed to utilize comparable amount of hospital services. But unfortunately every patient is unique and every hospital is unique and the anticipated length of stay is far from accurate. We used large amount of historical data on our patients, compared the length of stay against their demographics, vital statistics and lab results. We attempted to use artificial neural networks (ANN), as a predictive modeling tool to learn this historical data and predict the length of stay for a new patient. We found that the neural network was able to predict the LOS 95% of the time within one day of error. We believe that ANN can be used to reliably predict the LOS at the time of admission

Keywords:
length of stay, artificial neural networks, prediction model

Introduction

Artificial Neural Network (ANN) is a computer algorithm that is modeled after the brain neural cell network. Scientists believe that humans learn new patterns by association. The human brain constantly looks for patterns in the real world, and associates these patterns with the outcomes. The brain cell network makes changes to the connections to store these patterns. After learning these large number of patterns and outcomes for those patterns, the brain cells will be able to predict an outcome for a pattern that is unique, based on the past experience. Thus an ANN can be trained using a large number of examples, to learn the implicit relationships between the variables that influence an outcome. Thus a trained ANN can be used to predict an outcome based on a set of variables that it has not seen before. We have referenced a few works in the past that have used this technology to predict LOS [1,2.3]. We attempted to use this technology to learn the influence of patients' demographics, vitals signs, and lab results in the total LOS, then use a trained network to predict the LOS based on those influencing factors that are available at the time of admission

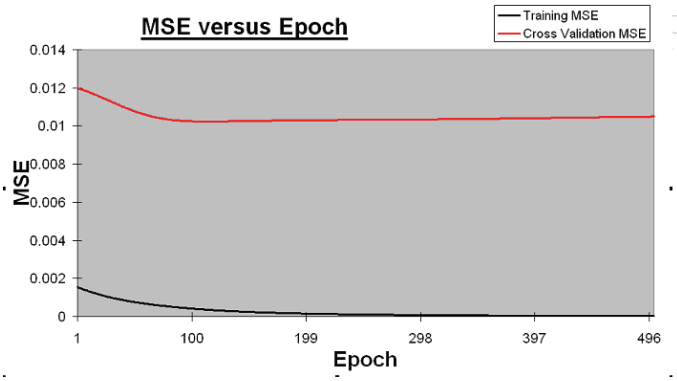
Materials and methods

We gathered the actual LOS data from our own patients, for the past 5 years. We tabulated these patients' demographics, such as age, gender, ethnicity, religion, city, state and active problems, vital statistics such as weight, height, blood pressure, respiration, pain score, and lab results such as chemeistry and hematology that are available at the time of admission. We were able to gather data from about 2000 patients without any missing elements. The population included all age groups from infants to all the way to the 90s and has a mix of all ethnic populations. We analyzed the data for any correlation between any of the above factors against the actual LOS.

We built a correlation matrix so that we will be able to filter any combination of the demographics components like city, gender, ethnicity etc, and visualize the effect of that on the LOS against any age groups.

We used the correlation model that was provided by the Neural solution plug-in for Microsoft excel. We couldn't find any consistent correlation using this tool.

Figure 1 - Shows the cross validation set with the MSE increasing after 100 epochs



We attempted to use artificial neural networks, as a predictive modeling tool to solve this problem. We were able to capitalize on the large amount of historical data available on our patients. We split the patient data into 3 parts, a training, validation a test set with 1000, 500, and 500 patients respectively. We tried different ANN architecture, learning parameters, and transfer function to determine the best architecture for this problem. We trained the network with the demographics data against the actual LOS on the training set and tested the accuracy of prediction by the

trained neural network on the test set. We found that the neural network was able to predict the LOS 95% of the time within one day of error. We are currently studying the value of feeding this anticipated LOS with additional parameters, like vital statistics and lab results to a series of trained networks, to fine tune the prediction accuracy.

Results

The artificial neural network learned demographic pattern to predict the LOS in the training set within 3000 epochs as shown in Figure 4 very accurately.

While training we used a cross validation set to compare the reduction in the mean square error (MSE) while learning, so as to stop the training when the MSE tend to increase in the cross validation set. That way the neural networks is prevented from over fitting the training set, but to make it more generalized so as to predict the test cases with a fair amount of accuracy.

Table 1 - The neural network learned the LOS very accurately as shown here within 3000 epochs. The LOS after 50, 250, 1000, and 3000 epochs are shown below

LOS	50	250	1000	3000
16	12.3	15.47	15.983	16.002
6	7.0	5.57	5.947	6.001
7	7.8	5.24	6.910	7.006
7	7.7	6.72	6.977	7.001
7	7.2	6.48	7.139	7.005
2	5.3	4.91	2.250	2.015
7	5.9	5.08	6.900	7.004
5	5.6	3.95	4.962	5.001
23	14.5	22.36	23.012	23.008
3	6.7	3.91	3.284	3.013
5	10.6	6.24	4.981	5.011
4	8.1	4.27	3.983	4.003
4	2.6	4.51	4.088	4.011
7	5.4	4.27	7.053	7.006
5	10.3	4.36	5.028	5.005
7	10.9	5.79	6.970	7.007
4	10.5	5.18	3.917	4.007
4	6.2	4.28	3.994	4.006
10	7.0	10.98	9.902	10.007
7	12.5	7.36	7.043	7.012
22	21.2	21.66	22.005	22.022
2	8.4	4.81	2.266	2.001

After the training we tried to use the trained neural network to predict LOS on a test set that the neural network has not seen before. The following table reflects the performance of the network.

The following table shows the prediction for LOS for all patients by trained network. The actual average LOS for all patients was 7.6 against the Neural Network that predicted the average to be 8.0. The current LOS prediction based on the national benchmarks data gives an average LOS value of 4.5. Thus the neural network prediction is very close to the actual since it is based on the local rather than the national aggregate data showing the value of local data in predicting the outcome since the local demographic mix and the local factors are more valuable.

Table 2 - Predicted Length of stay by NNW

	All		599pt
	LOS	Current	NN
Average=	7.6	4.5	8.0
Total=	4436	2607	4637

We were also able to train the NNW on a particular population of White Baptist, and then use the trained NNW to predict the LOS for that group. This will help us to predict outcomes even more accurately, if we have sufficient number of training data for that population.

Table 3 - Predicted LOS for White Baptist

	All		73pt
	LOS	Current	NN
Average=	7.2	5.1	7.7
Total=	512	361	545

We used the White Baptist since we had more patient data in that group than any other group.

Discussion

We believe that if a large number of historical data is available, an ANN can be used to reliably predict the LOS at the time of admission. Also as new evidence becomes available, like the vitals and lab results, those data could be used to continuously fine-tune the predicted length of stay. Once the care providers see the accuracy of predicted anticipated length of stay, and how it changes based on the accumulation of new evidence during the course of the patient stay, they would be able to fine tune their delivery of care to optimize the quality of the outcomes, enhance patient throughput and maximize reimbursement.

References

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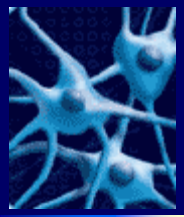

Artificial Neural Networks to Predict Patient's Length of Stay

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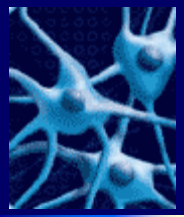
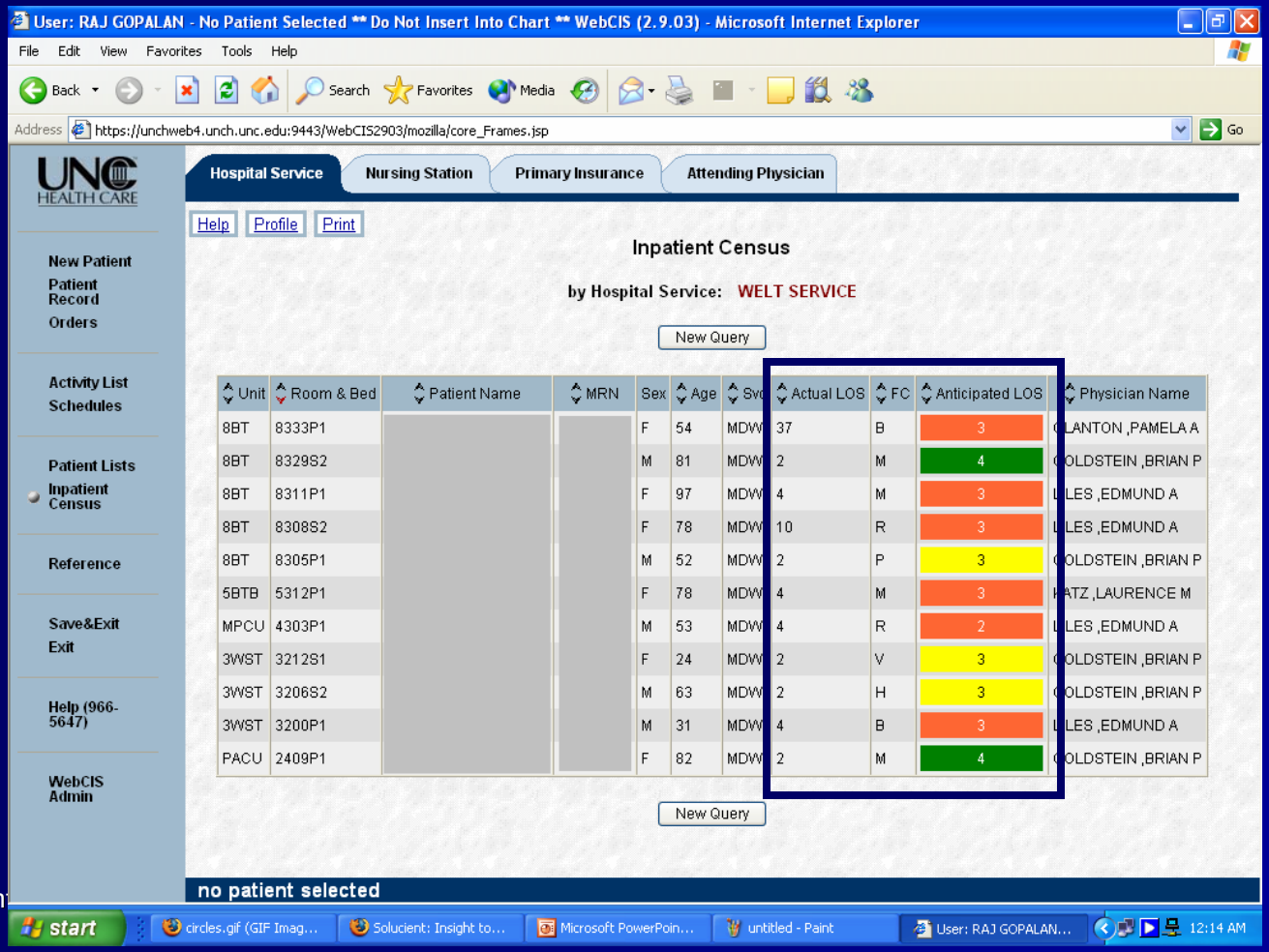


Why predict Length of Stay?

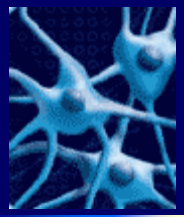
- Pre-admission authorization
- Bed-need assessment
- Concurrent review and discharge planning
- Reimbursement review and adjustment
- Identifying opportunities to reduce costs, save time and improve performance

- How computed today?
  - DRGs
  - ICD-9 codes
  - Insurance
  - Age groups

Traffic light Indicator in UNC EMR (WebCIS) census

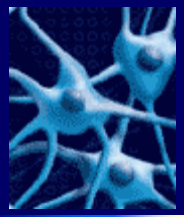


What do we know about a patient @ admission



- Age
- Gender
- Ethnicity
- Religion
- City
- Insurance Info
- Dept/Division

- Vitals
  - Ht, Wt, Pulse, BP, Resp, Pain Score
- Chemistry
  - Sodium, Potassium, Chloride, Bicarbonate Calcium, Urea, etc..
- Hematology
  - WBC, RBC, Platelets, Hg, MCV MCHC, etc..

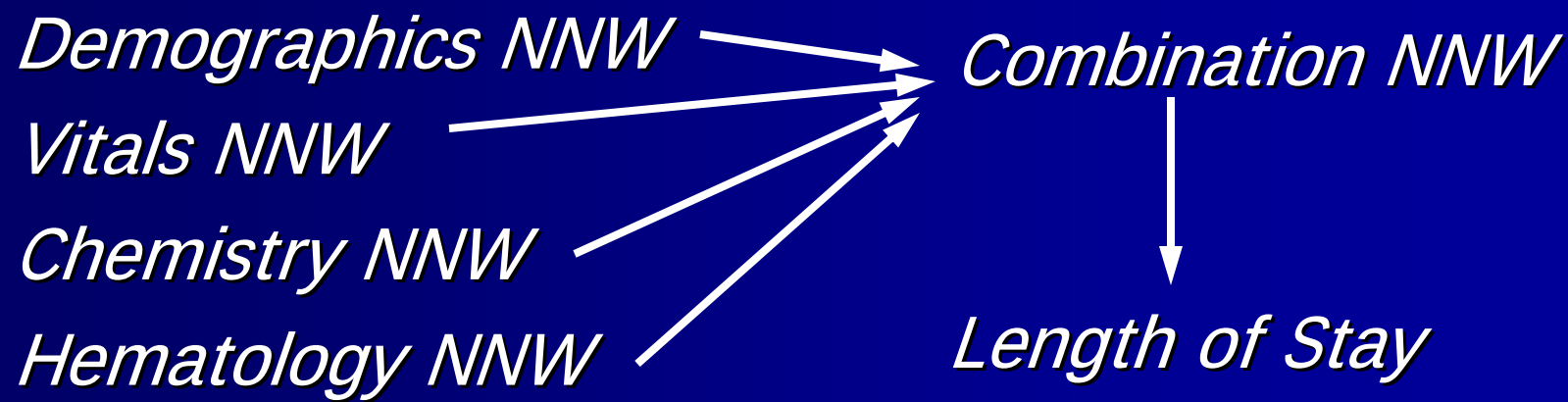


Data gathering...

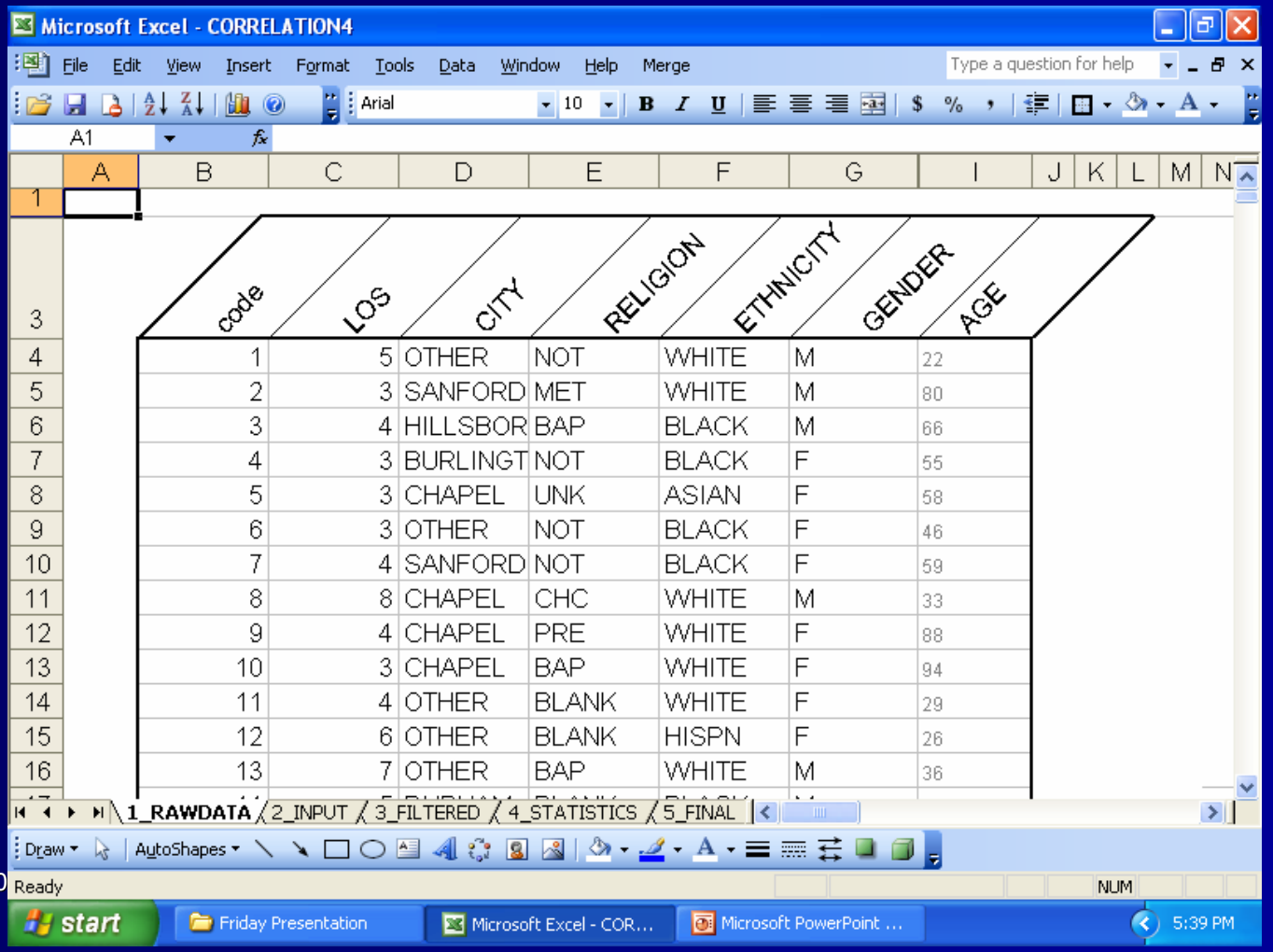
- *Analyzed Data from the past 5 years*
- *Selected Patients who has majority of these values*
- *Filtered by Labs & Vitals taken on the day or immediately before or after admission.*
- *Selected 2000 best representative patients...*

Our ANN Architecture

- *Single NNW*
  - *Not able to perform well*
- *Chain for NNW*

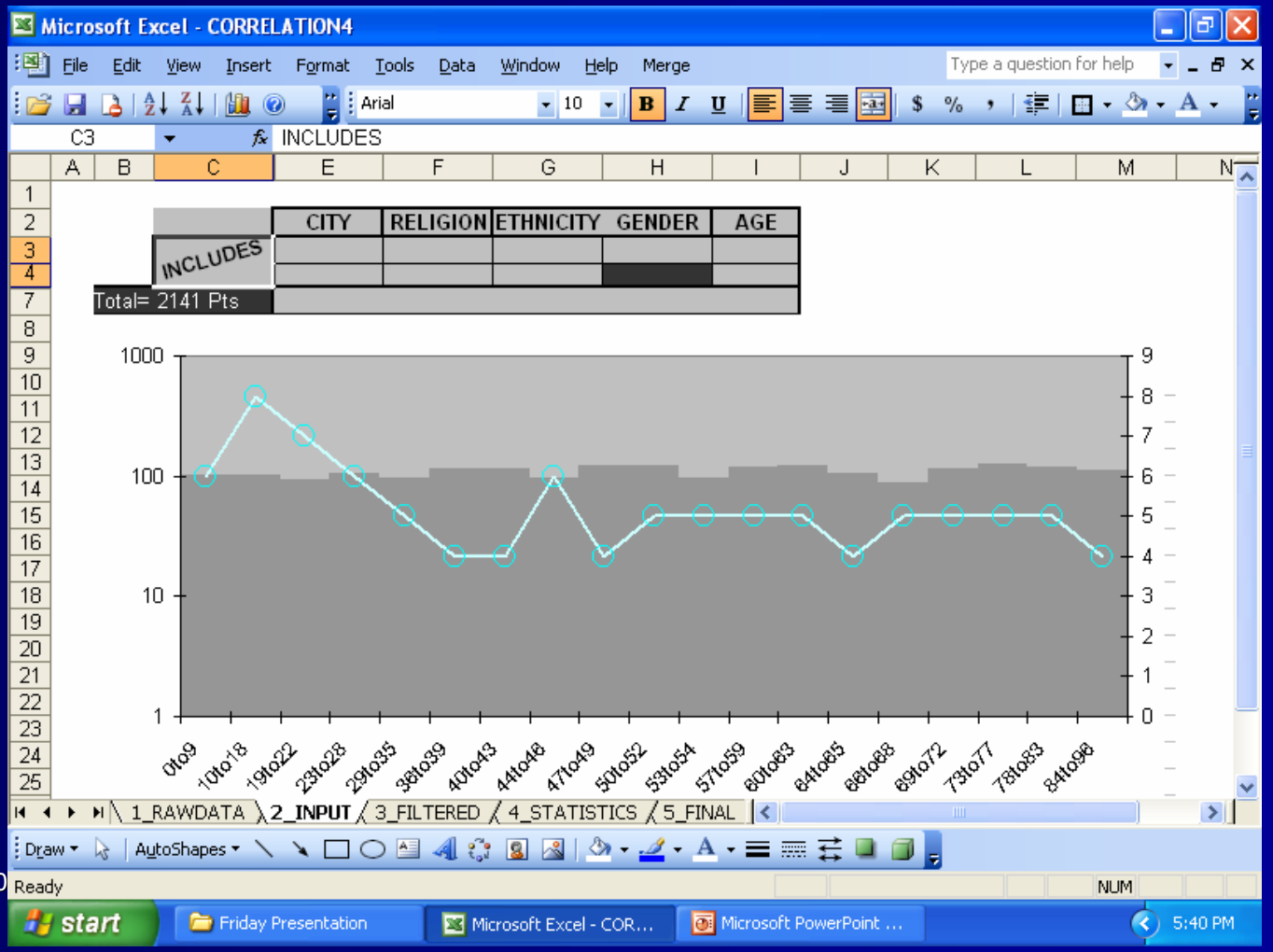


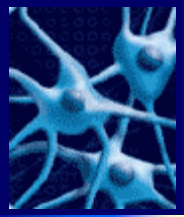
Gathering Data



code	LOS	CITY	RELIGION	ETHNICITY	GENDER	AGE
1	5	OTHER	NOT	WHITE	M	22
2	3	SANFORD	MET	WHITE	M	80
3	4	HILLSBOR	BAP	BLACK	M	66
4	3	BURLINGT	NOT	BLACK	F	55
5	3	CHAPEL	UNK	ASIAN	F	58
6	3	OTHER	NOT	BLACK	F	46
7	4	SANFORD	NOT	BLACK	F	59
8	8	CHAPEL	CHC	WHITE	M	33
9	4	CHAPEL	PRE	WHITE	F	88
10	3	CHAPEL	BAP	WHITE	F	94
11	4	OTHER	BLANK	WHITE	F	29
12	6	OTHER	BLANK	HISPN	F	26
13	7	OTHER	BAP	WHITE	M	36

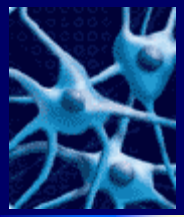
Is there a correlation between any of these values and LOS?





Experimental Design

- Training Set
- Validation Set
- Test Set
- Epoch
- Back propagation
- Hidden Nodes
- Minimize Mean Square Error



Training

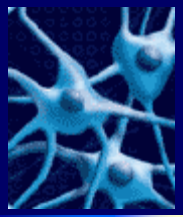
LOS	50	250	1000	3000
16	12.3	15.47	15.983	16.002
6	7.0	5.57	5.947	6.001
7	7.8	5.24	6.910	7.006
7	7.7	6.72	6.977	7.001
7	7.2	6.48	7.139	7.005
2	5.3	4.91	2.250	2.015
7	5.9	5.08	6.900	7.004
5	5.6	3.95	4.962	5.001
23	14.5	22.36	23.012	23.008
3	6.7	3.91	3.284	3.013
5	10.6	6.24	4.981	5.011
4	8.1	4.27	3.983	4.003
4	2.6	4.51	4.088	4.011
7	5.4	4.27	7.053	7.006
5	10.3	4.36	5.028	5.005
7	10.9	5.79	6.970	7.007
4	10.5	5.18	3.917	4.007
4	6.2	4.28	3.994	4.006
10	7.0	10.98	9.902	10.007
7	12.5	7.36	7.043	7.012
22	21.2	21.66	22.005	22.022
2	8.4	4.81	2.266	2.001

		MSE		
	50	250	1000	3000
AVERAGE	3.535098	0.544377	0.032714	4.3642E-05
		DIFF		
AVERAGE	3.472	1.144	0.224	0
MEDIAN	3	1	0	0
MAX	19	5	2	0

There is a point at which the network should stop training

Results

	All		599pt
	LOS	Current	NN
Average=	7.6	4.5	8.0
Total=	4436	2607	4637



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  - [3] Tuj V, Gurrriere MRJ. Use of a neural network as a predictive instrument for length of stay in the intensive care unit following cardiac surgery. Symposium on computer applications in medical care (SCAMC) 1993: 26220-229.

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MEDINFO 2007

The Effect of Computer-assisted Prescription in Critical Care Unit

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Objetive

In this work we propose to determine in what proportion computer-assisted prescription (CAP) reduces errors in medical indications if we compare it with hand-written medical prescription (HWP) in Intensive Care Unit (ICU) in Belgrano Hospital in Buenos Aires, Argentina.

Will determine if there are advantages between CAP and HWP. A retrospective analysis was used over an amount of 98 medical indications in ICU (intensive care unit) registered during the first quarter of 2006.

Introduction

- Advantages and benefit-cost which CAP enjoys at present are, in a way, affected by some legal aspects.
- There are existing contradictions between vanguard law and Digital Signature Law 25.506 and General Law of Medicine Exercise (law Nº 17132) which in its article 19 sub-sections 7 reads: “Prescriptions shall be hand-writing, in Spanish, dated and signed”. This fact at present complicates the situation of **physicians who use CAP** because they run the risk of being sanctioned.

Materials and Methods

we have chosen 43 traditional hand-written prescriptions and 55 computer-assisted ones to elaborate this study and to compare existing differences between them both.

Computer Program

It consists in an electronic form with the following fields:

drug /posology /doses /administration route/date of beginning and end of the treatment.

The output is the printing of a report with daily indications for each patient.

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Analyzed variables

- 1- **Incorrect information**: Information which is not relevant for patient treatment and which can lead to confusion. Indications which do not correspond to a patient and have been prescribed by mistake.
- 2- **Incorrect doses**: Doses calculated by mistake or indications wrongly transcribed.
- 3- **Omissions**: Lack of any of the elements in the indications, for example, when a transcription has not been made because somebody forgot to do it.
- 4- **Illegibility**: When two or more members from the committee cannot understand one or more words.

BIOCOM

Results

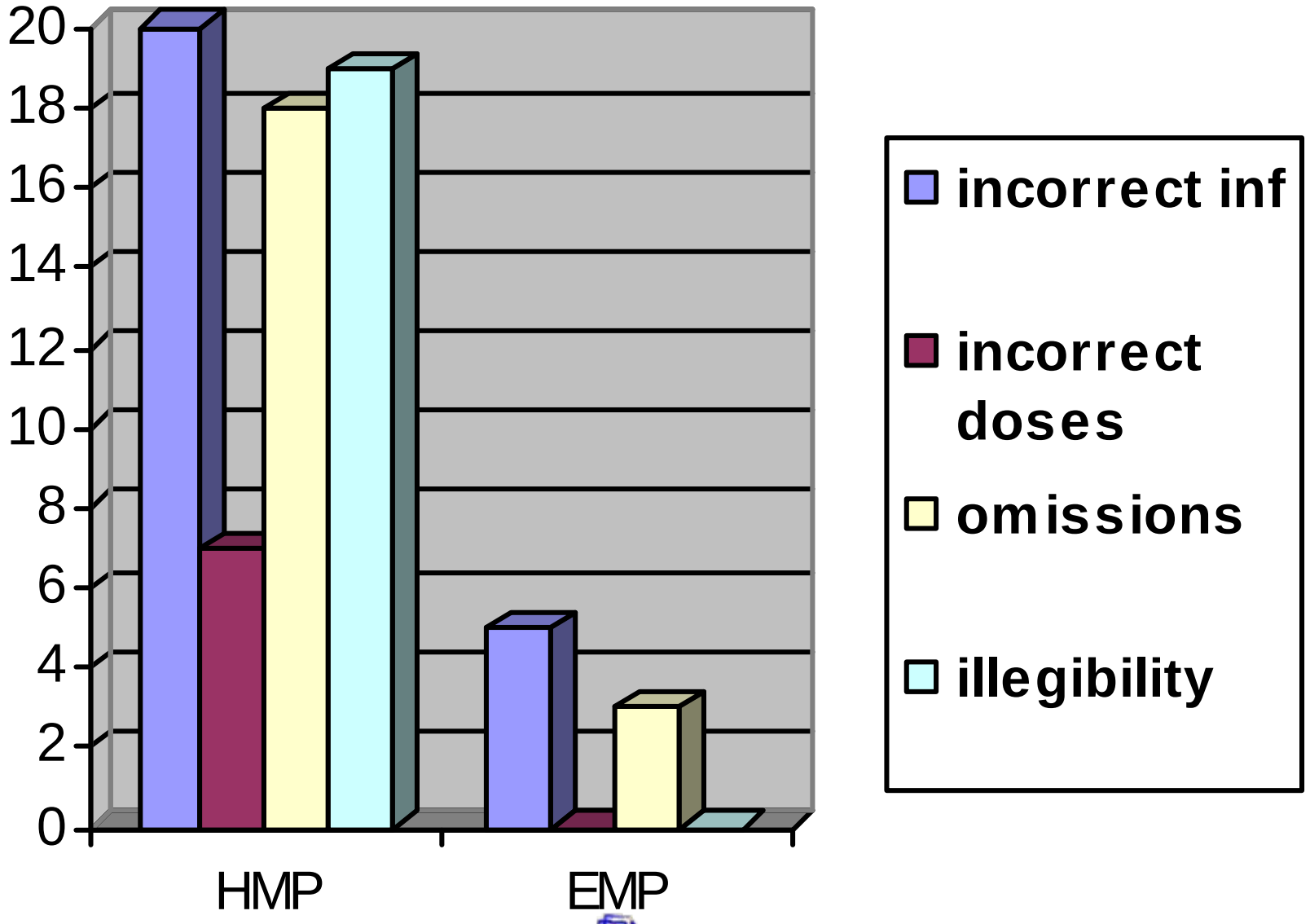
T otal of prescription mistakes (HWP) = 41,86 % (CAP)= 7,27%.

incorrect information
(HWP) = 20,93 %
(CAP) = 5,45%,

omissions
(HWP) = 18,60 %
(CAP)= 3,64%,

incorrect doses
(HWP) = 6,98 %
(CAP)= 0%,

illegibility
(HWP) = 18,60 %
(CAP)= 0%.



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Discussion

Results are eloquent:

41% of mistakes in HWP vs.

7% in CAP.

Main causes in this difference are illegibility problems and mistakes in transcription in daily indications.

Discussion

- It is important to consider that in many works it is indicated that Medical Error has an important incidence in morbidity and mortality of patients and longer permanence of patients in hospital so it has a high incidence in increase of health costs basically for bad administration and limitless resources use.

Conclusions

- To incorporate CAP to daily practice, it will be necessary to count with the digital signature of the physician; in this way it will be used as a legal proof tool. It is important to consider that a wrong manual indication could generate, for omission, illegibility, loss, damage or other, a medical mistake which produces a bad praxis with a morbidity and health cost easily avoidable if CAP is used.

Thank you for your attention…! You can send your comments, doubts or suggestions by email to :

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The Effect of Computer-assisted Prescription on Critical Care Unit

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Hospital General de Agudos Manuel Belgrano and
BIOCOM an Argentine Biocomputer Research Group

Abstract

Objective: To determine if computer-assisted prescription (CAP) reduces the frequency of prescription errors in the Intensive Care Unit (ICU) of Belgrano Hospital.
Method: A retrospective analysis was used to compare errors between computer-assisted and handwritten prescriptions (HWP) in 98 Medical indications: 43 handwritten and 55 Computer-assisted ones. Prescriptions were reviewed by expert staff. The items to be considered are: 1- incorrect information, 2- incorrect dose, 3- missing information, 4- illegibility.

Results:

1- Incorrect information HW=20,93% - CA=5, 45 %,

2- Incorrect dose HW=6, 98 % - CA=0%,

3- Missing information HW=18, 60% - CA=3, 64 %,

4- Illegibility HW=18, 60 % - CA=0 %.

Conclusions: Computer-assisted prescriptions sensibly reduce medical prescription errors compared to handwritten prescriptions. We found a total of 41, 86 % errors in handwritten medical prescriptions versus just 7, 27 % in computer- assisted ones.

Keywords:

prescription drugs; medication errors; computer-assisted medication systems

Introduction

In this work we propose to determine in what proportion computer-assisted prescription (CAP) reduces errors in medical indications if we compare it with hand-written medical prescription (HWP) in Intensive Care Unit (ICU) at Belgrano Hospital in Buenos Aires, Argentina.

Computer-assisted prescription (CAP) avoids main causes of medical errors at the moment of prescribing and/or making indications, because it basically avoids mechanical work of data transcription not only by doctors, who update indications given the previous days, but also by nurses' and pharmaceutics' work. CAP ends with discrepancies produced by data interpretation and transcription. It constitutes an indispensable election tool to improve quality in medical attention optimizing safety in patients and, in that way, diminishing expenses caused by medical errors.

CAP (computer-assisted prescription) integrated with CCH (computerized clinical history) not only optimizes processes and reduces mistakes in medication, but also constitutes a fundamental support for decision taking and allows detecting interaction between drugs-taking by patient.

Advantages and benefit-cost which CAP enjoys at present are, in a way, affected by some legal aspects. There are existing contradictions between vanguard law and Digital Signature Law 25.506 and General Law of medicine exercise (law Nº 17132) which in its article 19 sub-sections 7 reads: "Prescriptions shall be hand-writing, in Spanish, dated and signed". This fact at present complicates the situation of **physicians who use CAP** because they run the risk of being sanctioned.

With this work we hope to make a contribution so that legislators review this kind of impediment which constitutes an attempt against modernization and health and life of patients.

Materials and methods

Intensive care unit is formed by two bodies and a CAP system. Not all professionals use this system because of different reasons which go from lack of aptitude to accept these new information technologies to manifest criticism to CAP. So as to objectively determine if there are advantages between CAP and HWP, a retrospective analysis was used over an amount of 98 medical indications in ICU (intensive care unit) registered during the first quarter of 2006.

Analyzed variables are:

1- **Incorrect information:** information which is not relevant for patient treatment and which can lead to confusion or those indications which do not belong to a patient and have been prescribed by mistake.

2- **Incorrect doses:** Doses calculated by mistake or indications wrongly transcribed.

3- **Omissions:** Lack of any of the elements in the indications, for example, when forgetting to make a transcription.

4- **Illegibility:** When two or more members from the committee cannot understand one or more words.

Results

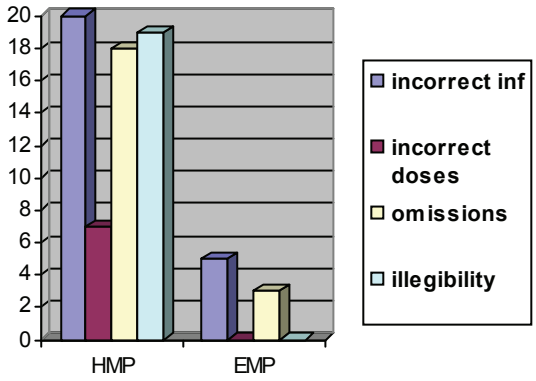
According to our controls, the results obtained are: incorrect information (HWP) = 20,93 % (CAP) = 5,45%, incorrect doses (HWP) = 6,98 % (CAP)= 0%,

Omissions (HWP) = 18,60 % (CAP)= 3,64%,

Ilegibility (HWP) = 18,60 % (CAP)= 0%.

Total of prescription mistakes (HWP) = 41,86 % (CAP)= 7,27%.

The difference between HWP and CAP is significant giving p <0,001



Discussion

Results are eloquent: 41% of mistakes in HWP vs. 7% in CAP. Main causes in this difference are illegibility problems and mistakes in transcription in daily indications. It is important to consider that in many works it is indicated that Medical Error has an important incidence in morbidity and mortality of patients and longer permanence of patients in hospital so it has a high incidence in increase of health costs basically for bad administration and limitless resources use.

Conclusions

To incorporate CAP to daily practice, it will be necessary to count with the digital signature of the physician; in this way it will be used as a legal proof tool. It is important to consider that a wrong manual indication could generate, for omission, illegibility, loss, damage or other, a medical mistake which produces a bad praxis with a morbidity and health cost easily avoidable if CAP is used.

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Prospective Evaluation Strategy for Implementation of a Web-Based Care Planning and Communication System in General Practice

Svetla Gadzhanova, Richard Reed, Libby Kalucy

Department of General Practice, Flinders University, South Australia

Abstract

Global burden of chronic disease is increasing rapidly. E-health systems can play an active role to benefit the management of patients with chronic conditions.
HealthConnect SA is conducting a trial of a web-based care planning and communication system. The system is expected to facilitate the communication and collaboration between members of the primary health care team and to improve the health outcomes of the patients. A prospective evaluation methodology using mixed qualitative and quantitative techniques is designed to identify factors which influence the adoption of such a system in primary health care. The evaluation findings will inform the business needs and requirements for implementation of a state-wide online care planning and communication system.

Keywords:

internet, communication, care planning, general practice

Introduction

Global burden of chronic disease is increasing rapidly and is projected to account for 75% of all deaths by 2020 (World Health Organization 2004). Effective prevention and management of chronic conditions is a key policy objective of the Australian health system. It relies on coordinated care from a multidisciplinary team [1]. New chronic disease management items (GP Management Plan and Team Care Arrangement) were introduced as part of the National Chronic Disease Strategy in Australia to support General Practitioners (GPs) in providing care for patients with chronic medical conditions, including patients who need multidisciplinary care [2]. A care plan is a personalized management plan containing details of a patient's problems and needs. It outlines goals, treatment services and strategies to achieve those goals, and planned activities for monitoring progress and for reviewing the care plan. The care plan is developed between the patient, his/her family or nominated representative, and the health care provider (or provider team). The plan can relate to services from one or a number of health care providers or agencies [2].

E-health technologies and systems can play an active role to benefit health care providers and patients. Health*Connect* is an Australian national strategy to improve safety and quality in health care by establishing a range of standardised electronic health information products and services for health service providers and consumers. Health*Connect* South Australia is conducting a 12 month trial of a secure web-based system for communication and collaboration between health care providers involved in care planning. Flinders University is contracted to conduct a formal, independent evaluation of the trial.

Methods

Demonstrating a clear and unambiguous advantage for its users is a critical factor for adoption of an innovative electronic system into clinical practice [3, 4]. Implementing such a system requires attention to timing of events, acquisition and delivery of resources and development of human resource support structure [5].

The trialled web-based system (OzDocsOnline) enables health providers to work together to improve the management of chronic conditions. It is a tool enabling health care providers to create, share and store care plans on a secure server. Patients are able to access their care plans securely via the Internet.
A prospective, formative evaluation methodology using mixed qualitative and quantitative techniques was designed to determine the factors influencing the diffusion of the system in primary health care and to meet the main information needs of HealthConnect SA for the implementation of a state-wide care planning system after the end of the trial.

The evaluation methodology involves collecting data from the following information sources:

Surveys of adopting organizations (General Practices) to determine practice characteristics initial expectations and attitudes to the system towards the end of the trial.

Regular interviews with Division of General Practice liaison officers who disseminate the system to practices in their area to establish progress and issues arising during its implementation.

Case studies to provide in-depth understanding of the effects of implementation of the system in different contexts.

Focus groups with other health providers (allied health, specialists, pharmacists) and consumers to determine their erception of the effects of the system in care planning.

Monitoring Medicare item numbers relevant to care planning.

Monitoring the web-based system to determine extent of use.

The evaluation also aims to assess overall satisfaction and barriers in uptake of the system in different settings in order to make recommendations for improvements.

Results

The trial has been widely promoted and the current participants include three divisions of General Practice from South Australia, 35 general practices, 70 General Practitioners, 200 allied health providers (dietitians, physiotherapists, podiatrists, psychologists, social workers, occupation therapists, etc), 15 specialists / pharmacists and 45 patients with electronic care plans on the system.

Six month after the trial commenced the evaluation showed seven factors that influence the adoption of the innovative electronic care planning system in primary health care:

1/ **Proper timing of events** – implementation at the right moment and proper scheduling of the implementation steps;

2/ **Strong organizational structure** – strong personal relationships between the implementers and the adopters;

3/ **Effective implementation activities** – using wide and effective promotion methods (existing networks, information evenings, newsletters), dissemination of adequate communication/promotion materials;

4/ **Adequate resources** – proper IT equipment and secure broadband connection, prior computer knowledge, prior experience with EPC items, adequate training in the new system;

5/ **Comprehensive and timely support** – central helpdesk support, email address for enquiries, phone/mobile phone support, user manuals for the system;

6/ **Motivated adopters** – financial incentives in the training phase to encourage the uptake of the new system, secure broadband grants;

7/ **High-level system effectiveness** – the system has to:

- Be simple and highly integrated with existing clinical processes and systems (such as Medical Director);
- Be easy for all parties to learn and use;
- Facilitate the communication and collaboration between the health care team;

- Be accessible at each point of care;
- Secure and protective of medical information and patient privacy;
- Make a positive difference to time and revenue for health providers and to health outcomes for patients.

Discussion and conclusion

Adequate evaluation of health informatics initiatives is essential for efficiency and effectiveness of future initiatives [6]. The proposed evaluation methodology identified seven challenging factors in the uptake and use of a secure web-based system for electronic care planning. Addressing these aspects will enhance the likelihood of success of implementation and adoption of suchan innovative system for electronic care planning and communication in primary health care settings.

Acknowledgements

This study is funded by the Australian Government through Health*Connect* SA and PHC Research Evaluation Development Strategy of the Australian Department of Health and Ageing.

References

[1] National Health Priority Action Council (NHPAC), "National Chronic Disease Strategy", Australian Government of Health and Ageing, Canberra, 2006

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[5] Robert Paton and James McCalman, "Change management", 2nd edition, 2000, SAGE Publications Ltd.

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Department of General Practice, Flinders University Adelaide

Prospective evaluation strategy for implementation of a web-based care planning and communication system in general practice

Introduction

♦ Global burden of chronic disease is increasing rapidly and is projected to account for 75% of all deaths by 2020 (World Health Organization 2004).

♦ Effective prevention and management of chronic disease is a key policy objective of the Australian health system. It relies on coordinated care from a multidisciplinary team [1].

♦ A personalized care plan which outlines goals, treatment services and care to achieve those goals make it easier for General Practitioners (GPs) to manage the care for patients with chronic medical conditions, including patients needing multidisciplinary care [2].

♦ E-health technologies and systems and a change in traditional business processes can play an active role to benefit health care providers and patients.

Introduction (2)

♦ Health*Connect* is a national strategy to improve safety and quality in health care by establishing a range of standardised electronic health information products and services for health service providers and consumers.

♦ Health*Connect* South Australia is conducting a 12 month trial of a web-based care planning and communication system for primary health care management of patients with chronic conditions.

♦ Department of General Practice at Flinders University is conducting a formal, independent evaluation on the trial to determine aspects that affect the implementation and uptake of such an innovative system in primary health care.

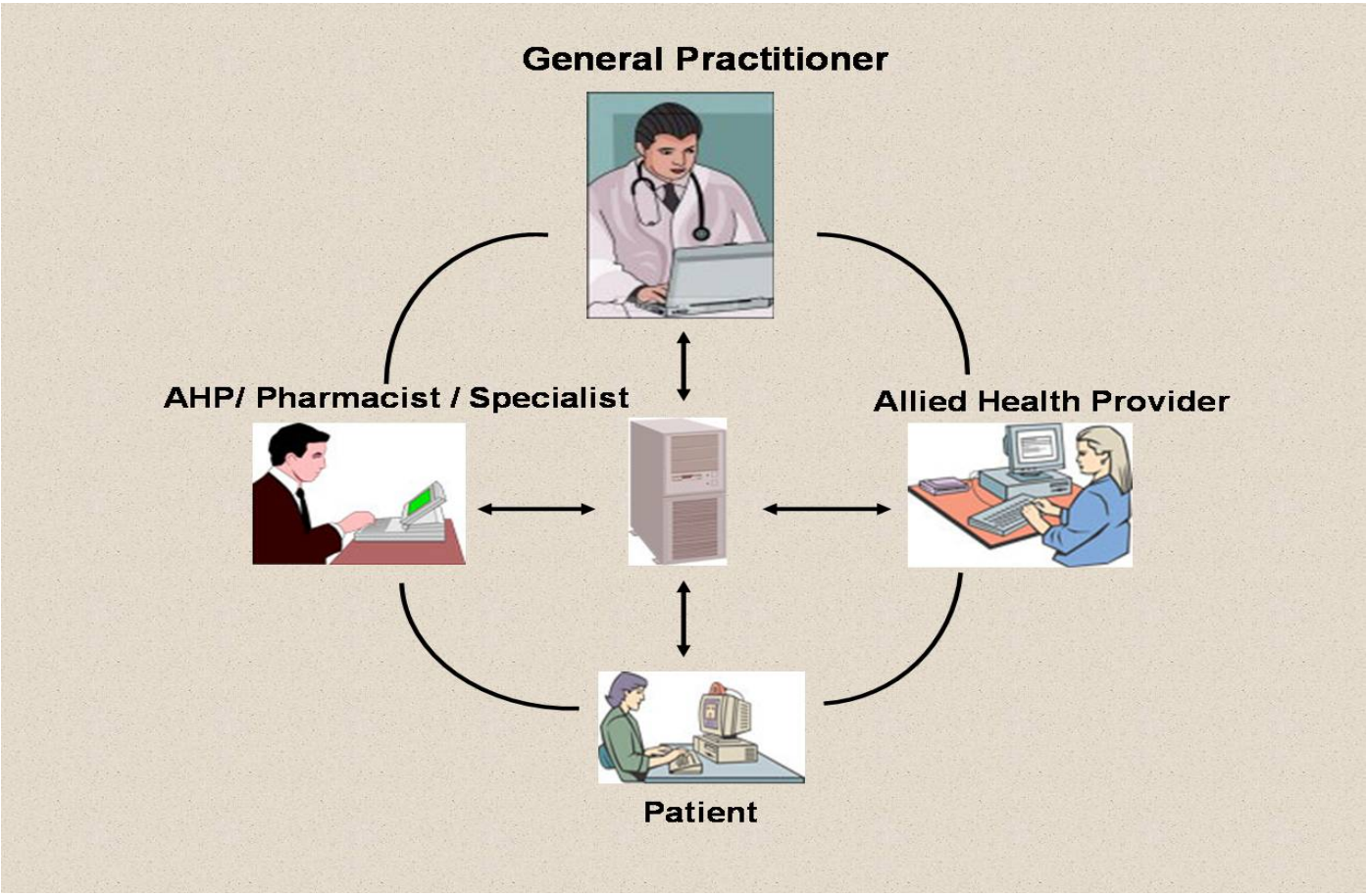
Innovative health systems

A critical factor for adoption of an innovative electronic system into clinical practice is to have a clear and unambiguous advantage for the users [3,4].

Issues such as timing of events, acquisition and delivery of resources, and development of human resource support structures [5] must be addressed to implement such as system.

The trialled web-based system (OzDocsOnline) enables health providers to work together to improve the management of chronic conditions. It is a tool enabling health care providers to create, share and store care plans (GPMPs and TCAs) on a secure server. Patients are able to access their care plans securely via the Internet.

The care planning system



Web-based care planning and communication system

Evaluation Methods

A prospective, formative evaluation methodology using mixed qualitative and quantitative techniques is designed to:

- determine the factors that influence the diffusion of an innovative system for electronic care planning in primary health care
- meet the information needs of Health*Connect* SA for implementation of a state-wide care planning system at the end of the trial (what makes an electronic care planning system effective for management of chronic conditions?)

Evaluation Methods (2)

Information sources	Purpose
Surveys of General Practices	Practice characteristics, expectations, attitudes
Interviews with Division liaison officers	Progress, implementation issues
Case studies	Effects in different contexts
Focus groups with health providers, consumers	Perception of system effects
Monitor Medicare item numbers, web based system	Extent of use

Participants

Current trial participants :

- Three divisions of General Practice in urban and rural South Australia
- 35 general practices
- 70 General Practitioners
- 200 allied health providers (dietitians, physiotherapists, podiatrists, psychologists, social workers, occupational therapists, etc)
- 15 specialists / pharmacists
- 45 patients with electronic care plans

Interim results at 6months

Factors which influence the adoption of an electronic care planning system in primary health care:

1. **Proper timing of events** – implementation at the right moment and proper scheduling of the implementation steps;
2. **Strong organizational structure** – strong personal relationships between the implementers and the adopters;
3. **Effective implementation activities** – effective promotion methods (existing networks, information evenings, newsletters), dissemination of adequate communication/promotion materials;
4. **Adequate resources** – proper IT equipment, secure broadband connection, prior computer knowledge, prior experience with EPC items, adequate training in the new system;

Interim results (2)

5. **Comprehensive and timely support** – central helpdesk support, email address for enquiries, phone/mobile phone support, user manuals for the system;
6. **Motivated adopters** – financial incentives in the training phase to encourage the uptake of the new system, broadband security grants;
7. **High-level system effectiveness – the system needs to be**
   - simple and fit with existing clinical systems (such as medical director) and processes,
   - easy to learn and use for all parties,
   - facilitate communication and collaboration in health care team,
   - accessible at point of care,
   - secure, protect medical information and patient privacy,
   - make a positive difference to time and revenue for health providers and to health outcomes for patients.

Discussion and Conclusions

- Adequate evaluation of health informatics initiatives is essential for efficiency and effectiveness of future initiatives [6].
- The proposed evaluation methodology identified seven factors which influence uptake and use of a secure web-based system.
- Addressing these factors will enhance the likelihood of successful implementation and adoption of electronic care planning and communication in primary health care settings.

References

[1] National Health Priority Action Council (NHPAC), "National Chronic Disease Strategy", Australian Government of Health and Ageing, Canberra, 2006

[2] Australian Government of Health and ageing, Chronic Disease Management Medicare Items, 2005

[3] Greenhalgh T, Robert G, Macfarlane T, et al, "A model of diffusion in service organizations", The Milbank Quarterly, 2004, volume 82 (4), 581-629.

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GRHANITE™ - Sustainability in Data Collection, Information Sharing and Research

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Abstract

A prerequisite to quality medical research is access to high quality medical data. Australia has a strong record in medical research, but currently no Australian organization has the capability to link both primary and secondary care data on a large scale and in a sustainable manner. Issues are: ethics, consent, security and providing sustainable, on-going incentives for collaboration. The University of Melbourne is developing technologies designed to address these issues - GRHANITE™ - 'Generic Rural Health Academic Network Information Technology for the Enterprise'. GRHANITE™ provides participants with tools for managing consent, linking and extracting data from clinical repositories, extracting data only where consent is explicit and the secure uploading of data to a central repository in a de-identified, but linkable manner. Once linked, data can be used for research, but importantly, the data can contribute directly to clinical care processes in an ethical and secure manner. Any clinical use of the data is possible. As the capabilities of the clinical toolset increase, incentives for continued and further collaboration grow promoting long-term growth and sustainability.

Keywords:

medical record linkage, confidentiality, informed consent, automatic data processing, integrated advanced information management systems

Methods

The work of the author (Boyle D.I.R.), Morris A.D. et-al for the Diabetes Audit and Research in Tayside, Scotland project demonstrates that systems providing clinical benefits can grow from small research linkage projects to initiatives national in scope. This project now aggregates diabetes data daily from over 1,000 general practices and 50 hospital clinics without being mandated (diabetes pop 192,012, 3.97M user operations, >5,000 users – Nov 2006). Although data is primarily collected for clinical purposes, it has contributed greatly to the diabetes research capability of Dundee University as literature searches reveal. Australia is however different from the UK and different issues apply. What the Scottish experience demonstrates though, is that if the framework in which clinical systems function is cleverly managed, large collaborations can grow and comprehensive data for clinical research can result.

This broad methodology has been applied to the University of Melbourne, Rural Health Academic Network (RHAN) in its development of GRHANITE™ technologies designed to comprehensively link data across North-East Victoria, Australia. Each participating RHAN site (primary or secondary care) hosts a GRHANITE™ Consent Server. This server manages all issues of consent across the organization, the secure, de-identified extraction of data and communication with a central GRHANITE™ Repository. This repository performs deterministic record linkage and data aggregation for the purposes of clinical information sharing and decision support as well as providing anonymous data for research. All possible measures are taken to maximize the ease with which consent can be managed (opt-in or opt-out) in a highly secure and ethical environment. These same ease-of-use and security measures have the potential to grant clinicians immediate, context-sensitive ethical access to clinical data where consent for this has been granted by the patient.

Results

GRHANITE™ technologies are still under development. At this time (November 2006), pilot data extractions to a central GRHANITE™ Repository are under way. Collaborations with local general practices and the Goulburn Valley Hospital Diabetes Clinic are being utilized to build the initial decision support tools. These tools will demonstrate the capability of the system to support continuity of care and clinical functionality – in this case, for diabetes services between the hospital and primary care.

Conclusions

Although still under development, feedback from local clinical and healthcare IT professionals has been positive. It is unusual for consent to be managed by a specific consent application and GRHANITE™ is unusual in managing consent on behalf of whole organizations. A key facet of the GRHANITE™ Repository is its ability to link and provide clinical sharing capabilities without the central repository holding ANY person-identifiable information. It is early days for the GRHANITE™ technologies, but it is hoped that as the clinical utility of the

system grows, the incentives for the clinical community to collaborate will grow. If this development mirrors the experiences of Scotland, these further clinical incentives will lead to increased collaboration in an on-going and sustainable manner. The GRHANITE™ technologies are not limited in scope to Australia.

GRHANITE™ - Sustainability in Data Collection, Information Sharing and Research

GeneRic HeAlth Network Information Technology for the Enterprise

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Background

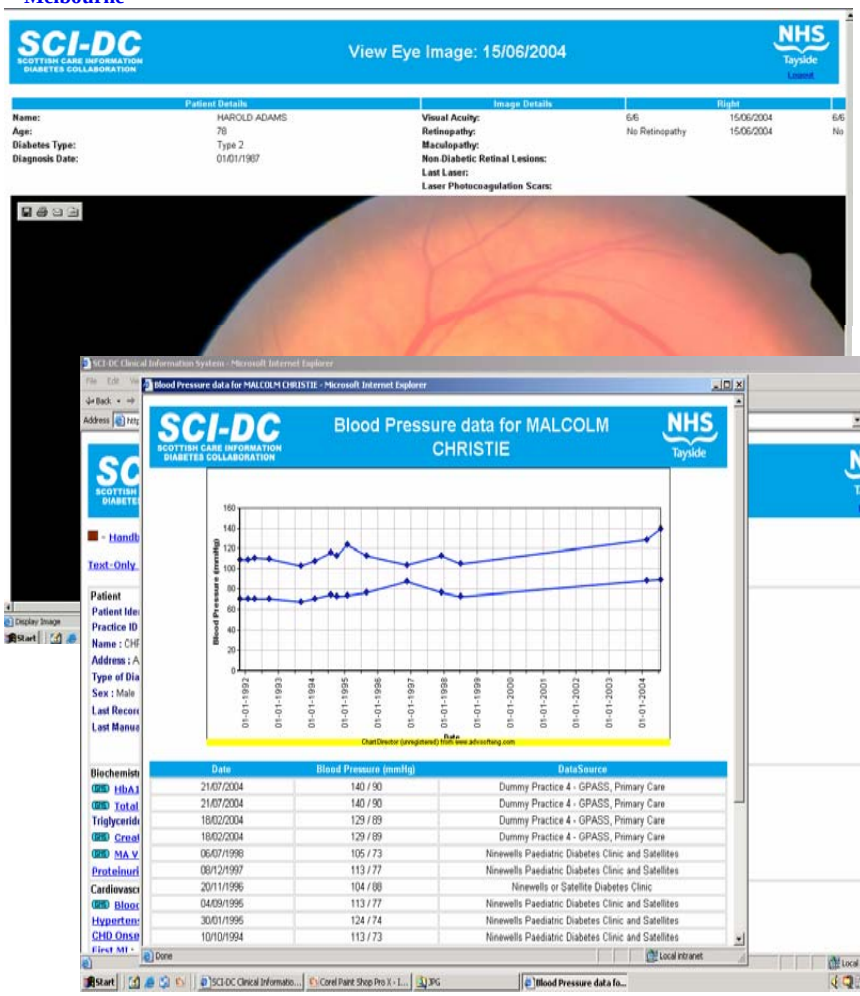
- HL7 and other messaging standards are at the heart of many national and international efforts to allow clinical information exchange. Such activities are effective, but costs are high, development timescales are long and interfaces are normally only developed between major clinical systems[1].
- Scotland has demonstrated another, pragmatic technique that can be used to link data for clinical care and research that is less dependent on messaging standard development. i.e. small systems can be linked as well as large ones [2].
- This Scottish system has proven itself through effectively providing an electronic health record for all patients in Scotland known to have diabetes [3],[4] (~190,000)

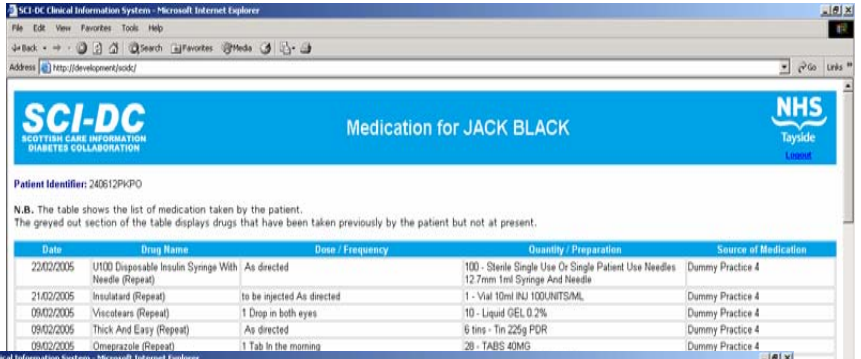
The Scottish Experience

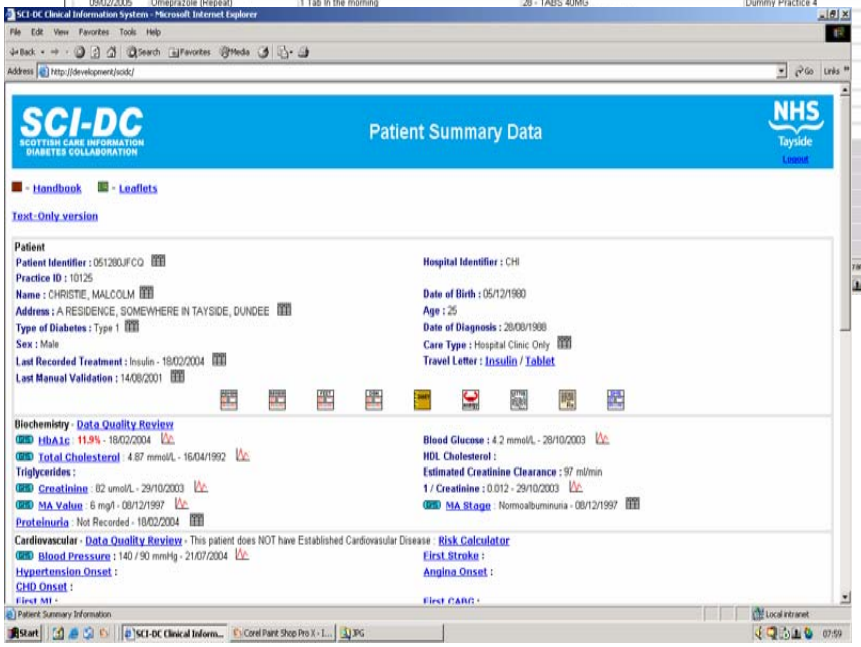
SCI-DC
SCOTTISH CARE INFORMATION DIABETES COLLABORATION

- Using a generic interface product developed by Dundee University (GENIE), data from any ODBC-compliant database can be extracted.
- This technology has been used to link data on a daily basis from over 1,000 general practice and hospital sites across Scotland.
- A central health record for diabetes (and cardiovascular disease) was constructed allowing patient care information to flow regardless of where the patient goes.
- This system is thought to provide the only fully population-based diabetes register (and care system) for a whole country in the world (Scottish population: ~5.1M).
- ~190,000 patient records are on the system, and there are >5,000 users spanning primary and secondary care (Nov 2006).
- Being a University of Dundee and National Health Service development, this system has achieved this for a total cost estimated to be around £10M – (~£10 (~$24 AUD) per patient with diabetes per year)
- Data from this system is at the core of Scottish Managed Clinical Networking for diabetes and underpins a wide variety of research programmes at the University of Dundee

SCI-DC Sample Screens



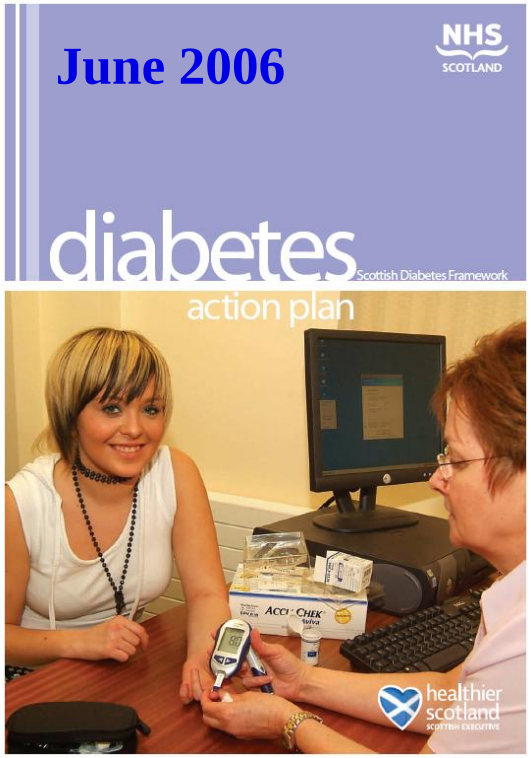


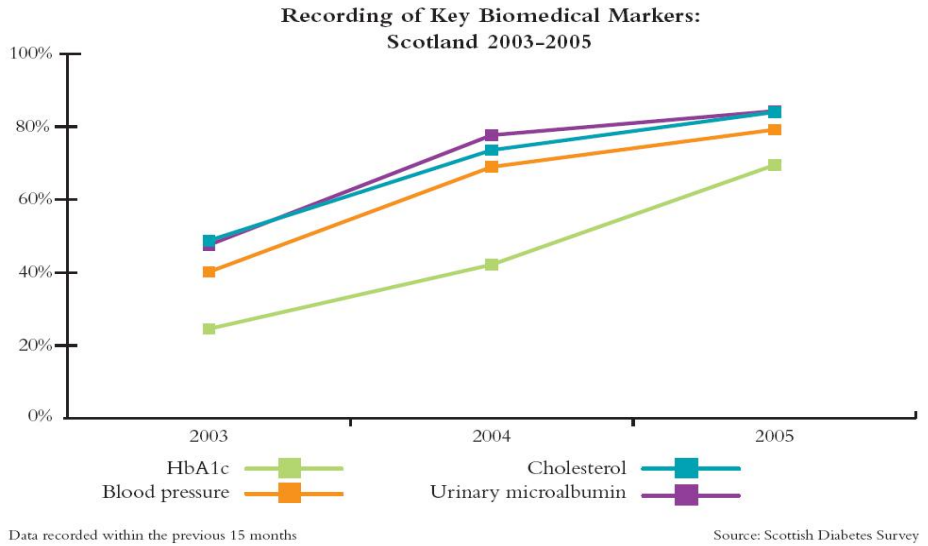


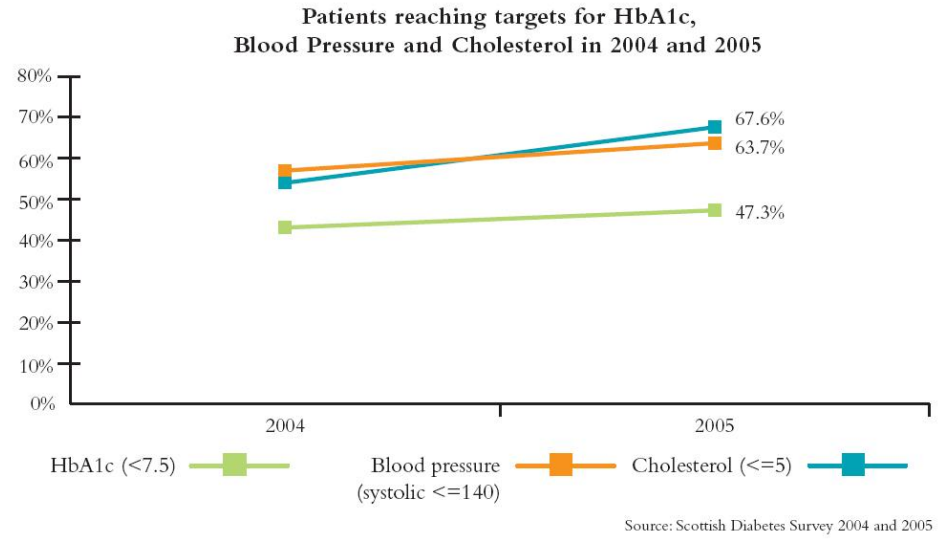
GRHANITE™ is still under development, but capabilities like these are one goal of GRHANITE™.
A demonstrator application is due for completion by November 2007

Evidence from Scotland demonstrates data quality improvement and improvements in patient outcome[4]

(People networks most important – IT underpins the network)







Australia - specific issues

Australia cannot implement strategies like those employed in Scotland without addressing the following issues:

- *No unique patient identifier (one is planned, but timescales are unknown)*
- *The divided commonwealth-state health financing system and the fee for service system discourages collaboration and shared-care systems*
- *Confidentiality, Ethics and Security are very public issues requiring the utmost respect with organisations such as the Australian Privacy Foundation carefully scrutinising activities in this area*
- *Information technology is a key enabler for improving communication, but improvements in patient outcome are a product of human intervention – effective collaboration across clinical communities is a necessity – as are structures that promote such collaboration*

Approaches to resolving the issues

There is no reason the methodologies employed in Scotland cannot be utilised in Australia but the problems specific to Australia must be addressed at a fundamental level

Identified prerequisites:

- **Managing the people issues – establishment of collaborative networks**
  - This ePoster is primarily about the technical aspects of supporting collaboration. Technology is a key enabler, but is ONLY an enabler.
- **Managing consent processes**
  - Comprehensive consent management at source
  - Flexible consent processes managing consent for research, clinical information sharing, even audit.
  - Consent processes that are opt-in or opt-out allowing operation in a variety of health environments based on advice from local ethics committees.
  - Consent processes that will work for any size of organisation – from a single-handed GP to a 1,000 bed hospital.
- **Managing record linkage**
  - For clinical information sharing, linkage must be performed. Given there is no Australian unique identifier, this process must use identifiers such as name, address, date of birth, even phone number to ensure linkage is accurate. Linkage errors when sharing health records must not happen.
  - Sharing personal identifiers is not good practice. Ideally, a linkage process that does not need to divulge personal identifiers would be preferable.
- **Managing security**
  - If clinical data is to be moved electronically, security mechanisms must be there to protect the rights of the individual.
  - All communications must be encrypted and secured against hacking.
  - All communications must be secured using reliable means of confirming user and client PC identity. This is usually established via user logins and digital certification.
  - Mechanisms must be established to ensure data can only be accessed by authorised individuals on a need-to-know basis.
  - Audit trails and auditing procedures must be present in all processes.

GRHANITE™ Technologies to resolve the fundamental issues

To-date, no application has been identified that can manage all the issues identified. GRHANITE™ technologies are being developed to fill this gap.

- GRHANITE™ has a generic interfacing capability that means it can link to any ODBC-compliant database. Users define the connection at install-time.
- It can use consent fields in a database, or can manage consent on behalf of the client database.
- It has a flexible (opt-in or opt-out) consent system that manages consent for whole organisations regardless of their scale.
- It manages consent for research, clinical and audit uses of data.
- No patient identifiers leave the organisation – non-reversible and dictionary attack-secured encrypted hashes are utilised for central linkage.
- The system manages its own X509 public and private key encryption processes to secure each site and each client PC connecting to the system – No need to purchase certificates. Techniques similar to Windows Activation are also utilised to guarantee the security of each connection.
- In addition to the above, messages are encrypted using constantly changing session encryption keys. Only publicly ratified and validated state-of-the-art encryption libraries are utilised.
- Code obfuscation is utilised.
- Approved health organisations only can install the product after the issuing of a passphrase-protected configuration file. Identified organisation administrators are responsible for allocating use accounts and user rights.
- GRHANITE™ performs a delta (Δ) data comparison to extract encrypted data changes each day or as otherwise scheduled – very small data quantities over the network.

GRHANITE™ – GeneRic HeAlth Network Information Technology for the Enterprise

GRHANITE™ by Example

Hospital

Hospital Computers

Consent & Security

Name: Joe Bloggs

DoB: 14/07/1993

HBA1c: 11.2

cDOpy28aFAKyaqDdq5xo+OhmxGlOMGY
NTyJ1qf+TSHZhC974lkxaixZSdTNGp5ne8
UZPKF2mz0Xgw3QuSWaadwvKlYkKQ7b
mFOPnpjnSHkM=

Joe Bloggs consented and de-identified

Web Services

So long as consent has been granted, Joe's de-identified record is automatically transferred to the databank

GRHANITE™ Databank

cDOpy28aFAKyaqDdq5xo+OhmxGlOMGY
NTyJ1qf+TSHZhC974lkxaixZSdTNGp5ne8
UZPKF2mz0Xgw3QuSWaadwvKlYkKQ7b
mFOPnpjnSHkM=

General Practice

Practice Computers

Consent & Security

Name: Joe Bloggs

DoB: 14/07/1993

cDOpy28aFAKyaqDdq5xo+OhmxGlOMGY
NTyJ1qf+TSHZhC974lkxaixZSdTNGp5ne8
UZPKF2mz0Xgw3QuSWaadwvKlYkKQ7b
mFOPnpjnSHkM=

Joe Bloggs attends GP and identity established. De-identified hashes matched

Web Services

Hash matching and session key management

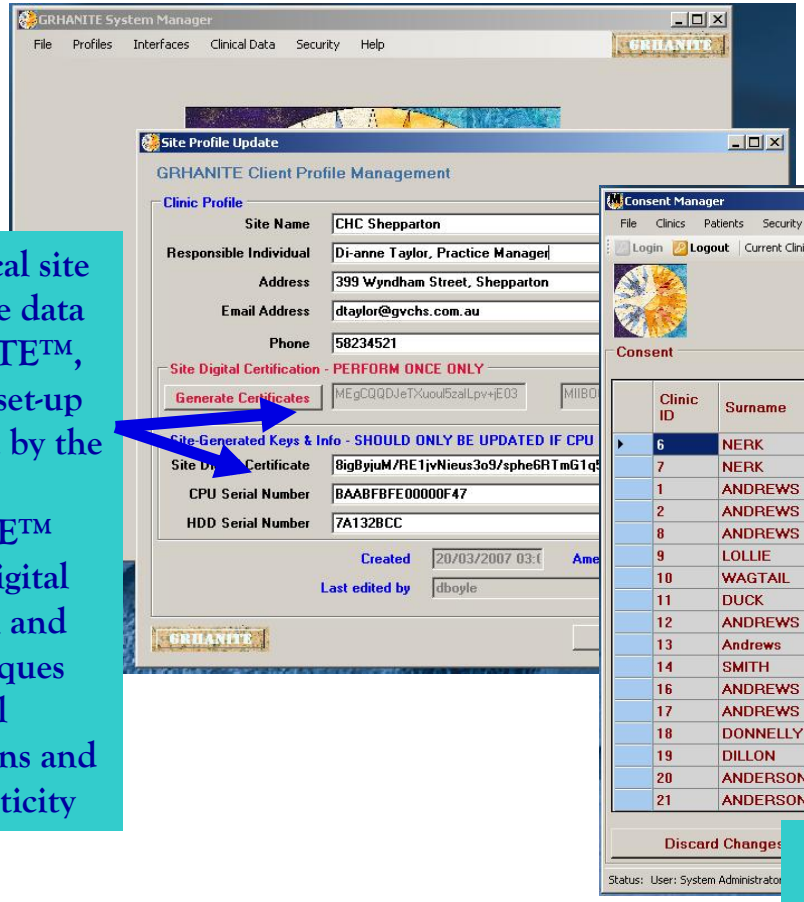
Secure website link established to view Joe Bloggs record

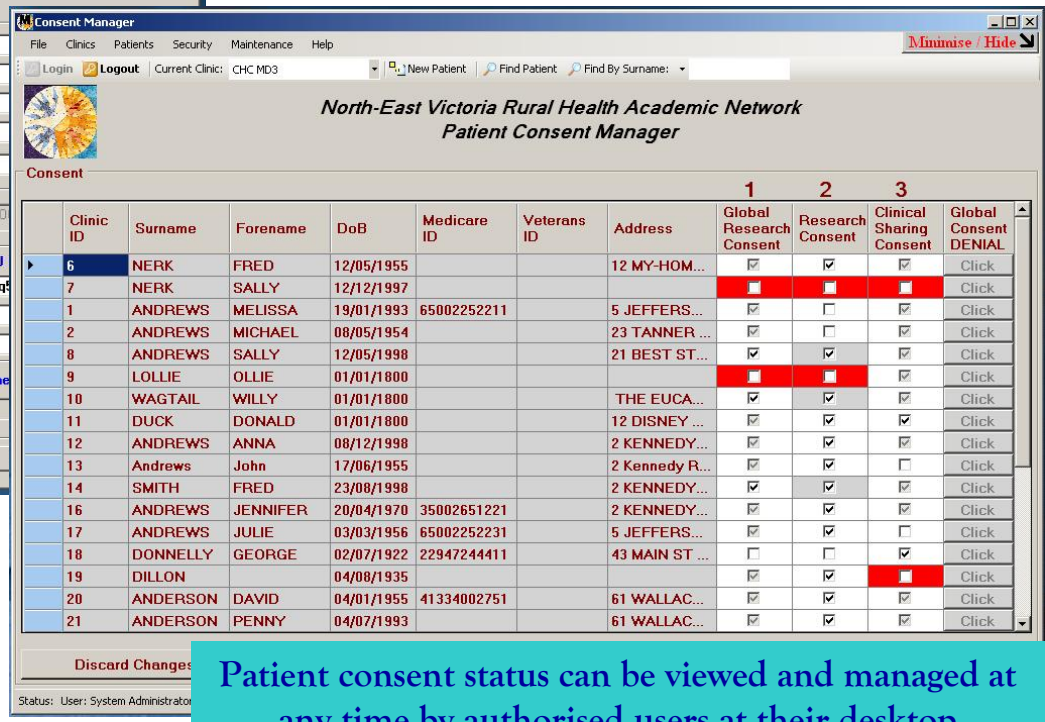
Name: Joe Bloggs

DoB: 14/07/1993

HBA1c: 11.2

GRHANITE™





Before a clinical site can contribute data via GRHANITE™, they must be set-up and authorized by the central GRHANITE™ authority. Digital Certification and other techniques secure all communications and verify authenticity

Patient consent status can be viewed and managed at any time by authorised users at their desktop

- *GRHANITE™ is the technology underpinning the CONDUIT™ (Collaborative Networks Using Information Technology) project*
- *CONDUIT™ is the technical component of the North East Victoria Rural Health Academic Network (RHAN). This network has several goals, including managing the people aspects of establishing a Managed Health Network – initially for diabetes.*

Results and Conclusions

- GRHANITE™ has been developed to demonstrator status and is ethically managing de-identified, linked, consented data from Medical Director V3 and Practix V1.3.
- A generic interface is being finalised – this will allow connections to most modern healthcare database systems – including ad-hoc systems.
- Collaborations have been established with organisations to support large scale development, testing and implementation.
- Techniques as utilised in Scotland are being used to ensure the large-scale applicability of the system.
- Diabetes service provision across North-East Victoria, Australia will be the first example of the clinical utility of the system.
- A diabetes demonstrator website is planned for completion by October or early November this year.
- Because of the comprehensive management of consent and security, we hope that this technology can finally remove the barriers to clinical information sharing between primary and secondary care.
- Comprehensive research data for consented patients should be a valuable by-product of the system. Crucially, this includes primary care data that is a largely un-tapped research resource in Australia.
- As far as we are aware, this is the FIRST TIME a central databank holding live clinical data has been able to do so WITHOUT holding patient identifiers. If we can do it, shouldn't everyone?

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Information Technology Supported Clinical Handover - A Pilot Study

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Abstract

Major improvements in the clinical handover process have been introduced to the Women's and Children's Hospital (WCH) in line with recently published Australian recommendations. The enhancement of this process by using the newly developed OACIS Clinical Handover module in a paediatric medicine setting is reported. The assessment included a pre-pilot survey questionnaire conducted to assess the medical staff opinions regarding the existing handover process with a follow up questionnaire after one week of using the OACIS computer augmented process. A further questionnaire will be conducted with the next rotation of medical staff.

Keywords:

continuity of patient care, medical errors, quality of health care, safety

Introduction

The implementation of Salaried Medical Practitioners' awards has changed the way healthcare personnel work in hospitals. No longer is a patient looked after by one doctor or only one team during an admission. Additionally, a doctor may have little or no day to day contact with a patient he/she is responsible for on a given shift. Also with increasing complexity of care, more and more patients now require care by multiple teams. Thus clear accurate and efficient communication is required to ensure optimal safe care.

In order to ensure good communication of relevant information about patients to all the team members, effective handovers are now deemed indispensable.

There has been a number of reports on clinical handover in recent years, particularly in Australia, ranging from descriptive to evaluative studies and suggestions for good practice[1-5]. While every format cannot be directly applicable in every clinical situation, most reports agree that the handover helps improve patient safety, aids medical education, improves patient confidence and fosters job satisfaction for the medical staff.

Recognition of the importance of the clinical handover process resulted in a Clinical Handover Improvement Project at the WCH in 2004. Prior to this paediatric medical handover was an informal process. The mission statement of that project was "that within six months 100% of paediatric evening and night trainee medical officers (TMOs) will follow a standard template of clinical handover." The implementation strategies and future plans resulting from the Improvement Project included the following:

- establishment of executive support and appropriate budget,
- to explore the possible roles for IT applications in handover,
- to address all issues pertaining to the morning handover.

At the time of the WCH handover improvement project, a clinical information system module to support clinical handover was being developed (OACIS system, careconnect.sa). . There are plans to introduce it to the integrated public hospital system in South Australia, providing the planned pilot study at the WCH and Royal Adelaide Hospitals does not display any major problems.

This study reports the pilot in the Department of General Medicine, WCH, including the utility of the new handover module and the criteria for assessment of key performance indicators.

Materials and methods

The Department of General Medicine (DGM) has a throughput of approx 3-3,500 patients each year. Three concurrent teams comprising a consultant, registrar and resident medical officer manage the patients during normal working hours. After hours, a single team of one registrar and two RMOs manage the patients until midnight; one registrar is on call from midnight until the following morning. There is a consultant on-call during these 2 shifts. The after hours team provides cover for all paediatric medicine inpatients both general and subspecialty.

At 08:00, the morning handover is held in a dedicated room. The Senior Registrar or one of the Consultants facilitates the meeting which is also attended by the nursing shift coordinator from the main medical ward and the Medical Emergency Team nurse who also contribute.

The general and subspecialty day teams handover to the after hours team at 16:30 -17:00. Both medical and nursing staff use the patient list summary reports (PLSRs) prepared from the careconnect.sa OACIS clinical information system.

OACIS is an Open Architecture Clinical Information System which is comprised of a series of integrated applications designed to deliver benefits to the public healthcare sector of South Australia via information technology. It is Australia's largest multi-hospital integrated real-time common clinical information system. The integrated modules available prior to the handover pilot included

- **Clinical display**, which provides a single point of access to the integrated online patient record. It includes demographics, encounters, outpatient appointments, medications, laboratory results, imaging reports, operating theatre procedures and emergency department attendances. This allows the clinician to view a comprehensive history in real time that charts and displays information and results without having to wait for paper records to be delivered.
- **Order Entry,** which is an electronic ordering system for diagnostic, therapeutic, pharmaceutical, medical and surgical patient services and incorporates best practice information into multi-disciplinary order sets. This enables clinicians to submit prescriptions, referral requests, restricted antibiotic approval requests and requests for diagnostic, medical, surgical and therapeutic services electronically.
- **Separation Summary,** which communicates information from the public hospitals to General Practitioners and other referring providers, thus ensuring continuity of ongoing healthcare. The summary gives a comprehensive account of the encounter, tests and continuing care requirements, and may be sent by hardcopy, electronically or by secure fax to the referring provider.
- **Clinical Reporting Repository (CRR)**, which provides the capability to query, analyse, and explore the substantial clinical data held across the patient population in the OACIS Data Repository (the data store for OACIS) to facilitate clinical decision making . The repository facilitates tracking of trends over time and leads to higher quality care. This allows research and reporting which has previously, not been possible.

The only changes to the established handover process needed prior to commencing the pilot were to provide the hardware for projection of the OACIS modules within the handover room and also to provide the individual training for the users.

The process was evaluated in two ways:

1. A pre implementation survey was done with all the staff attending the handover.. This was repeated one week after deployment of the handover module. The survey will be repeated with the next rotation of trainees.

Written feedback was also sought from the users of the system by means of a notebook left in the handover room. User comments were collated and acted upon and where necessary modifications made to the OACIS module or the handover process.

Results

The results indicated that all the staff were positive about the handover process.. The majority felt that the meetings started on time and that there were few distractions. There was universal agreement that the new electronic handover provided instant access to relevant investigations and past medical details (which were not easily available in the previous format).

In the one week post-implementation survey, several staff felt the new handover process took too long. Many of the respondents also gave valuable suggestions to improve the efficiency of this process. These changes have been introduced and the overall impact will be reassessed in the final survey.

Further benefits were noticed during the period of evaluation. Details of past admission and results of prior tests were instantly available at the time of handover. One could also access references online and this was helpful in planning the care for complex patients. The system has enabled the teams to recognize reportable incidents and provision has been made to insert reminders for these to be documented and reported.

Discussion

This paper describes the successful implementation of an IT supported handover module in a busy medical unit. It has been feasible to integrate the new format with existing patient management software and enhance the efficiency of the handover process.

The addition of the handover module to the handover process has obvious advantages:

- the ability to enter free text information,
- record jobs to do
- flag urgent issues into the database
- have the ability to print out customised lists (this was well received by the medical staff)
- allow the information to be accessed by all authorized staff involved in the care of a patient, thus ensuring continuity of care.

A list of patients is displayed prominently on the screen, thus enabling all the team members to be involved in the discussion.

Nursing staff were also very receptive to the introduction of the new module. Patient management plans can be accessed by ward staff (where authorised) thus keeping them informed of the medical plans.

The survey was limited by the small group of respondents (11 medical and nursing staff). Moreover, the medical unit already had an efficient handover process in place and so the introduction of the new handover module did not result in major improvements. It will be interesting to conduct this process in an environment where no pre-existing formal handover is established. We plan to continue assessing the impact of this module as it is introduced and taken up by other medical, surgical and allied health units in this hospital as well as the other South Australian public hospitals.

We believe there are exciting potential future advantages for this module. Preliminary work has already established that the OACIS system is enhanced with the availability of bedside computing through wireless or hard wired systems and this should improve the utility of the handover module. Communication with different teams will be more efficient and, therefore, safer.

The quality of the handover can be monitored by key performance indicators generated from the CRR and data collected at the time of the handover.

Conclusion

The addition of an IT module to an already established clinical handover has enhanced the quality of the information transfer between clinicians. It has improved the quality of patient care.

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Improving Healthcare in South Australia

IT Supported Clinical Handover - A pilot study

David Morris, Chris Pearson, Murali Narayanan, Eileen Hancock & Anna Baker

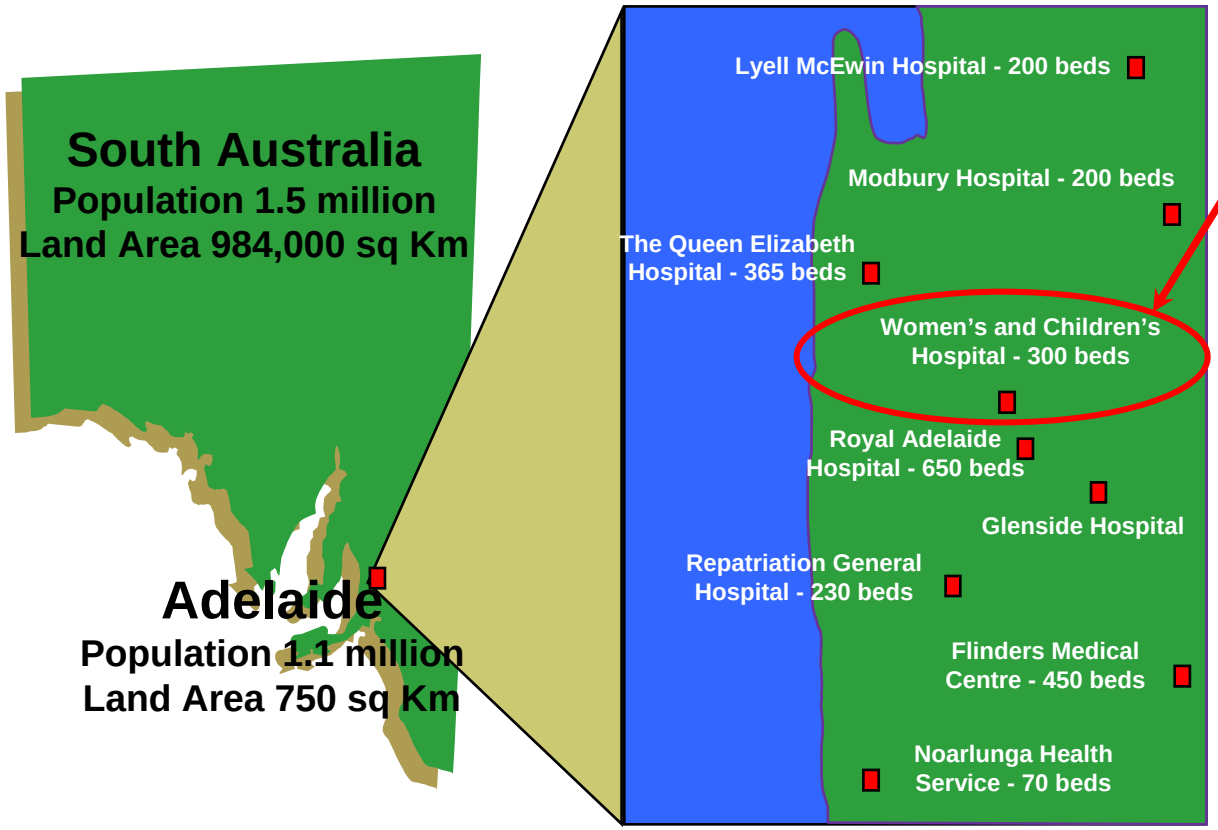
Government of South Australia

Department of Health

South Australian Public Health System

There are 82 public hospitals and health services

Distribution of Metropolitan public hospitals



We are here

Demographic

Metropolitan Adelaide (DH Annual Report 2004-05)

Average daily available beds	3,206
Accident & Emergency attendances p.a	310,661
Outpatient visits p.a	1,373,503
Inpatient separations p.a	250,549

* Source: Australian Bureau of Statistics, 2001 Census Basic Community Profiles Table B01

Illustration only. Not to scale

The rationale for Handover

- Major contributory factor in incident leading to harm to patients
- Changing patterns of medical staff rostering move to shifts
- Background in UK safe working hours European paper suggested IT to support Handover process

Handover via Oacis

- The public hospital clinical system used in 9 metro hospitals
- Established as the daily tool of junior medical staff
- Supporting an already established process

Basic requirements for Handover tool

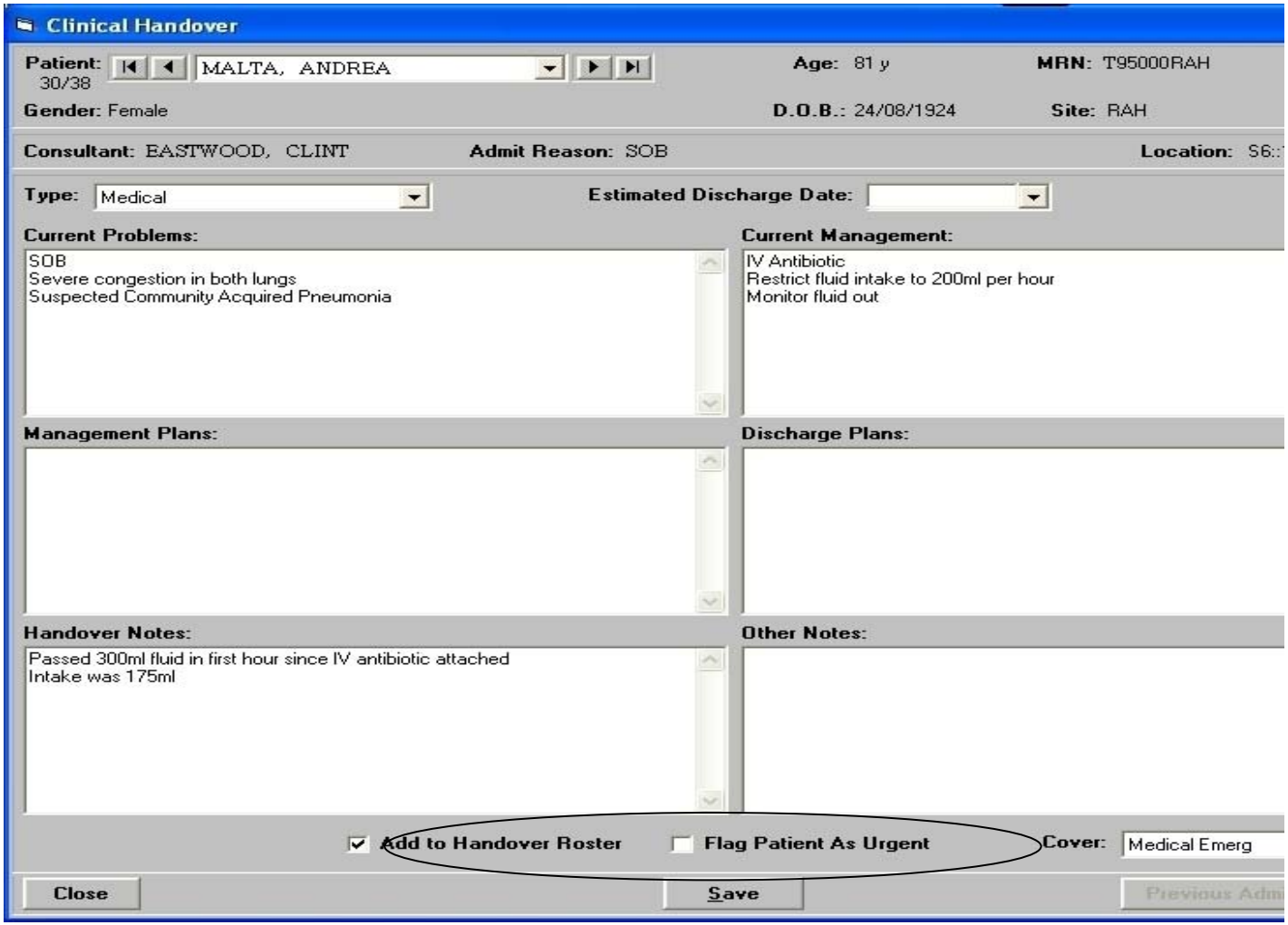
- Sufficient and relevant information should be exchanged to ensure patient safety;
- Tasks not yet complete are clearly understood by the incoming team;
- Tasks should be prioritized;
- Plans for patient care are easily accessible; and
- The name and contact number of the doctor responsible for the care of the patient is easily accessible.

Viewing the Handover Screen

Roster column descriptions

- **H** indicates Handover note
- **U** indicates Urgent note
- **C** indicates Current note
- * indicates note from other discipline

Using the Handover Screen

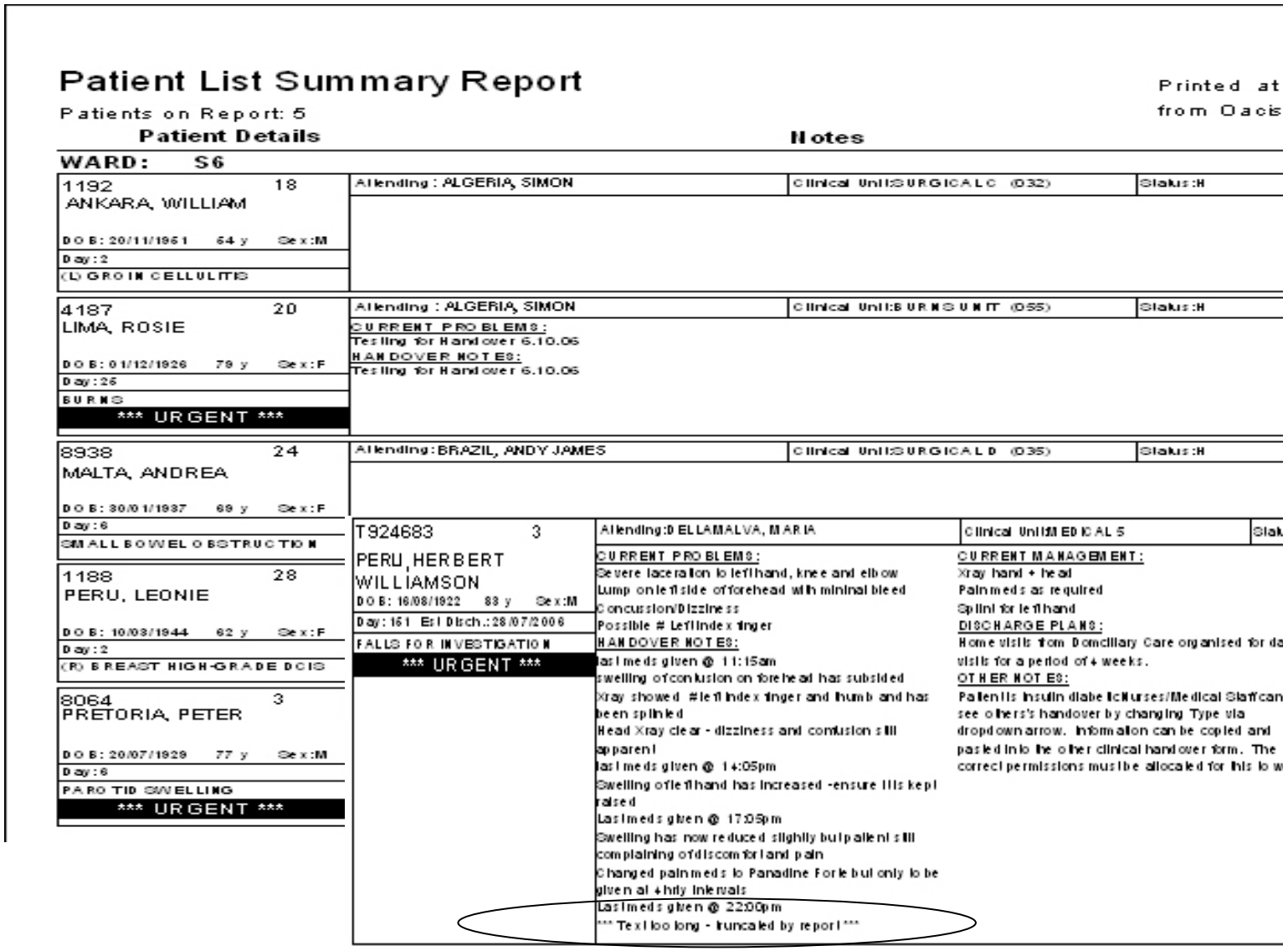


Type in notes in to text boxes + estimated discharge date

Tick

- **Handover**
- **Urgent**

Printed Work List



Patient List Summary Report

Printed at
from Oacis

Patients on Report: 5

Patient Details | **Notes**

WARD: S6

Patient Details	Notes		
1192 18 ANKARA, WILLIAM DOB: 20/11/1951 64 y Sex:M Day:2 (L) GROIN CELLULITIS	Attending: ALGERIA, SIMON	Clinical Unit:SURGICAL C (D32)	Status:H
4187 20 LIMA, ROSIE DOB: 01/12/1926 79 y Sex:F Day:26 BURNS *** URGENT ***	Attending: ALGERIA, SIMON CURRENT PROBLEMS: Testing for Handover 6.10.06 HANDOVER NOTES: Testing for Handover 6.10.06	Clinical Unit:BURNS UNIT (D55)	Status:H
8938 24 MALTA, ANDREA DOB: 30/01/1937 69 y Sex:F Day:6 SMALL BOWEL OBSTRUCTION	Attending: BRAZIL, ANDY JAMES	Clinical Unit:SURGICAL D (D35)	Status:H
1188 28 PERU, LEONIE DOB: 10/03/1944 62 y Sex:F Day:2 (R) BREAST HIGH-GRADE DCIS			
8064 3 PRETORIA, PETER DOB: 20/07/1929 77 y Sex:M Day:6 PAROTID SWELLING *** URGENT ***			
T924683 3 PERU, HERBERT WILLIAMSON DOB: 16/08/1922 83 y Sex:M Day:161 Est Disch.:28/07/2006 FALLS FOR INVESTIGATION *** URGENT ***	Attending: DELLAMALVA, MARIA CURRENT PROBLEMS: Severe laceration to left hand, knee and elbow Lump on left side of forehead with minimal bleed Concussion/Dizziness Possible # Left index finger HANDOVER NOTES: last meds given @ 11:15am swelling of contusion on forehead has subsided Xray showed #left index finger and thumb and has been splinted Head Xray clear - dizziness and contusion still apparent last meds given @ 14:05pm Swelling of left hand has increased -ensure it is kept raised Last meds given @ 17:05pm Swelling has now reduced slighlly but patient still complaining of discomfort and pain Changed painmeds to Panadine Forte but only to be given at 4 hrly intervals Last meds given @ 22:00pm *** Text too long - truncated by report ***	Clinical Unit:MEDICAL 5 CURRENT MANAGEMENT: Xray hand + heal Pain meds as required Splint for left hand DISCHARGE PLANS: Home visits from Domciliary Care organised for da visits for a period of 4 weeks. OTHER NOTES: Patient is insulin diabetic Nurses/Medical Staff can see others's handover by changing Type via dropdown arrow. Information can be copied and pasted into the other clinical handover form. The correct permissions must be allocated for this to w	Stat

Benefits

- Access to Urgent and Cover rosters
- Can be viewed from any location within the Hospital
- Identifies patients most in need of review
- Improved Communications
- No longer working from memory

Benefits

- **Patient Safety Increased – as a result of improved, legibile information**
- **Continuity of Care – improved transfer of clinical information**
- **Decreased Repetition**
- **Handover notes available on Patient List Summary Report**

Evaluation

- The introduction of the Oacis Handover module was well received in the Unit. The greatest impact to the Unit was at the regular meetings at 8am each day. Due to the visibility of the patient list on the screen the order of patients being “handedover” became more structured.

- Access to clinical notes resulted in a more concise delivery of information. The inclusion of clinical notes on the Patient List Summary Report meant doctors could focus more on listening than each of them handwriting notes for themselves.

- Generally it was felt Handover had become more formalised, thorough and increased educational opportunities.

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Drug Interactions During Three Decades

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Abstract

Physicians may inadvertently prescribe improper combinations of drugs. Changes in the epidemiological panorama of potential drug interactions were studied during three decades, from 1983 to 2003. During the study period polypharmacy increased with 61%. Overall, potential drug interactions increased (relative risk 1.177 95% confidence interval 1.104-1.256), although the more severe interactions decreased (relative risk 0.714 95% confidence interval 0.587-0.868). Potential drug interactions and polypharmacy among the elderly should be closely monitored.

Keywords:

community pharmacy services; decision making, computer-assisted; drug interactions

Introduction

As long as mankind has used plants, animals and inorganic substances to cure and alleviate health disorders, drugs have probably been used in combinations to potentiate their intended effects. It may be favourable to use a combination of drugs if the combination is well documented to enhance the effect or to reduce adverse effects. However, it has been shown that physicians may inadvertently prescribe improper combinations resulting in less effect or more adverse drug reactions [1]. The present study was conducted in order to make an analysis on changes in the epidemiological panorama of potential drug interactions during three decades, from 1983 to 2003.

Materials and methods

The prescriptions from all individuals (n=8,318; 8,726; 8,214) with two or more prescriptions during three periods of fifteen months, October to December 1983-84, 1993-94 and 2003-2004, were collected from an ongoing cohort study in the county of Jämtland [2]. The potential interactions were detected by a computerized system and classified according to clinical relevance (types A–D), type D being the most severe [3].

Results

The relative risk of receiving potentially interacting drugs increased for type C interactions (relative risk 1.177 95% confidence interval 1.104-1.256) and decreased for type D interactions (relative risk 0.714 95% confidence interval 0.587-0.868) from 1983-84 to 2003-04. The relative risk was positively correlated to the increase in polypharmacy and for the more severe type D interactions an exponential relationship was displayed. Polypharmacy for included subjects increased over time with 61%, from 9.05 filled prescriptions per subject in 1983-84 to 10.6 in 1993-94 and 14.6 in 2003-04.

Discussion

To avoid drug interactions and adverse drug reactions prescribers should regularly check the patient's list of medication, computerized or not. The patient's age and number of medications are significant predictors of medication discrepancy. The toxicity of drug combinations may sometimes be synergistic and be greater than the sum of the risks of toxicity of either agent used alone. Screening for drug interactions should include all medication, both for inpatients and outpatients, nursing homes included. To ensure effective partnership between different healthcare professionals and the patient, good communication is essential both technically and, not at least, personally [4].

The present study was conducted in year 2005, prior to the new Swedish legislation introducing two new national databases for which the Jämtland cohort has served as a model. The Swedish National Prescribed Drug Register is intended for statistical, epidemiological, and scientific purposes, whereby drug and disease associations and the risks, benefits, effectiveness, and health economical effects of drug use may be explored [5].

For clinical purposes the equivalent information is made available by the new Swedish National Pharmacy Register, which provides prescription dispensing information for the majority of the population with the objective to improve drug utilization. The medication history in the register may be accessed online by registered individuals, prescribers,

and pharmacists. Different systems for electronic health care records contain functionality for automated detection of drug interactions. These prescribing systems should be linked to the National Pharmacy Register in order to alert physicians at the point of care not to prescribe any inappropriate drugs (or duplicates) in combination with drugs already prescribed by other physicians and filled by the patient at pharmacy [6].

The advantages of the new databases compared to the Jämtland cohort are obvious; the new databases are mandatory, comprising all individuals filling prescriptions on a national level, probably constituting one of the largest and most comprehensive prescription databases in the world. To further develop these databases, exposure to drugs within hospitals and over-the-counter sales should be added. The Jämtland cohort may well be used for longitudinal studies, with its unique historical material [4].

Conclusion

Due to a pronounced increase in polypharmacy the reason for prescribers and pharmacists to be aware of drug interactions has grown over time. The risk of receiving potentially interacting drugs has increased for the type C interactions although it has decreased for the more severe type D interactions. This could be a result of changes in the market, more awareness among prescribers as well as introduced modules for interaction detection in electronic prescribing systems.

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Drug Interactions during Three Decades

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Keywords

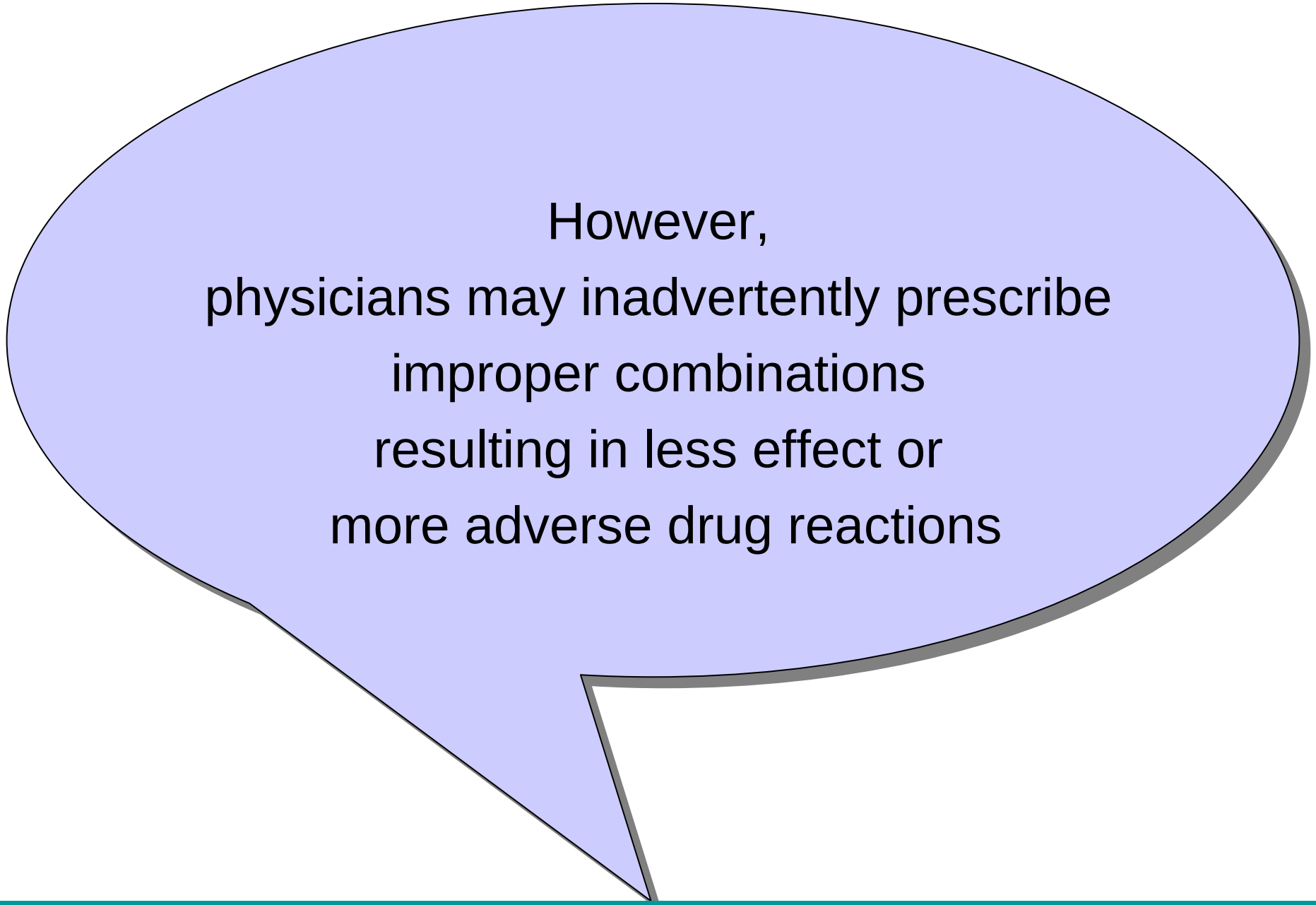
Community pharmacy services

Decision making, computer-assisted

Drug interactions

As long as mankind has used plants,
animals and inorganic substances
to cure and alleviate health disorders,
drugs have probably been used in combinations
to potentiate their intended effects

It may be favourable to use
a combination of drugs,
if the combination is well documented,
to enhance the effect or
to reduce adverse effects


However,
physicians may inadvertently prescribe
improper combinations
resulting in less effect or
more adverse drug reactions

Aim of study

to evaluate the change in risk over time of receiving potentially interacting drugs, from 1983 to 2003

Materials and Methods

- Three periods of fifteen months;

  1983, 1993, 2003
- Prescriptions from all individuals

  (n=8,318; 8,726; 8,214) with two or more prescriptions
- Collected from an ongoing cohort study in the county of Jämtland, Sweden
- Computerized interaction detection system

Results

Polypharmacy increased with 62%, from 1983 to 2003

Study period	Filled prescriptions per subject
1983	9.05
1993	10.6
2003	14.6

Results

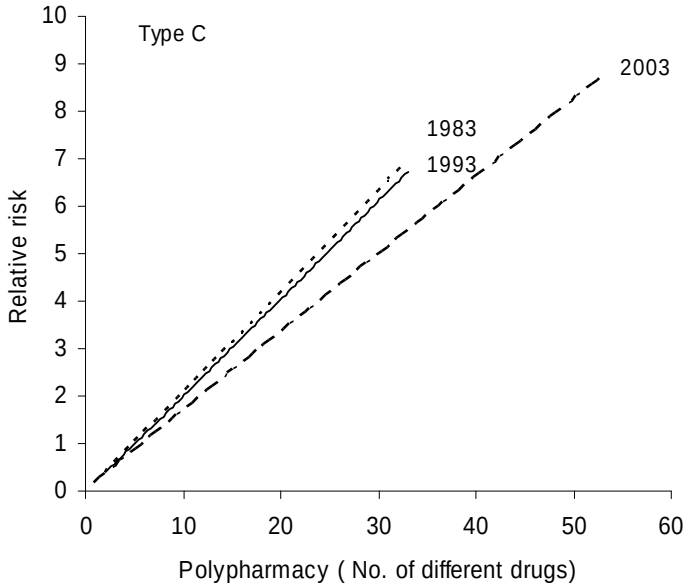
Relative risk of potentially interacting drugs

- *increased* for type C interactions
  relative risk 1.177 (95% C.I. 1.104-1.256)

- *decreased* for type D interactions
  relative risk 0.714 (95% C.I. 0.587-0.868)

Results

Relative risk positively correlated to
the pronounced increase in polypharmacy



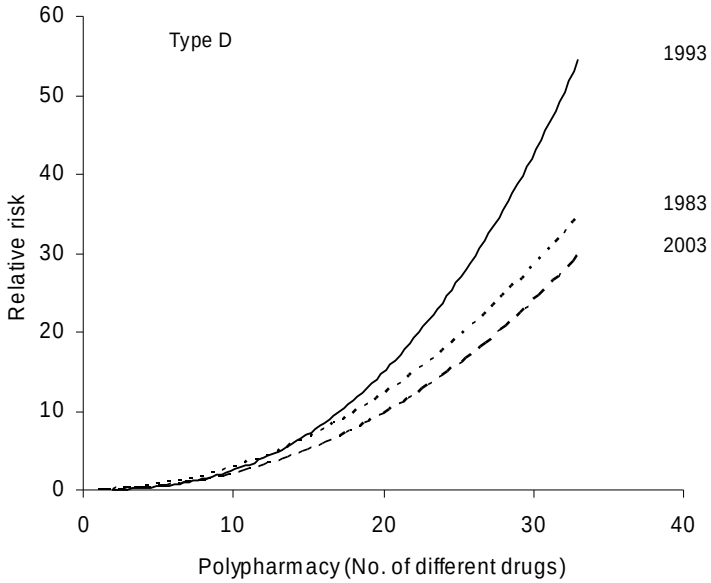


Fig. 1 Relative risk of potential interactions type C and D correlated to polypharmacy. 1983, 1993 and 2003 refer to the study periods Oct 1983 - Dec 1984, Oct 1993 - Dec 1994 and Oct 2003 - Dec 2004 respectively.

Conclusions

- pronounced increase in polypharmacy
- reason for prescribers and pharmacists to be aware that drug interactions has grown over time
- risk of receiving potentially interacting drugs

  has increased for the type C interactions,

  but decreased for the more severe type D interactions

References

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The Efficiency of Applying Short Message Service for Surgical Patient's Families

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[c]Armed Forces Taichung General Hospital, Taiwan

Abstract

This study was to build a web-based short message service (SMS) system in operating room. We approached the efficiency of SMS for patient's families during the time series of surgery process (pre-, intra-, and post-operation). In this study, 322 participants received 685 text messages. The findings show the usability of SMS applied to the clinical care, especially for reducing family's anxiety and improving their satisfaction. Therefore, it is suggested to exploit the effectiveness of personal medical care.

Keywords:

anxiety, surgical patient, short message service

Introduction

Patient's families usually appear stressful and helpless because of lacking information about the patient during the waiting time. The scholars also discovered high-level anxiety in both patient themselves and their family throughout the waiting period [1]. In order to achieve a good surgical patient management, it's possible to apply a novel technique for the communication between the hospital and patient/patient's family. Cellular phone is a well-established technology of communication in hospitals and commonly used with many benefits in patient care [2, 3, 4].

Materials and methods

We conducted the project in the OR that served about five hundred patients every month. The data was collected from HIS database, contents of storage text messaging, satisfaction questionnaires and anxiety scale. The investigators used available proprietary web-based software operating on Office 2003 Microsoft Windows personal computer to enter, edit, and store messages for delivery to the patients in the operation room (every8D.com, Taiwan). Outside of the operation room, mobile telephone and smart phone were considered as endorsement. The content of messages and exact time were recorded in the web database (figure1).

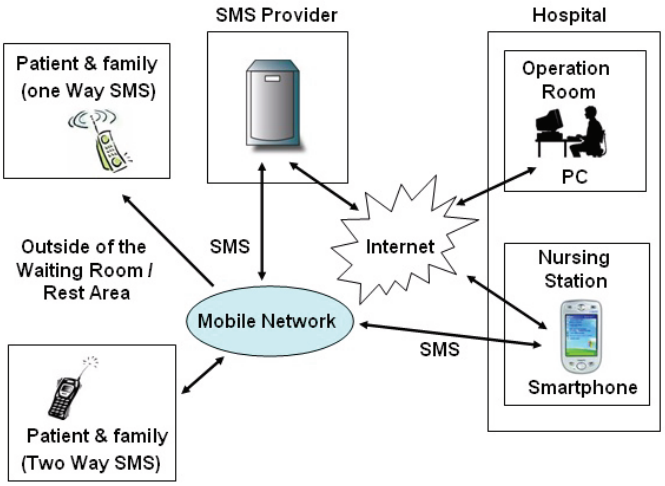

Figure 1 - The system architecture of web-based SMS system for surgical patient families

Results

The operation room totally served three hundred twenty-two participants who received 685 text messages and 283 participants answered satisfaction questionnaires (87.89) between August 20 and October19, 2005. The participants were sent 2 to 5 text messages. In all questionnaire items, the statistic data described phenomena that participants' satisfactions were high level (mean4.3, SD.69).The families reported that they were very anxiety during the waiting period when the patient in OR, the mean of anxiety score were 7.8, and 96.4% families reported the SMS could reduce their waiting anxiety(mean=2.3 ,SD=.12). About time management, 92% participants were strong agreed that the SMS provided an opportunity to arrange their time, and they did not always stay at the waiting area.

Table1 - Demographic characteristics of participants (n=283)

Variable	n	%
Source		
Outpatient	29	10.3
Inpatient	154	89.7
Patient age		
<18	12	4.3
18,<40	98	34.6
40	173	61.1
Patient gender		
Female	167	59.0
Male	116	41.0
Operation duration		
<1hour	52	18.4
>1hour ,2 hours	45	15.9
>2hours,4 hours	162	57.2
>4 hours	24	8.5
Family age*		
<18	10	3.6
18,< 40	147	51.9
40	126	44.5
Family gender*		
Female	159	56.2
Male	124	43.8
Family's education status*		
Primary+ secondary	54	19.1
High school and higher	229	80.9

* Family who received the text messages

Table 2 - Patient/family satisfaction (n=283)

Topic	mean	SD
Better time arrangement	4.3	.63
Waiting at other place	4.3	.72
Reduce waiting time	4.3	.67
Get real time information	4.5	.61
Reduce family's anxiety level	4.5	.59
Reduce family's business delay	4.4	.63
Reduce patient's anxiety for surgery	4.3	.72
Reduce patient's anxiety for family waiting	4.4	.69

Table 3 - Text messages of patient/family's opinion (n=283)

Variable	mean	SD
Pre-operation identify	4.4	.58
Patient name	4.4	.59
Disease diagnosis	4.3	.65
Surgery site	4.3	.68
Surgery category	4.3	.68
Surgery time, initial/ending	4.4	.59
Intra-operation information	4.4	.58
Emergency information	4.4	.66
Surgery status information	4.6	.55
Surgery finish information	4.6	.52
Post-operation follow up	4.4	.53
Clinic information	4.6	.55
Education information	4.3	.63
Medication reminder	4.5	.53

Conclusion

A web-based SMS build a general communication system between health delivery and people. Because the internet and cellular phone are universal, it's much easily and smoothly to develop a SMS system in hospital. It's believed that SMS is feasible to be applied in other situations such as outpatient department, medicine delivery and health information supplies.

Acknowledgments

This project was funded by the operation room at Armed Forces Taichung General Hospital, Taiwan. Thanks to all the members of 322 persons who consenting the SMS project and 283 persons answered the questionnaires. The SMS participants joined in it so well.

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The Efficiency of Applying Short Messaging Service for Surgical Patient Families

Fan-Pin Huang, MSN, Shuo-Chi Liu, MS, Su-Mei Shih, MSN, Yao-Hua Tao, BS, Jeng-Yuan Wu, BS, Shaw-Yeu Jeng, PhD, Po-lun Chang, PhD

Research purpose

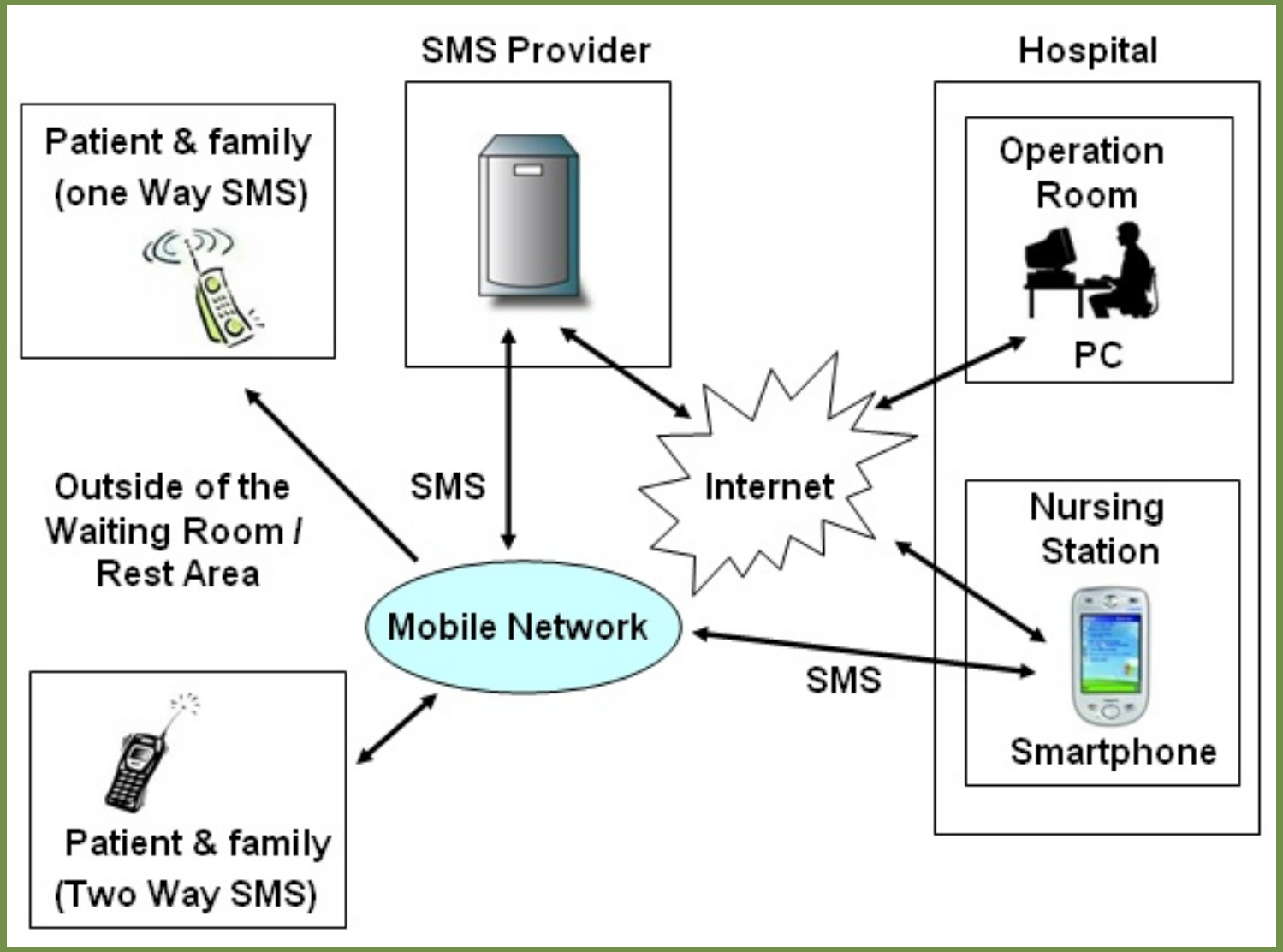
- *develop a web-based short messaging service (SMS) system in the operation room (OR).*

- *integrated and analyzed the limits of SMS in OR.*

Method and material

- *a cross-sectional study with quantitative method and convenience sampling was used to gather data in this study.*
- *both participant satisfaction and individual-opinion scale were scored up as 1 to 5 in this study (5= strong agree).*
- *anxiety scale were scored up 0-10.*

The structure for surgical patient family with a web-based SMS system



Research process

- *approached the content of SMS with operation diagnosis, patient sources and time series (pre-, intra-, and post-operation).*

Results

- *gather data between August 20 and October 19,2005.*

- *three hundred twenty-two participants received 685 text messages and 283 participants answered satisfaction questionnaires (87.89％).*

Demographic characteristics of the SMS participants

(n=283)

Variable	n	%
Source		
Outpatient	29	10.3
Inpatient	254	89.7
Patient age		
<18	12	4.3
≧18,<40	98	34.6
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Demographic characteristics of the SMS participants

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(n=283)

Topic	mean	SD
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96.7% reported it reduce families' waiting anxiety

Text messages of patient/family's opinion

(n=283)

Variable	mean	SD
Pre-operation identify	4.4	.58
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Clinic information	4.6	.55
Education information	4.3	.63
Medication reminder	4.5	.53

Discussion

- *this study captured self-reported anxiety, autonomy, and SMS demands.*
- *the automated paging system provided the advantage of personalized messages.*
- *the SMS system function is more convenience and excellent than before.*

Conclusion

- *The findings show the usability of SMS that applied to the clinical care, especially for reducing family anxiety, real time information, physician-patient communication, medical care processes and patient's safety.*

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Fluent Software Implied in the Methodology of Numerical Simulation of Two-Phased Flows (liquid melting – gas) With the Separation Interface Specific for the Filling Process of the Pattern for theFramework of Fixed Partial Dentures

Cosmin Sinescu[1], Meda Negruiu[1], Mihai Romînu[1], Romeo Resiga[2], Sebastian Muntean[2]

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[2] University of Polytechnics of Timisoara, Laboratory of Numerical Simulation and Parallel Calculation of the National Centre for System Engineering with Complex Fluids

Abstract

This study presents the methodology of numerical simulation of two-phased flows (liquid melting – gas) with the separation interface specific for the filling process of the pattern for the framework of fixed partial dentures, as well as a series of numerical results for a typical geometry. Considering the presented issues, it is recommended to increase the revolution of the pouring table to 700 rotations / minute in the case of titan, creating similar conditions concerning the volume mass force between the two alloys.

Keywords:

numerical simuation, dental alloys casting, Fluent

Introduction

This study presents the methodology of numerical simulation of two-phased flows (liquid melting – gas) with the separation interface specific for the filling process of the pattern for the framework of fixed partial dentures, as well as a series of numerical results for a typical geometry.

The installation for melting and for pouring of titan - Titanplus (Seit Elettronica, Italy) is composed of a rotating table on which the pouring device is placed in dynamic balance.

The speed capacity of the pouring table is n = 500 rotations/minute, which corresponds to an angular speed of

$$\varpi = \frac{\pi n}{30} = 52.36\, rad / s$$

The heating and the melting of titan is accomplished with the help of high frequency currents. The metal pieces are placed in a crucible furnace that is set in position on the rotating table. When the melting temperature is reached, the rotating table, having the revolution n, the crucible furnace is sliding into position from where the melted metal is flowing into the pattern (the pouring shape). The flow of the melted metal into the pattern takes place especially due to the centrifugal force; the gravitational force can be neglected in this case [3].

Figures 1 and 2 present the field of analysis used to obtain the final study alternatives of the filling of the pouring cavity. Because of the great amount of calculations, two or three processors have been used at the same time as a calculating method. This method requires a partitioning of the main field into subfields, each sub domain being linked to one processor. The partitioning is made in such a way, so that the surface of the interfaces between the subfields has a minimal area and the number of junctions of the digitization network on the interfaces to be minimal. This condition is essential for the minimization (reduction) of data communications between the processors at every iteration of the solution algorithm.

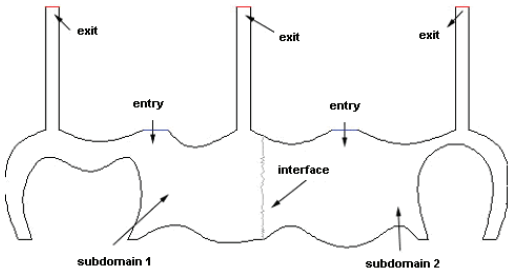

Figure 1 - The field of analysis, with the setting of the entrance/exit sections and partition into two subfields for parallel calculations on two processors

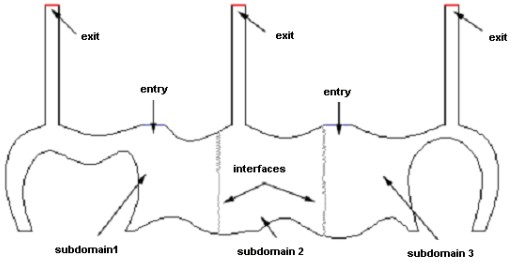

Figure 2 - The field of analysis with the setting of the entrance/exit sections and the partition into three subfields for parallel calculating on three processors

Figure 3 present the digitization network that has been used. In the details of figure 4, the used network of quadrilaterals can be observed in the neighborhood of the wall for a correct representation of the high speed gradients, with the triangulation from the inside (interior) which permits the covering of the fields with complicated geometry.

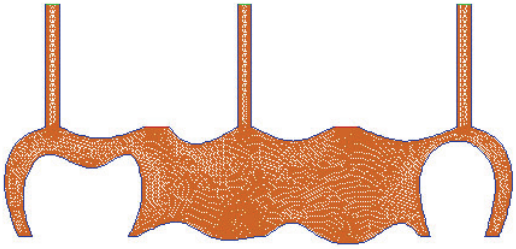

Figure 3 - The mixed digitization network of the field of analysis

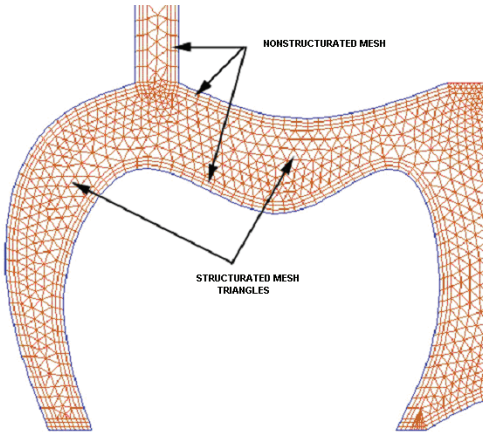

Figure 4 - Detail of the mixed digitization network

The final version for the configuration of the disposition of the ventilation channels, as well as the optimized digitization network represent some of the important accomplishments of the present study and guarantee the accuracy and the power of pointing out of the results obtained through the numerical simulation.

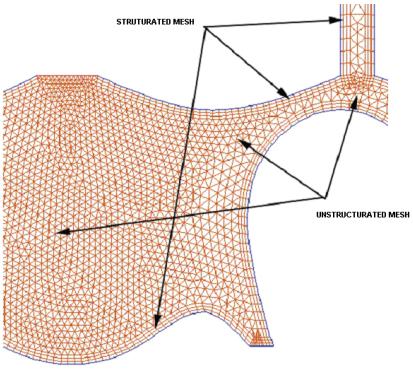

Figure 6 - Detail of the mixed digitization network. In the entrance section no quadrilateral elements are used. The layer of structured network embodies only the solid frontier, where the thick viscid fluid adheres to the wall

The local treatment of the ramifications (embranchments) is reduced to the study of the flow of the fluid into a "T"-type.

Coming back to the estimation of the entering speed of the melted metal into the cavity of the pattern,

with the hypothesis that $v_1 \cong 0$ and $v_2 \approx v$ (the medium speed in the hydraulic alimentation (supply) path) we have

$$v^2 = \frac{2}{1+\zeta}\left[\frac{\omega^2\left(r_2^2 - r_1^2\right)}{2} + \frac{p_1 - p_2}{\rho}\right]$$

In the initial stage – corresponding to the start of the flow, inside the pouring cavity the fall of the entrance/exit pressure is null and the entering speed of the melting is

$$v = \sqrt{\frac{52.36^2\left(0.14^2 - 0.1^2\right)}{2}} = 3.6\,m/s$$

After the crucible furnace has completely been emptied, due to the hydrodynamic resistance of the ventilation paths and because of the viscid chafe afferent to the flow into the pouring cavity, a difference of pressure of approximately 32000 Ps (in case of an Co- Cr alloy) appears between the entrance/exit and the speed decreases to the value of

$$v = \sqrt{\frac{52.36^2\left(0.14^2 - 0.13^2\right)}{2} - \frac{32000}{8700}} = 0.17\,m/s$$

The observation is made, that - during the filling process - the entrance speed of the melting into the cavity is consid-

erably decreasing onto the final [4]. This variation has been taken into consideration in the numerical simulation. Synthesizing the methodology of the numerical simulation, the calculation of the speed in the entrance section is made this way:

1 . first, calculation are made with a speed value of 3,6 m/s, according to the beginning of the emptying of the crucible furnace;

2. after the first interval of time, r_1 is recalculated corresponding to the liquid volume flown into the pouring form and the super- pressure p_2 is noted (p_1 is known as the atmospheric pressure);

3. the speed is recalculated in accordance with the previous relation;

4. the evolution in time continues for the new time span with the new speed value;

5. the time steps are calculated successively until the complete filling of the pouring cavity with melted metal [5].

Material and method

The numerical simulations have taken place at the Laboratory of Numerical Simulation and Parallel Calculation of the National Centre for System Engineering with Complex Fluids that functions at the University of Polytechnics of Timisoara.

The hardware infrastructure of the laboratory contains:

- 1 Linux Server, dual Pentium III, 1000 MHz, 2 GB RAM memory, 3xHDD 30 GB;
- 1 Windows Server, dual Pentium III, 1000 MHz, 2 GB RAM memory, 2xHDD 30 GB;
- 14 Working Stations, Pentium III, 1000 MHz, 1 GB RAM memory, 2xHDD 30 GB;
- Computer network infrastructure Linux /Windows, 2 Fast Ethernet Switch Allied Telesyn 24x100 Mbit, with management;
- Internet connection with optical fiber;
- uninterruptible tension sources;
- Network Printer Laser Jet HP 2200 DN, Printer Desk-Jet HP 1100C, Printer Laser XEROX P8 ex.

The software infrastructure of the laboratory is conceived to assure maximum of flexibility for the covering of a large scale of applications, in the educational field, as well as in the scientific performance research. Each working station is able to operate in Windows and Linux sub systems. The Fluent 5.5 program package is available in the Linux cluster configuration, which represents the world standard in the field of numerical simulation of fluid flow [1]. Fluent can be used in the multi-user mode (different problems are resolved simultaneously on different computers), but also in parallel calculation mode (a problem is solved simultaneously on several processors) [2]. In the Linux configuration, the network is used for the developing of parallel calculus algorithms utilizing the « Message Passing Interface » and the « Portable Extensible Toolkit for Scientific Computations » created at Argonne National Laboratory as information sources. In the Windows 2000 network, the whole usual Microsoft infrastructure is available (Visual Studio 6.0, MSDN Universal, Microsoft Office XP).

For the acquisition, processing and analysis of experimental data we use the graphic development tool LabVIEW (Laboratory Virtual Instrument Engineering Workbench). For post processing, analysis and interpretation of numerical data obtained from the simulation of the fluids flow phenomena, the Tecplot 8.0 program is available, together with its special CFD modules and the digitization network generator. A double investigation has taken place - for the titan melting and for the Co-Cr alloy. From the flowing point of view, the essential difference between the two situations is represented by the density of 4500 kg/m^3, respective 8700 kg/m^3. As the acceleration of the mass forces is determined by the rotation speed, its value remains the same in both situations. On the other hand, the mass force per fluid volume unit is equal to the product between density and centrifugal acceleration. The result shows that in case of the Co-Cr alloy, the mass force per volume unit is practically the double of that of the titan melting. This difference is responsible of the more rapid filling (and much more complete, in general) of the pouring form in the case of the Co-Cr alloy. The configurations are presented, in which the liquid phase is found at the following moments of time: 0.01 s, 0.06 s, 0.12 s, 0.25 s, 0.6 s, 1.4 s, 2.0 s and 3.0 s.

The first set of eight figures (tables 1-2) corresponds to the flow of the titan melting. It can be observed that the spurts of melted metal generated at the exit from the supply mouths are getting into contact with the inferior wall (in the following, we will be using the terms inferior/superior, although correctly it would be “at the little/large radius (beam)”, depending on the real disposition on the rotating pouring table) and are generating an ascendant spurt. At the 0.25 seconds moment this spurt enters the central ventilating channel. Subsequently, the filling of the left part of the pouring form starts, being almost filled at 0.6 s. The central area is filled in proportion of 75 % after 1.4 seconds and after 2 seconds approximately 50 % of the right part of the cavity will be filled. The almost complete filling of the cavity is accomplished in 3 seconds, with the visible existence of a few pouring imperfections afferent to the air bubbles trapped between the liquid mass and the solid walls near the supply mouths. We also appreciate the fact, that through the subsequent cover of these little imperfections with the ceramic layers, they will not have a

significant influence on the final quality of the prosthesis. The second set of seven figures (tables 3-4) present the succession of the filling phases with the Co-Cr melting. In the first filling phases, the evolution is almost identical to the titan melting; notable differences appear after 0.6 seconds. The mass force per volume unit is practically double in this case, encouraging a more uniform and complete filling of the pouring cavity. Practically, the pouring process can be considered finished after 2 seconds. The same little flaws or imperfections remain visible as in the case of the Co-Cr alloy.

The essential difference is that under the circumstances of maintaining of the same revolving of the rotating table - the titan pouring process lasts approximately 3 seconds, while for the Co-Cr alloy, there are only 2 seconds necessary to fill the form. Considering that titan is poured at a temperature over 1700 ºC and the Co-Cr alloy at 1300 ºC, the result shows, that the heat loss -and at the same time - the decrease of the temperature of the melting during the pouring process, is much smaller for Co-Cr. This is the main explanation for the different results obtained in practice with the two types of materials, in favor of the Co-Cr alloy.

Results

At first, a demonstration of the flow properties of titan, respective Co-Cr is presented; then, there is an explanation of the mathematic model that stands at the base of the FLUENT program that has been used for calculating. The capacity (the abilities) and limitations of this model are pointed out and the VOF type is found as proper for these particular investigations. The next step is represented by the analysis of the hydrodynamic of the supply path of the pouring form in order to evaluate the entrance speed of the melting into the cavity, as well as the variation in time of this speed.

For the numerical experiments, a typical geometry has been established for the fixed partial dentures and study versions have been carried out – with and without the taking into consideration of the embranchment of the supply channel, together with two versions of disposition of the ventilation channels. Initially, the field of analysis has been digitized with an unstructured network, this assuring the necessary flexibility for the approach of complex geometries. After that, a mixed network has been constructed, with quadrilateral elements near the solid wall and a triangulation inside the domain. This mixed network leads to the best numerical results.

The numerical simulations are the result of a great volume of calculations. As an example, the used time step (restricted because of stability considerations) is 10^{-4} seconds, which means that for a sequence of three seconds, $3x10^4$ time steps are needed. For every time step, the equation system that governs the two-phased flow is calculated iteratively, with a medium number of 3 iterations; this means a total of almost 10^5 iterations. The version of parallel calculation on three processors shows as a result a single iteration per second in its best shape, which gives us a rolling time of 10^5 seconds, which represent 28 hours. It must be said, that this version is the final result of multiple optimizations after more than 500 hours of pure calculation.

In the case of the version with a single processor (in our case PIII/GHz), one study version lasts three an a half days when optimized. Although this might seem an excessively large time span, the calculation effort is fully justified by the quality of the obtained results.

The preliminary numerical results have pointed out a series o problems of pure hydrodynamic origin, which may lead to the incomplete filling of the cavity of the pattern:

- The asymmetry of the embranchment of the supply channel, corroborated with the geometry of the cavity, may lead to a preferential filling of only one part of the cavity; this is why a careful execution of the distribution network of the melting to the cavity, with the best choice of the entrance angles into the cavity.
- even when assured of an even (uniform) repartition of the melting flow through the supply mouths of the cavity, there may appear difficulties caused by the improper disposition of the ventilation channels. This problem expresses the necessity of placing the ventilation channels on the same side with the supply mouths of the cavity.

As a result of these preliminary observations, an optimal disposition of the ventilation channels has been established (a number of three for the investigated case)- on the same side with the supply mouths. The calculation of the time variation of the effective flow supply permitted a realistic estimation of the length of the pouring process.

For titan three seconds are necessary, while for the Co-Cr alloy only two seconds are needed to accomplish a complete filling of the cavity. This difference is explainable by the significant difference of density (from simple to double).

Conclusion

Considering the presented issues, it is recommended to increase the revolution of the pouring table to 700 rotations / minute in the case of titan, creating similar conditions concerning the volume mass force between the two alloys.

The results presented in this study are no final solution for the problem of the geometric design of patterns for the pouring of frameworks for fixed partial dentures, but they

clearly point out the drawbacks that appear in practice and offer alternatives for eliminating them. We feel that these investigations must be extended and thoroughly analyzed, the numeric experiments being less costly and offering much more details about the intimacy of the pouring phenomena than physical experiments. The physical experiment should only be considered as a final validation of the results proposed by the numerical studies.

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The PROE Software Implied In Numerical Analysis of the Fixed Partial Denture Behaviour

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University of Dentistry,
"Victor Babe" University of Medicine and Pharmacy of Timioara
[2] University of Polytechnics of Timisoara

Abstract

The numerical simulation is a new method that allows evaluating the prognostic of some therapeutically solutions, in our case of the behavior of the prosthetic restorations such as fixed partial prostheses.

Materials and methods

The tool that is used is called MODELA and it can scan through contact, in successive steps, the shape of a solid object. The sum of the points identified as being solids is mathematically preceded and transformed in a virtual three-dimensional representation that is made according to the scanned solid surface. The scanning failure depends on the shape that is scanned and it can be of maximum 0.5 mm, equal to the rise of the needle scan.

Results

The maximum deformations were registered mainly at the fixed partial prostheses that are made of gold, the following were the ones made of ceramics, composite resin, titan, as for the minimum deformations were registered for Co-Cr alloys. A general characteristic was the existence of some maximum tensions at low temperatures (-100C) that reduced afterwards as the temperature increased. It is very important to point out this topic, as it explains the high fragility level of the fixed partial prostheses at low temperatures. This fragility is compensated by metal through its structure, but the ceramics, a material that has a low elasticity, can be broken when making similar trials.

Conclusions

The fixed partial prostheses made out of gold present a reduction of the maximum tensions recorded (at 500C) of 72.01% from the initial recorded value at -1000C, when using the same loading force. The fixed partial prostheses completely made out of ceramics presents a reduction of the initial values of 74.04%. The fixed partial prostheses that is made of composite resin gets to 81.14% of the initial values, while the Co-Cr fixed partial prostheses gets to 51.28%. The one made out of titan records a reduction of the tensions to 64.36% of the initial values. The lowest reductions were recorded in the cases of fixed partial prostheses made out of composite resin (18.86%), followed by ceramics (25.96%), gold (27.99%), titan (45.64%)and Co-Cr (48.72%)

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The Food and Exercise Simulation Program for Metabolic Syndrome People

Eun Yeob Kim[a], Tae Hwa Han, Man Young Park, Jong Pill Choi, Rae Woong Park

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Abstract

In this program, the food database was established based on "Food Values of Portions Commonly Used" and the exercise database was established based on the unit calorie consumption per hour. In fact as our developed simulation program, the metabolic syndrome people managed preponderantly contribute to mitigation and healthy improvement

Keywords:

Metabolic syndrome, food, menu

Introduction

It is actual in the field of all modern society that using computer are performed partially in organization food company, such as a university, a research institute, and a hospital but user position health computer program nothing. It considered like this point from the research which it sees and the menu and the motion which apply the computer the program which is the possibility of being in parallel to the important diseased patients and a personal satisfaction and a healthy degree and it provided it raised the base research for and to sleep it accomplished it did.

Methods

The metabolic syndrome simulation program

- C# languages using development

- Food database(n=1819) and Exercise database(n=39)

Table 1. Food Data base

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]

Table 2. Exercise Data base

[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]
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[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		

Results

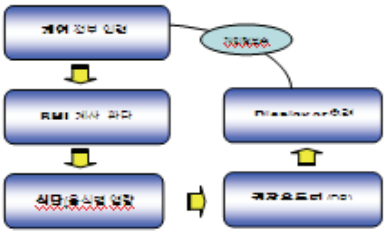

Figure 1 - Program Follow

Figure 1 - Main screen

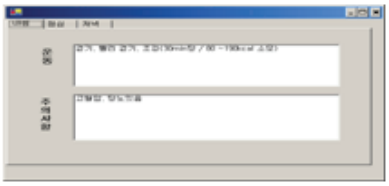

Figure 2 - Exercise screen

Table 3 - 1 day food & exercise

Conclusion

From the research which it sees in the object it followed 6 people in the menu and motion simulation program

Metabolic syndrome people “food and exercise” resulted low calorie food menu and aerobic exercise

The individual the direct menu easily will apply the motion law program from the research which it and the possibility health control effectively from daily life

Acknowledgements

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The Food and exercise simulation program for Metabolic syndrome people

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Introduction

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Abstract

To evaluate the appropriateness of residents' In this program, the food database was established based on "Food Values of Portions Commonly Used" and the exercise database was established based on the unit calorie consumption per hour. In fact as our developed simulation program, the metabolic syndrome people managed preponderantly contribute to mitigation and healthy improvement

Keywords

Metabolic syndrome, Food, menu

Method

Construction of Renal Dosing Reference The metabolic syndrome simulation program

-C# languages using development

- Food database (n=1819)

- Exercise database(n=39)

Results

Table 1. Food Data base

Food group	Numbers of Food	Food group	Numbers of Food
Rice	52	braised foods	57
noodles and mandu	41	fried foods	83
bakeries and confectioneries	186	seasoned vegetables	120
gruels	21	kimchies	16
soup and hot soup	124	raw fished	37
seasoned-fermented foods	8	salt-fermented foods	35
steamed foods	40	stew and casserole	68
grilled foods	53	seasonings	57
pan-fried foods	45	beverages	88
stir-fried foods	101	fruits	89
milk and dairy products	45	meats, vegetables and nuts	139
dduk	20	others	276

Table 2. Exercise Data base

Item	kal	Item	kal
Ironing	65	walk slowly	80
walk fast	114	stairs jumpping	188
Bicycle	92	study	4
fold quilt	114	window shopping	65
Clean	69	clean floor	114
Cook	68	drive	41
rush hours subway ride	53	go up and down stairs	141
computer game	44	eat	38
Sleep	24	singing	41
Dance	150	laugh	33
Bath	84	mountain	196
skipping	224	jogging	196
swim(free-sty)	518	swim(balanced)	273
ride the surf	176	aerobics	126
Tennis	176	ski	186
basketball	200	bowling	90
softball	90	volleyball	200
ping-pong	200	baseball	180
Cycle	111	aquatic ski	200
dodge ball	102		

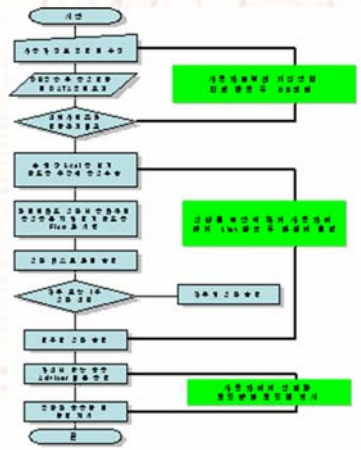

Figure 1. Program flowchart

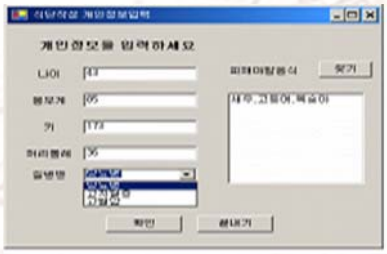

Figure 2. Personal information input screen

Figure 3. Menu screen

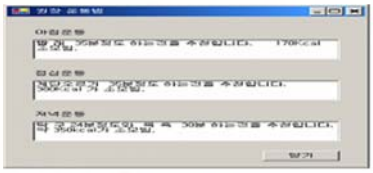

Figure 4. Promotion exercise screen

Conclusion

From the research which it sees in the object it followed 6 people in the menu and motion simulation program.

Metabolic syndrome people "food and exercise" resulted low calorie food menu and aerobic exercise.

The individual the direct menu easily will apply the motion law program from the research which it and the possibility health control effectively from daily life.

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Comparing Messages in an Online Communication Forum for Cancer Patients with Patients' Messages to a Clinical Nurse Specialist

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Abstract

WebChoice is an online support system where cancer patients can exchange messages with other patients in an open communication forum as well as send personal e-mails to a clinical nurse specialist (CNS) who responds to their concerns. We compared the content of messages posted in the open forum with personal e-mail messages sent to the nurse. While patients were concerned with similar topics in both communication areas, there were differences in the types of messages sent. More patients actively used the patient-nurse email service compared to the forum, suggesting that nurses can play an important role in online systems supporting cancer patients over the Internet.

Keywords:

online systems, communication, nurse-patient relations, neoplasms

Introduction

Despite a growing interest in online support forums and patient-provider communication systems, knowledge of the relative use and benefits of these communication systems is still limited. In particular, there is little information about how patients' communications with care providers online differ from communications in discussion groups. Additionally, while a few studies have analyzed online messages between patients and physicians, online patient-nurse communication and the potential for nurses to support patients via the Internet is as of yet largely unexplored. The purpose of this study, therefore, was to compare the content of patient-nurse messages to messages posted on an online discussion forum for cancer patients. The study is part of a larger ongoing trial testing the effects of WebChoice, an internet support system for breast- and prostate cancer patients [1]. WebChoice includes tools for symptom monitoring, tailored information to support self-management, support forums for anonymous group discussion, as well as a more "private" communication area to exchange messages with a CNS specializing in cancer care.

Methods

We examined forum postings and e-mail messages by patients who logged on to WebChoice at least once from March - October 2006, resulting in a sample of 355 postings and 174 e-mails. Messages were coded according to the 'type' and 'topic' categories listed in Table 1 below. The 'type' categories are consistent with the coding schema of Klemm *et al* [2]. A message could belong to more than one category. An e-mail with questions about lymphedema and anxiety, for example, would be coded as *information seeking* for 'type', and *symptoms* and *feelings* for 'topic'. Messages were independently coded by two of the authors (AJ and TA) and 10% were coded by both to compare interrater agreement, established at 98 % for e-mail messages and 97 % for forum postings.

Results

Table 1 shows the percentages of e-mails and forum postings coded under the various 'type' and 'topic' categories.

Table 1 - Percentage of messages categorized by type and topic

		E-mails (*174 total*)	**Postings** (*355 total*)
TYPE	Personal experiences/ opinions	66	75
	Information giving	2	20
	Information seeking	62	20
	Encouragement / Support	0	17
	Thanks	22	8
TOPIC	Health personnel / institutions	21	20
	Treatment / Tests / Test results	63	59
	Symptoms / Side-effects	64	66
	Energy / Fatigue / Sleep	9	10
	Feelings	14	10
	Sexuality / Partner	3	7
	Family / Colleagues / Others	5	3
	Living with cancer / Lifestyle	22	23
	Metastasis / Relapse	7	8

The average number of topic categories per e-mail or posting was 2.4 (±1.5) and 2.3 (±1.3), respectively. As seen in Table 1, patients were concerned with largely the same topics in their e-mail messages and in their forum postings, but the type of message or posting varied, with e-mails being more 'information seeking' in nature and postings being more 'supportive' and 'information giving' to others.

There were also differences in use of the e-mail component of the WebChoice system compared to use of the discussion forum in terms of the number of participants actively using these two different components. 71% of participants given access to WebChoice logged on at least once in the data collection period (43 females and 31 males). Of these active WebChoice users, more patients used the patient-nurse communication area (n=45 or 61% of WebChoice users) compared to those submitting messages to the forum (n=34 or 46% of users). This holds true for breast cancer patients as well as prostate cancer patients. 72% of female users who logged on to the system at least once between March to October 2006 sent at least one e-mail to the nurse while 58% submitted at least one posting. 45% of active male users sent an e-mail to the nurse while 29% contributed to the forum. However, while more patients wrote e-mails to the nurse compared to the number of patients who submitted a posting in the forum, those patients actively participating in the discussion forum submitted on average more postings (10.4±10.5) compared to the average number of e-mails sent to the nurse (3.9 ± 4.6).

Discussion and conclusion

This sample of messages and forum postings, although small, provide useful information for health professionals interested in online communication systems. In a number of computer-based support systems for patients the communication areas are consistently highlighted as the most popular sections of the system, yet our knowledge about patients' use and benefits of different features within these communication areas is limited. A preliminary usage analysis of WebChoice suggest the forum is so far the most visited section in this support system [3], but the fact that more patients submit messages to the nurse via e-mail compared to the forum, and that the nature of messages in these two communication areas differ, suggest that opportunities for patient-nurse communication can provide valuable support for patients beyond that of support offered by participation in online discussion groups. Patients often experience multiple symptoms during treatment and rehabilitation, yet short hospital admissions allow little time for detecting and relieving these. Moreover, side-effects of certain treatments are often worst after the patients are discharged to home.

Therefore, patients could greatly benefit from support through an Internet based system, where they can communicate with a care provider independent of scheduled hospital or doctor appointments in an environment that is readily accessible and even anonymous. In this sample almost all of the questions patients asked via e-mail could be appropriately addressed by the CNS and did not require advice from a physician or other specialist. This suggests that online communication with a nurse may potentially reduce not only needless patient suffering and worrying but also the numbers of doctor's appointments scheduled. As cost concerns and shortages of health professionals continue to rise, online peer- and professional support provided by nurses could prove a viable health care supplement that can improve delivery of high quality patient care in the future [4].

Acknowledgments

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Comparing Messages in an Online Communication Forum for Cancer Patients with Patients' Messages to a Clinical Nurse Specialist

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Background

Despite a growing interest in online support forums and patient-provider communication systems, knowledge of the relative use and benefits of these communication systems is still limited. In particular, there is little information about online patient-nurse communication and the potential for nurses to support patients via the Internet.

Purpose

To compare the content of patient-nurse messages to messages posted on an online discussion forum for cancer patients as part of an ongoing trial testing the effects of WebChoice, an internet support system for breast- and prostate cancer patients.

About WebChoice

WebChoice is an internet support system for breast- and prostate cancer patients where

- **Patients can monitor symptoms over time.**
- **Patients have access to evidence-based self-management options tailored to their reported symptoms as well as general information about living with cancer.**
- **Patients can ask questions to a clinical nurse specialist via e-mail and exchange experiences with other patients in anonymous discussion groups.**

An ongoing randomized clinical trial evaluates effects of WebChoice on patient outcomes

Sample

- **71% of participants given access to WebChoice logged on at least once in the data collection period (43 females with breast cancer and 31 males with prostate cancer).**

- **We examined 355 forum postings and 174 e-mail messages submitted by patients who logged on to WebChoice at least once from March - October 2006.**

Method

- **Postings and messages were coded according to various ‘type’ and ‘topic’ categories as listed in Table 1 and 2 on the following slides. A message could be coded under more than one category.**

- **All messages were independently coded by two of the authors (AJ and TA) and 10% were coded by both to compare inter-rater agreement, established at 98 % for e-mails and 97 % for postings.**

Results

Table 1. Percentage of Messages Categorized by Type

	E-MAILS (174 total)	POSTINGS (355 total)
Personal experiences / opinions	66	75
Information giving	2	20
Information seeking	62	20
Encouragement / Support	0	17
Thanks	22	8

Results

Table 2. Percentage of Messages Categorized by Topic

	E-MAILS (174 total)	POSTINGS (355 total)
Health personnel /institutions	21	20
Treatment / Tests / Test results	63	59
Symptoms / Side-effects	64	66
Energy / Fatigue / Sleep	9	10
Feelings	14	10
Sexuality / Partner	3	7
Family / Colleagues / Others	5	3
Living with cancer / Lifestyle	22	23
Metastasis / Relapse	7	8
AVERAGE NUMBER OF TOPIC CATEGORIES	2.4 (±1.5)	2.3 (±1.3)

Results

- **More patients used the patient-nurse communication area (n=45 or 61% of WebChoice users) compared to those submitting postings to the forum (n=34 or 46%). This holds true for breast cancer patients as well as prostate cancer patients:**
- **72% of female users sent at least one e-mail to the nurse while 58% submitted at least one posting.**
- **45% of male users e-mailed the nurse while 29% contributed to the forum.**
- **However, patients submitted on average more postings (10.4±10.5) compared to the average number of e-mails sent to the nurse (3.9 ± 4.6).**

Discussion and Conclusion

The fact that more patients submitted messages to the nurse via e-mail compared to the forum and that the nature of messages in these two communication areas differ suggest that opportunities for patient-nurse communication can provide valuable support for patients beyond that of support offered by participation in online discussion groups.

Discussion and Conclusion

Most of the questions patients asked via e-mail could be appropriately addressed by the clinical nurse specialist and did not require advice from a physician or other specialist.

Online peer- and professional support provided by nurses could prove a viable health care supplement that can improve delivery of high quality patient care in the future.

Acknowledgments

We thank Laura Slaughter and Gro H. Grimsbø for helpful discussions. The research was funded by the Norwegian “Health and Rehabilitation” Grant # 2003/3/0429

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Gender Differences in Online Messages Among Cancer Patients

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Abstract

While previous research on online patient discussion groups has provided insights into patients' information and communication needs, we still know relatively little about whether women and men use online discussion groups differently and, if so, in what ways they differ. In this study we explored gender differences in messages submitted to online support groups in WebChoice, an internet support system for breast- and prostate cancer patients. Both men and women often shared personal illness experiences and they were equally supportive to each other, but women made use of online discussion groups considerably more frequently than men. Men were more information seeking and less information giving than women, and they were more thankful in their responses.

Keywords:

Online discussion groups, gender differences, cancer

Introduction

There is a widespread use of discussion groups for patients with different diseases on the Internet, and a few studies have analyzed information needs and message types posted in online support groups. However, little is still known about gender differences in the use of online discussion groups. Therefore, the purpose of this study was to explore gender differences in messages submitted to online support groups that are part of the WebChoice application, an online support system for breast- and prostate cancer patients [1]. WebChoice allows patients to monitor symptoms over time, and provides access to evidence-based self-management options tailored to their reported symptoms. It also provides a communication area where patients can ask questions to a clinical nurse specialist and exchange experiences with other cancer patients in anonymous discussion groups. This study is part of a larger ongoing randomized clinical trial that evaluates effects of WebChoice access on patient outcomes. Each participant is followed up for one year. The experimental group in the trial has unlimited access to a disease specific support group as well as a mixed support group for both breast- and prostate cancer patients.

Methods

We examined all forum postings from 43 women and 31 men undergoing treatment for breast- or prostate cancer who logged on to WebChoice at least once between March - October 2006 (constituting 71% of study participants in the experimental group with access to WebChoice). There were 355 forum postings that were coded according to response categories in Klemm et al's coding scheme [2] as listed in Table 2. Each posting was coded under one to three response categories, dependent on the number of category types within the same posting (e.g. the participant was sharing personal experiences as well as seeking information). All postings were coded independently by two of the authors (AJ and TA) with an inter-rater agreement of 98%. Uncertainties were resolved through discussion.

Results

Participation in the online support groups

As seen in Table 1 below, more women made use of the internet support system compared to men. Women also participated considerably more in the online support groups than men, and they submitted more postings.

Table 1: Gender differences in number of forum postings

	Male	Female
Subjects logged on to *WebChoice*	31 (42%)	43 (58%)
Total and average # of postings	66	289
# of subjects submitting posting(s)	9 (29%)	25 (58%)
Average # of postings pr subject who submitted postings	7,44	11,52

Type of messages in the forum postings

Table 2 shows that personal experiences, such as telling about their illness and treatment history, was the most frequently used message type for both men and women, which is consistent with other studies [2]. Contrary to findings reported by Klemm et. al [2], women in our study were more information giving (e.g. sharing personal knowledge with others and giving advice) than men, while men were more information seeking (e.g. asking others

about their experiences). Both gender groups were equally supportive of each other, but men were more often thankful in their responses than women.

Table 2 - Gender Differences in Response categories

	Male	Female
Personal experiences	46 (70%)	220 (76%)
Information giving	8 (12%)	64 (22%)
Information seeking	19 (29%)	53 (18%)
Support	12 (18%)	49 (17%)
Thanks	14 (21%)	16 (6%)

Discussion and conclusion

This study revealed interesting gender differences in messages submitted by breast cancer patients compared to prostate cancer patients. Considering that breast cancer treatment is more standardized than treatment for prostate cancer, however, the finding that men were more information seeking and less information giving than women might be related to the diagnosis as well as potential gender differences in communication style. More research on online communication among patients with less gender specific diagnoses is needed to explore this further.

Further research is also needed to explore the extent to which men and women passively participate in the online support groups by 'lurking' i.e. reading the postings but not actively participating themselves.

Another important issue to address in future research is to look at which topics patients bring up for discussion in different types of communication arenas, for example online support groups versus traditional support groups. Since online discussion groups allow anonymity, participants might address concerns that are important to them but too embarrassing to discuss face to face with others. Not only can participation in an online discussion group provide opportunities for discussion of more sensitive issues, it can also allow participants to distance themselves more to certain participants or topics than what is "socially acceptable" in traditional, face to face support group discussions, where it is expected that all participants share and listen to other participants' experiences and fears.

While certain barriers to participate in discussion networks might be fewer and the availability provided by the Internet better compared to traditional support groups, many patients no doubt prefer talking to someone face to face. One reason for our interest in exploring gender differences in messages submitted in the WebChoice system is to increase our knowledge about and awareness of who participates in these discussion groups, who don't, and for what reasons. If our goal is to provide systems for communication about health related problems that are useful for everyone, we should be attentive to differences in preferences and aim to offer a wide enough variety of options for communication in order that it can be tailored to the needs of each patient. It is obvious that these types of research goals require a broader investigation than the current exploration, and some logical next steps in this research area would be to ask why fewer men participate in online discussion groups compared to women and whether the differences observed here are true also of communication/ participation in traditional support groups.

Acknowledgments

We thank Laura Slaughter and Gro Hjelmeland Grimsbø for useful discussions.

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Gender Differences in Online Messages Among Cancer Patients

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Background

While previous research on online patient discussion groups has provided insights into patients' information and communication needs, little is known wether women and men use online discussion groups differently

Purpose

We explored gender differences in messages submitted to online support groups contained in an internet support system for breast- and prostate cancer patients called *WebChoice*

About WebChoice

WebChoice is an internet support system for breast- and prostate cancer patients where

- **Patients can monitor symptoms over time**
- **Patients have access to evidence-based self-management options tailored to their reported symptoms as well as general information about living with cancer**
- **Patients can ask questions to a clinical nurse specialist on mail and exchange experiences with other patients in anonymous discussion groups.**

A currently ongoing randomized clinical trial evaluates effects of WebChoice on patient outcomes

Sample

- **We examined 355 postings submitted by 43 women and 31 men undergoing treatment for breast- or prostate cancer and who logged on to WebChoice at least once during a period of eight months**

- **The sample constitutes 71% of study participants in the experimental group with access to WebChoice**

Procedure

- **Each posting were coded under 1 to 3 response categories, dependent on number of category types within the same posting (e.g. the participant were sharing personal experiences as well as information seeking)**

- **All postings were coded independently by two of the authors with an inter-rater agreement of 98%. Uncertainties were solved through discussion**

Results

Women participated more in discussion groups

- More women than men made use of the internet support system
- Women participated considerably more in the online support groups than men
- Women submitted more postings each

Results

Gender Differences in Number of Forum Postings

	Male	Female
Subjects logged on to WebChoice	31 (42%)	43 (58%)
Total avergage # of postings	66	289
# of subjects submitting posting(s)	9 (29%)	25 (58%)
Average of postings pr subject who submitted postings	7,44	11,52

Results

Women were more information giving while men were more information seeking

- Personal experiences was the most used message type for both men and women
- Women were more information giving than men, while men were more information seeking
- Both gender groups were equally supportive of each other
- Men were more often thankful in their responses than women

Results

Gender Differences in Response Categories

	Male	Female
Personal experiences	46 (70%)	220 (76%)
Information giving	8 (12%)	64 (22%)
Information seeking	19 (29%)	53 (18%)
Support	12 (18%)	49 (17%)
Thanks	14 (21%)	16 (6%)

Conclusion

This study revealed interesting gender differences in messages submitted by breast- and prostate cancer patients.

However, more research on online communication among patients with less gender specific diagnoses is needed to explore gender differences in communication style further

Acknowledgments

We thank Laura Slaughter and Gro Grimsbø for useful discussions
This research was funded by The Norwegian “Health and Rehabilitation” Grant

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Klemm P, Hurst M, Dearholt SL, and Trone SR, 1999. Cyber: Solace: Gender Differences on Internet Cancer Support Groups. Comput Nurs 17(2): 65-72

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BioHealth – Encouraging the Use of eHealth Security and Identity Management Standards

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Abstract

Shared care and cross-border interactions require a reliable and stable framework based on the application of standardised solutions. These are often not sufficiently known, diffused and not implemented. The EC funded project BioHealth aims to raise awareness on eHealth standardisation, to inform on security standards and to facilitate their practical implementation. It also evaluates socio-economic and cultural aspects concerning eHealth with particular reference to the introduction of emerging technologies such as biometrics and RFID.

Keywords:

eHealth, security, standardisation, id management, biometrics

Introduction

Major social and economic changes are presently taking place in Europe. Thus the mobility of the citizens poses a major challenge on a continent which is still divided into many different regions with differing individual healthcare solutions, reimbursement systems and legal and ethical backgrounds. In many European countries the traditional social services are being linked to health services. Technological advances offered by new approaches, e.g. telemedicine, ask for new -international- solutions. The increased accessibility provided by eHealth solutions implies a growing need for security. Facilitating patient mobility -one of the goals of the Lisbon strategy Communication to the Spring European Council: "Working together for Growth and Jobs: A new Start for the Lisbon Strategy", Brussels, 2 February 2005, COM (2005) 24.- asks for standardisation. Security standards are high on the agenda. Identity management (IdM) and biometrics are to support the current deployment of reliable and interoperable security solutions. However, the acceptance, use and implementation of standards do not meet expectations.

Methods

Standardisation initiatives in eHealth

eHealth systems must be secure and privacy compliant at all times. They have to be based on trustworthy and reliable communication and application security services and they have to be failsafe and available at all times Blobel B: Analysis, Design and Implementation of Secure and Interoperable Distributed Health Information Systems. Series "Studies in Health Technology and Informatics" Vol. 89. IOS Press, Amsterdam 2002.. Cross-border solutions must make sure that the technical solutions are interoperable, but comply -at the same time- with the national legal and cultural requirements. The privacy and data of those involved needs to be protected. Standards facilitate interoperable solutions. However, almost each European country has its own national standardisation body issuing national standards.

The European Commission has been supporting standardisation activities for many years. CEN, the European Committee for Standardisation, was founded in 1961. The major activities of CEN/TC 251 -responsible for Health Informatics- standardisation are currently directed to "EHR communication" and to updating "Secure User Identification - Strong Authentication Using Micro-processor Cards". CEN/ISSS provides market players with a comprehensive range of standardisation services and products. Focus Groups report on the current standards' environment in a particular area of public interest to provide recommendations on necessary standardisation work for the future. CEN/ISSS eHealth Standardisation Focus Group investigated standards' requirements in the area of eHealth in support of "eEurope 2005 Action Plan". Presently main priorities of the European standardisation activities are the harmonisation of identification and authentication of the European citizen. Other important Standards Developing Organisations (SDOs) are -amongst others- ITU (International Telecommunication Union) and ETSI (European Telecommunications Standards Institute).

In some countries, international standards range first, followed by national ones. Established in 1998, ISO/TC 215 - Technical Committee Health Informatics of the International Standards Developing Organisation ISO- has been focusing on eHealth-related standards activities. Some important standardisation activities are currently "Privilege Management and Access Control" and "Public Key Infrastructure". ISO/TC 215 liaises with several other organisations like CEN or DICOM. ISO/IEC JTC1/SC17 - Joint Technical Committee on Biometrics- hosts working groups on ePassport, driver license and health. For other international organisations and more details see BioHealth

Consortium: Deliverable 2.1: Guidelines on the standardisation activities, their implementation and how to gain maximum benefit – available after registration at http://biohealth.gsf.de..

Challenges

eHealth with its many stakeholder groups strongly requires standards which procure tangible benefits in order to be accepted by the users. This, however, asks for those most affected -citizens, patients and healthcare employees- to increase their influence on the SDOs. Therefore, awareness -achieved by a respective level of information, education and training measures- are vital. Standards or even information thereof are mostly difficult to access; users are often not aware of their existence. Decision makers as well as Small and Medium Enterprises, however, depend on this information for writing tenders, or for developing interoperable systems. The varying and often competing standards at the different levels pose an additional problem. Missing legal regulations at European level hinder well proven national initiatives to successfully being transferred to European level.

BioHealth

BioHealth (Security and Identity Management Standards in eHealth including Biometrics) aims at promoting, in a European framework, the diffusion, knowledge and understanding of security standards in the area of eHealth. It especially emphasizes privacy rules, id management and implementation of biometrics as a Privacy Enhancement Technology.

Many people consider information about their health to be highly sensitive and to deserve strong protection. In shared care several health professionals may be sharing one patient record across differing health systems in different institutions and even across borders. Information associated with identities may change over a period of time. Adequate IdM and systems that interact with other information systems are required. Biometric technologies are a key technology for secure identification and for personal verification. Emerging technologies like radio frequency identification (RFID) hold the promise of improving patient care. Via RFID chips medical drugs in hospitals can be tracked. They can be used to follow up a patient in an emergency setting or to monitor a person and enable him/her to continue living at home. Tagging and biometrics raise a number of significant legal and ethical questions. Differing legal regulations cause additional problems. BioHealth addresses these issues.

BioHealth aims to raise awareness, confidence and acceptance among the users of security technologies by providing information on standardisation activities, standards and related subjects. The BioHealth portal serves for information exchange, coordination and community-building. It is open to contributions from the various stakeholder groups. Policy makers are contacted to advance convergence of the standardisation policies in eHealth on a European level. Presently, eHealth security standards are being analysed and optimised for use by the stakeholders.

Discussion

Changes caused by the introduction of a new system have often been underestimated. eHealth requires the support of those involved. Systems have to be secure and reliable at all levels and at all times. This will decrease perplexities and build the necessary trust to accept and support eHealth. Standardised and interoperable solutions are a necessity. Strong authentication methods have to ensure that the information can only be accessed by the entitled person. New technologies like biometrics or RFID are on the verge of being introduced. Their relation with privacy issues is a very delicate issue and any objection raised in terms of threatening data protection has to be taken seriously. Standards, on the other hand, have to be known, they have to be understood, they have to be appropriate and affordable.

Conclusion

eHealth provides solutions to 21st century healthcare. Interoperability is a necessity. This is facilitated by standards. Though significant work has been done on the required standardisation in recent years, many of the results are not known to the user nor has the standards' usability been fully evaluated. BioHealth informs users on security related standardisation in eHealth. The project's work focuses on standards' analysis, the security of data and identity management, and the legal, societal and ethical issues concerning IdM, biometrics and the new technologies related to eHealth security. BioHealth will support the implementation of standards by setting up guidelines. A website [http://biohealth.gsf.de] is available as a first step to an open platform for those interested this topic. Thus BioHealth intends to make a sounding contribution to eHealth in Europe.

Acknowledgment

The authors would like to thank the European Commission for funding the BioHealth project.

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tion Systems. Series “Studies in Health Technology and Informatics” Vol. 89. IOS Press, Amsterdam 2002.

[3]BioHealth Consortium: Deliverable 2.1: Guidelines on the standardisation activities, their implementation and how to gain maximum benefit – available after registration at http://biohealth.gsf.de.

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BioHealth
Encouraging the Use of eHealth Security and Identity Management Standards

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European Healthcare 2006

- Europe's health sector employs 9.3% of the EC's workforce.
- Europe's health sector is worth over 8.5% of its gross domestic product. The estimated size of the European eHealth market is €20 billion.

- 50,000 people die each year of healthcare-related infections in the EC.
- The EC estimates the costs of healthcare-related infections at £1 billion a year in the UK alone.

Healthcare becoming eHealth necessitates changes

- Care
  - Patient - Doctor treatment -> shared / collaborative care
  - Acute care -> preventive care
  - Cooperation with other domains (bio-informatics, public health, social care)
  - Increased communication
  - Administrative changes
- Role of the citizen
  - Access to health related information
  - Educate the citizen
  - Personalised electronic health care records

Need for EHR, Data Protection and Privacy, Identity Management

New Developments and Requirements to be met

- Technological Advances
  - Telemedicine (e.g. tele-consultation, home-monitoring)
  - Paper-based records -> digitalised electronic health record (EHR)
  - New technologies (e.g. wireless, multimedia, RFID)
- European Challenges
  - Increased movement of citizens
  - Diverse healthcare systems
  - Healthcare systems at differing development stages
  - Multitude of languages, cultures and ethics
  - Contradictory laws

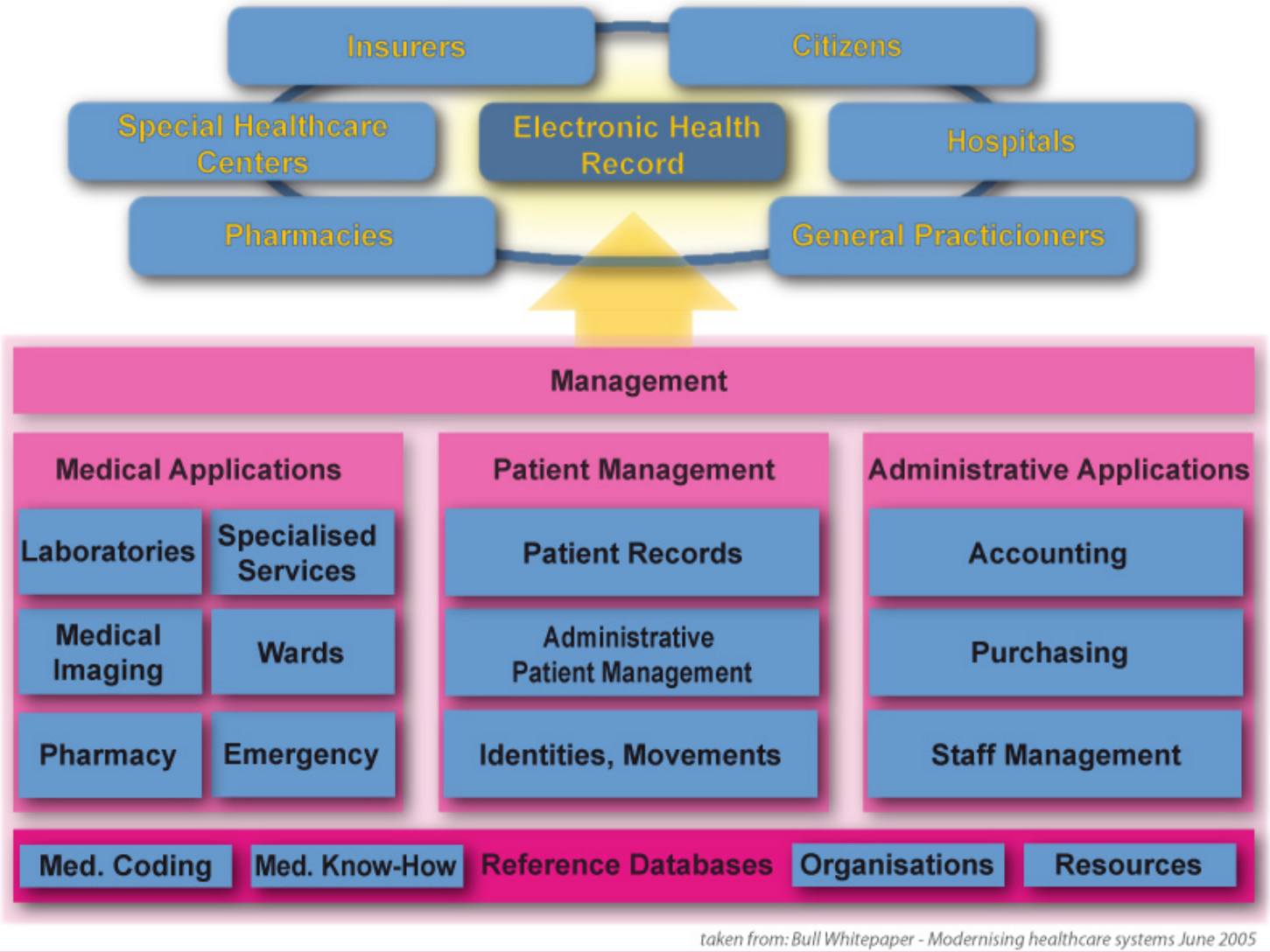
This requires secure, reliable, interoperable and standardised solutions

The BioHealth Project

- Creates awareness and acceptance on security, data protection, id management and related issues
- Informs on
  - eHealth Security Standards presenting the results of existing standardisation efforts
  - Security and Identity management pointing out special European requirements in eHealth
  - Identity management and new technologies and on critical issues connected to these
- Provides information and expert advice on standardisation related to eHealth security and facilitates the practical implementation
- Demonstrates the competitive advantages gained when applying standards
- Facilitates European and cross-boarder solutions

Thus it enforces the use of security related standards in eHealth

Security concerns all areas of healthcare



taken from: Bull Whitepaper - Modernising healthcare systems June 2005

eHealth Security requires

- **Data protection** "the implementation of administrative, technical, or physical measures to guard against the unauthorized access to data" [1]
- **Data safety** "the protection of data from unauthorized (accidental or intentional) modification, destruction, or disclosure" [1]
- **Privacy** "the subjective condition a person experiences when he or she has the power to control information about him-/herself and when he or she must exercise that control consistent with his/her interests and values" [1]
- **Safe and reliable communication**
  - Confidentiality
  - Data Integrity
  - Authenticity
  - Accountability
- **Failsafe and full-time available systems**

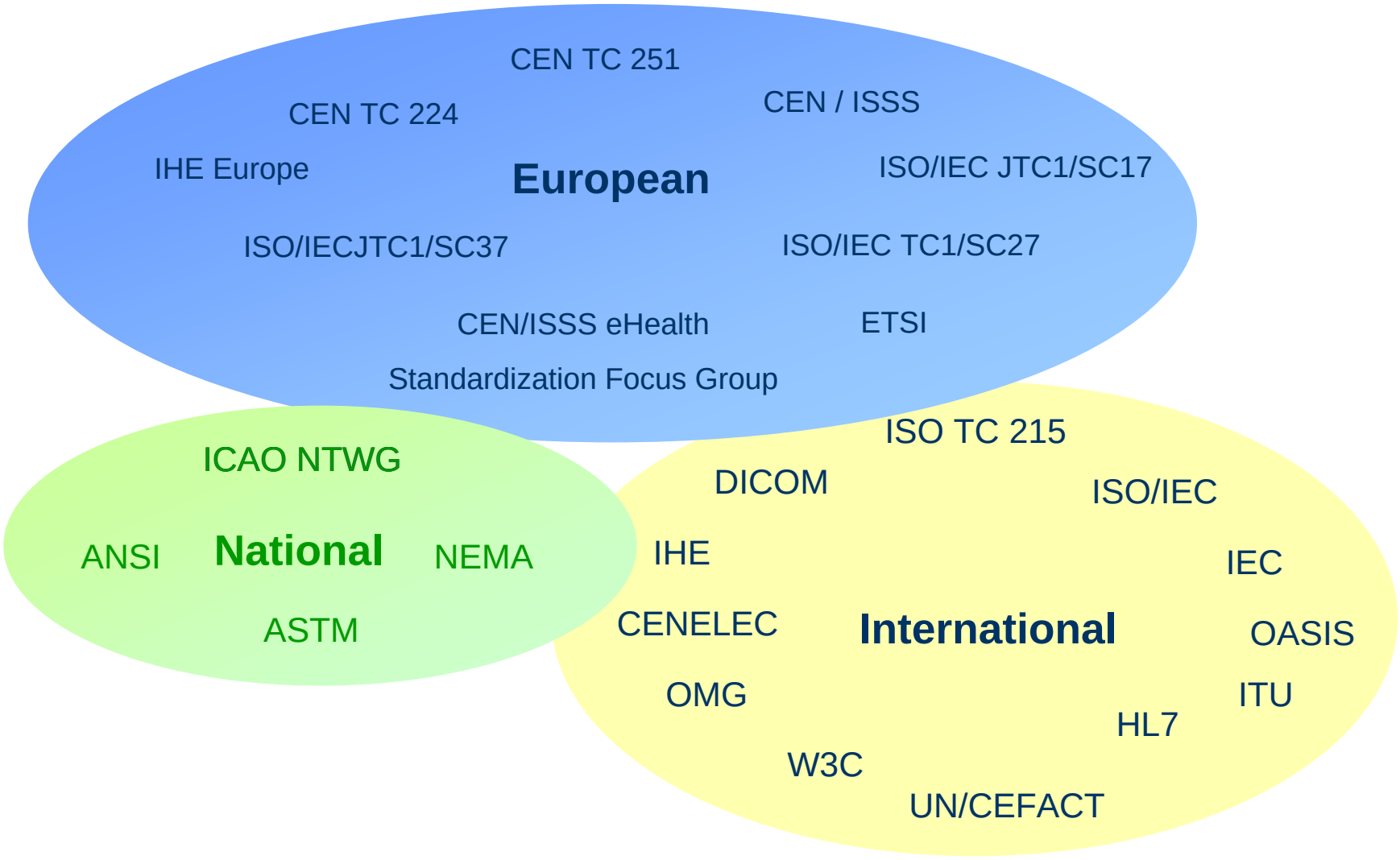
[1] Alliance for Telecommunications Industry Solutions
http://www.atis.org -accessed: 01-06-2007

BioHealth deals with the following aspects/technologies

- ***Standardisation***
  - Legal
  - Ethical
  - Technological
  - Organisational
  - Financial
  - Regional and National Differences
  - Political

- ***Technologies for Id Security***
  - Tokens
  - Biometrics
    - Fingerprint recognition
    - Face image
    - Iris Recognition
    - Hand Geometry
    - Signature dynamic
    - Voice recognition
    - Vascular biometrics
    - DNA analysis

Standards Developing Organisations concerned with eHealth security



Consortium and Competences

- **GSF - National Research Center for Environment and Health**, Germany
  Coordinator; links to academical, industrial and political bodies
- **Bull Hungary**, Hungary
  Industrial Partner; development of health related security technologies (health cards, Near Field Communication (NFC)), links to Insurance Bodies, involved in the development of the Hungarian eHealth platform
- **CNR-IBB - National Research Council of Italy**, Italy
  Convenor of ISO/IEC JTC1/SC37 WG7 (Biometrics); Expert in ethical and societal issues concerning identity management and the use of the new technologies in healthcare

Consortium and Competences

- **ITS Norway**, Norway
  Standardisation expert; involved in id management and biometrics; e-government and the definition of the Norwegian e-passports
- **IMA -Institute of Microelectronic Applications**, Czech Republic
  Small Medium Enterprise deals with intelligent security solutions, involved in many security related projects, new developments with RFID, advisor for the National Czech e-solutions
- **eHCC – eHealth Competence Center**, University of Regensburg, Germany
  Expert for Security in eHealth ; involved in many standardisation bodies and activities

By the end of 2008 BioHealth aims to have

- A training programme on eHealth standardisation
- Guidelines on eHealth standards
- Increased the knowledge and use of eHealth standards
- Set up a lasting network on eHealth standardisation

Would you like to keep up to date or participate?

- BioHealth http://biohealth.gsf.de or biohealth@gsf.de
- Innova http://www.europe-innova.org

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Use of Medical Informatics to Improve Patient Safety, Quality of Care and Training: Innovative Software for Resident Hand Off Communication and Training.

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Abstract:

Missed hand-offs and breakdowns in verbal and written communications are key sources of medical injury and thus major concerns in the delivery of safe patient care. The Joint Commission on Accreditation of Healthcare Organizations [JCAHO] has recognized these pitfalls and added this as a new requirement in the National Patient Safety Goals. We designed an electronic application called eHand-offs to standardize and supervise communications among medical residents about patient information during admissions, transfers, and discharges. eHand-offs also functions as a surveillance tool for administrators to track patient hand-offs, ensuring added patient safety and enhancing resident supervision and training. With this background, a national survey of program directors of internal medicine residencies was conducted to get a national consensus about hand-off communication. It was concluded from the survey that standardization and tracking of hand-off data using an electronic, secure, and standardized software application, will help improve continuity of care, reduce medical errors and improve resident supervision and training. A secure software application with face-to-face communication is preferred as the hand-off method of choice by our respondents.

Keywords:

handoffs, healthcare communication, patient safety, electronic sign out

Methods

The objective of this study was to assess the current opinions held and strategies used within residency programs with respect to the hand-off communication during shift changes. The contemporary strategies for hand-offs and program directors' opinions on the future of these hand-offs were two important issues investigated. An online survey link was posted utilizing the Association of Program Directors of Internal Medicine [APDIM] list serve. This survey consisted of ten questions, some of which are single answer type others with multiple answers. Responses were analyzed and are presented in the form of graphs.

Results

A total of 107 respondents completed the survey. Of these, 26% were unaware of the standardization of hand-offs as a JCAHO patient safety goal. The most commonly used methods at present are paper-based (44%) and face-to-face sign-out (44%). More than 95% of respondents agreed that hand-offs should be standardized and that standardization will prevent medical errors. 92% of respondents believe that sign-out communication is important in liability issues and 69% agree that standardization of sign-outs will help in reducing liability lawsuits. However, when the question of whether hand-off data should be made a part of the permanent medical record, 71% said it should not. 77.5% respondents were agreeable to using a secure server along with a Face to Face sign-out. Excel/Word sign-out along with a telephone sign-out was unpopular at 17.6%, but Excel/Word in conjunction with Face-to-Face sign-out was satisfactory to 55.9%. Face-to-Face sign-out by itself was given a 47.1 % approval rating. Lack of resources, resident non-compliance, and administrative issues were the top three problems selected as reasons why implementing a secure computerized hand-off system might fail.

Conclusion

It may be extrapolated that standardization of hand-off communication and tracking of hand-off data using an electronic, secure, and standardized software application like eHand-offs, will help improve continuity of care, reduce medical errors and improve resident supervision and training. A secure software application with face-to-face communication is preferred as the hand-off method of choice by our respondents. Facilitating resident cooperation via educating them to develop the culture of patient safety, persistent will power from administrators and appropriate resources are all needed to implement this choice.

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Analyzing Content of Patient-Physician messages with Self-Organizing Maps

Karita H. Ilvonen[a], Steven M. LeVine[b], Joseph F. Terdiman[c]

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[b] *Division of Research, Kaiser Permanente, USA.*
[c] *Division of Research, Kaiser Permanente,, USA.*

Abstract and objective

This paper is a part of an extensive research effort, in which our overall objective is to understand the impacts of patient-physician messaging service on provider efficiency and use of resources. In this poster presentation we evaluate the usefulness of Self Organizing Maps (SOM) technology for analysis of unstructured patient-originated electronic messages. A one-by-one hand analysis of a subset of the messages was performed in order to evaluate the accuracy of the topographic method. This study looks at two specific research questions: 1) What broad categories of requests are submitted by the patients 2) how can the requests be understood in the context of health care information provisioning by primary care physicians to patients with a specific chronic disease. Topographic mapping of message types confirmed the patterns seen through manual analysis. Sub-mapping of messages by symptom themes allowed more granular understanding of the clinical decision processes involved. SOM technology has potential for analyses of large data sets of unstructured messages for research purposes.

Keywords:

patient-physician messaging, chronic care management, self-organizing map, efficiency

Methods

A study cohort of 281 diabetic patients receiving primary care at the Kaiser Permanente Medical Center in Oakland, California was defined. The cohort consisted of self-selected patients using the CyberKaiser electronic messaging system during a study period of one year (March 2003-February 2006). We combined Electronic Health Record Data, messaging free text data and demographic data for our analysis. Diabetics were defined on the basis of ICD-9 codes. We used Foundation™ software to analyze the unstructured text of the patient messages and categorized the messages manually into 12 different categories (e.g. appointment request, medical advice, lab result interpretation etc.) based on the initial requests made in them. We also recorded the number of request made in individual messages. The software used draws Self Organizing Maps (SOMs) from the unstructured data and helps us to circumscribe major categories and to identify the most frequently used terms ('themes') in the messages.

CyberKaiser system

CyberKaiser is a secure web-based electronic mail system designed to support the transmission of clinical information between members and physicians of the Kaiser Permanente health care system, based in Oakland, California. Patients and providers were recruited on a voluntary basis, at no extra charge to the patient. There are no intermediary agents pre-selecting or filtering the messages, which are sent directly to and from the physicians. The service level agreement for physician replies is two business days. Proxy accounts for family members of patients are allowed where a dependent adult-adult or adult-child relationship can be attested.

Self Organizing Maps

Self Organizing Map (SOM) was used for the broader context analysis. However, in-depth analysis of the complexity of the messages required categorizing them by hand. We examined the initial message of each thread send by the patient within the study period for review. Request types were categorized and statistical analysis performed on the results.

Results

The visualization of CyberKaiser messages send by diabetic patients grouped messages by common themes. The visualization recognized five large groups of messages talking about appointments, pain and symptoms, prescriptions, 'thank yous' and administrative issues. The topographic mapping software was also used for identifying 30 most commonly used words in the messages.

The one-by-one hand analysis found that most messages have a single request on action on them and provide a lot of background information.

Conclusions

Self-organizing maps allow parsing of large amounts of text information contained in patient-provider email. Context analysis findings and categorization of the requests are expected to advance the future development of these ser-

vices and answer to some concerns on the messaging as an appropriate medium for healthcare communication.

Analyzing Content of Patient-Physician messages with Self-Organizing Maps

Lic (Tech.) Karita H. Ilvonen – Helsinki University of Technology
MD Steven LeVine – Division of Research, Kaiser Permanente
MD, PhD. Joe Terdiman - Division of Research, Kaiser Permanente

Objective

- Part of an extensive research effort, in which our overall objective is to understand the impacts of patient-physician messaging service on provider efficiency and use of resources.
- We evaluate the usefulness of Self Organizing Maps (SOM) technology for analysis of unstructured patient-originated electronic messages.
- A one-by-one hand analysis of a subset of the messages was performed in order to evaluate the accuracy of the topographic method.
- Two specific research questions: 1) What broad categories of requests are submitted by the patients 2) how can the requests be understood in the context of health care information provisioning by primary care physicians to patients with a specific chronic disease.
- Topographic mapping of message types confirmed the patterns seen through manual analysis. Sub-mapping of messages by symptom themes allowed more granular understanding of the clinical decision processes involved.

Methods

- A study cohort of 281 diabetic patients receiving primary care at the Kaiser Permanente Medical Center in Oakland, California was defined.
- The cohort consisted of self-selected patients using the CyberKaiser electronic messaging system during a study period of one year (March 2003-February 2006).
- We combined Electronic Health Record Data, messaging free text data and demographic data for our analysis.
- Diabetics were defined on the basis of ICD-9 codes.

Methods 2

- We used Foundation™ software to analyze the unstructured text of the patient messages and categorized the messages manually into 12 different categories (e.g. appointment request, medical advice, lab result interpretation etc.) based on the initial requests made in them.
- We also recorded the number of request made in individual messages.
- The software used draws Self Organizing Maps (SOMs) from the unstructured data and helps us to circumscribe major categories and to identify the most frequently used terms ('themes') in the messages.

Self Organizing Map

- Self Organizing Map (SOM) was used for the broader context analysis. However, in-depth analysis of the complexity of the messages required categorizing them by hand.
- We examined the initial message of each thread send by the patient within the study period for review.
- Request types were categorized and statistical analysis performed on the results.
- Figure 1 presents and example graphic of a SOM used for the context analysis. This graphic organizes all messages sent by diabetic patients in the cohort to a map outlining five different areas. For example an area where the most common themes are refill, prescriptions and pharmacy includes mostly messages where patients request to refill their prescriptions.

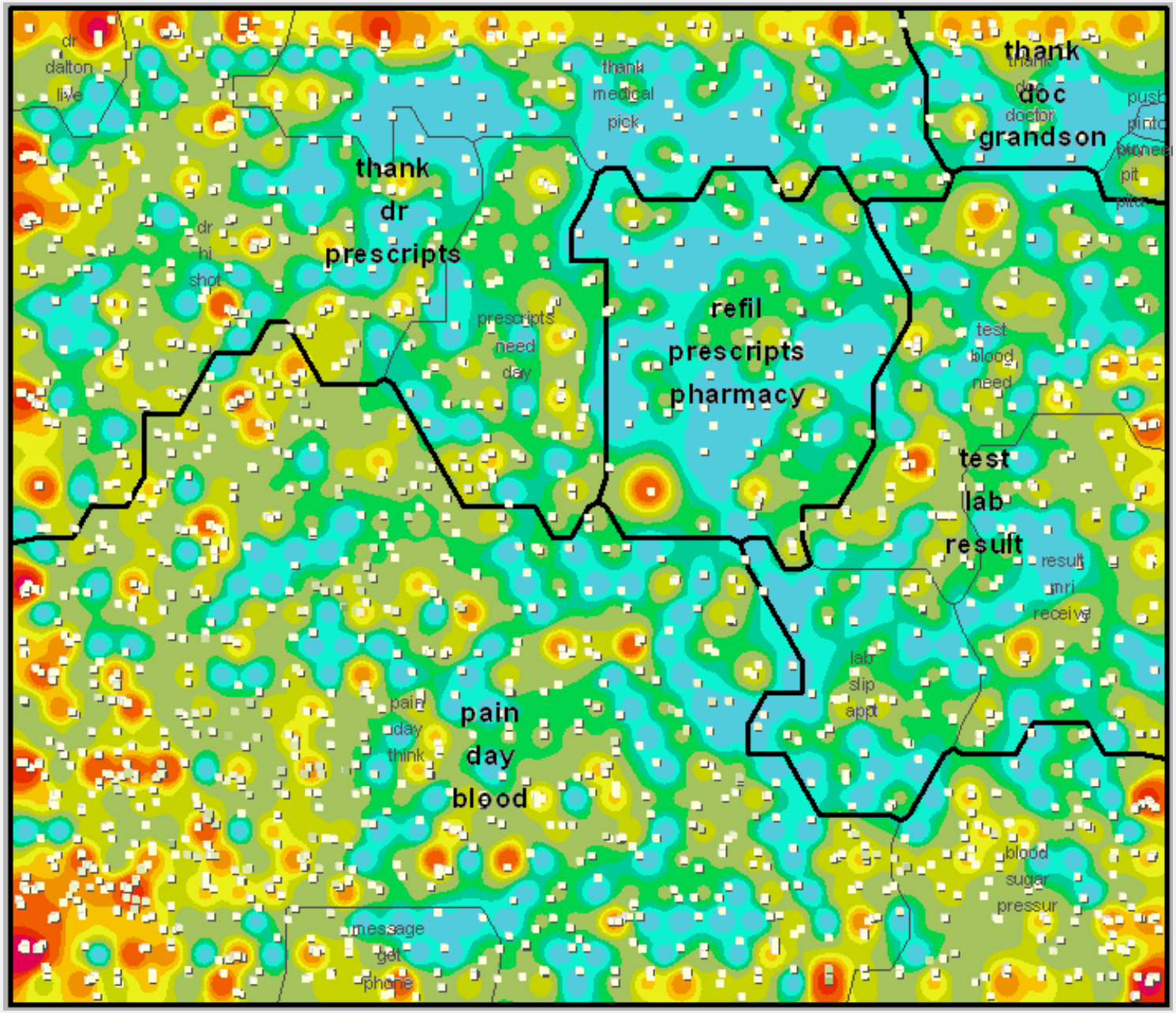

Figure 1: Self Organizing Map (SOM) of all messages sent by diabetic patients in cohort

Using a glossary

- The categorization presented in figure 1 is on a very abstract level because words that are likely to appear in a message with any topic like ‘thank’ and ‘dr’ are still included.
- A diabetes glossary was used to vertically classify the themes identified in unstructured data when using the Foundation Software.
- Vertical classification of unstructured data refers to the process of capturing unstructured data and organizing it so that it can be meaningfully accessed and analyzed according to specific topic(s) as identified in the glossary.
- Glossaries are lists of related words, their meanings and synonyms. We used a glossary of clinical and other diabetes related words in running the following SOM (figure 2).

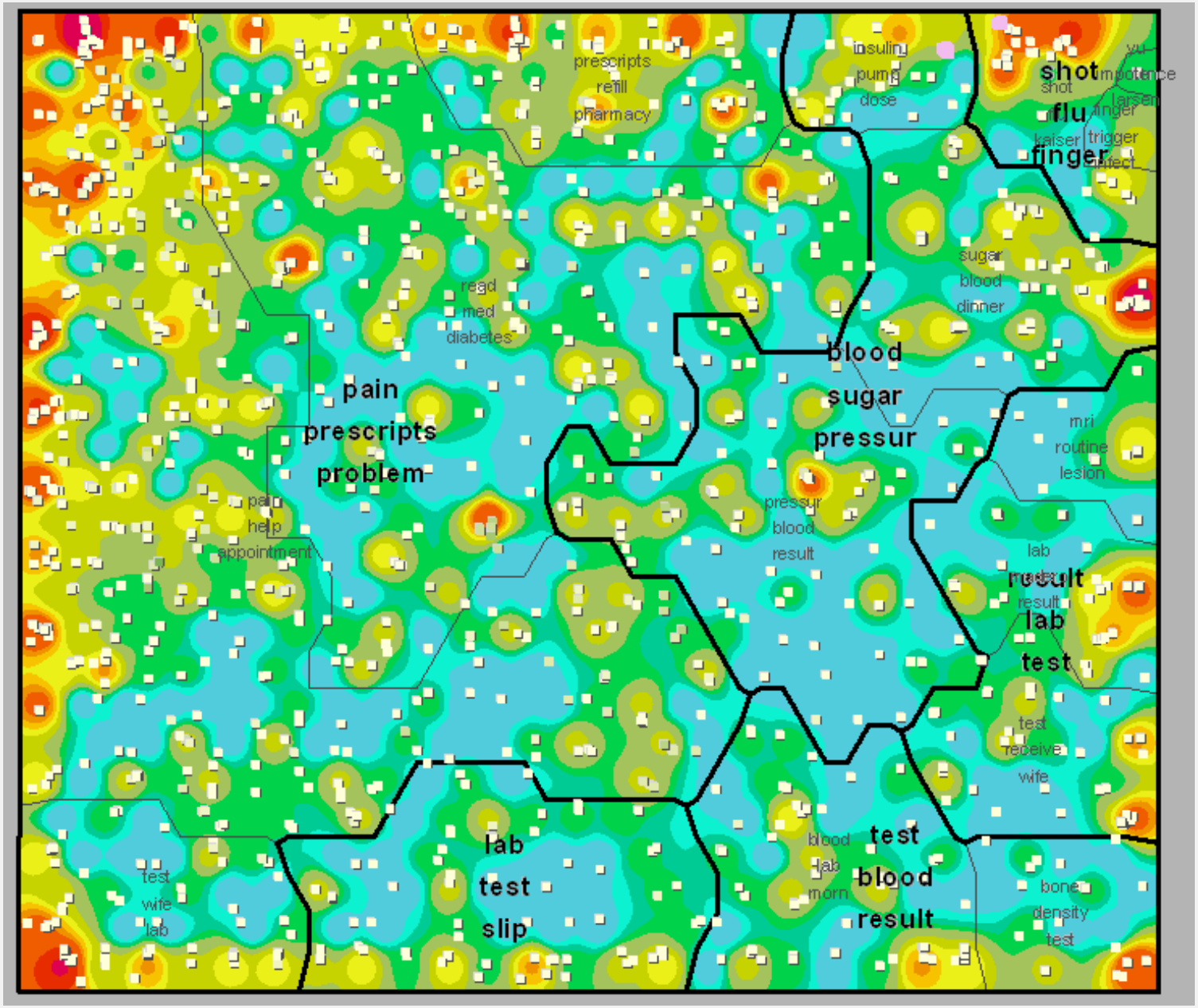

Figure 2: Diabetes messages using a glossary

Results

- The visualization of CyberKaiser messages send by diabetic patients grouped messages by common themes.
- The visualization recognized five large groups of messages talking about appointments, pain and symptoms, prescriptions, ‘thank yous’ and administrative issues.
- The topographic mapping software was also used for identifying 30 most commonly used words in the messages.
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- Self-organizing maps allow parsing of large amounts of text information contained in patient-provider email.
- Context analysis findings and categorization of the requests are expected to advance the future development of these services and answer to some concerns on the messaging as an appropriate medium for healthcare communication..

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Using the Latest Web Technologies to Improve Communication and Implement a Cultural Change in Junior Doctors in a Large UK Health Trust

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Bristol Royal Infirmary, United Bristol Healthcare Trust, Bristol, UK

Abstract

The Internet is universally accepted as a means of communication and is an under used resource within the NHS. We developed a Junior Doctors Website and content management system and in doing so have seen a cultural change in how information is communicated in United Bristol Healthcare Trust

Keywords:

junior doctor, internet, communication

Introduction

United Bristol Healthcare Trust is a large NHS Teaching Hospital Trust. It employs 360 Junior Doctors across 4 different sites. They are employed on a semi-permanent basis and rotate between specialties, hospital sites and other Trusts. A Junior Doctors Committee was formed to represent these Junior Doctors and found significant difficulty in communicating with them. In particular the Trust was unable to disseminate medico-legal information, clinical guidance and Trust news. In turn, Junior Doctors felt unable and unaware of how to feedback problems to the Trust and wanted better access to clinical and career guidance, time management information and social news. The principal reason for the breakdown of communication was a reliance on a Trust e-mail system. Access was only available on-site, limited and slow and relied on Junior Doctors registering and using an account. There was no list of personal e-mail addresses.

With changing work patterns as a result of the European Working Time Directive and less face to face contact within the hospital the need for excellent communication is greater than ever. The internet is universally accepted as a means of communication. Our aim was to develop a Junior Doctors website accessible from work and home. As part of its development it needed to contain useful content to entice continuing and regular use. It required the ability for users with privileges to be able to directly and easily create areas on the site and upload information as and when necessary creating a live system.

Methods and results

We formed a Junior Doctors web development team. 4 members divided responsibilities into content management, technical development, marketing and overall coordination. We initially designed a static HTML site, residing in our Trust intranet. Using Server Side technologies we were able to develop a content management system as well as other interactive aspects including notice boards, timetables and rotas. We used our secure logon system to create a database of Users e-mails to further aid communication.

There were a number of hurdles to overcome to reach this point. We had to engage the IT department and Trust Board to show the value of our proposals and then obtain their backing to progress with the development and deployment of the site. To ensure awareness of the site across the Trust we also ran an advertising campaign. We have developed an internet site managed by Junior Doctors for the Junior Doctors and the Trust. The site is now being used by doctors of all levels as a means of communication and as a clinical resource and will indirectly improve patient care.

Discussion and conclusions

By forming a Junior Doctors' based web team and using our skills and knowledge of web technologies we are resolving our communication problems. In doing so we are changing the culture of how information is disseminated and received in out Trust. This site requires on going commitment to provide up to date content as well as technical development. The communication problems we encountered are unlikely to be confined to our Trust and other NHS Trusts may benefit from hearing about the process we have been through. We would also like to hear about other groups experiences and learn from them. Our ultimate goal is to create a system that can be used as a Junior Doctors management tool that could be used in all Trusts across the NHS.

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The Improvement of Timeliness and Data Quality of Notifiable Disease Reporting by Implementation of an Electronic Reporting System

Anna YH Tong, N T Cheung, Watson CH Tsui, Chris HY Choi, Joycelyne KH Cheung, Vicky H Fung, WN Wong, Antonio CH Sek

Health Informatics Section, Hospital Authority of Hong Kong

Abstract and objective

Physicians' reporting of suspicious or confirmed communicable diseases to government department of infectious disease management is very important for prompt outbreak identification and control to protect the community. The inefficient paper and fax reporting traditionally used cannot cope with imminent infectious risk An electronic reporting system has been developed to facilitate frontline case reporting and infection management works. A proper design and implementation of the reporting system integrated with clinical workflow gains clinicians' acceptance and in turns improves the timelines and data quality of the case reporting. The electronic reporting data available in the system is then be used by different users of the infection management by providing real time operational management reports to facilitate infection management works. Study has been started to use the electronic reporting data to further improve case notifications by cross-checking with laboratory data and cluster outbreak identification across the territory.

Keywords:

electronic notification, infectious diseases, reporting, infection, surveillance

Methods

Hospital Authority of Hong Kong (HA) manages 43 public hospitals with 47 specialty outpatient clinics and 74 general outpatient clinics (GOPCs). Centre of Health Protection (CHP) of Department of Health is the government body for the infection management of the community. Clinicians are required by law to report suspicious and confirmed cases of 32 Notifiable diseases to Central Notification Office (CENO) of CHP, together with hospital Infection Control Teams (ICTs) and Head Office Infection Control Team (CCID). The inefficient paper and fax reporting traditionally used cannot cope with imminent infectious risk and an electronic reporting system named Notifiable Disease and Outbreak Reporting System (NDORS) has been developed to facilitate frontline case reporting and infection management works.

A NDORS Project Working Group with frontline hospital infection control teams and head office infection management staff, clinicians, health informaticians and IT staff was established in April 2005 for detailed study the user requirements, the clinical workflow of case reporting and the follow-up actions of different levels of hospital infection control teams, and development and implementation of an the electronic reporting system. The problems of paper and fax reporting were identified to be dealt with the electronic reporting system (*appendix*). A 4-month pilot study of NDORS implementation was carried out in 3 public hospitals and 3 GOPCs in March 2006. After pilot evaluation, NDORS was fully implemented to HA hospitals and clinics in July 2006. Study has been started to use the electronic reporting data to further improve case notifications by cross-checking with laboratory data and cluster outbreak identification across the territory.

Results

For the 3-month full roll-out period of NDORS, in parallel with paper and fax reporting, there were 2330 cases (i.e. 95%) reported via NDORS to relevant parties. Since the pilot run of NDORS, there was 1059 clinicians used NDORS to report the Notifiable diseases. The average time interval taken between a doctor submitting a case and receiving the CENO system reply was 35s (2s to 4min18s). About 15 cases (1 %) of the NDORS reported cases were sent to CENO system via auto fax, due to server or network problems and non-compliance with validation rules set for electronic data transfer between the two systems. Positive feedbacks were received from different levels of users including convenience, timeliness and data quality (both for the completeness of data and the decrease of duplication of case reports) of case reporting with NDORS. The efficiency of infection disease management works was improved with the electronic reporting data and real time management reports.

Conclusion

Prompt identification and control of infectious disease outbreaks would minimize the impact of the communicable diseases outbreak to the community. Proper design and implementation of electronic reporting system improves the acceptance of the users and in turns, the timeliness and data quality of infectious disease notification. The effi-

ciency of infection management works is improved. The reporting data would be used to further facilitate the case notification and surveillance of cluster outbreak in the community.

Appendix

Comparison of Paper & Fax Reporting and Notifiable Disease and Outbreak Reporting System (NDORS)

Paper & Fax Reporting	NDORS	Benefits
Filling paper form	▪ Clinicians report case via all the CMS workstation during their clinical care of the patients ▪ Interfacing with patient master index demographic data ▪ Electronic forms with structured data fields with different checking rules	▪ Improve timeliness of case reporting by providing a more convenient way of reporting which is integrated with clinical workflow ▪ Decrease time used for reporting ▪ Improve data quality
Fax to Hospital ICTs, CCID of HAHO & CENO of CHP	▪ Submission of case reports to Hospital ICTs, CCID of HAHO & CENO of CHP simultaneously by clicking the "submit" button ▪ Updated information can be accessed +/- sent to 3 different parties via auto fax	▪ Decrease works used for reporting ▪ Prevent discrepancy of data among the 3 different parties
Loss of paper forms	▪ All case reporting records are stored in and viewed by clinical staff via NDORS	▪ Better history tracking for notifiable disease reporting records ▪ Decrease duplication of case reporting (by providing case report history view and checking rules of case report duplication) ▪ Records can be edited & updated via NDORS and updated information can be accessed +/- sent to 3 different parties via NDORS ▪ Online management reports for infection control management, surveillance and research
Reporting with reference to different sources of criteria for reporting (paper records, CHP website)	▪ Information provided on the updated list of notifiable diseases to be reported, the updated criteria of reporting &the updated contact details of different parties	▪ Improve data quality ▪ Decrease works for reporting ▪ Improve communication among different users

*The **improvement** of **timeliness** and **data quality** of **Notifiable disease reporting** by implementation of an **electronic reporting system***

Anna YH Tong, N T Cheung, Watson CH Tsui,
Chris HY Choi, Joycelyne KH Cheung, Vicky H Fung, WN Wong,
Antonio CH Sek

Health Informatics Section
Hospital Authority of Hong Kong

Goals

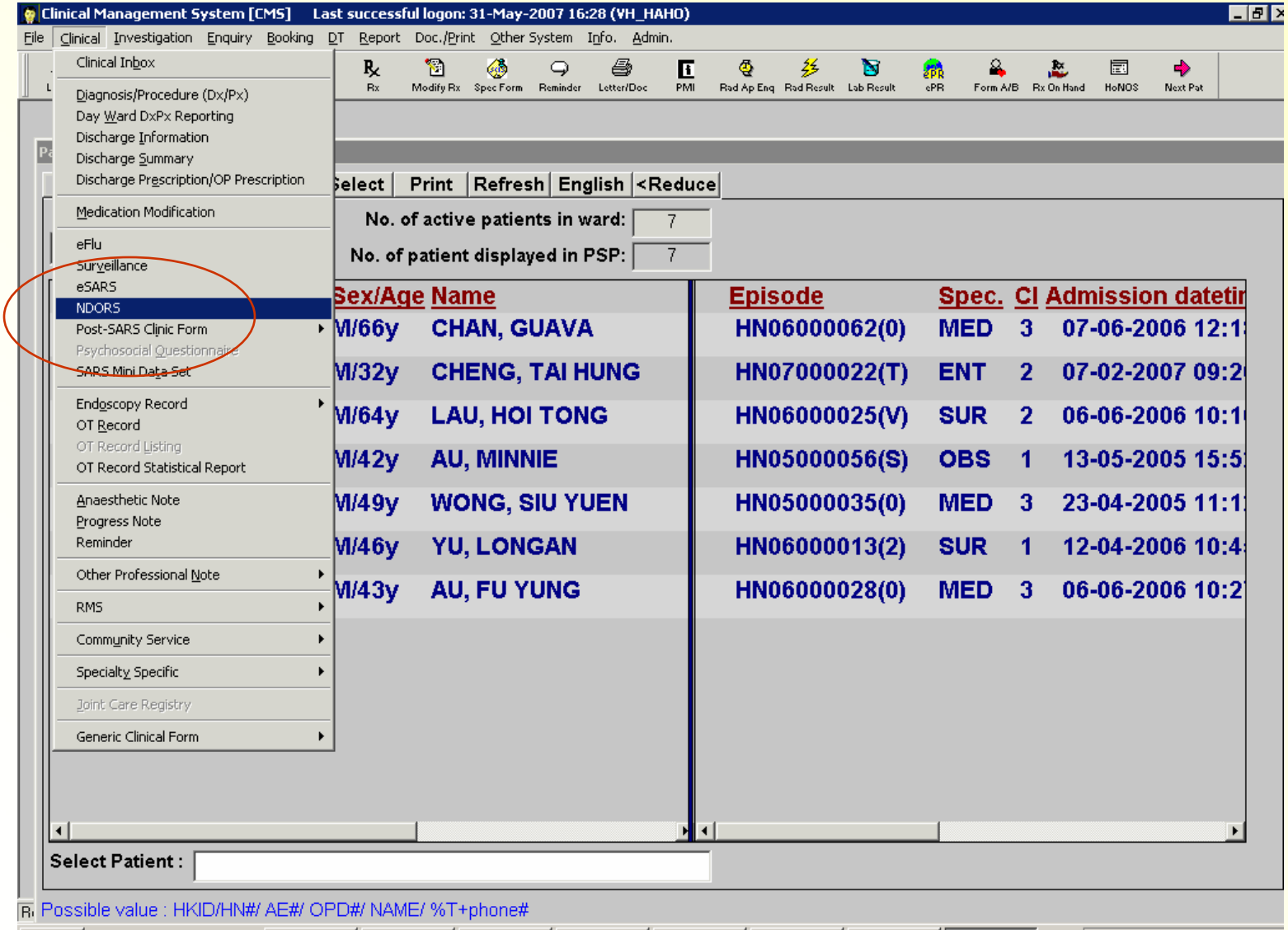
- More **convenient** way of reporting
- **Timely** reporting to relevant parties
- **Accurate** and structured / standardized data
- Real time access & sharing of the most updated data by different group of users
- **Prompt** Outbreak identification and control across Clusters

⇨ Better than paper & fax reporting, both in timeliness and data quality

Functions

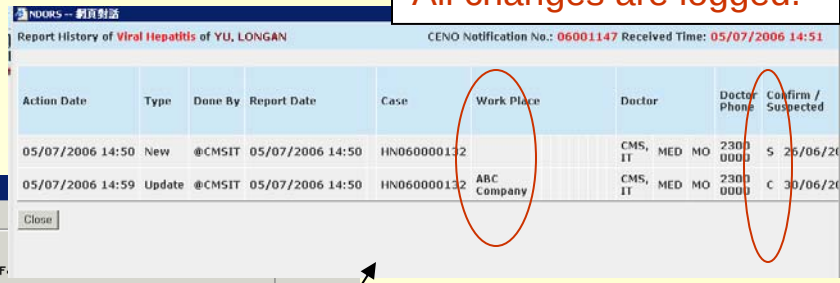
- **To report Notifiable Diseases thru' CMS**
- **Electronic data to be sent to CENO of CHP and to be accessed by ICT/CCID of HA in a timely manner**
- **Data can be updated by different parties and updated information can be shared with different users online**
- **Have report functions**
- **To alert different parties on a timely manner**

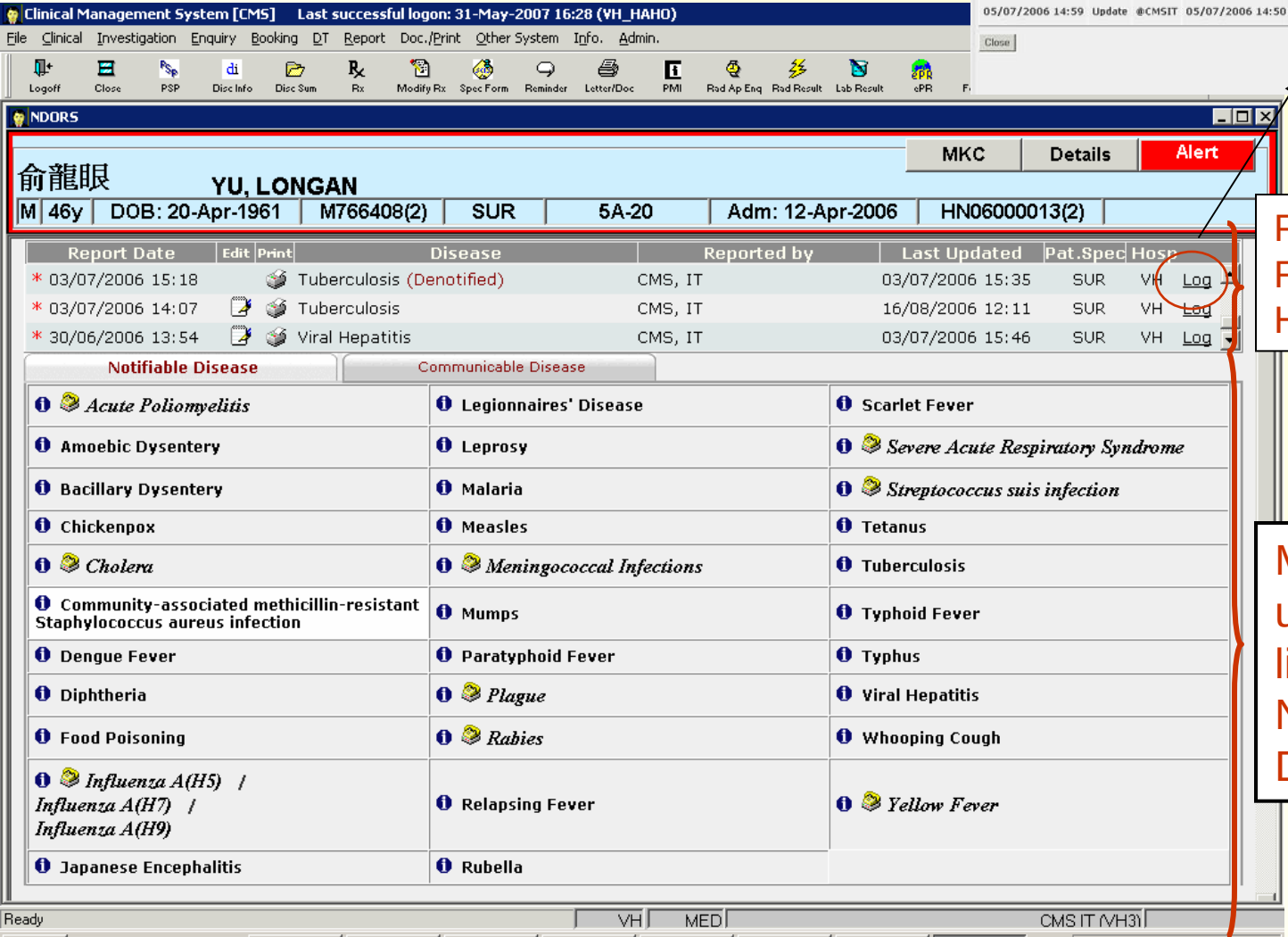
Notifiable Disease & Outbreak Reporting System



Provision of most updated info about Notifiable Diseases & case reporting history of the patient

All changes are logged.

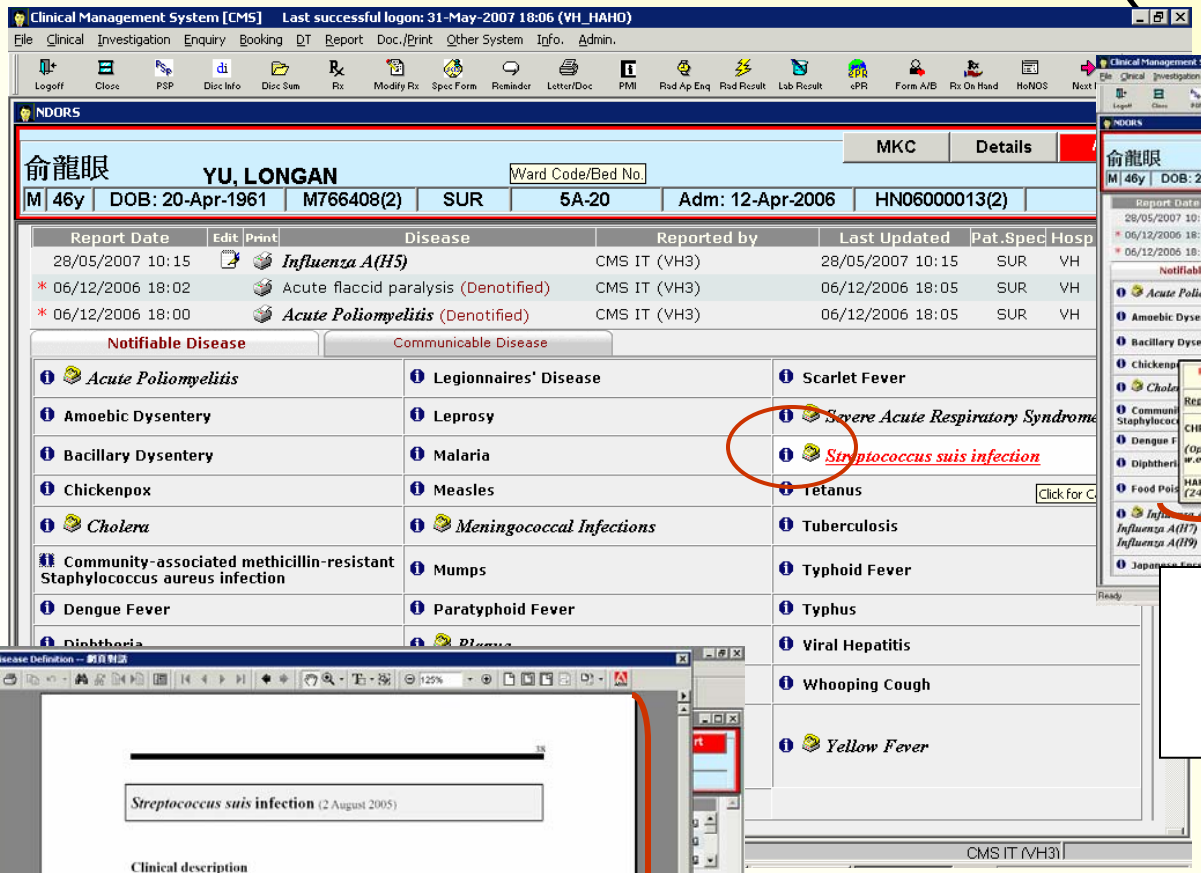


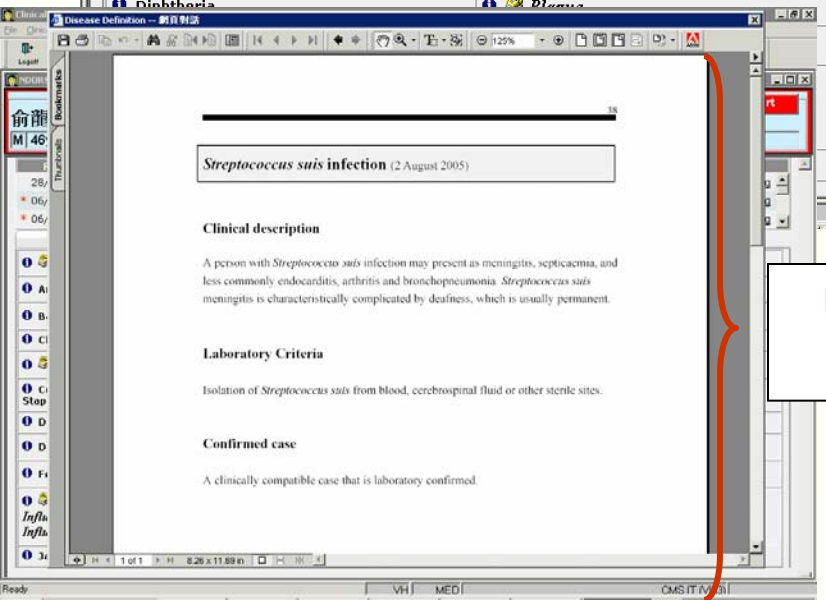


Patient's Reporting History

Most updated list of Notifiable Diseases

Provision of most updated info about Notifiable Diseases (cont')



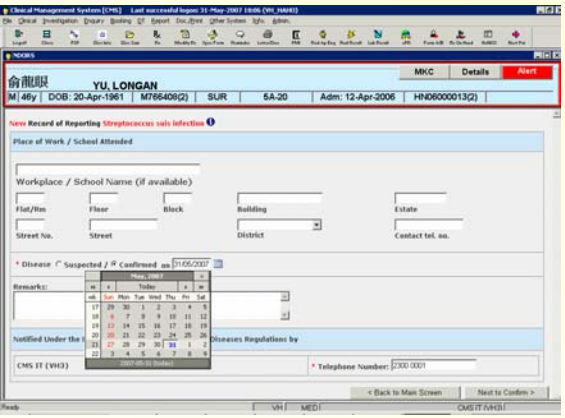


Updated criteria for reporting

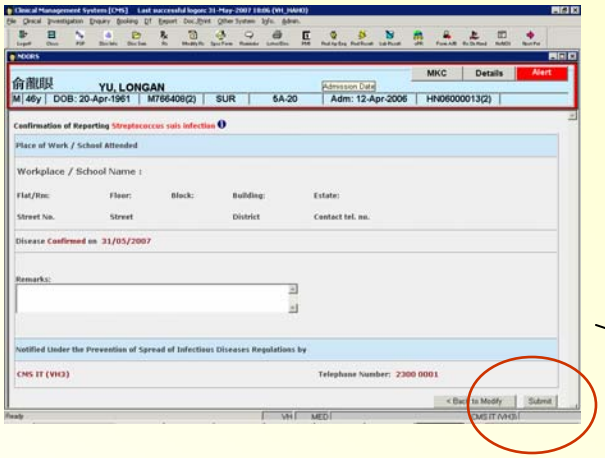
Relevant information

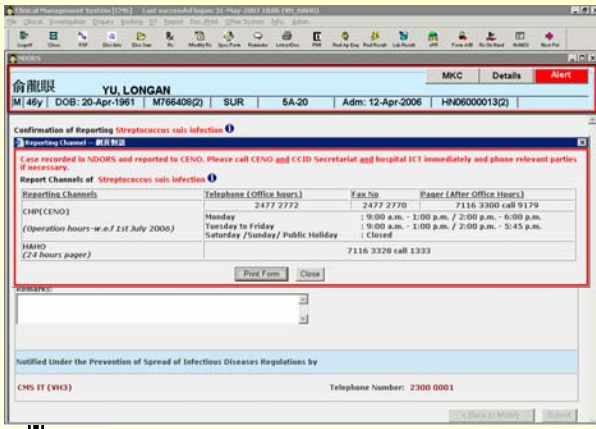
e.g. Communication mechanisms with Infection Control Team

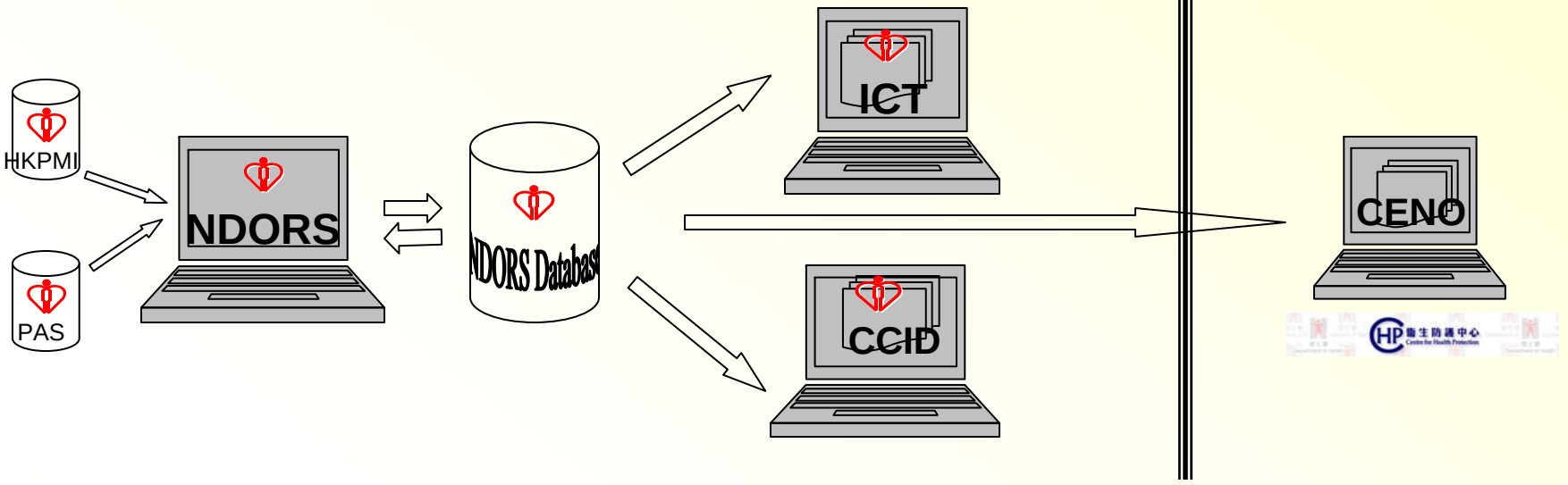
Just a "Click" → case reporting information is accessed by Infection Control Teams within HA & other government department in a timely way



Structured scope and data format

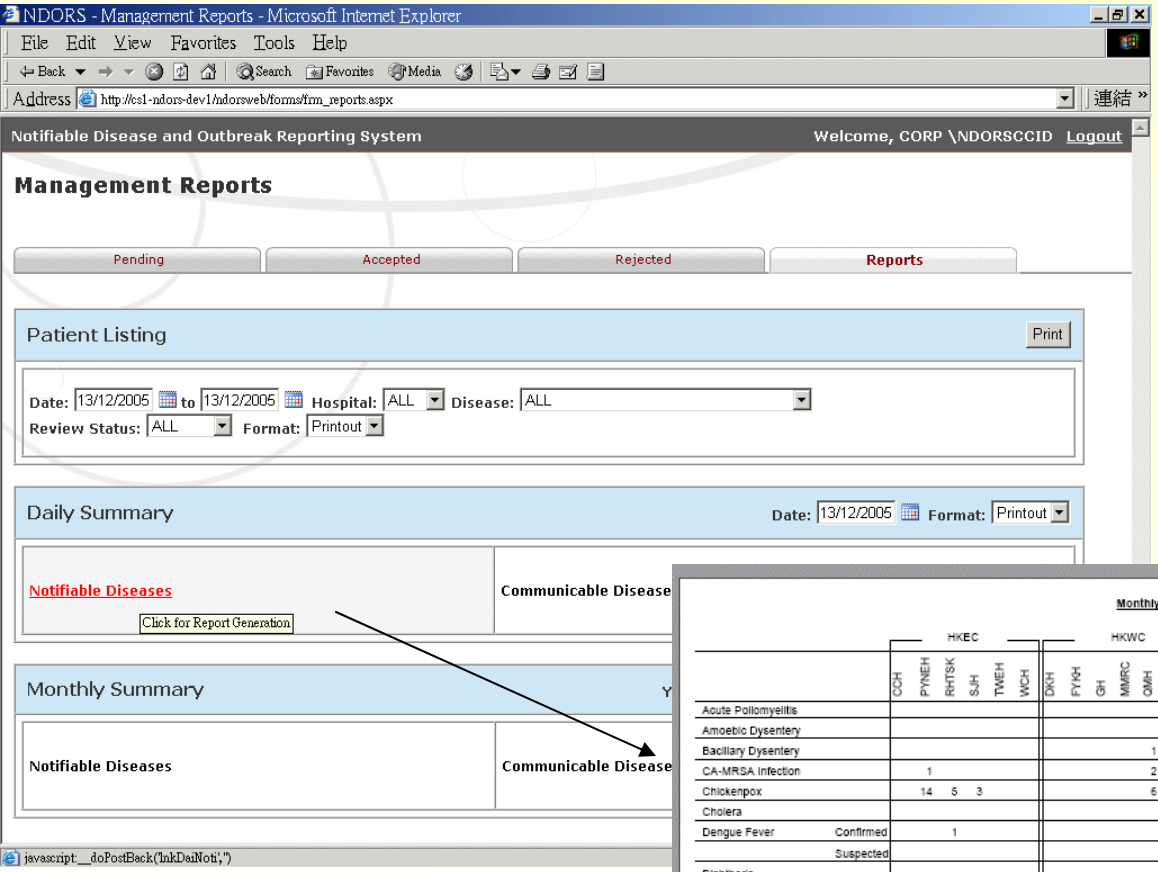


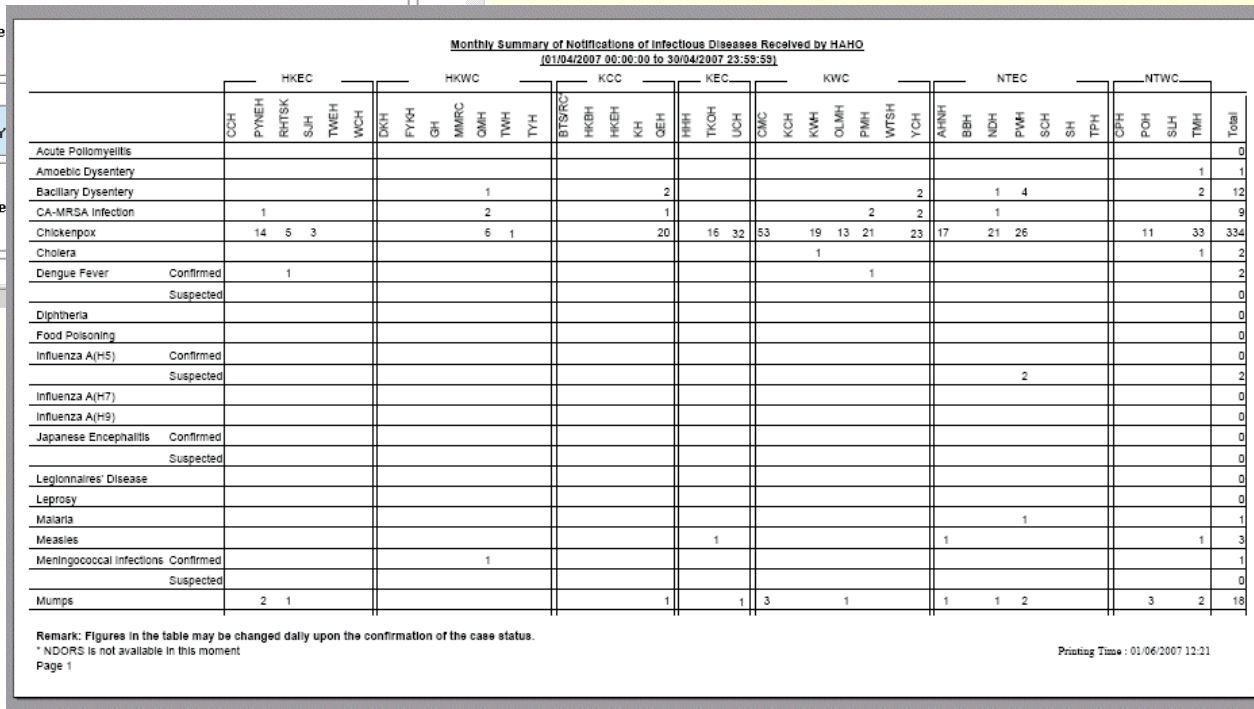




Firewall

Management Reports





Monthly Summary of Notifications of Infectious Diseases Received by HAHO
(01/04/2007 00:00:00 to 30/04/2007 23:59:59)

		HKEC					HKWC						KCC				KEC			KWC							NTEC						NTWC				
		CCH	PYNEH	RHTSK	SJH	TWEH	WCH	DKH	FYKH	GH	MMRC	QMH	TWH	TYH	BTS/RCC	HKBH	HKEH	KH	QEH	HHH	TKOH	UCH	CMC	KCH	KWH	OLMH	PMH	WTSH	YCH	AHNH	BBH	NDH	PWH	SCH	SH	TPH	CPH	POH	SLH	TMH	Total
Acute Poliomyelitis																																								0
Amoebic Dysentery																																							1	1
Bacillary Dysentery												1						2										2			1	4							2		12
CA-MRSA Infection			1									2						1									2	2			1										9
Chickenpox			14	5	3							6	1					20			16	32	53		19	13	21	23	17		21	26					11		33		334
Cholera																									1														1		2
Dengue Fever	Confirmed			1																							1													2
	Suspected																																								0
Diphtheria																																									0
Food Poisoning																																									0
Influenza A(H5)	Confirmed																																								0
	Suspected																																2								2
Influenza A(H7)																																									0
Influenza A(H9)																																									0
Japanese Encephalitis	Confirmed																																								0
	Suspected																																								0
Legionnaires' Disease																																									0
Leprosy																																									0
Malaria																																	1								1
Measles																					1									1									1		3
Meningococcal Infections	Confirmed											1																													1
	Suspected																																								0
Mumps			2	1														1			1		3			1				1		1	2				3		2	18

Remark: Figures in the table may be changed daily upon the confirmation of the case status.
* NDORS is not available in this moment
Page 1

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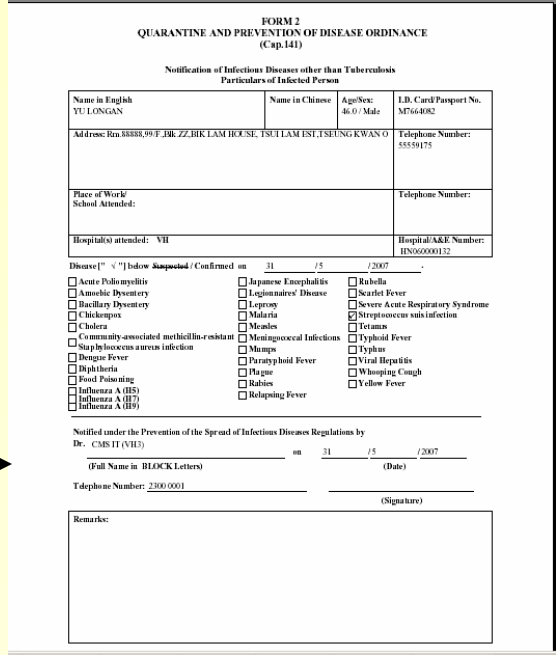
Evaluation Study

- A 4-month pilot study of NDORS implementation was carried out in 3 public hospitals and 3 GOPCs in March 2006.
- After pilot evaluation, full roll-out to all HA hospitals and clinics in July 2006

Results

- For the first 3-month full roll-out period of NDORS (in parallel with paper and fax reporting)
  - 2330 cases (i.e. 95%) reported via NDORS
  - 1059 clinicians used NDORS to report the Notifiable diseases
  - The average time interval taken between a doctor submitting a case and receiving the CENO system reply was 35 sec (2 sec to 4min18 sec)
  - About 15 cases (1 %) of the NDORS reported cases were sent to CENO system via **auto fax**
    - due to server or network problems and non-compliance with validation rules set for electronic data transfer between the two systems
  - Positive feedbacks were received from different levels of users including
    - convenience
    - timeliness
    - data quality (both for the completeness of data and the **decrease of duplication of case reports**) of case reporting with NDORS
    - improved efficiency of infection disease management works



FORM 2
QUARANTINE AND PREVENTION OF DISEASE ORDINANCE
(Cap.141)

Notification of Infectious Diseases other than Tuberculosis
Particulars of Infected Person

Name in English	Name in Chinese	Age/Sex:	I.D. Card/Passport No.
YU LONGAN		46.0 / Male	M766408(2)
Address: Rm.88888,99/F,Blk ZZ,BIK LAM HOUSE, TSUI LAM EST,TSEUNG KWAN O			Telephone Number: 55559175
Place of Work/ School Attended:			Telephone Number:
Hospital(s) attended: VH			Hospital/A&E Number: HN06000132

Disease [" √ "] below ~~Suspected~~ / Confirmed on 31 /5 /2007 .

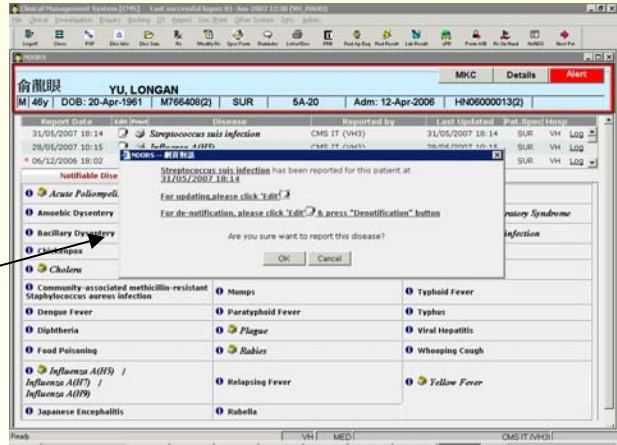
- ☐ Acute Poliomyelitis
- ☐ Amoebic Dysentery
- ☐ Bacillary Dysentery
- ☐ Chickenpox
- ☐ Cholera
- ☐ Community-associated methicillin-resistant Staphylococcus aureus infection
- ☐ Dengue Fever
- ☐ Diphtheria
- ☐ Food Poisoning
- ☐ Influenza A (H5)
- ☐ Influenza A (H7)
- ☐ Influenza A (H9)
- ☐ Japanese Encephalitis
- ☐ Legionnaires' Disease
- ☐ Leprosy
- ☐ Malaria
- ☐ Measles
- ☐ Meningococcal Infections
- ☐ Mumps
- ☐ Paratyphoid Fever
- ☐ Plague
- ☐ Rabies
- ☐ Relapsing Fever
- ☐ Rubella
- ☐ Scarlet Fever
- ☐ Severe Acute Respiratory Syndrome
- ☑ Streptococcus suis infection
- ☐ Tetanus
- ☐ Typhoid Fever
- ☐ Typhus
- ☐ Viral Hepatitis
- ☐ Whooping Cough
- ☐ Yellow Fever

Notified under the Prevention of the Spread of Infectious Diseases Regulations by
Dr. CMS IT (VH3) on 31 /5 /2007
(Full Name in BLOCK Letters) (Date)
Telephone Number: 2300 0001
(Signature)

Remarks:

Sample of NDORS generated auto-fax

Duplication check



Comparison of Paper & Fax Reporting and NDORS

Paper & Fax Reporting	NDORS	Benefits
Filling paper form	▪ Clinicians report case via all the CMS workstation during their clinical care of the patients ▪ Interfacing with patient master index demographic data ▪ Electronic forms with structured data fields with different checking rules	▪ Improve timeliness of case reporting by providing a more convenient way of reporting which is integrated with clinical workflow ▪ Decrease time used for reporting ▪ Improve data quality
Fax to Hospital ICTs, CCID of HAHO & CENO of CHP	▪ Submission of case reports to Hospital ICTs, CCID of HAHO & CENO of CHP simultaneously by clicking the "submit" button ▪ Updated information can be accessed +/- sent to 3 different parties via auto fax	▪ Decrease works used for reporting ▪ Prevent discrepancy of data among the 3 different parties
Loss of paper forms	▪ All case reporting records are stored in and viewed by clinical staff via NDORS	▪ Better history tracking for notifiable disease reporting records ▪ Decrease duplication of case reporting (by providing case report history view and checking rules of case report duplication) ▪ Records can be edited & updated via NDORS and updated information can be accessed +/- sent to 3 different parties via NDORS ▪ Online management reports for infection control management, surveillance and research
Reporting with reference to different sources of criteria for reporting (paper records, CHP website)	▪ Information provided on the updated list of notifiable diseases to be reported, the updated criteria of reporting & the updated contact details of different parties	▪ Improve data quality ▪ Decrease works for reporting ▪ Improve communication among different users

Thank you

Please send your comments and suggestions to Dr Anna Tong

tongyh@ha.org.hk

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Using the Latest Web Technologies to Improve Communication and Implement a Cultural Change in Junior Doctors in a Large UK Health Trust

Louise Beckham, Jonathan Shaw, Su Underwood, Jonathan Bloor

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Abstract

The Internet is universally accepted as a means of communication and is an under used resource within the NHS. We developed a Junior Doctors Website and content management system and in doing so have seen a cultural change in how information is communicated in United Bristol Healthcare Trust

Keywords:
junior doctor, internet, communication

Introduction

United Bristol Healthcare Trust is a large NHS Teaching Hospital Trust. It employs 360 Junior Doctors across 4 different sites. They are employed on a semi-permanent basis and rotate between specialties, hospital sites and other Trusts. A Junior Doctors Committee was formed to represent these Junior Doctors and found significant difficulty in communicating with them. In particular the Trust was unable to disseminate medico-legal information, clinical guidance and Trust news. In turn, Junior Doctors felt unable and unaware of how to feedback problems to the Trust and wanted better access to clinical and career guidance, time management information and social news. The principal reason for the breakdown of communication was a reliance on a Trust e-mail system. Access was only available on-site, limited and slow and relied on Junior Doctors registering and using an account. There was no list of personal e-mail addresses.

With changing work patterns as a result of the European Working Time Directive and less face to face contact within the hospital the need for excellent communication is greater than ever. The internet is universally accepted as a means of communication. Our aim was to develop a Junior Doctors website accessible from work and home. As part of its development it needed to contain useful content to entice continuing and regular use. It required the ability for users with privileges to be able to directly and easily create areas on the site and upload information as and when necessary creating a live system.

Methods and results

We formed a Junior Doctors web development team. 4 members divided responsibilities into content management, technical development, marketing and overall coordination. We initially designed a static HTML site, residing in our Trust intranet. Using Server Side technologies we were able to develop a content management system as well as other interactive aspects including notice boards, timetables and rotas. We used our secure logon system to create a database of Users e-mails to further aid communication.

There were a number of hurdles to overcome to reach this point. We had to engage the IT department and Trust Board to show the value of our proposals and then obtain their backing to progress with the development and deployment of the site. To ensure awareness of the site across the Trust we also ran an advertising campaign. We have developed an internet site managed by Junior Doctors for the Junior Doctors and the Trust. The site is now being used by doctors of all levels as a means of communication and as a clinical resource and will indirectly improve patient care.

Discussion and conclusions

By forming a Junior Doctors' based web team and using our skills and knowledge of web technologies we are resolving our communication problems. In doing so we are changing the culture of how information is disseminated and received in out Trust. This site requires on going commitment to provide up to date content as well as technical development. The communication problems we encountered are unlikely to be confined to our Trust and other NHS Trusts may benefit from hearing about the process we have been through. We would also like to hear about other groups experiences and learn from them. Our ultimate goal is to create a system that can be used as a Junior Doctors management tool that could be used in all Trusts across the NHS.

Junior doctors internet @ UBHT

Using the Latest Web Technologies to Improve Communication and Implement a Cultural Change in Junior Doctors in a Large UK Health Trust

Jon Shaw, Louise Beckham, Su Underwood, Jonathan Bloor

United Bristol Healthcare Trust, Bristol, UK

Contents

- Introduction
- Problems identified
- Solutions devised
- The site developed
- E-mail system developed
- Content management system developed
- Conclusions and future developments
- Contacts and acknowledgements

Introduction

- A communication problem was identified between the Trust and Junior Doctors
- The European Working Time Directive has changed working patterns
- Communication becomes even more important
- Technology is available to aid communication
- This technology is underutilised in the NHS
- We used the latest web technologies to improve communication

Communication Problems

- 360 Junior Doctors
- Transient population
- 4 Hospital sites
- Rotation between different Trusts
- Rotation between different specialties
- Junior Doctors Committee unable to contact all Junior Doctors
- Severe time pressure at work
- No available list of Junior Doctors
- No list of used e-mail addresses
- Important information not disseminated
- Changing work patterns due to European Working Time Directive

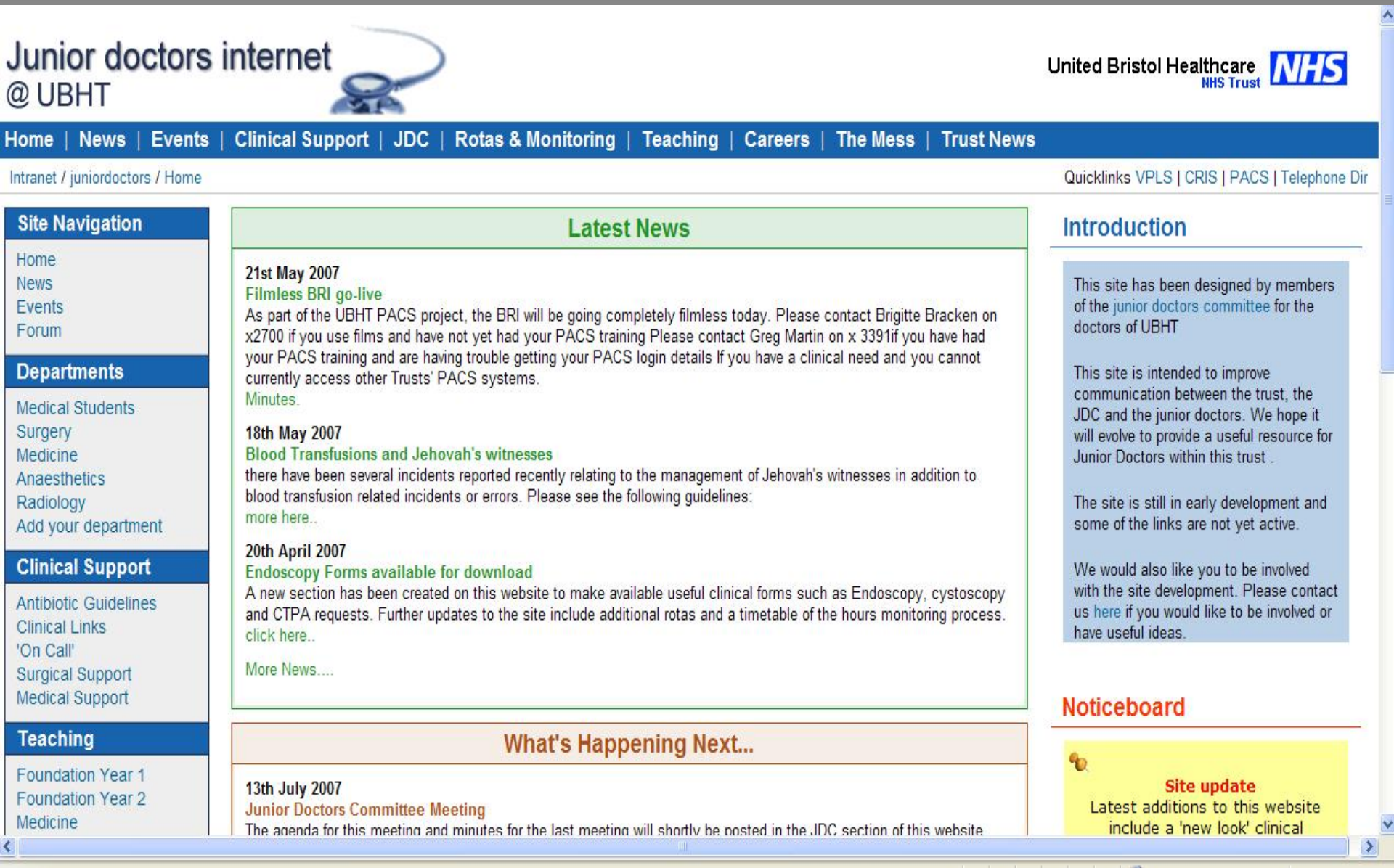
IT Problems

- Reliance on Trust e-mail system
- Trust e-mail only accessible from work
- Slow computer access
- Limited computer access
- No access to information from home

Solutions

- Internet site
- New e-mail system
- Database of users and e-mail addresses
- Content management system
- Continuing development of above

Junior Doctors Site



Junior Doctors Site

Junior doctors internet
@ UBHT

United Bristol Healthcare NHS Trust

Home | News | Events | Clinical Support | JDC | Rotas & Monitoring | Teaching | Careers | The Mess | Trust News

Intranet / juniordoctors / Teaching Timetables / Medical SHO

Quicklinks VPLS | CRIS | PACS | Telephone Dir

Site Navigation

Home
News
Events
Forum

Departments

Medical Students
Surgery
Medicine
Anaesthetics
Radiology
Add your department

Clinical Support

Antibiotic Guidelines
Clinical Links
'On Call'
Surgical Support
Medical Support

Teaching

Foundation Year 1
Foundation Year 2
Medicine

Teaching Timetables

Home | F 1 | F 2 | Medical SHOs | Surgical SHOs | Anaesthetics

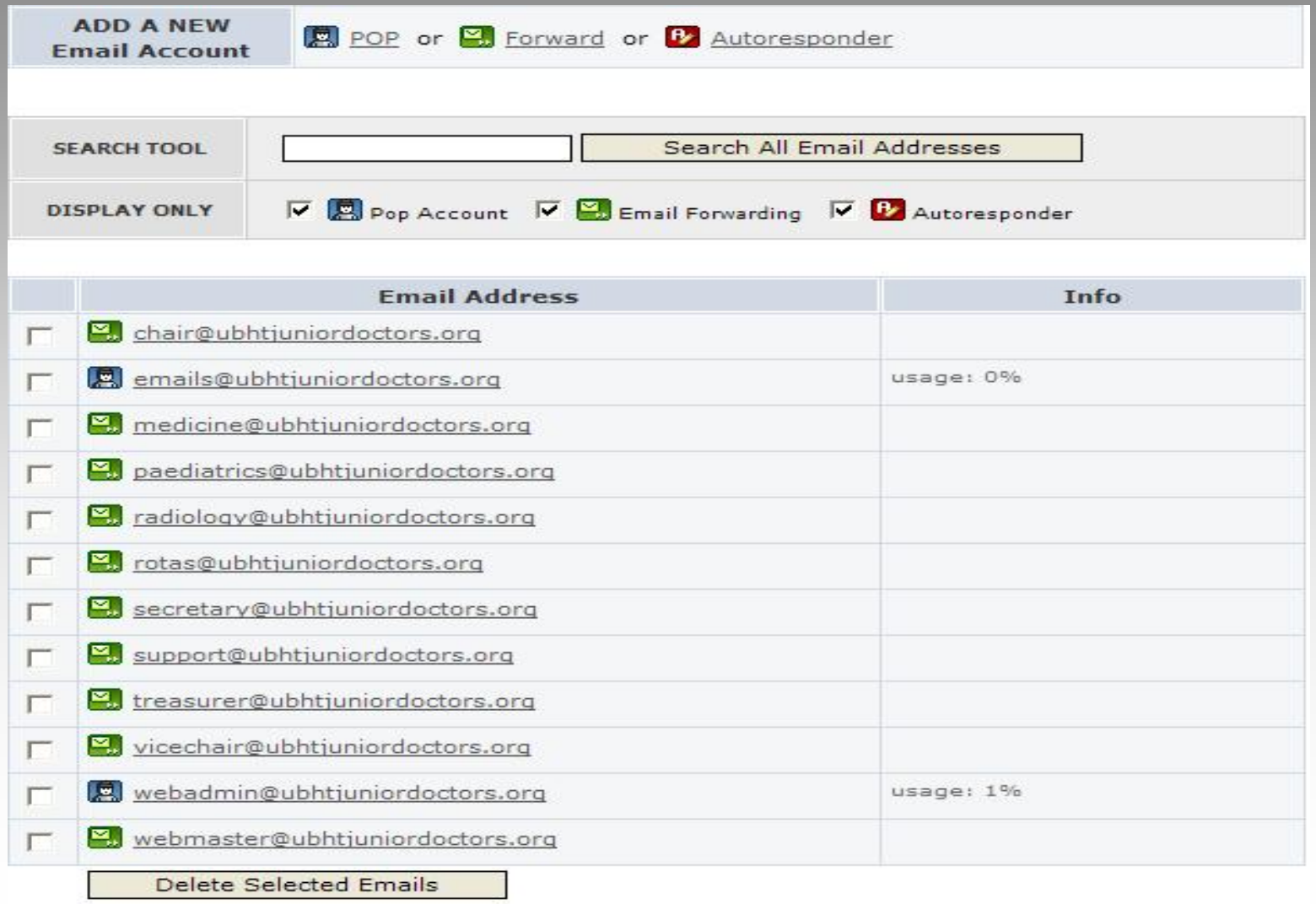
Medical SHO Teaching programme

Programme of Medical SHO Teaching 14:30-16:00 (August 2006 – June 2007)

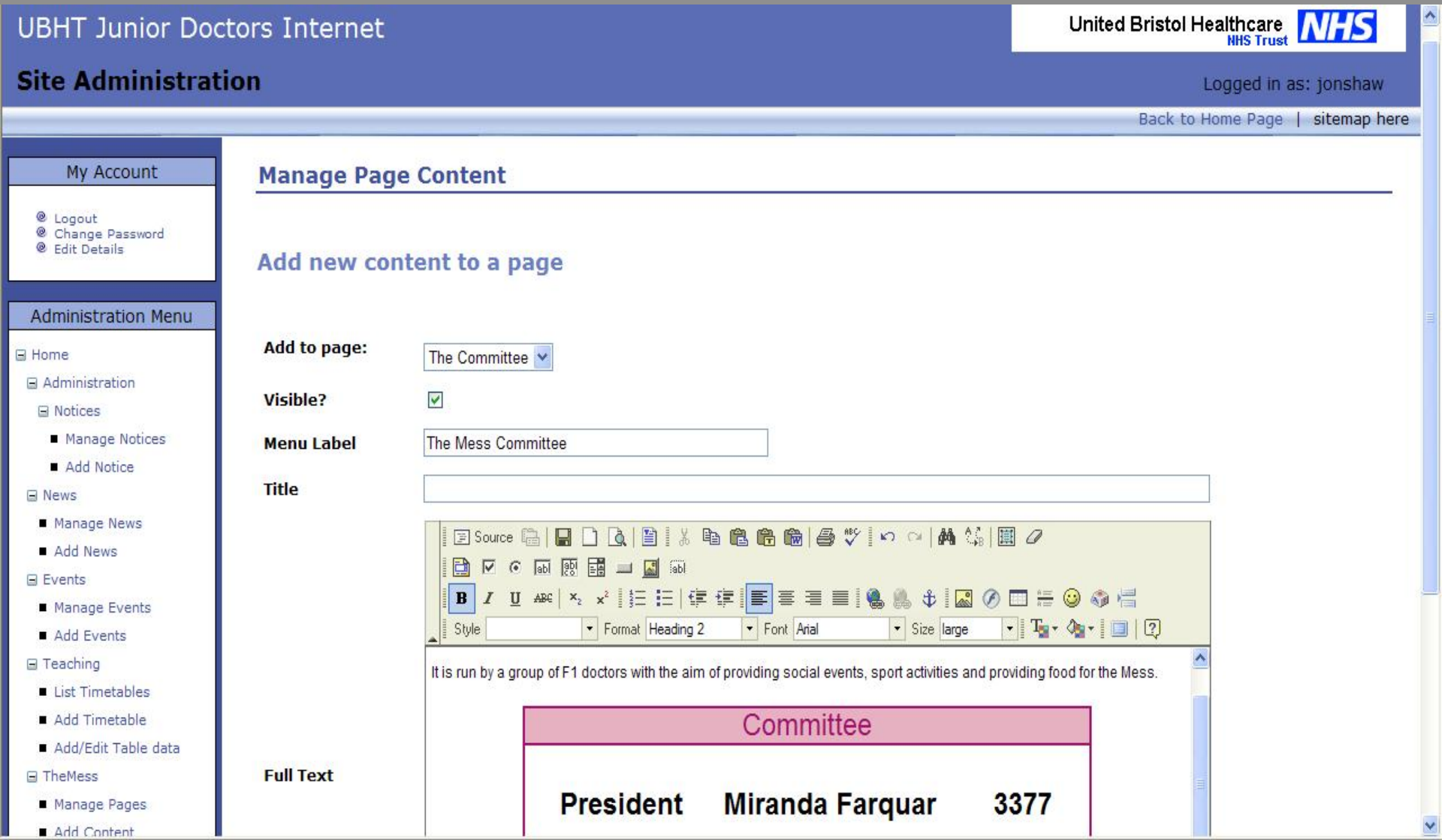
last updated: 15/01/2007

Date	Venue	Subject	Speaker
08/08/06	T 1	**Psychiatry** - Old Age Liaison	Dr Val Henderson
15/08/06 *sponsored	T 5	**Gastro**	Dr Peter Collins
22/08/06 sponsored	T 1	**Geriatrics**	Dr Simon Croxon
29/08/06	L 3	**Respiratory** – Tuberculosis MMC @3.30pm	Dr Martin Hetzel Dr Geoffrey Wright
05/09/06	T 6	**Neurology** – Surgical management of itracerebral bleed and its outcome	Dr Marcus Bradley
13/09/06	BMSC	**Wednesday Practical** Emergency airway management	Dr Andy McIndoe
19/09/06	T 5	**Gastro**: Etiology & management of Upper GI Bleed	Dr T Creed
26/09/06	T 5	**Diabetes**	Dr Colin Dayan

E-mail System



Content Management System



Conclusions

We have developed an internet site for Junior Doctors that is changing the culture of how information is communicated in our Trust

Future Developments

- Integrated live rota system
- Integrated hours monitoring
- Integrated handover system
- Integrated competency assessment

Junior doctors internet @ UBHT

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Aknowledgements

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Su Underwood
(Assisstant Medical Director)

Trust

Ron Kerr
(Chief Executive)
Jonathan Sheffield
(Medical Director)
Andrew Hooper
(Head of IT)
Chris Berrington
(IT Development Manager)

A Web-based Clinical Information System Supporting Pattern Identification Examination of a Stroke in Oriental Medicine

Bo Young Kim, Ho Yeon Ko, Byung Kap Kang, Mi Mi Ko, Jin Seok Moon, Sun Mi Choi

Dept. of Medical research, Korea Institute of Oriental Medicine, Korea

Abstract

We developed a web-based clinical information system that can examine symptoms for Stroke in oriental medicine. This research enforced clinical research to examine closely Stroke's symptoms in oriental medicine. In this clinical research, We made out case report form(CRF) by many oriental medicine specialists to normalize typical symptoms that examine the Stroke. It needs confirmation whether clinical data by this CRF can examine. So, we confirmed if specialist's diagnosis views only CRF consist with specialist's diagnosis in real clinical environment. At this phase, we need system that should be convert the CRF row data to oriental medical language and then specialists can diagnoses by it. In addition to, we have developed a web-based system because it works anywhere, anytime through several specialists.

Keywords

Stroke, Clinical Laboratory Information Systems, Oriental Medicine, Signs and Symptoms, World Wide Web

Introduction

Unfortunately, an oriental medicine has not yet standardized most of disease and symptoms. That's why pattern identification for examination of various symptoms in oriental medicine is so important. So, we decided to do symptoms examination about cerebrovascular disease that happens most frequently. In this research, it is most important that establish the gold standard of Stroke diagnosis. Therefore, we developed a web-based clinical information system of pattern identification to establish gold standard about Stroke.

Methods

In this research, we developed the CRF entry system on web and then keep it in the web database. Specialist (it means Oriental Medical Doctor) sees clinical information that is stored on web and then diagnose. Because it can not diagnose from CRF row data, the data has converted to Oriental Medicine standard terminology.

A web database has the metadata table that being combined each CRF question and answer information do mapping to a symptoms. A metadata table is comprised of mapping information of CRF item and symptoms terminology in Oriental Medicine by several specialists. When specialist logged in, the web page shows doing to do mapping per CRF clinical item that is stored recently. A mapping result of per item is same that see a patient. That is, a CRF data that is gathered in this research is data of such as medical record contents that a doctor sees a patient. Specialist sees this web page and input diagnosis result. And then several specialists decide diagnosis accuracy with this diagnosis result and clinical data of CRF.

Results

This system shows hereafter that such mapping mechanism is possible for conversion to medical records from CRF clinical data. Also, it can know that is possible to link composition with standard terminology. Forward research, we will progress a research about medical document applied HL7 CDA conversion and Clinical Document Repository (CDR).

Acknowledgment

This study was supported by the Ministry of Science and Technology (M10527010001-06N2701-00110).

References

1.Dong-Jin Kim,Seon-Ho Kim,Kyung-Mo Park,Sun-mi Choi. Development environment for automatic generation of clinical data acquisition system, In *J Kor Soc Med Informatics*;2005;12(1):95-104

2. Das, A.K., and Musen, M.A. (2002). Synchronus: A reusable software module for temporal integration. *Proceedings Annual AMIA Symposium*, San Antonio, TX, pp.195-199.

A Web-based Clinical Information System
Supporting Pattern Identification Examination of a Stroke in Oriental Medicine

Korea Institute of Oriental Medicine

Bo Young Kim

Background

- ***Today of Oriental Medicine***
  - *Unfortunately, an oriental medicine has not yet standardized most of disease and symptoms.*
  - *That's why pattern identification for examination of various symptoms in oriental medicine is so important.*
  - *decided to do symptoms examination about cerebrovascular disease that happens most frequently.*
- ***Importance of Establishment Gold Standard for Stroke Diagnosis***

Introduction

- ***Development of web-based clinical information system***
  - *to establish gold standard about Stroke pattern identification.*
  - *be capable of examine symptoms for Stroke in oriental medicine.*
  - *to normalize typical symptoms that examine the Stroke.*
  - ***This research enforced clinical research to examine closely Stroke's symptoms in oriental medicine.***

Introduction

Overall Scenario

Period : June 14,2006 to September 6,2006

Collecting information : CRF, pattern identification of Specialist

CRF Collecting

login

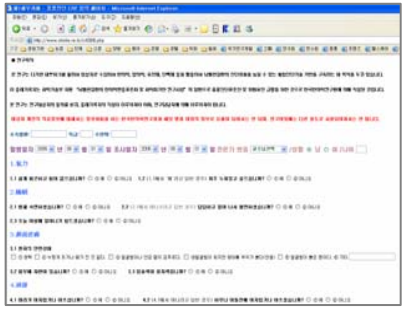
Methods before collecting

Patients

Examine
by paper-based CRF

Residents

Web-Entry system
Electronic Entry system
by paper-based CRF



CRF

save

Web-based Database
for Clinical Data

CRF CRF CRF

Meta-table

KIOM
Korea Institute of Oriental Medicine

Methods after collecting

Establishment of Gold standard for Stroke Diagnosis

by normalize typical symptoms

Case Report

converted to oriental medical terminology

mapping

diagnose

view

Stroke specialist
(oriental Medical Doctor)

Web-based Database
for Clinical Data

CRF CRF CRF

Meta-table

KIOM
Korea Institute of Oriental Medicine

Method mapping mechanism

- A web database has the metadata table that being combined each CRF question and answer information do mapping to a symptoms.
- A metadata table is comprised of mapping information of CRF item and symptoms terminology in Oriental Medicine by several specialists.

METATABLE	question	classification	answer

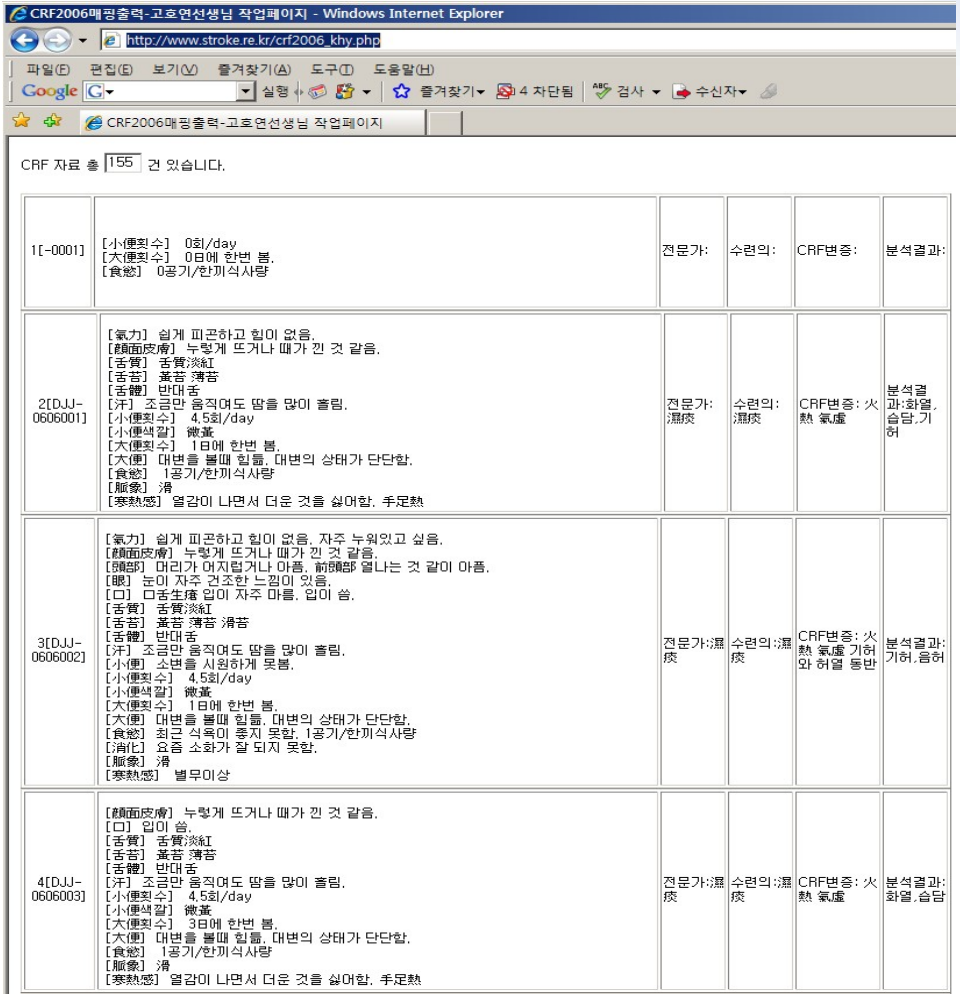
Ex) Meta-table

번호	내용	속성	비고	메타분류	지문1	지문2	지문3	지문4	지문5	지문6	지문7	지문8	지문9	지문10
1_1	성계 계곡에도 한이 흐르신다고)	문장		형태또는 mile										
1_2	한 스에서 '에'다고 반크 고주) 자주 누설하고 싶으신다고)	문장		형태또는 service										
2_1	흰색 수염이셨습니다)	형태												
2_2	한 스에서 '에서도'반크 고주) 반짝이고 별이 나서 끌렸어셨습니다)	형태		묘사구절										
2_3	모습 아주에 빛이나기 하셨습니다)	형태		형태										
6_1	골격의 명칭설명	형포 유형		상반	구성하고 있다.	나머지	얼굴있이	하지 만 상대에	얼굴있이	골은	기타			
				포은포함	포은포함		포은포함		붙다	포은				
6_2	피부(표피)에 자리(존재)이 있습니다)	형포 유형												
6_3	인골이 존재로(작용)한다)	형포 유형		물질유도										
4_1	대부가 아니한거나 아프신다)	형한												
4_2	(4.1에서 아니다고 반크 고주) 부모나 아들 집에 아니한거나 아프셨습니다)	형한												
4_3	(4.1 또는 4.2에서 에다고 반크 고주) 대부의 아는 부모가 아프셨습니다)	형한		이 주(물체) 물체유형	선주지(위생한) 위생포	주장지(위포함) 위포포	선주지(물 처한) 물포포	주장지(위포함) 위포포	어지선서 물포포		방어방법(퍼스펙트) 스펙트포	기타		
4_4	(4.1 또는 4.2에서 에다고 반크 고주) 대부가 아깝게 끌렸어셨습니다)	형한		주장고 하기 않다. 위포함	빛나주 된 장이 아니다. 위포함	커도주 곳이 아니다. 위포함	속이 제소하주 언서 아니다. 주느위포	속이 제소하주 언서 어지않다. 주느위포	기타					
5_1	골격의 연구분야	명		수업 명칭또는	어안	성상	기타							
5_2	한이 저주 피로감 느끼며 아프신다)	명		명칭포										
5_1	가세가 아프신다)	계열		명칭포										
5_2	몸소에가 한이 왔고 별에이 끝났신다)	계열		소유위포										
7_1	골격의 큰 별에 분야	口 口		구성성장(口형포함) 口형포함	위치(口포)	기타								
7_2	한이 저주 아프신다)	口		口포										
7_3	한이 소신다)	口		口함										
7_4	몸은 별이 크신다)	口		소유										
8_1	골격의 특징	형포		외소 형포또는	외진	진	약	형포	기타					
8_2	골격의 분류	형포		형포	큰포	포함	포함	포함	포함		형포포	특포	기타	
8_3	골격의 분류	형태		형포 큰포 큰포함	큰포 부포 부포함	포함 포포 포포함	포함 원인 원인함	포함 유도포함 유도포함함	포함 기타		형포포	특포		
9_1	흉반에 가슴이 끌렸고 싸여 보였습니다)	형한		형한포 포함										
9_2	(9.1에서 '에'다고 반크고주) 가슴이 보도들이 아프신 싸여 보였습니다)	형한		형한위포										
9_3	(9.1에서 '에'다고 반크 고주) 가슴이 반짝이거나 별이 나는 느낌이 보였습니다)	형한		형한포함										
9_4	(9.1에서 '에'다고 반크 고주) 가슴이 무한가비거나 힘찼기된 싸여 보였습니다)	형한		한										
10_1	표골은 근육이로 된은 별이 끝났신다)	부		물부										
10_2	수의 경에 된은 별이 끝났신다)	부		물부										
11_1	소년은 시절에에 보신다)	소부	소부포부함											
11_2	소년은 부주에 보별 보신다)	소부												
11_3	소년의 포골은 아픈신다)	소부		형포	큰	작								
12_1	대년은 어둠에 크별 보신다)	노부												
12_2	대년은 보통 에 주으신다)	노부		부함										
12_3	대년의 포골은 아깝습니다)	노부		포										
12_4	대년의 관에가 반짝한다)	노부		부포										
12_5	년이년은 안팎은 골포에으게신다)	노부		부위포인물 작용										
13_1	흉은 식욕은 좋은 별이다)	흉한		흉한포함	흉한포함									
13_2	큰 과 식사량은 별에서 하신다)	흉한												
14_1	호흡 소속가 잘 하신다)	폐신	폐신포함											
14_2	(9.1에서 '에서도'다고 반크 고주) 소이 호스합거나 폐(가)하신다)	폐신		주신										
15_1	흉반에 배에서 주은주은 바은 소에가 난 싸여 보였습니다)	복한		복위함, 복위계포										
15_2	자율은 부위 보시	복한 - 자율등		right hypochondrium	epigastric p.	left hypochondrium	right lumbar p.	umbilical p.	left lumbar p.		right inguinal p.	pubic p.	left umbilical p.	
15_3	활은 부위 보시	복한 - 장등		right hypochondrium	epigastric p.	left hypochondrium	right lumbar p.	umbilical p.	left lumbar p.		right inguinal p.	pubic p.	left umbilical p.	
16_1	골격의 명칭(별포)	뼈포		이 만주 년(복포포함)	팔(뼈)	상(뼈)	지상(뼈함)	중상(뼈함)	기타					
		뼈포		복포포함	뼈뼈	뼈뼈	뼈함뼈	뼈함뼈						
17_1	별골이 나서서 아픈 보포 끝났신다)	흉위 함		부위										
17_2	심에 좀 안별골은 아픈신다)	흉위 함		수신계(주느위)	수신계(포느위)	수직계(부포위)	수직계경(부포뼈)	기타						
		흉위 함		부느위	포느위	부포위	부포위뼈							
17_3	오목에선 (포에) 별이 나거나 오목에 별이 이 나는 별이신다)	흉위 함		두위계위										

Method diagnosis mechanism

- When specialist logged in, the web page shows doing to do mapping per CRF clinical item that is stored recently.
- A mapping result of per item is same that see a patient. That is, a CRF data that is gathered in this research is data of such as medical record contents that a doctor sees a patient.
- Specialist sees this web page and input diagnosis result. And then several specialists decide diagnosis accuracy with this diagnosis result and clinical data of CRF.

Diagnosis Result View


CRF2006매핑출력-고호연선생님 작업페이지 - Windows Internet Explorer

http://www.stroke.re.kr/crf2006_khy.php

파일(F) 편집(E) 보기(V) 즐겨찾기(A) 도구(T) 도움말(H)

CRF2006매핑출력-고호연선생님 작업페이지

CRF 자료 총 155 건 있습니다.

1[-0001]	[小便회수] 0회/day [大便회수] 0日에 한번 봄. [食慾] 0공기/한끼식사량	전문가:	수련의:	CRF변증:	분석결과:
2[DJJ-0606001]	[氣力] 쉽게 피곤하고 힘이 없음. [顔面皮膚] 누렇게 뜨거나 때가 낀 것 같음. [舌質] 舌質淡紅 [舌苔] 薄苔 薄苔 [舌體] 반대舌 [汗] 조금만 움직여도 땀을 많이 흘림. [小便회수] 4.5회/day [小便색깔] 微黃 [大便회수] 1日에 한번 봄. [大便] 대변을 볼때 힘듦, 대변의 상태가 단단함. [食慾] 1공기/한끼식사량 [脈象] 滑 [寒熱感] 열감이 나면서 더운 것을 싫어함. 手足熱	전문가:濕痰	수련의:濕痰	CRF변증: 火熱 氣虛	분석결과:화열,습담,기허
3[DJJ-0606002]	[氣力] 쉽게 피곤하고 힘이 없음. 자주 누워있고 싶음. [顔面皮膚] 누렇게 뜨거나 때가 낀 것 같음. [頭部] 머리가 어지럽거나 아픔. 前頭部 열나는 것 같이 아픔. [眼] 눈이 자주 건조한 느낌이 있음. [口] 口舌生瘡 입이 자주 마름. 입이 씀. [舌質] 舌質淡紅 [舌苔] 薄苔 薄苔 滑苔 [舌體] 반대舌 [汗] 조금만 움직여도 땀을 많이 흘림. [小便] 소변을 시원하게 못봄. [小便회수] 4.5회/day [小便색깔] 微黃 [大便회수] 1日에 한번 봄. [大便] 대변을 볼때 힘듦, 대변의 상태가 단단함. [食慾] 최근 식욕이 좋지 못함. 1공기/한끼식사량 [消化] 요즘 소화가 잘 되지 못함. [脈象] 滑 [寒熱感] 별무이상	전문가:濕痰	수련의:濕痰	CRF변증: 火熱 氣虛 기허와 허열 동반	분석결과:기허,음허
4[DJJ-0606003]	[顔面皮膚] 누렇게 뜨거나 때가 낀 것 같음. [口] 입이 씀. [舌質] 舌質淡紅 [舌苔] 薄苔 薄苔 [舌體] 반대舌 [汗] 조금만 움직여도 땀을 많이 흘림. [小便회수] 4.5회/day [小便색깔] 微黃 [大便회수] 3日에 한번 봄. [大便] 대변을 볼때 힘듦, 대변의 상태가 단단함. [食慾] 1공기/한끼식사량 [脈象] 滑 [寒熱感] 열감이 나면서 더운 것을 싫어함. 手足熱	전문가:濕痰	수련의:濕痰	CRF변증: 火熱 氣虛	분석결과:화열,습담

KIOM
Korea Institute of Oriental Medicine

Results

- This system shows hereafter that such mapping mechanism is possible for conversion to medical records from CRF clinical data.
- Also, it can know that is possible to link composition with standard terminology. **Forward research**, we will progress a research about medical document applied **HL7 CDA conversion and Clinical Document Repository (CDR).**

Reference and etc.

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Data Protection in Shared Health Records: Requirements and Challenges

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Abstract:

This short paper presents the evolution of electronic health records and focuses on their main characteristics and requirements. Furthermore, it also examines the conflicting goals of health information availability and data protection for shared health record systems.

Keywords:

shared health records, data protection, privacy and confidentiality

Introduction

One of the very first uses of computers in health care was for administrative and financial purposes [1]. Healthcare professionals have tried to find systems that would provide easy and intuitive access to the information which they need during consultations with their patients [2]. The advent of computers and computer networks offered us the capability to access medical information from anywhere and anytime[3,4].

The implementation of shared health records demands a satisfactory level of security. This is invariably achieved through applying and enforcing strict, and often quite complicated, rules and procedures in the access process, which perplex and confuse users. The current challenge is to implement a shared health record system, which is easy and secure to use, and satisfies all stakeholders, such as patients, health professionals, healthcare providers, and other groups in terms of legal or financial requirements.

Electronic health records characteristics and requirements

The new communication technologies offer clinicians creative ways to interact with their patients and to provide higher quality of care [2]. The Internet evolves and supports broadband communications, it becomes the technology of choice for linking medical experts with other clinicians and patients at a distance [5,6] Indeed today, distribution of biomedical information through the internet is increasingly commonplace and accepted [7].

Successful implementation of shared health records will have to meet the users' needs for acceptable levels security and privacy, and also to address some important legal issues.

The basic requirements of shared health records are:

- Comprehensiveness
- Confidentiality
- Accessibility
- Liability
- Authentication
- Flexibility
- Permission
- Accessibility in emergency cases
- Maintaining Integrity of the health record

There are some legal issues regarding health records such as:

- Jurisdiction
- Legally valid agreements
- Legal implications of shared practice of medicine
- Patient's right to review and release their records

Current and future challenges of data protection in shared health records

Some patients and doctors have expressed concerns about the use of the new technology in shared health care record services. Most of these concerns are related to data protection and confidentiality issues. Also some doctors are afraid that shared care record service will damage confidentiality.

Some issues should be considered while moving from a paper-based record system to a computer-based one, such as the needed time of transmission, resources, management and administration tolls and staff, and basic technology infrastructure. These factors often relate to technical challenges. Another risk is system failures. In case of system failure, stored information may be unavailable at the time of need. In this case, paper records could serve as backup until the computer system becomes available again [2, 8]. This matter of availability might be one of the major problems of security.

People will always try to destroy security systems, no matter how sophisticated they are.

Some people will find ways to get secure information by exploiting human weakness to bring pressure to bear on someone with legitimate access to health information. [8].

The concept of security is intrinsically correlated with other aspects of EHR, including legal, technical, social, political and financial. The nature of these relationships between security and other issues depends on the specific user of the electronic patient records.

Conclusion

In every generation of health records, their implementation has faced serious challenges. The most recent phase of EHR, based on internet technology, presents us with a number of critical challenges related to security and privacy.

The concept of information security, as a whole, comprises the three aspects of confidentiality, integrity and availability. The advanced technologies needed for implementing secure systems almost always make the use of the system more complex for the users. This complexity can reduce the benefits of using new technology and limit its advantages. The grand challenge for the future will be to provide a secure and at the same time user friendly electronic health record system.

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Determining Requirements for a Electronic Child Record in Youth Health Care

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Abstract

The Electronic Child Record for Youth Health Care (ECR YHC) is seen as the solution for the problems that are experienced with information exchange. An integral ECR YHC will support youth health care and early risk detection. The Dutch government strives for the introduction of this national ECR YHC on 1 January 2008. Eight organizations had planned a route to involve users in the system development. Method: Eight institutions described technical and functional requirements that serve as a basis for the ECR YHC. For this, the Delphi method was used. Results: An expert panel of 52 experts has given its opinion on the Basis Data Set YHC, functional requirements for an ECR YHC, the data that are exchanged in electronic messages, the flow chart YHC based on the national guideline for YHC, and usability requirements. This showed a high level of consensus on the functional requirements. Conclusion: the method followed yields a high support among the care professionals and the results of this project will be used for the national tender of an ECR YHC.

Keywords:

Electronic Child Record, youth health care, Delphi technique, requirements gathering, system specifications

Introduction

Information exchange is important for a qualitative well functioning youth health care. Optimization of the information exchange is inevitable in two areas. First, the availability and exchange of data between perinatology, the administrations of immunizations, the council administration and the institutions that deliver the care to the youth of zero to nineteen years old. Second, the information exchange at population level for the purpose of epidemiological research like national monitoring. Hereby ICT will play an important role.

In the present situation the information exchange does not run optimal. Problems are [1]:

- Obtaining recent data of the youth costs a lot of effort. Thus, there is no insight in the correlation between the data whereby preventive actions are hard to perform.
- Monitoring of YHC is not possible to the full extend because it is hard to access data or because data are lacking.
- It is hard to indicate what added value the sector delivers to the health of children and the prevention of the risks for health.
- The aims of the national guideline YHC for 0-19 year old children are impossible to reach without information and communication technology (ICT) support. Because uniformity in information and in health care can not be realized, the quality of care is not guaranteed.

The implementation of an ECR for the YHC should optimize the information exchange whereby existing problems will be solved [1]. The Electronic Child Record implies the following for the youth health care institutions involved [2]:

- Optimal care will be given to the youth of 0-19 years.
- Care professionals can have current and relevant data of the child at their disposal at all times.
- Data of the council administration, administration of immunization and birth can be obtained automatically by electronic messages.
- Records can easily, safely and completely be transferred to other institutions by the use of standards for data and messages. For this the Health Level 7 version 3 (HL7 v3) [3] standard will be used.
- More insight in the work processes will be obtained whereby the processes can be organized in a better way.
- Research for the organization itself but also for the system for following the child and for policymaking can take place easier.

For this it is necessary to connect to the' National Health Index (landelijk schakelpunt in Dutch)', an indexing system that makes it possible to electronically query and exchange patient information in a safe way [4] This is part of the national health information infrastructure developed by NICTIZ, the Dutch National IT Institute for Healthcare [4].

For realization of the objectives a project has been started with eight institutions for YHC. The research question for

this phase of the project was: What are the requirements of the care providers for the ECR YHC? The Basis Data Set YHC of NICTIZ [5] and the electronic HL7 v3 messages [3] need to be part of the research.

Materials and methods

Design

To determine the requirements of the care providers a consensus method, the Delphi method, was used. Delphi method is used to systematically reach consensus for certain issues in different rounds by means of the judgment of experts. Normally a Delphi study consists of two to four rounds that follow each other in a period of some weeks. One of the benefits of the Delphi technique is that there is no social pressure on the participants. This makes it easier to give deviant opinions [6]. After each round the answers of the panel are analyzed, summarized and reported.

Different forms of the Delphi method can be distinguished. In this study we used mainly the policy version, because this so called Kantian approach is characterized by problem solution via synthesis of different parts to a rounded product [7, 8]. This is a constructivist form that can contribute excellently to a suitable approach of the development and use of an ECR YHC. Van Houten [9] indicates that this Delphi version is usable for incompletely structured problems that know several solutions and only can be dealt with from several disciplines or points of view [8].

In other sources the nominal group technique [10] for reaching consensus will be addressed as well. The specific thing of this method is that in the final round the anonymity is cancelled by organizing a meeting. For the ECR YHC project two rounds have been carried out: one anonymous written round an one panel meeting. The anonymity in this second round was kept by using voting devices with numbers, so the individual responses could not be retrieved.

Expert panel

The expert panel for this study existed of 66 experts in the field of YHC. The participating organizations themselves were responsible for an equal representation of the experts. All relevant health professions were represented in the expert panel.

Questionnaire

A questionnaire was developed because there was no questionnaire available to make an inventory of the requirements of the care providers. For this questionnaire existing documents from YHC and literature on electronic records were used. The questionnaire starts with a couple of characteristics of the respondent including the discipline and institution to which the respondent belongs.

First the Basis Data Set YHC developed by NICTIZ, in collaboration with the Organization of Care Operators (Z-org), GGD Nederland (the Dutch Council Care Service) and the Vereniging Nederlandse Gemeenten (the Association of Dutch Councils) is used. The Basis Data Set YHC is a collection relevant data that is minimally needed for the exchange of data between organizations in youth health care. It is a standard with respect to content with concepts and data relevant to youth health care. With the Basis Data Set YHC it is also possible to perform research in YHC. The set as a whole is included in the questionnaire.

Second, a cluster of unique personal details is presented. NICTIZ has made arrangements on these often occurring data groups, called HL7 v3 Common Message Element Types [3], for the connection to the national infrastructure arrangements. For patient details the CMET patient can be used. Similar arrangements have been made for health professionals in the CMET Provider. All messages from and to the ECR YHC use the same data. The CMET Patient NL has been admitted to the questionnaire as an addition to the Basis Data Set YHC. This consists of common patient data like name, date of birth, gender address and insurance, adapted to the Dutch situation.

Third, to get insight in the workflow of the preventive care for youth of 0-19 and to improve these, a flow chart has been developed (Figure 1). The chart gives an overview of the workflow that are part of the Basis Tasks Package YHC [11]. By means of a time line phases of life that a child goes through from 0-19 years are shown. On this time line the processes and moments of contact are put down. This makes the flow chart an important description of the functionality of the ECR to support the workflow.

The fourth part of the questionnaire are the functional specifications developed by GG&GD Amsterdam and GGD Rotterdam. In these functional requirements it has to be indicated exactly what the ECR YHC should be able to, to make sure that care providers can make complete and reliable reports. These specifications are complemented with requirements for usability of the ECR YHC.

Next to that, the questionnaire has been complemented with results of analysis of documents that are used in the participating institutions.

Cut off point for consensus

The aim of the Delphi method is reaching consensus on the requirements of the care providers for the ECR YHC [6,7,8,9]. For answering the questions a three point Likert Scale has been used. This had the following answering possibilities:

- 0 for not agree
- 1 for unclear or doubt

- 2 for agree

The cut off points for consensus were the following [12]:

1. A percentage agreement equal to or higher than 75%: When 75% or more of the panel members agree with the specification this accepted. Specifications for which there is disagreement have been presented again to the panel in the consensus meeting, together with the comments and the arguments that have been given by the panel members. As a result of these comments some new statements have been formulated.
2. From the remarks that have been given for a specification by the panel members should emerge that the subject was unambiguously understood. When this is not the case, the item is not due for consensus and is presented again, if necessary with explanation.

For questions that do not result in consensus, statements are formulated with the help of the remarks and suggested changes

of the expert panel. In the consensus meeting these statements are presented to the expert panel. By means of electronic voting devices the panel voted using the same answering possibilities and cut off points as described above.

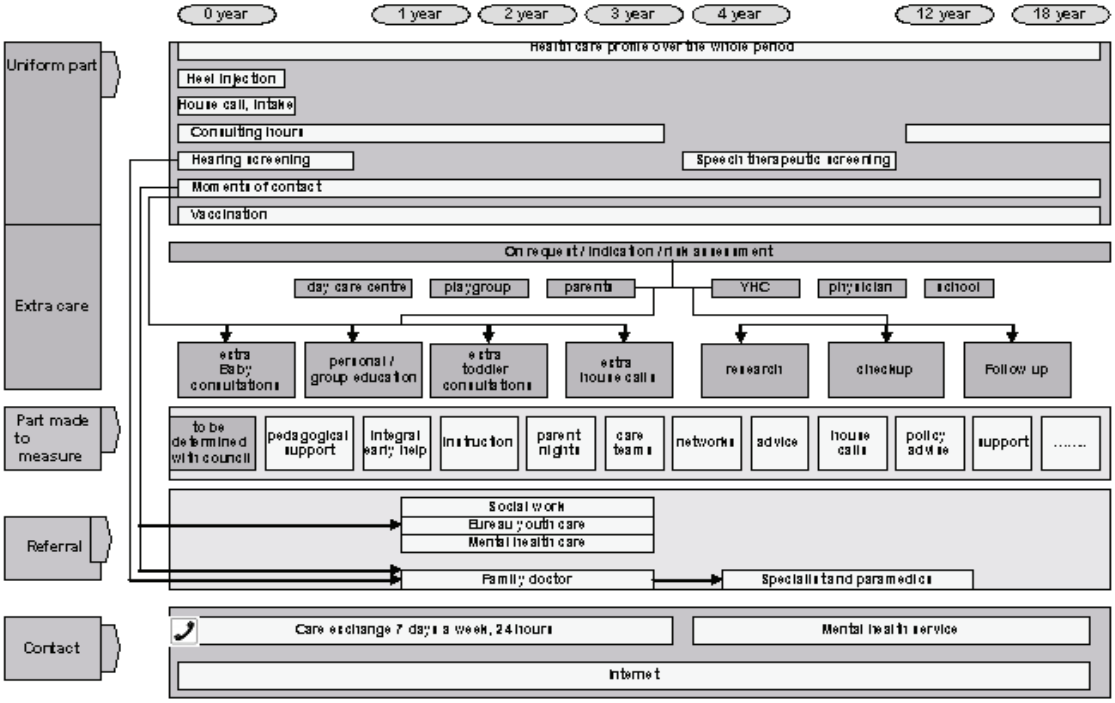

Figure 1 - The workflow chart for the Youth Health Care

Analysis

For analysis of the scores on the questionnaire SPSS software has been used. For answering the question, descriptive statistics has been used. The programme for the electronic voting generates these statistic measures itself.

Results

In total 66 questionnaires have been sent, 52 have been completed and returned (response of 79%). The professions of the respondents are shown in Table 1. The project started with five organizations. After the questionnaire was sent out, another three joined the project. Because of the later participation the representation of these organisations is relatively low compared to the other five. Next to that, for one of the organizations three members of the expert panel filled in the questionnaire together because of time pressure for returning the questionnaire. This has been indicated as three respondents.

At the consensus meeting 52 experts were present (response 79%). On some concepts not everybody voted.

Abstinence of voting on a concept has mainly been done because the subject was one in which one was not involved or not informed.

With the help of the Basis Data Set YHC [4] a Data Set ECR YHC has been developed. The Basis Data Set YHC consists of 53 concepts. For every concept attributes (observation or variable) and value sets (answering possibilities) are formulated.

The 53 concepts of the Basis Data Set YHC have been added to the questionnaire.

The expert panel members were asked for their opinion with reference to the completeness of the data and they were asked if they had additions. The additions needed to be specified as completely as possible. This meant specification in attributes, preferably with value sets.

In the written question round consensus has been reached for 25 concepts (47,2%). For the concepts for which no consensus was reached, 57 statements were formulated. These statements were presented in the consensus meeting. On 47 statements voting took place, for 29 of these, consensus has been reached (62%). On 10 statements no voting took place because new information was available, whereby statements were no longer relevant. The statements for which no consensus was reached have been discussed in focus groups consisting of representatives of the expert panel. The focus groups have decided which concept should be added to the Basis Data Set YHC, in what form and in what way addition should take place.

Example congenital heart defect

In the questionnaire the following statement has been presented to the expert panel: “The specifications ‘congenital heart defect’ are complete.” Sixty percent of the expert panel agreed with this statement. This meant no consensus was reached on this statement. In connection with the written remarks of the expert panel, the following statement has been presented at the consensus meeting: “Heart defect is added in accordance with the national standard Tracing of inherent heart defects.” There was no voting on this statement because one agreed unanimously.

In the focus group it was decided to add the following attributes and value sets to the Basis Data Set YHC (see Table 2).

Table 1 - Panel

Discipline	Amount	%
Health centre physician	9	17,3
Health centre assistant	3	5,8
Physician	4	7,7
Nurse of staff	1	1,9
District nurse	13	25,0
Physician of youth health care	6	11,5
Nurse of youth health care	3	5,8
Assistant youth health care	2	3,8
Remedial educator	1	1,9
Speech therapist	1	1,9
Epidemiologist	2	3,8
Manager	5	9,6
Secretariat	1	1,9
Assistant physician of youth	1	1,9
Total	52	100

Patient data

Of the four statements that have been presented to the expert panel consensus has been reached for three of them (75%). For the concept ‘occupation’ no consensus was reached.

Flow chart YHC

Figure 1 shows the flow chart. The statement about the flow chart was as follows: ”In the flow chart all important processes that are relevant for the ECR YHC have been taken in.” For this statement there was a 82,2% consensus. This meant that the flow chart developed by two of the organisations (ICARE and GGD Drenthe) has been accepted by the other six organisations. That is why the flow chart will serve as a starting point for the design of the ECR YHC and is inserted in the specification.

Functional specifications

On the functional specifications ECR YHC of the GG&GD Amsterdam and Rotterdam 13 statements have been formulated. For two of the functionalities no consensus had been reached. Next, nine statements have been formulated for the consensus meeting. In this meeting consensus was reached for seven statements (78%).

Example

In the questionnaire the following statement has been presented to the expert panel: “The specifications in relation to the data registration are complete.” In round one 60,4% of the expert panel agreed on this statement. As a result the following statements were presented at the consensus meeting:

1. Add: For research it is possible to search in all records on the basis of entries. For this statement 100% agreed.
2. Add the working area of the employee, for example for which school district one works. For this 56.8% agreed. The statements and the results have been discussed in a focus group. The group decided that it should be possible to mention the school in the ECR YHC.
3. In one glance it should be visible what risk factors there are for a child. For this statement there was 100% consensus. This requirement was added.
4. The system gives a timely alert when certain time limits are about to be exceeded. For this 97,8% agreed. This requirement was added to the specifications.
5. It should be possible to register in the system how many times parents/care takers call to consulting hours by telephone and with what questions. For this 90,5% agreed. This requirement was added to the specifications.

Table 2 - Additions for the concept of 'Congenital heart defect

Attribute	Value set
Examined	0=Not examined 1= Examined, no special circumstances 2= Examined, special circumstances
Intervention	0=None 1=Education/advice 2=Extra moment of contact 3=Referral
Follow up	Free text
Overall impression researcher	1=Fatigued 2=Passive 3=Undernourished impression, thin 4= Dysmorphism
Overall impression parents	Free text
Effort tolerance	First year during feeding of effort (for example crying): 1=Easily fatigued 2=Perspire 3=Rapid breathing 4=Hungry, but can not empty bottle 5=Stops drinking from the mother's breast 6=Blue or grey skin colour Toddler age: 7= Rapid fatigue with effort like walking (stairs), cycling 8= interruption of play by crouch School going and Adolescent age: 9= Fainting (in particular with effort) 10=Easily fatigued 11=Heart palpitation 12=Pain in the chest

Usability requirements

On the requirements for usability 29 statements have been formulated. For 25 statements (86,2%) consensus was reached. In the consensus meeting three new statements were presented to the expert panel. For these 100% agreement was reached.

Example

In the questionnaire the following statement had been presented to the expert panel: "I can work in more than one record at a time." Next, in the consensus meeting the following statement has been presented: "More records of children of one family can be edited at the same time." For this 96% agreed and it was added to the specifications.

Discussion and conclusion

Aim of this project was to determine the requirements for an Electronic Child Record for Youth Health Care. This aim has been reached to a high extend. For most concepts there was agreement. For some concepts consensus could not be reached and were elaborated on in focus groups of experts. The response in round one (the questionnaire) was 79 %. The attendance at the consensus meeting was high as well, again 79%. All members of the project team participated enthusiastically in determining the Data Set ECR YHC and further specifications for the system.

Despite everyone's effort a short comment on the study should be given. First on the Delphi method. In this study two rounds were used: one written question round and one consensus meeting. Next, in the focus groups it has cost time and effort to get to complete specifications for the data set ECR YHC and the system. It might be that this effort would not have been necessary when extra rounds had been scheduled. We did not choose to have extra rounds because of planning of the project and the amount of investment in time and manpower that these extra rounds would have cost.

The second comment relates to the completeness of the Data Set YHC. Performing the study was under time pressure because of project planning. Because of that the results of the written question round have not all been checked with the Basis Data Set of NICTIZ. In the consensus meeting a discussion started on a couple of statements because these were about concepts that were already in the Basis Data Set YHC. Next to that, for a statement on the immunization administration new information was presented during the consensus meeting what made the statement irrelevant. Because of the effort of the experts in both the consensus meeting and in the focus groups, a Basis Data Set ECR YHC and a list of specifications were created that gained a lot of professional support.

The controversial subjects that still exist have been discussed in the focus groups. A part of these subjects relate to the planning of contact moments and registration of data for both internal and external use. At that moment it was decided to start a working group that had to tackle the issues concerning requirements for the ECR related to planning and registration. Currently, a national tender is ongoing for the procurement of the ECR YHC, and this work is part of the specifications.

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Determining Requirements for an Electronic Child Record in Youth Health Care

Het project EKD JGZ

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Introduction

The following issues exist in the present information management in youth health care (YHC) in the Netherlands:

- Obtaining recent data about children's health costs a lot of effort
- Monitoring is not possible because it is hard to access data or because data are lacking
- It is hard to determine what added value the YHC delivers to the health of children and the prevention of the risks for their health
- The national guideline YHC for 0-19 year old children requires support with information and communication technology (ICT): an electronic child record

The project

- A project to develop a electronic health record for children has been started by eight YHC institutions.

- The research question for this phase of the project was: ‘What are the requirements of the care providers for the ECR YHC?’

- To determine the requirements of the care providers the Delphi consensus method was applied, using two rounds of questionnaires: round one a traditional questionnaire sent via email and round 2 a consensus meeting with an electronic voting system.

Delphi method applied

- Expert panel: 66 experts in the field of YHC
- Questionnaire 1 was based on the national dataset for YHC, documents from YHC, literature on electronic records, Health Level 7 version 3 patient data specifications, the workflow chart for preventive care for youth, and existing functional specifications
- Questionnaire 2 contained items with no consensus in round 1 and new input / clarifications on the same topics
- Cut off point for consensus: a percentage agreement equal to or higher than 75% and the remarks given by the panel members indicate that the subject was unambiguously understood
- Analysis: first round descriptive statistics, second round electronic voting program with descriptive statistics

Results

- Response of 79% in both rounds (n=52)
- National dataset for YHC: 25 of 53 concepts obtained consensus in round 1 (47,2%). In round 2, the consensus meeting, 57 statements were presented. Voting took place on only 47 statements: 29 of 47 obtain consensus (62%).
- The statements for which no consensus was reached have been discussed in focus groups, resulting in additional concepts
- Flow chart YHC: 82,2% consensus
- Functional specifications: 11 of 13 statements obtain consensus (85%)
- Usability requirements: first round: 25 of 29 statements obtain consensus (86,2%), second round: 100% consensus

Results: (example) data items for YHC, required additions to national set:

Data on growth and development, for example the national Van Wiechenschema

Audio logic screening

Screening of visual impairments

Target height calculation

Calculation of Body Mass index

Calculation of growth charts

Care plan

Mood

Behavior

Concentration

Hygiene

Allergies

Life events

Child abuse

Heart rhythm, tone, murmur

Speech assessment

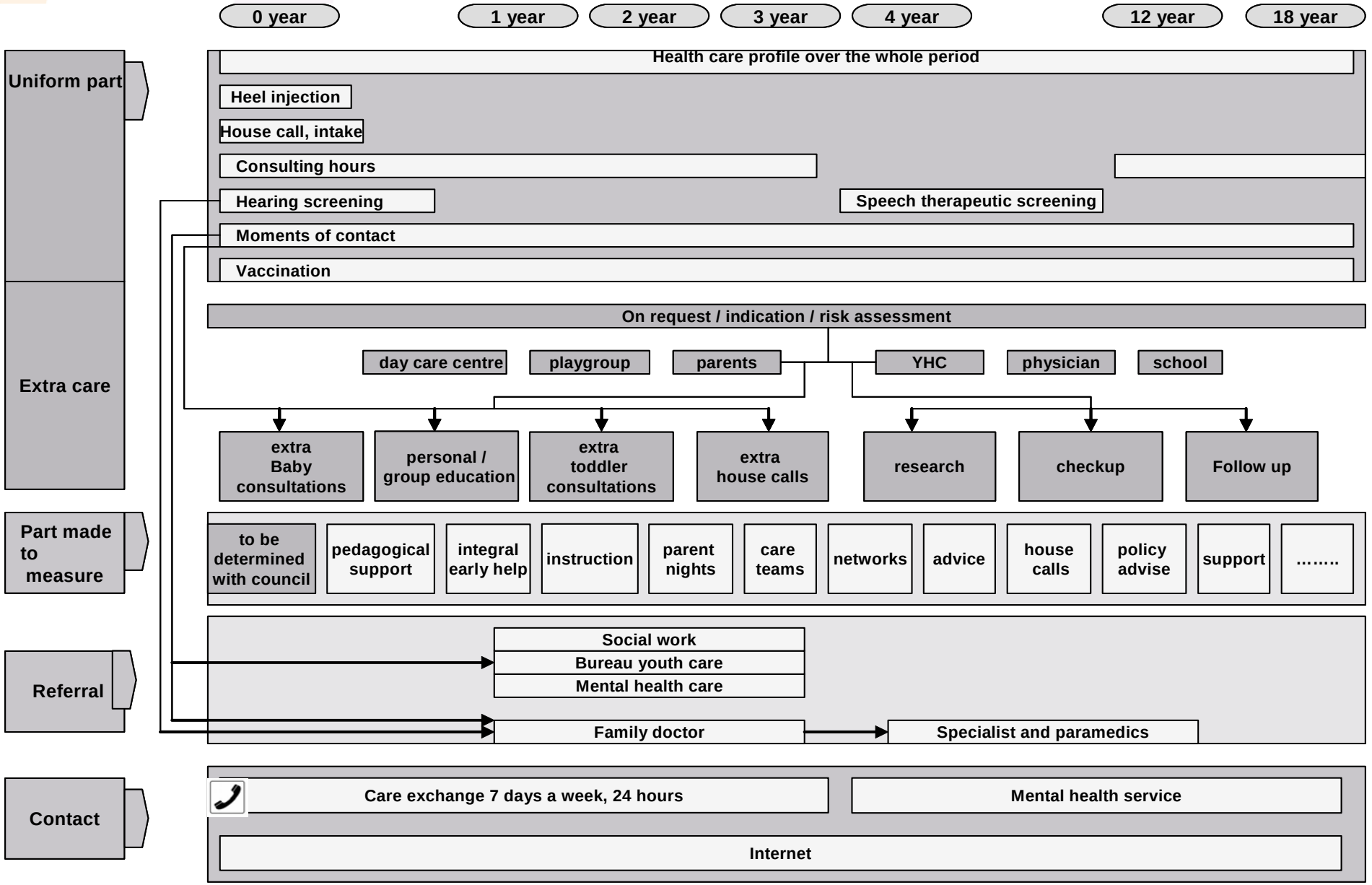
Use of alcohol / drugs / smoking

Example added concept:

‘Congenital heart defect’

Attribute	Value set
Examined	0=Not examined 1= Examined, no special circumstances 2= Examined, special circumstances
Intervention	0=None 1=Education/advice 2=Extra moment of contact 3=Referral
Follow up	Free text
Overall impression researcher	1=Fatigued 2=Passive 3=Undernourished impression, thin 4= Dysmorphism
Overall impression parents	Free text
Effort tolerance	**First year** during feeding of effort (for example crying): 1=Easily fatigued 2=Perspire 3=Rapid breathing 4=Hungry, but can not empty bottle 5=Stops drinking from the mother’s breast 6=Blue or grey skin colour **Toddler age:** 7= Rapid fatigue with effort like walking (stairs), cycling 8= interruption of play by crouch **School going and Adolescent age:** 9= Fainting (*in particular with effort*) 10=Easily fatigued 11=Heart palpitation 12=Pain in the chest

Result: example workflow



Example functional requirements

- For research it is possible to search in all records on the basis of entries
- Add the working area of the employee, for example for which school district one works
- It should be possible to mention the child's school in the record system for YHC
- In one glance it should be visible what risk factors apply to a child
- The system gives a timely alert when certain time limits are about to be exceeded
- It should be possible to register in the system how many times parents/care takers call to consulting hours by telephone and with what questions

Discussion & Conclusion

- The method followed yields a high support among the care professionals for concepts that need to be included in the electronic child record (ECR) in YHC
- Due to time pressure, double statements were presented in round 2, which could have been prevented
- Focus groups needed a lot of time, which might have been prevented by adding a third round
- The results of this project will be used for the national tender of an ECR for YHC

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Does Healthcare Staff Change Working Procedures in Relation to Inter-Disciplinary Documentation in the Electronic Patient Record?

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Abstract

A comparativ and qualitative investigation with observation studies, interviews with staff observed and focus group interviews.

The study design included two groups: Group 1 (mono-professional documentation) consisted of two departments that had not introduced the electronic patient record (EPR). Group 2 consisted of two departments that had introduced the EPR.

The study showed that working procedures and division of work with documentation had not changed when comparing departments with EPR with departments without EPR. The division of work in departments with EPR clearly showed that decisions on the department's working procedures had not been taken. Decisions on who does what when a new electronic tool is introduced have not been taken. The mono-professional documentation thus continues as a new documentation method for inter-disciplinary documentation has not been considered.

Keywords:

working procedure, inter-disciplinary documentation, inter-disciplinary collaboration, electronic patient record

Introduction

Denmark is about to introduce an EPR for systematic and structured documentation enabling retrieval and reuse of data. The EPR is supposed to be inter-disciplinary and not just a common record.

It is expected that the EPR will result in organisational changes, changed work procedures and ways of dividing the work [1], in documentation of treatment and care and thus health professional services [2]. These changes will be a part of the construction of the EPR taking its starting point in a B-EPR (Basic structure of the EPR) made by the Danish National Board of Health [3].

When the EPR is introduced it is expected that there will be a change from mono-professional to inter-disciplinary documentation. This will be a major change for healthcare staff.

The approach to documentation in healthcare staff is different and influenced by ways of organising knowledge, insight, skills and education. Consensus thus has to be reached con-

cerning documentation methods and education in the new documentation methods. Fink [4] writes: ”The organisation based on profession and science constitutes a risk that the profession does not stick to the case and that the case is considered secondary or is neglected in the professional work"

Methods

A comparative and qualitative investigation [5] with

- Observation studies
- Interviews with observed staff
- Focus group interviews.

The study design included two groups. Group 1 consisted of two departments that had introduced the EPR (paper documentation form). Group 2 consisted of two departments that had introduced the EPR (electronically based documentation form). The study was carried out in June 2005.

Observation studies were conducted at four surgical departments with similar specialities. The departments in question collaborate concerning surgical specialities.

Routines of documentation and communication concerning patients were observed at all four departments for two days at each department using the same observation guide. Working procedures were recorded by the two observers (the authors of this paper) in a table (Figure 1).

Communi-cation Nurse	*Documenta-tion Nursing record*	*Documenta-tion Medical record*	*Communi-cation Doctor*

Figure 1 - Observation guide

Analysis of the completed tables from the observation studies are compared in the following way:

- Mono-professional documentation
- Everything noted by each healthcare professional on personal notes
- Inter-disciplinary communication

Figure 2 shows a schematic view of specific times when collection of professional documentation/communication data on a patient was made.

Time	***Documentation***	***Parts in the documenta-tion***
Morning	*Written documentation of the patient from the day before.*	*Nursing record Medical record*
Morning	*Oral report written down*	*Nurse-nurse dialogue*
Before meeting the patient	*Written down what the nurse has communicated to the doctor*	*Nurse-doctor dialogue*
Before meeting the patient	*Written down the communi-cation between doctor and nurse*	*Doctor-nurse + other healthcare staff dialogue*
Meeting with the patient	*Written down communica-tion between patient, doctor and nurse*	*Patient-doc-tor-nurse dia-logue*
After meeting with the patient	*Included written documen-tation in medical and nurs-ing records and record of other healthcare staff*	*Medical record Nursing record Other health-care staff records*
	Included written supporting notes	*Nurse's own notes*

Figure 2 - Specific times in the observation study

Observation studies were followed by individual interviews with the observed healthcare staff using a structured interview guide. The interviews were used to validate the observations. The interviews were opinion condensed and subsequently opinion categorised.

As follow-up on observation studies and interviews with individual staff focus group interviews were conducted at each of the two departments with EPR.

The focus group interviews were opinion condensed and subsequently opinion categorised.

Participants

The following participated in the study:

- 12 doctors with seniority between 4 and 30 years
- 11 nurses with seniority between 5 and 33 years.

Results

Results on working procedures concerning documentation and communication concerning the patient were divided into:

- Collection of information
- Communication before meeting with the patient
- Meeting with the patient
- Communication after meeting with the patient
- Documentation

Collection of information

Before healthcare staff met with the patient information was collected.

At the two departments without EPR the nurse on night duty either gave a thorough status on patients or no report.

The nurses themselves also read the paper records.

At the departments with EPR the nurse on night duty at one of the departments made a deviation report on one observation day but no deviation report was given on the second observation day. Furthermore, the daytime nurse read the EPR. At the other department with EPR the nurses read about patients in the EPR without having received report from the nurse on night duty.

The doctors started with a morning conference where they received report on patients from the attending doctor. Patient records were not used at morning conferences. The working procedure applied to all departments involved in the study.

In focus group interviews doctors at one of the departments with EPR reported that they searched information about patients as a supplement to the morning conference.

Healthcare staff collected more information before meeting with the patient and the other staff involved in the care of the patient. Here the available information was medical and nursing records or the EPR.

The nurses collected the continuing documentation material during the day on a note. All eight used notes. The note was the nurse's own or a common note for the department including all patients where comments are written on each individual patient.

The observation studies revealed that all healthcare staff read the documentation of their own staff group before meeting with the patient. The doctors did not read the documentation on patients they knew. One doctor from a department without EPR read the documentation during the meeting with the patient.

The distribution of reading other staff groups' documentation showed that five in eight nurses always read documentation of other staff groups; three in eight nurses sometimes read documentation from other staff groups. None of the eight doctors read documentation of other staff groups.

In focus group interviews doctors said they read documentation by other staff groups.

In the interviews in connection with the observation studies it was asked directly if documentation from other staff groups was read. Two in nine possible in departments without EPR answered "no" and one in ten possible in departments with EPR answered "no". In departments without EPR seven in nine possible answered "yes" and in departments with EPR nine in ten possible answered "yes". This is not in accordance with the results of the observation studies.

In departments without EPR all nine read documentation from other staff groups compared with eight in ten at departments with EPR. In departments without EPR eight in ten consulted other staff groups compared with ten in ten in departments with EPR.

The admission description in the medical record and the nursing record were read by the nurses. Relevant parts of the medical record were read by a third of the informants at department without EPR compared with half at departments with EPR.

Doctor's notes from rounds were read by one in nine at departments without EPR. Notes from rounds were not used in the daily documentation.

The medicine list was checked by doctors and nurses by five in nine at departments without EPR and by three in ten at departments with EPR. At the two departments without EPR the medicine list was electronic. This was also the case for one department with EPR. At departments without EPR, blood samples were checked by both doctors and nurses in three out of nine compared with two in ten at departments with EPR.

At departments with and without EPR all nurses read the daily notes by nurses.

The healthcare staff 's patient information comes from oral reports in three out of four in departments without EPR and no persons reported in departments with EPR.

However, doctor-nurse communication was highlighted by both doctors and nurses at departments with and without EPR.

Communication before meeting with the patient

In six of the eight observation studies there was communication/dialogue between the doctor and the nurse to prepare before meeting with the patient. The two cases where there was no communication took place at a department with EPR. This is in accordance with doctors knowing the patient in advance.

Observations showed that in departments without EPR communication took place before meeting with the patient. The same observation was made at departments with EPR.

In focus group interviews one department stated that they were now better prepared for rounds because they had consulted the record before meeting with the patient. They also stated to have a better overview of the patient's situation.

At the same time it was pointed out that it can be difficult to get an overview of complicated cases where patients have been admitted for a longer period.

Meeting with the patient

In the department without EPR the doctor brought the medical record with him to the meeting with the patient.
Doctor-nurse communication during the meeting with the patient took place in six out of eight cases. In one case where there was no communication there was no direct meeting with the patient. The doctor was briefed by phone by the nurse and the doctor made prescriptions by phone. This was unusual and caused by an emergency surgery. In the other case dialogue was sparse due to external circumstances.

Communication after meeting with the patient

At departments without EPR there was only doctor-nurse communication after the meeting with the patient in two out of four possible situations.

At departments with EPR there was no doctor-nurse communication after meeting with the patient.

Documentation

After the meeting with the patient documentation was made in the medical record.

At departments without EPR healthcare staff groups each had their own record. The doctor dictated notes to the medical record and the nurse wrote in her own mono-professional record.

In departments with EPR the nurses all made their own documentation in the EPR; two doctors dictated to the EPR and two doctors made their own documentation in the EPR.

At the two departments with EPR the design of the patient records was different. There was non-structured and structured documentation. Before the department with non-structured documentation began using the EPR they analysed present and future workplace procedures.

The other department worked with structured documentation and standard plans. In the standard plans there were some charts which could be used by all healthcare staff. At this department with EPR they had not worked consciously with workplace procedures only indirectly by working with functionalities in the use of the EPR in different situations.

When asking the question how to pass on information concerning the patient, all dictated or wrote in the record as described above. Based on the answers it appeared that healthcare staff communicated internally about the patient.

At departments both with and without EPR nurses passed on problems/deviations orally to other nurses.

At departments both with and without EPR the junior doctors dicussed with another doctor whereas more experienced doctors did not.

Documentation of the meeting with the patient was made by the doctor immediately after the meeting at departments both with and without EPR.

The nurses made their documentation at the end of the day except for one who made her documentation immediately after the meeting as she had the available time that day.

Another general pattern was that doctors and nurses did not document the same number of times during a day. The nurses documented three times a day and the doctors once a day unless there were complications in the patients.

Conclusion

We conclude:

- That work porcedures and division of work concerning documentation had not changed significantly in departments with EPR compared with departments without EPR.
- That the daily communication between staff groups had not disappeared using the EPR as attention was given to communicate nuances in the treatment and care of patients orally.

Specifically concerning the documentation and communication flow we can conclude:

Collection of information for doctors and nurses had not changed significantly in departments with EPR. The doctors' morning conferences were still run without using the patients' records. The use of notes was also the same in departments with EPR. Doctors' notes from rounds were still only read by a few in staff groups including the doctors themselves; on the other hand, nurses' daily notes were still read by all nurses in the departments with EPR. The admission notes from the doctor and the nursing record were read by all nurses. Relevant parts of the medical record were read by more people in departments with EPR compared with departments without EPR. Communication took place between healthcare staff groups before meeting with the patient by reading the EPR. This was also the case in departments without EPR.

The meeting with the patient had changed as the patient's record was not brought to the meeting in departments with EPR. The healthcare staff had read the EPR, which is always accessible and updated, before the meeting and felt more updated on the patient's situation.

Communication after the meeting with the patient had changed as departments with EPR did not have any communication after the meeting with the patient.

Mono-professional work procedures in departments without EPR concerning documentation and communication including dialogues about the patient still existed in departments with EPR except in one EPR department where it was still possible to dictate to the medical secretary. At the EPR departments it was possible to see notes from all health professionals concerning the patient. However, we can conclude that this possibility was used to a limited extent. New procedures on documentation and communication had not been described or communicated to end users at the EPR departments. We can concluded that the work procedures used were similar to procedures in the same specialised departments without EPR. The timing of documentation of treatment and care was similar to departments without EPR and doctors still made their documentation immediately after treatment while the nurses collected notes and made their documentation at the end of their shift.

Discussion

When the health professional content must be ensured in the EPR organisational changes are necessary. We chose Leavitt's organisation model [1] to focus on the different variables of an organisational change. The variables in the model have been adapted to the areas we wanted to shed light on. In one department with EPR it was stressed again and again that the healthcare staff was better up-dated on the patient than before the EPR. EPR has thus changed/ increased the professional level from an inter-disciplinary perspective. At the same time their behaviour has changed. Doctors and nurses communicate and read the EPR together before they meet with the patient. This communication is very important for healthcare staff in order not to lose knowledge providing poor conditions for the inter-disciplinary work on a long term basis.

The work procedure has also partly changed documentation. At especially one department it has resulted in double-documentation to be minimised. This is due to the structure of EPR and the use of standard plans. At this department they have used the possibilities in the EPR to support healthcare professional processes through standard plans based on the guidelines in the department and reference programs [6][7].

Artefacts, notes - both common and personal - survive in departments with EPR. The overview provided by the artefacts has not been achieved by the two different EPRs as we have observed. According to Leavitt [1] new procedures have not been used in connection with different artefacts and the use has thus not changed.

Healthcare staff has not focused on these artefacts or learned how to work without using the artefacts. New procedures using the artefacts through the EPR could assist in providing an overview of the patient's documentation where problems are highlighted using the common data.

EPR has changed some procedures but still staff do as they normally do. EPR has to be used for some time before procedures are changed. Procedures will change, but gradually [8].

If procedures are not analysed and adapted, EPR can be perceived as a disturbing element and healthcare staff will experience that they do not control their own daily work [9].

Our observations showed that EPR had not influenced previous work procedures. The notes from rounds at EPR department were still not read. Despite this doctors continued to write notes from rounds every day, which means they continued the same procedures without considering if documentation could be made someplace else. This could be because it is not an activity for the doctors to document in the EPR but the purpose is to produce a detailed copy of what has happened. According to Berg M [10] documenting in the EPR is an activity which is directly relevant for the work itself, a process of finding "the right diagnosis".

The possibility of reading the patients' records electronically during the doctors' morning conference had not been used. If the procedure in connection with the doctors' morning conferences had been analysed at departments with EPR the result could have been to change morning conferences from conferences without using records to conferences using records. Doctors would thus not have to remember the patients' treatments etc. but could view the entire amount of documentation at the conference and make decisions accordingly.

Today healthcare staff knows the work division concerning documentation but it is not described in detail or discussed in the departments.

The future with common data in connection with e.g. meeting with the patients means that the inter-disciplinary effort must be focused to ensure necessary data are collected to use in different databases according to the Danish Quality Model [11], and that the meeting with the patient is the responsibility of the entire inter-disciplinary group.

Collection and use of high quality data also mean that documentation must be real-time. Today documentation is not real-time for the nurses. They still make their documentation at the end of a shift at departments with and without EPR.

The doctors at the one department with EPR still dictate to the medical secretary which is not real-time either. Moreover, there are differences in the documentation frequency; doctors document once a day and the nurses three times a day.

The lack of real-time registration will have consequences for patient safety due to mistakes in documentation if documentation is not up-dated.

The strengthening of the professional profile and the collabo-

ration on common data will increase the professional level according to Leavitt [1] affecting the three other variables. The variable documentation will change as a new method of documentation is needed to collect and use multi-disciplinary patient data instead of mono-professional.

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A full discussion of the study and the methodology used can be downloaded from www.olsgaardnicolajsen.dk (in Danish)

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Integration of Domain-Specific User Interfaces for Structured Data Entry in a Telemedicine Platform for Multi-Centric Research Networks

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Abstract

Standardized documentation of clinical data is essential to achieve semantic interoperability in today's heterogeneous clinical IT structures. In order to enhance data quality and user acceptance it is necessary to develop suitable user interfaces for Clinical Documentation Systems (CDS). Also, choosing the optimal storage format particularly depends on the specific purposes of the desired system. A system implementation based on the HL7 Clinical Document Architecture (CDA) is presented. There are promising results and a good user acceptance. Our approach provides a generic platform to build domain-specific user interfaces for structured data entry in a flexible and easily extensible way for multi-centric research networks.

Keywords:

remote data entry, electronic data capture, clinical documentation system, XML, HL7 CDA

Introduction

Clinical Documentation Systems (CDS) and standardized documentation can reduce the costs for data entry while the user interfaces can provide a high ease of use and support high data quality through data validation [1-2]. For storing medical data, XML standards like HL7 CDA [3] or CDISC ODM [4] can be applied. Both standards are developed by two independent organizations (HL7, CDISC) with two different objectives (primary care, medical research). In the following sections an approach is presented to integrate a Remote Data Entry (RDE) module into an existing telemedicine platform [5] using HL7 CDA. The module supports a user interface for clinical documentation (structured data and genealogies) in the German multi-centric research network for Epidermolysis Bullosa (EB), a rare hereditary skin disease. The EB network consists of 7 research centers throughout Germany involved in basic research as well as patient care.

Materials and methods

In close collaboration with the multi-centric research network the requirements for the RDE module and the structured data entry (SDE) forms were gathered. Flexibility (adjustable for different medical domains), extensibility (easy addition of further forms), maintainability (easy modifications of forms) and interoperability (interface to EPRs or EHRs) were identified as relevant requirements. A pool of data items for the SDE forms was determined and the items were grouped by topic and occurrence. The SDE forms should allow single-acquisition at patient recruitment as well as multiple-acquisition during the course of the study. Extensible table lists where data entry tables can be dynamically extended at runtime should also be possible.

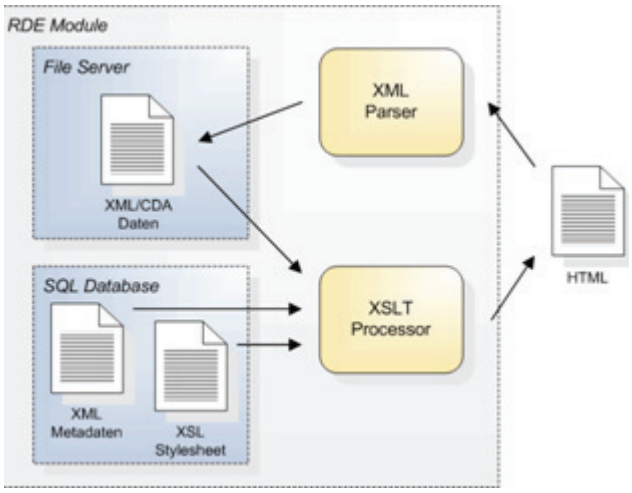

Figure 1 - Workflow for viewing and manipulating SDE forms

The RDE module was implemented on a web-based LAMPS architecture (Linux, Apache, MySQL, Perl, SSL) according to the requirements identified above. Metadata was stored in an SQL database using an entity-attribute-value (EAV) schema [6] whereas medical data items were stored in the file system. The HL7 CDA format was chosen as a suitable format for storing the medical data of SDE forms and facilitating reusability and interoperability with EPRs. During the development of the RDE module only Release 1 of HL7 CDA was available, which did not provide standard templates for structured clinical content. Local markup was devised for storing the required clinical

content in CDA R1-compliant fashion. A proprietary XML format was developed to support the different types of required SDE forms, and an XSLT stylesheet was applied to render the medical data items into HTML screen forms (Fig. 1). To guarantee consistent relationships between the XML metadata, the XSLT stylesheet and the CDA/XML document, a revision control system was integrated.

Results

The RDE module was introduced into production use in 09/2005 at the multi-centric EB research network. For entering research data six distinct SDE forms have been developed covering medical topics like patient histories, physical exams and lab findings (Fig. 2). Two clinical centers have entered more than 200 patients, and more than 150 sessions with an average of 60 minutes per sessions have been carried out. The system is currently being adapted for the additional domain of pediatric oncology.

Figure 2 – Transformation of HL7 CDA to HTML

Discussion

Storing clinical documentation content in a human-readable and machine-processable XML format allows the flexible adaptation of SDE forms for various medical domains. Creating HTML output by means of XSLT stylesheets and an XSLT processor has proved to be a robust and efficient method [7]. The architecture described here presents a setting where HL7 CDA is used primarily for data storage. However, standards like HL7 CDA or CDISC ODM can contribute to a potential semantic integration of data exchange formats. Concepts for integration of semantic interoperability into these formats already exist but are not yet fully developed (e.g. HL7 CDA Templates). In order to gain better usability the implementation of skip logic should be considered. Also, to further improve data quality, the existing simple validation checks should be extended to allow complex plausibility control mechanisms.

Conclusions and outlook

In conclusion the developed system offers great flexibility and adaptability for the definition of SDE forms for various medical domains within the same RDE platform. Using standards like XML, XSLT and HL7 CDA contributed significantly towards the flexibility of the system and could in the future pave the way for semantic interoperability with other clinical IT systems. Further development will focus on rolling out the system in additional medical domains as well as implementing complex input validation and skip logic.

Acknowledgments

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Integration of Domain-Specific User Interfaces for Structured Data Entry in a Telemedicine Platform for Multi-Centric Research Networks

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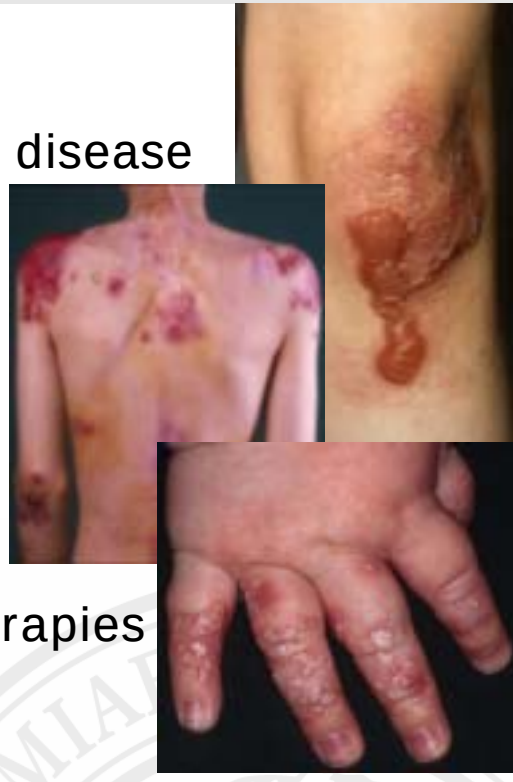
Department of Medical Informatics
Research Network Epidermolysis Bullosa

Friedrich-Alexander-Universität
Erlangen-Nürnberg

Introduction (1)
Research Network Epidermolysis Bullosa



- Multi-centric research network [1]
  - Epidermolysis Bullosa (EB): rare hereditary skin disease
  - 7 centers within Germany involved
    - patient care (2 centers)
    - research (5 centers)
- Expectations
  - better understanding of disease mechanisms
  - development of new diagnostic services and therapies
  - more comprehensive documentation
- Challenges
  - effective data exchange between centers
  - effective collaboration and data sharing
  - suitable communication structures

Introduction (2)
Requirements RDE & SDE

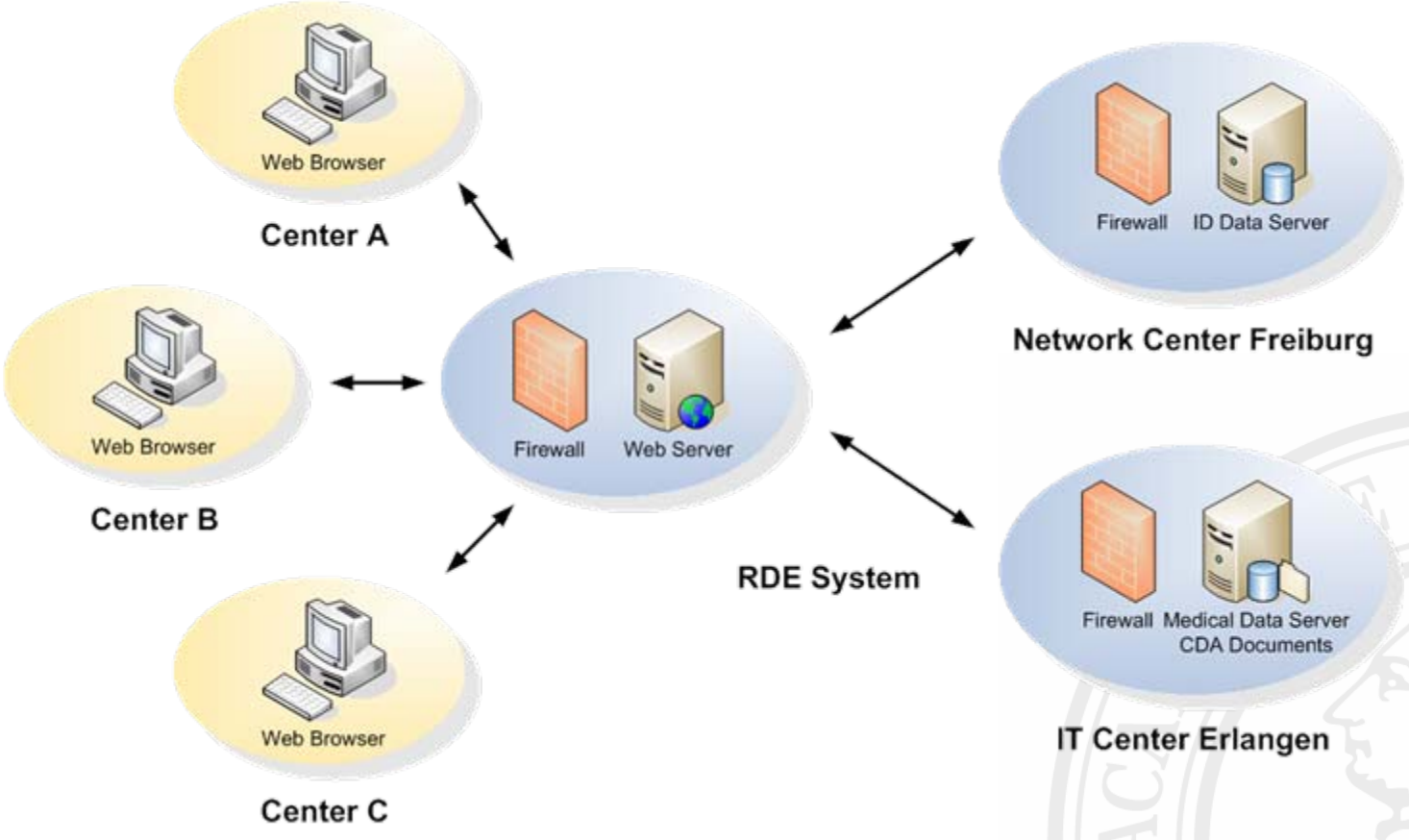
- Integrated telemedicine platform
  - remote data entry (RDE)
  - web-based
  - flexible and easily extensible platform
  - implementation of German data protection rules
  - acquisition and sharing of structured data, image data and genealogies
- Gathering requirements of structured data entry forms (SDE)
  - extraction of data items and grouping by topic and occurrence(s) within the clinical workflow
  - single-acquisition forms at patient recruitment
  - multiple-acquisition forms during course of study

Methods (1)
Components & Concepts

- Extension of existing telemedicine platform
  - addition of a web-based RDE module
  - LAMPS architecture (Linux, Apache, MySQL, Perl, SSL)
  - SDE forms
    - definition and meta information in XML file
    - parsing and rendering through XSLT
    - medical data in HL7 CDA R1
  - use of entity-attribute-value (EAV) concept for metadata storage
  - implementation of architecture requirements of the German Health Telematics Platform (TMF) [2]

Methods (2)
Data protection requirements

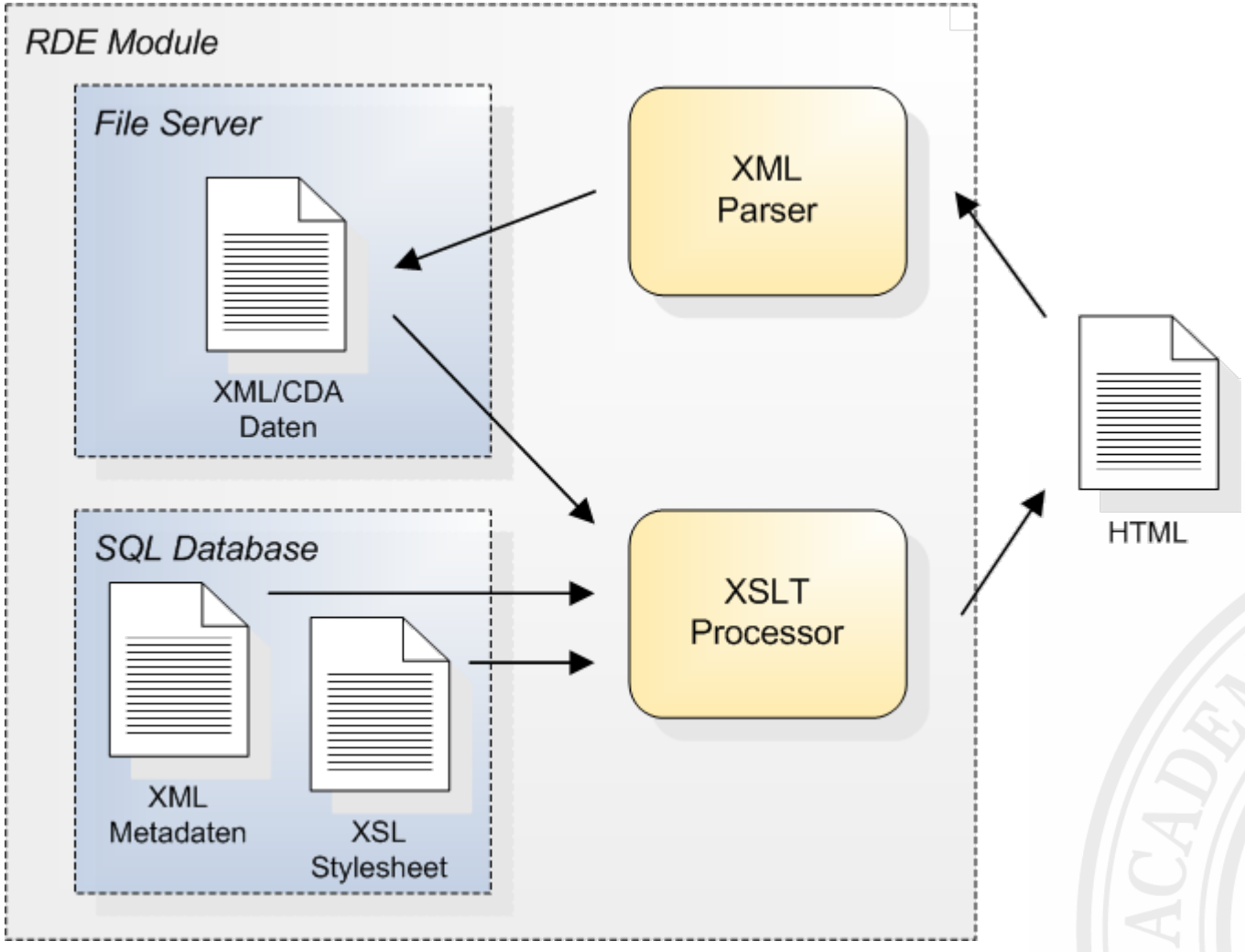
- separation of patient ID data and medical data



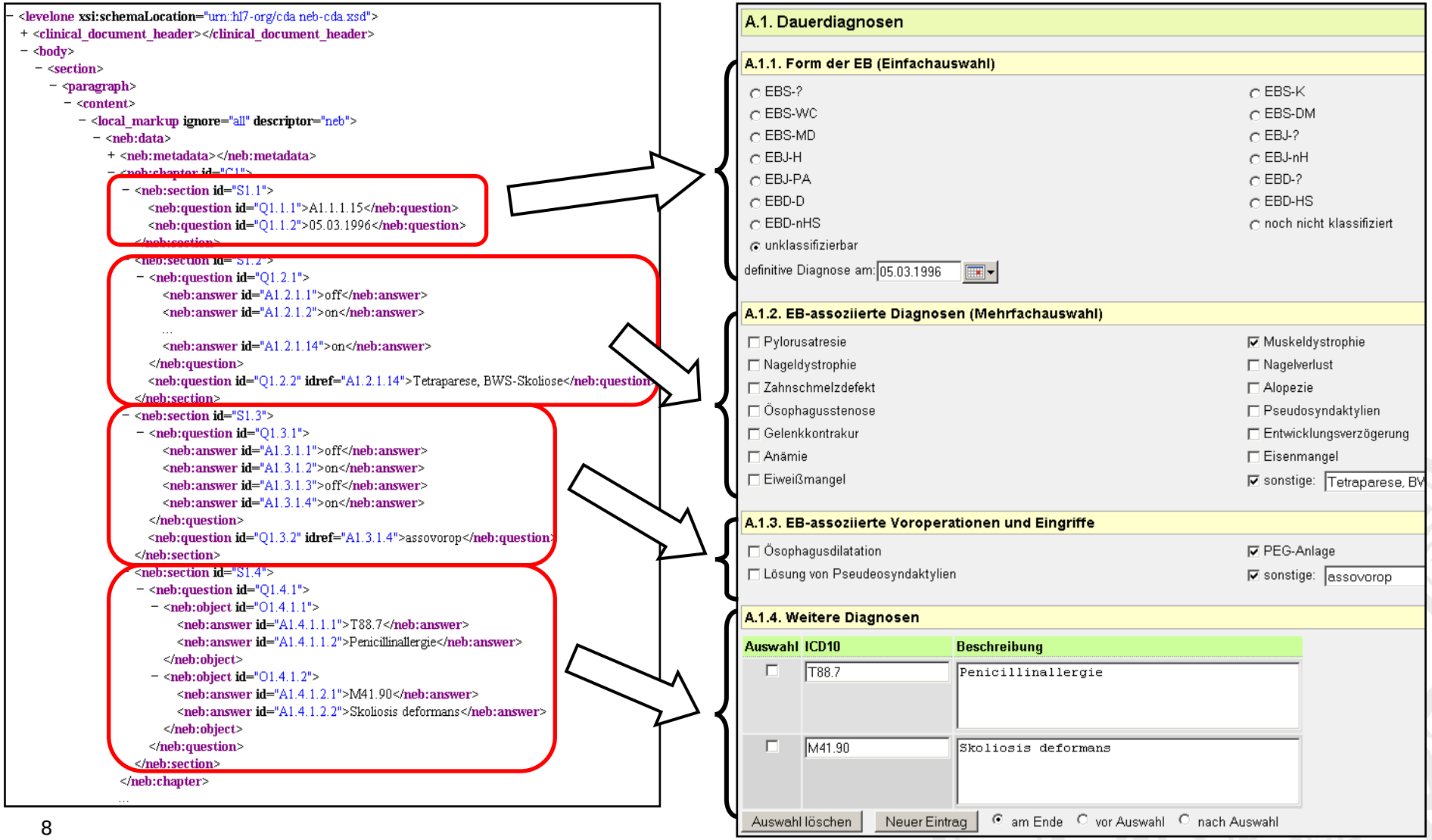
Methods (3)
Integration of HL7 v3 CDA R1

- CDA = Clinical Document Architecture
  - XML-based, 3 level architecture
  - header and body information (meta data/clinical data)
  - extensibility through <local-markup> segments
- proprietary namespace for local content
  - definable meta data elements for alignments, definitions and data containers
- validation of compatibility regarding all stored CDA data against the CDA schema
- suitable storage format for medical data

Methods (4)
XML-Architecture



Methods (5)
XSL-Transformation



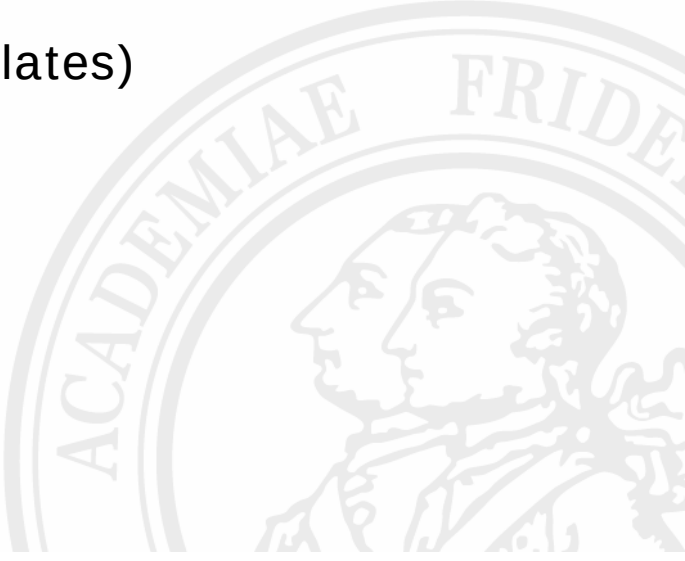
Results
Production use & features

- Production use since 09/2005
  - 150 sessions
  - 200 patients, 2 centers
  - 6 distinct acquisition forms (e.g. patient histories, physical exams, lab findings)
  - most complex document contains 111 items
  - CDA R1 structured elements primarily used for demographic data
  - adaptation for additional domain of pediatric oncology

- Features
  - integrated patient data management
  - flexible definable acquisition forms managed through revision control system
  - integration of existing graphical genealogies in Newick notation [3]
  - granular authorization management
  - plausibility checks
  - data export for further analysis

Discussion

- XML formats
  - flexible adaptation of SDE forms for various medical domains
- XSLT
  - robust and efficient method for generation of user interfaces
- HL7 CDA vs. CDISC ODM
  - data storage
  - still under development
  - semantic interoperability (HL7 CDA templates)
- Improved data quality
  - complex plausibility mechanisms



Conclusions and Outlook

- Flexibility and adaptability
  - definition of SDE forms for different medical domains
- Standards
  - XML, XSLT, HL7 CDA contribute to semantic interoperability and further interfaces to EHRs or EPRs
- Further development
  - roll out in additional medical domains
  - input validation
  - skip logic

Thanks for your attention!

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  - [3] www.uni-leipzig.de/~innere/tsh
- Acknowledgement
  - This project is being funded by the German Federal Ministry of Education and Research (Grant No. 01GM0301).
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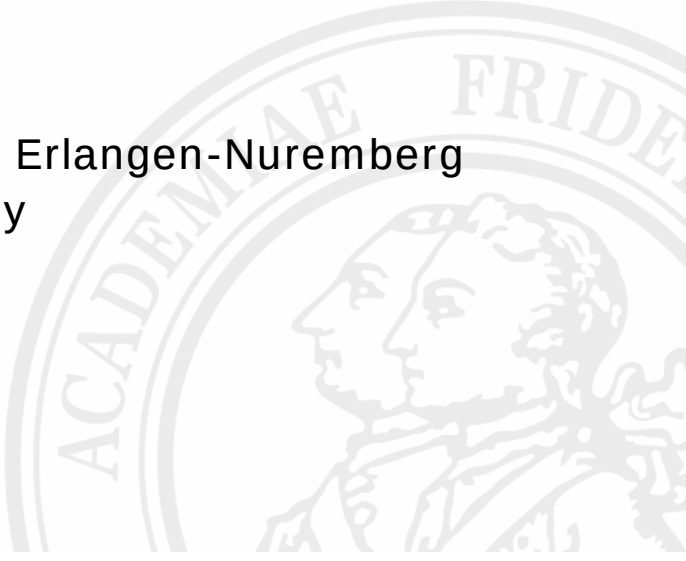

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Evaluation of Clinicians' Satisfaction of a Discharge Summary System (DSS) in a Taiwanese Teaching Hospital – The Reliability of an Evaluating Instrument

Yung-Yu Su[a], Khin Than Win[a], Herng-Chia Chiu[b], Gui-Fen Chiu[c], John Fulcher[a]

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[b]. Graduate Institute of Healthcare Administration, Kaohsiung Medical University, Taiwan
[c]. Department of Information Management, Kaohsiung Municipal Hsiaokang Hospital, Taiwan

Abstract

Evaluation is important in determining the success of electronic medical records (EMRs). Thus, this study introduces how to use both qualitative and quantitative methods in such research. This study provides a suitable assessment questionnaire including dimensions and attributes revised from the "updated DeLone and McLean IS Successful Model" tailored to the Taiwanese medical environment. In short, this study demonstrates the reliability of this evaluation tool and we believe it could be incorporated into EMRs from the perspective of patient safety, healthcare administration, and health informatics.

Key words:

evaluation research, HIS evaluation, evaluation instrument

Introduction

The development of information technology has enabled health professionals to improve the efficiency and quality of patient care. A Hospital Information System (HIS) integrates lots of sub-systems, and has the potential to improve patient care, cost containment and improve the efficiency of work practice [1]. An Electronic Medical Record (EMR) system is a part of HIS. Adoption of EMR could lead to better quality and more efficient healthcare. An EMR contains sensitive health data of individual patients; thus, it is important to realize whether such a system is both secure and error free for patient care in a healthcare organization. Thus, in order to assess current-generation EMRs in Taiwan, we adopte "goal-based evaluation" [2] in designing an appropriate evaluation tool in this research.

The purpose of the study is to establish a suitable evaluation instrument which includes dimensions and attributes for the "EMR evaluation" based on "Patient Safety". Accordingly, this research was performed in a teaching hospital in the south of Taiwan. This sample hospital has been using a Discharge Summary System (DSS) to improve the quality of patient care for more than two years. In order to protect the privacy of patient records, only attending physicians, residents, interns, and nursing specialist practitioners (NSP) are permitted to use this system. Therefore, forty-six physicians were invited to join this evaluation study as they are the main stakeholders in this DSS.

Methods

This research combined and revised both the "updated DeLone and McLean Information System model" [3] and the dimension of "Safety Quality"[4] to generate a more comprehensive model in evaluating this DSS. A Likert-scale was used in the questionnaires and answers were assigned a value of 1 to 7 from "strongly disagree" to "strongly agree". Hence, forty seven questions with a free-text question were developed to measure 7 categories (Figure 1): **System Quality, Information Quality, Service Quality, Safety Quality, Use Frequency, Work Impact, and Overall Satisfaction.** Consequently, this research found evaluating attributes based on the above research model by using literature review to satisfy the requirements of the Taiwanese medical environment. The research uses "cross-sectional" design to achieve its goal. Thus, research questionnaires were provided for the physician's office and were collected every week by researchers from May to the middle of June in 2006.

Results

The respondse rate of this research was 71.7% (33 of 46), and the data were analyzed by using the SPSS statistical software package. Demographic data are shown in Table 1. "Reliability analysis" was conducted and the Cronbach's value of "reliability analysis" shown in Table 2. However, obeying the hypothesis of "Factor analysis", the ratio of variables to samples is 1:2 [5]. As the sample size is 33, only the reliability can be tested in this research. Consequently, the final scale contained 42 questions which comprise 7 dimensions: System Quality, Information Quality, Service Quality, Safety Quality, Use Frequency, Work Impact, and Overall Satisfaction. The results of "Reliability analysis" show that those 42 questions follow the same trend in this research questionnaire.

Discussion

This is a successful study because a suitable assessment instrument was designed based on statistical techniques. To summarize the salient features of the analysis, several findings are of interest, and three reasons could be cited to explain this result. **Firstly,** it demonstrates that both "literature review" and "Delphi method" are important techniques in designing a research questionnaire. **Secondly,** it is essential to adopt clinicians' suggestions, to realize end-users' opinions and use suitable wording in such an evaluation study. **Thirdly**, HIS/EMR evaluation is very difficult to perform in a real medical environment because healthcare professionals are extremely busy with patient care. Thus, it needs to get the support and cooperation with healthcare professionals' to complete and gain useful data from them.

In addition, the most significant finding is that **"Safety Quality"** could be incorporated of the "updated DeLone and McLean Information System model" based on the aspects of technology. However, it still needs further research to demonstrate this result by using "Factor analysis" with large samples (more than 200).

Conclusion

This research demonstrates that Quantitative and Qualitative approach of cross-sectional survey design, Literature review, Delphi method, clinicians' opinions, and cooperation with healthcare professionals are the essential factors in such evaluation research. Additionally, large samples could help researchers to complete a successful evaluation study. The next stage of this research will further refine this instrument for Taiwanese EMRs evaluation.

References

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[5] Hinton, P.R. et al., *SPSS explained*. 2004, London; New York: Routledge.

Table 1 - Demographic Characteristics of Study Sample (N=33)

Dimensions	Cron-bach's α value	Corrected Item-Total Correla-tion	Items	P value
System Quality	0.872	0.642–0.776	4	0.018
Information Quality	0.951	0.772–0.892	7	0.000
Service Quality	0.916	0.677–0.796	8	0.000
Safety Quality	0.839	0.429–0.681	7	0.000
User Frequency	0.865	0.627–0.841	4	0.001
Working Influence	0.948	0.744–0.902	7	0.000
Overall Satisfaction	0.957	0.826–0.935	5	0.014
Total Dimensions	0.968	0.299–0.859	42	0.000
α = 0.005				

Table 2- Cronbach's a value of research questionnaire

Characteristic		Sample	Percentage
Clinical departments	Internal Medical	9	27.2
	Surgery	7	21.2
	Pediatrics	5	15.2
	Obstetrics and gynecology	6	18.2
	Eneurology	6	18.2
Gender	Male	11	33.3
	Female	22	66.7
Age	21-25	7	21.2
	26-30	18	54.5
	31-35	6	18.2
	36^{+}	2	6.1

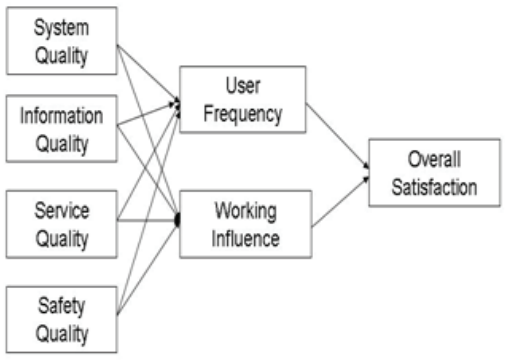

Figure 1 - Evaluation model

Figure 1 - Evaluation model

Evaluation of Clinicians' Satisfaction of a Discharge Summary System (DSS) in a Taiwanese Teaching Hospital – The Reliability of an Evaluating Instrument

Yung-Yu Su[a], Khin Than Win[a], Herng-Chia Chiu[b], Gui-Fen Chiu[c], John Fulcher[a]

a. Health Informatics Research Centre, University of Wollongong, Australia
b. Graduate Institute of Healthcare Administration, Kaohsiung Medical University, Taiwan
c. Department of Information Management, Kaohsiung Municipal Hsiaokang Hospital, Taiwan

Introduction

- **Hospital Information System (HIS)**
  - An HIS integrates lots of sub-systems, and has the potential to improve patient care, cost containment and improve the efficiency of work practice [1].

- **Electronic Medical Records (EMRs) System**
  - An EMR contains sensitive health data of individual patients.
  - Adoption of EMR could lead to better quality and more efficient healthcare.

- **The purpose of the study**
  - To establish a suitable evaluation instrument which includes dimensions and attributes for the "EMRs evaluation" based on "Patient Safety" in Taiwan.

Background of sample hospital

- **This research was performed in a teaching hospital in the south of Taiwan.**
  - 19 clinical branches and 498 general beds

- **It has been using a Discharge Summary System (DSS) to improve the quality of patient care for more than two years.**
  - In order to protect the privacy of patient records, only limited members are permitted to use this DSS.
    - Attending physicians,
    - Residents,
    - Interns,
    - Nursing specialist practitioners (NSP)

Methods

- **Research Design**
  - The research uses "cross-sectional" design to achieve its goal.
  - It adopted "goal-based evaluation" [2] in designing an appropriate evaluation tool.

- **Participants**
  - Forty-six physicians were invited to join this evaluation study.

- **Evaluation Model**
  - A more comprehensive model (Figure 1) was generated in this DSS by combining and revising
    - the "updated DeLone and McLean Information System model" [3]
    - the dimension of "Safety Quality"[4]

- **Evaluation Instrument**
  - A Likert-scale was used in the questionnaires and answers were assigned a value of 1 to 7 from "strongly disagree" to "strongly agree".
  - Forty seven questions with a free-text question were developed to measure 7 dimensions.

- **Performing this research**
  - Research questionnaires were provided for the physicians in five clinical departments.
  - The questionnaire were collected from May to the middle of June in 2006.

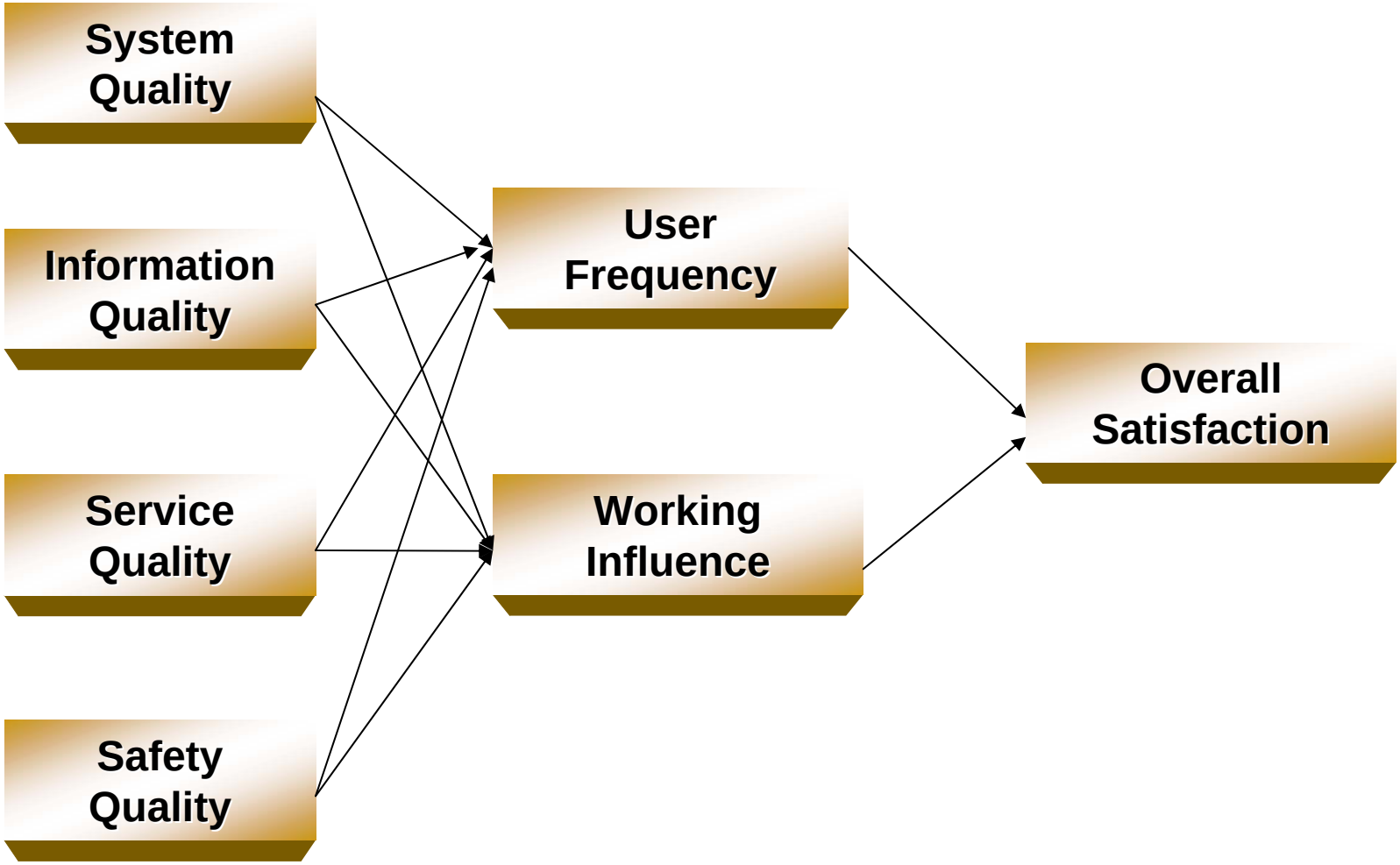

Figure 1 Evaluation model

Results

- The response rate of this research was 71.7% (33 of 46 physicians).
- The data were analyzed by using the SPSS 13.0 statistical software package.
- Demographic data are shown in Table 1.
- "Reliability analysis" was conducted and the Cronbach's α value of "reliability analysis" shown in Table 2.

Results

Table 1 Demographic Characteristics of Study Sample (N=33)

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Total Dimensions	0.968	0.299 – 0.859	42	0.000

α = 0.005

Discussion

- **To summarize the salient features of the analysis, several findings are of interest, and three reasons could be cited to explain this result.**
  - **Firstly**, both "literature review" and "Delphi method" are important techniques in designing a research questionnaire.
  - **Secondly**, it is essential to adopt clinicians' suggestions, to realize end-users' opinions and use suitable wording in such an evaluation study.
  - **Thirdly**, HIS/EMRs evaluation is very difficult to perform in a real medical environment because healthcare professionals are extremely busy with patient care.
    - Thus, it needs to get the support and cooperation of healthcare professionals' to complete and gain useful data from them.

Discussion

- **"Safety Quality" could be incorporated into the "updated DeLone and McLean Information System model" based on the aspects of technology.**
  - These attributes could be used to measure whether an EMR system could protect the privacy of patient records.

- **It still needs further research to demonstrate this result by using "Factor analysis" with large samples (more than 200) "[5].**
  - A "good" research questionnaire needs to satisfy the requirements of both "reliability" and "validity".

Conclusion

- **This research demonstrates the essential factors in such evaluation research.**
  - Quantitative and Qualitative approach of cross-sectional survey design,
  - Literature review,
  - Delphi method,
  - Cooperation with healthcare professionals to realize their insight opinions of implementing EMRs.

- **"Safety Quality" could be regards as an important dimension for EMRs evaluation study.**

- **The next stage of this research will further refine this instrument for Taiwanese EMRs evaluation.**

Reference

1. Su, Y.Y., Win,K. T.,Fulcher,J. *Electronic Health Record System Evaluation Based on Patient Safety*. In *Asia Pacific Medical Information Association Conference 2006*. 2006. Taipei, Taiwan.
2. Cronholm, S. and G. Goldkuhl, *Strategies for Information Systems Evaluation- Six Generic Types*. Electronic journal of Information System Evaluation, 2003. **6**(2): p. 65-74.
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5. Hinton, P.R. et.al., *SPSS explained*. 2004, London; New York: Routledge.

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- Our students in the Department of Medical Information Management at Kaohsiung Medical University who helped us to collect questionnaire and complete this research.

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An Effective Approach for Development of Regional Medical Information System Using XML Technology

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[b] *Government and Public Corporation Information Systems Division, Hitachi, Ltd., Tokyo, Japan*
[c] *kbsoft corporation, Nagasaki, Japan*

Abstract

The system proposed here accepts XML-documented patient records and transforms them into a common schema through the style sheet. Because we adopted an XML format, the users of this system will easily get the information exchanged among medical facilities. The characteristics of this system include; (1) automatic creation of an appropriate structure of database from the XML schema information for each hospital, enabling to store any records of XML format for which XML schema information is known in advance, (2) facilitation of a dynamic control of information flow by introducing an idea of standardized interface structure, (3) reduction of the costs at which regional medical information systems are built up and (4) increase of the number of hospitals sharing this DB of patient records by exploiting a common XML schema.

Keywords:

medical informatics, databases, information storage and retrieval

Introduction

XML is useful for both display of data (e.g., in a web browser) and also for electronic data interchange messaging between systems. Many trials other than those of our research are reported for structuring medical records with XML. In the United States, HL7 (Health Level Seven) is generally used to exchange medical information, and HL7 v2 messages have been translated into XML format; v3 messages will be exclusively in XML. In Japan, electronic medical records that are equipped and operating with an XML interface include OpenDolphin and Wine. Also expected to make an appearance are MML-supporting electronic medical records that are being newly sought in connection with a cooperative system of the Tokyo Medical Association (HOT Project).

Electronic exchange of medical for information among hospitals, it is necessary to standardize data formats. In Japan, however, exchanges of medical information are still underdevelopment, resulting in few hospitals which actually have their medical information exchanged with each other [1].

We proposed here an effective approach, for development of the regional medical information system and sharing patients DB among hospitals.

Methods

XML text Viewing and editing

We can create and edit XML files in a text format using the XML Schema design view of XMLspy (released by Altova).

Developing XML-to-XML Mappings

To develop an XML-to-XML mapping, what needs to get done is simply to load XML document and XML Schema in MapForce (released by Altova) and to drawn drag connecting lines between the elements or attributes of the source and target.

Generating Program Codes

MapForce generates XSLT style-sheets program codes for marshalling medical data from the source to the target content model. All code generated by MapForce can easily be used in XML data transforming.

Results

Exchange technology of medical information survey

There are no standards for medical information using XML interface, other than the MML until now in Japan. In European countries, the most popular standard is the Electronic Data Interchange (EDI) according to the UN/EDIFACT (United Nations/Electronic Data Interchange For Administration, Commerce and Transport standard) which is the message exchange standard for trading established by the United Nations to allow exchange of structured data. Furthermore, the Netherlands has developed a protocol called MEDEUR for medical purpose using the EDIFACT standard. The medical association in

the Netherlands is managing this system. In the United States, the Health Level Seven (HL7) is generally used to exchange medical information, and the HL7 SGML/XML Special Interest Group is developing the HL7 Document Patient Record Architecture. The MML is mainly designed to describe comprehensive medical information. In contrast, the HL7 is designed to exchange the database for each specific purpose (use case). Since many trials other than MML and HL7 are reported for structuring medical records with XML increasing need to transform one markup to another markup develops. ASTM E31.25 subcommittee, "XML DTDs for Health Care" is formed to enhance existing levels of interoperability among the various XML/SGML standardization efforts, products and systems in health care.

The rules for the exchange technology of the medical information are already in place. However, it is expected that various challenges and difficulties will happen at the next step when we start to use these technology in the medical information system [2]. Easy-to-use and the inexpensive system are hoped for as a medical information exchange system.

In the next stage of the survey of exchange technology of medical information, we will focus on a verifying effectiveness of the XML interface as the exchange standard while checking problems from implementation.

Proposed system architecture

As shown in Figure 1, although it was necessary to convert into common format on the client side, there were some problem in the user operation and in the cost. On the other hand, proposed system that to do data exchange in an integrated server is seem to be a ideal method. We expect that current problem can be solved (Fig.1).

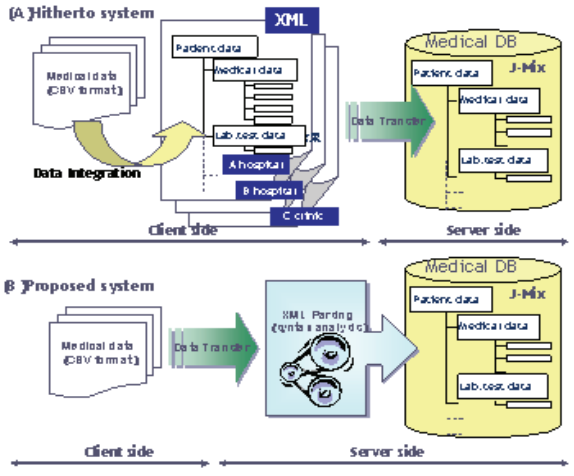

Figure 1 - Schematic diagram of Comparison between hitherto system and proposed system

XML schema design

First, to establish an analytical procedure of the medical data, the medical facilities were classified into the types of university hospitals, clinics, and National Hospitals. Medical information used by a certain medical facility type was described in terms of XML (XML document). Second, our XML schema was designed according to the types of university hospitals, clinics, and National Hospitals and data modeling (start XML schema). Furthermore, XML schema provides common medical information to each medical facility type (sample XML schema). Finally, we are aiming at making a model of XML schema for medical records that can be used in common with each medical facility group (model XML schema, as shown in the Figure 2 below. The XML element in this research was selected referring to J-Mix which is standardized medical terminology in Japan.

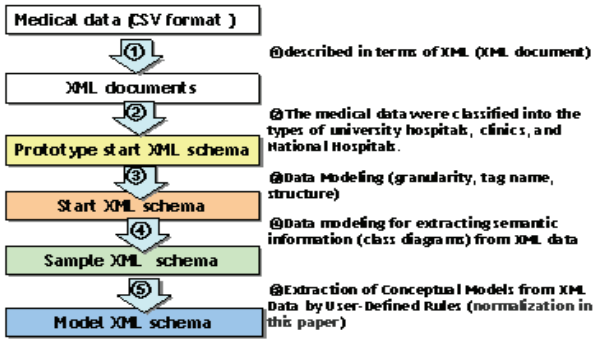

Figure 2 - Schematic diagram of making an model XML schema that can be used in common with each medical facility group

Conclusion

Our approach is also good for the infrastructure to improve the quality and accessibility of health care and to enable the delivery of integrated health care services (Fig.2). In the future, the technological approach for implementing the regional medical information system is based on XML, while its underlying capabilities allow for dynamic navigation according to personalized end-user preferences and authorities.

References

[1] Honda M, Yamanobe Y, Nakayama Y, Sudo H, andYanase K. Development of regional medical information system - using XML technology-. Japan Journal of Medical Infomatics 2005: 25(1): 1-5.

[2] Honda M, and Yamanobe Y. On the current problems of user authentication for EMR in HIS, MEDINFO 2004, M.Fieschi et al.(Eds), Amsterdam:IOS Press, 1644, 2004

An effective approach for development of regional medical information system using XML technology

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[c] *Kbsoft corporation, Nagasaki, Japan*

Abstract

The system proposed here accepts XML-documented patient records and transforms them into a common schema through the style sheet. Because we adopted an XML format, the users of this system will easily get the information exchanged among medical facilities. The characteristics of this system include;

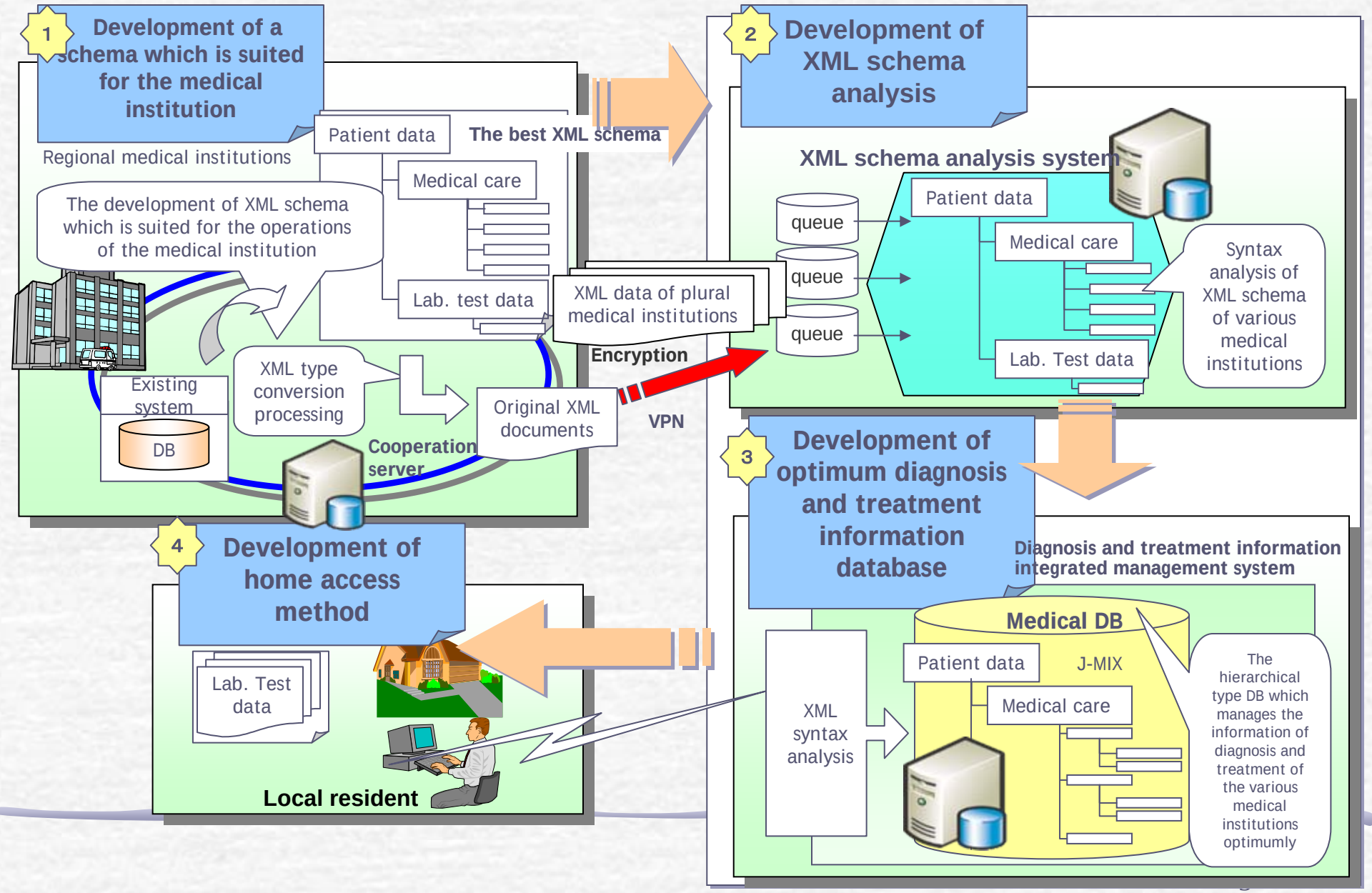
(1) automatic creation of an appropriate structure of database from the XML schema information for each hospital, enabling to store any records of XML format for which XML schema information is known in advance,

(2) facilitation of a dynamic control of information flow by introducing an idea of standardized interface structure,

(3) reduction of the costs at which regional medical information systems are built up and

(4) increase of the number of hospitals sharing this DB of patient records by exploiting a common XML schema.

Development of regional medical information system using XML technology



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2.Developing XML-to-XML Mappings

To develop an XML-to-XML mapping, what needs to get done is simply to load XML document and XML Schema in MapForce (released by Altova) and to drawn drag connecting lines between the elements or attributes of the source and target.

3.Generating Program Codes

MapForce generates XSLT style-sheets program codes for marshalling medical data from the source to the target content model. All code generated by MapForce can easily be used in XML data transforming.

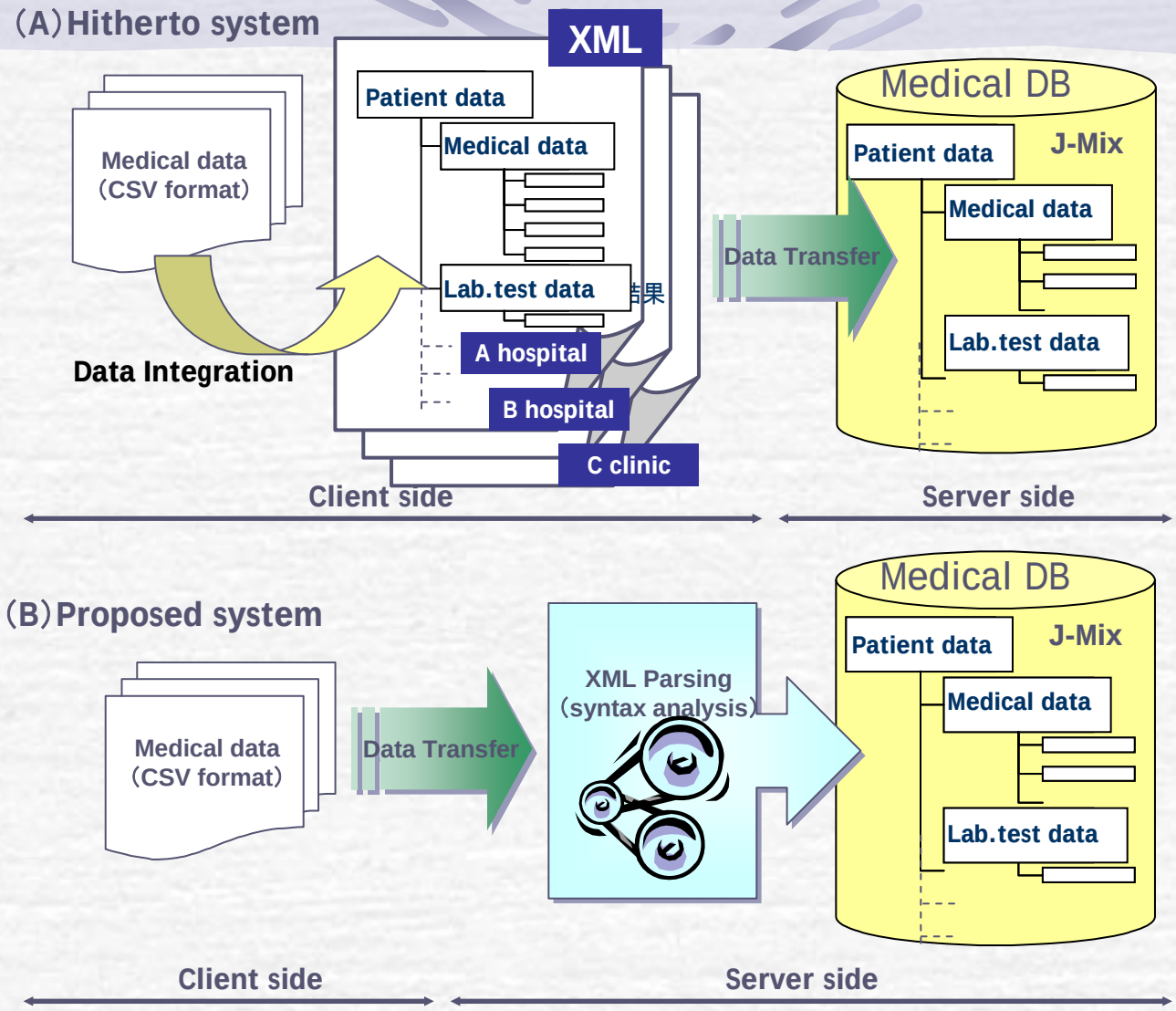
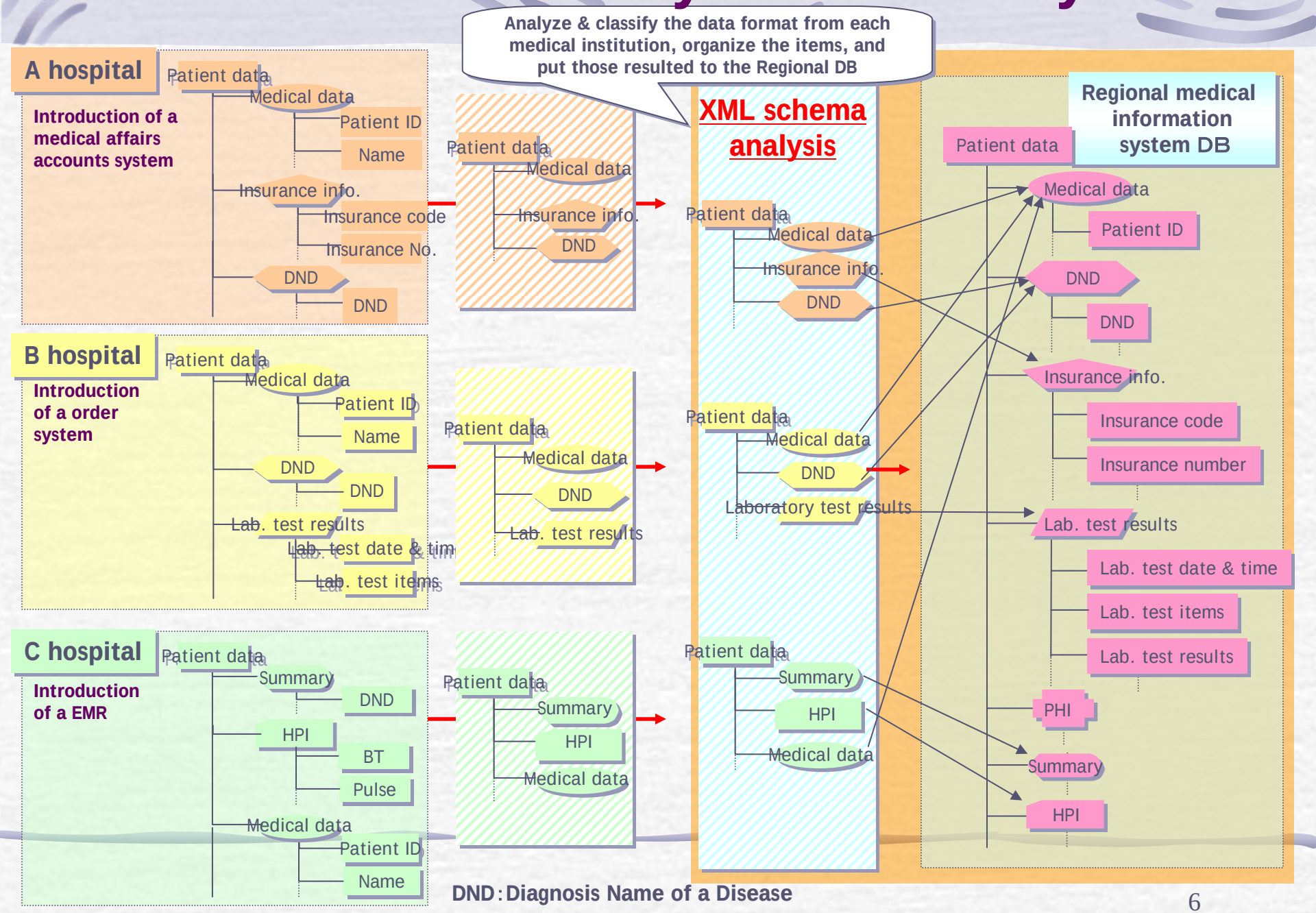
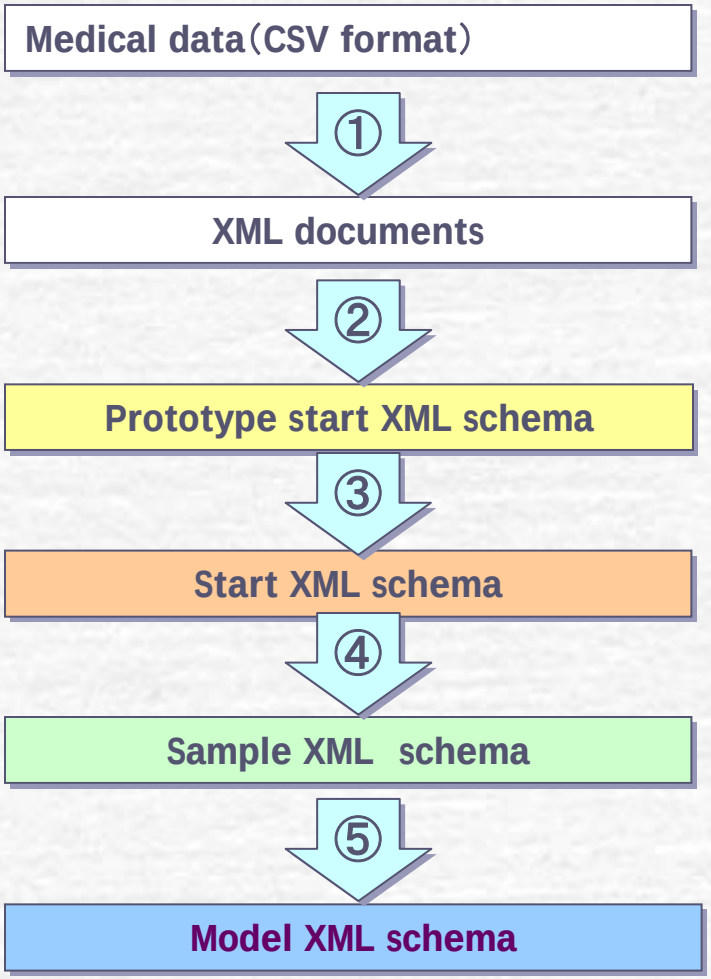


Fig. Comparison between hitherto system and proposed systems.

XML schema analytical summary





①described in terms of XML (XML document)

②The medical data were classified into the types of university hospitals, clinics, and National Hospitals.

③Data Modeling (granularity, tag name, structure)

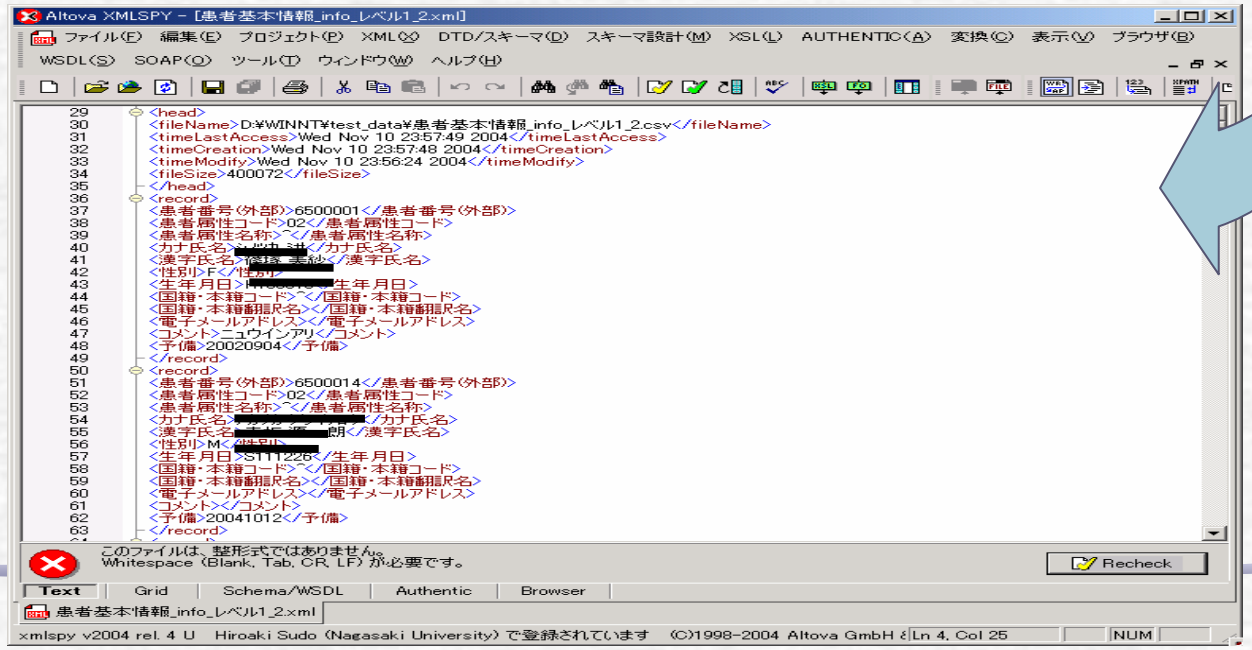
④Data modeling for extracting semantic information (class diagrams) from XML data

⑤Extraction of Conceptual Models from XML Data by User-Defined Rules (normalization in this paper)

Fig. Common XML schema making procedure (developping an XML schema for extracting semantic information from an XML data given).

The procedure which processes each medical institution diagnosis and treatment data with the XML schema (1)

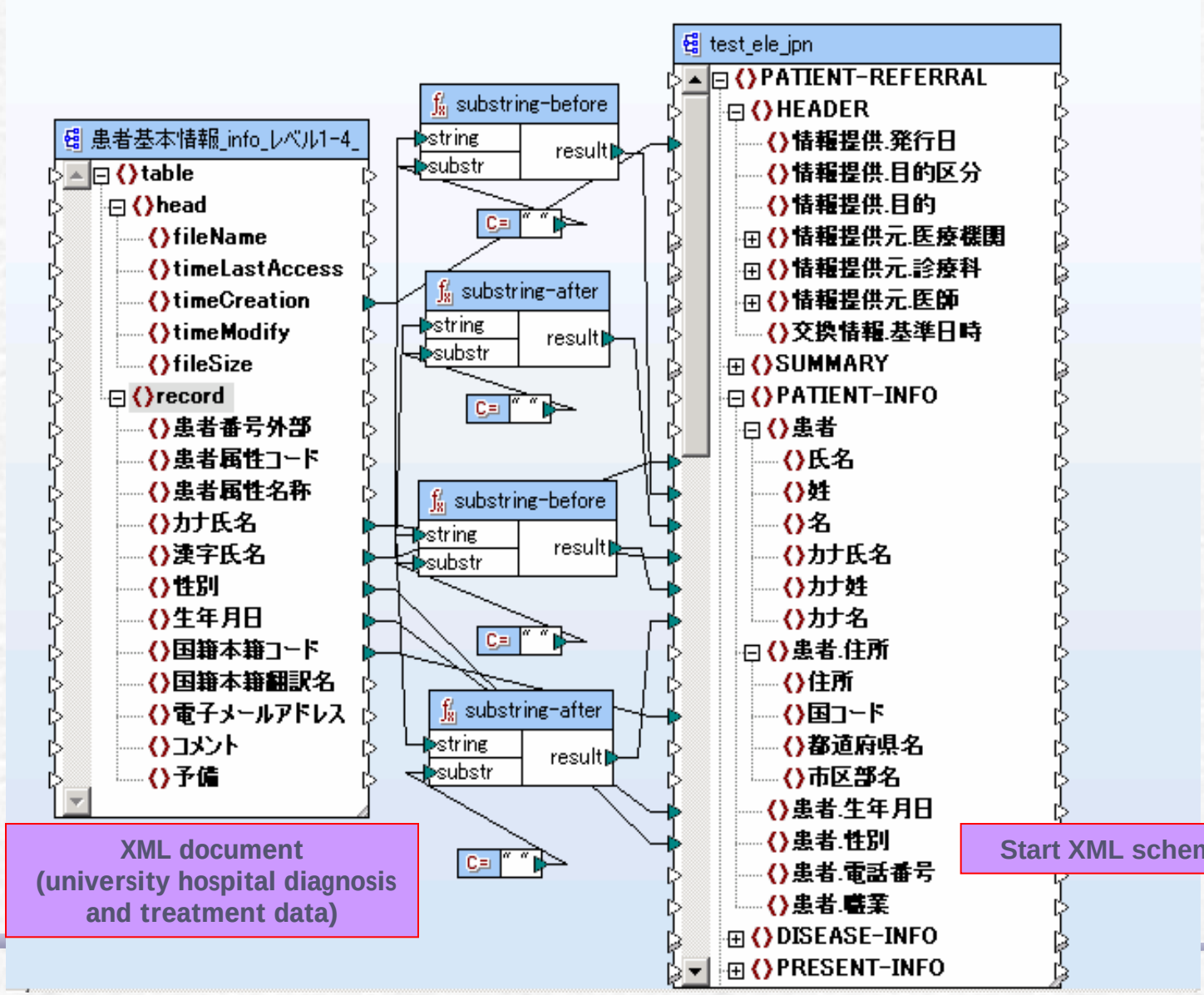
患者番号(外部),患者属性コード,患者属性名称,カナ氏名,漢字氏名,性別,生年月日,国籍・本籍コード,国籍・本籍名称,電子メールアドレス,コメント,予備
6500001,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,H100515,,,,ニュウインアリ,20020904
6500014,02,,ｱｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S111226,,,,20041012
6500027,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S290303,,,,20020729
6500030,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,H071114,,,,20030812
6500043,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S381020,,,,20040123
6500056,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S471207,,,,20020729
6500069,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S230306,,,,ノウコク,20040305
6500072,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S510403,,,,20021112
6500085,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S280111,,,,20020729
6500098,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S450517,,,,20040206
6500102,01,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S440218,,,,20020729
6500115,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,T150513,,,,２７二割,20021016
6500128,01,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S460628,,,,20020729
6500131,01,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S381017,,,,20020729
6500144,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S540919,,,,20020812
6500157,01,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S560923,,,,20020729
6500160,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S421225,,,,20020730
6500173,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S241119,,,,20021216
6500186,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S100512,,,,４１・１割,20040826
6500199,01,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S081120,,,,20020730
6500203,01,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,H050312,,,,20020730
6500216,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,H061203,,,,20031110
6500229,01,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S440515,,,,20020730
6500232,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S550102,,,,20020730
6500245,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,F,S240314,,,,20020730
6500258,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S090206,,,,20021009
6500261,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S270705,,,,20020730
6500274,02,,ｹﾝｺｳ ﾀﾞｲｲﾁ,健康 第一,M,S170205,,,,20021018



① Outputting patient data with the CSV file format

② Converts the data to the XML document

The procedure which processes each medical institution diagnosis and treatment data with the XML schema (2)



From a prototype start XML schema to a start XML schema

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <!--
3
4  This file was generated by MAPFORCE 2004
5
6  YOU SHOULD NOT MODIFY THIS FILE, BECAUSE IT WILL BE
7  OVERWRITTEN WHEN YOU RE-RUN XSLT GENERATION.
8
9  Refer to the MAPFORCE 2004 Documentation for further details.
10 http://www.altova.com/mapforce
11
12 -->
13 <xsl:stylesheet version="1.0" xmlns:xsl="http://www.w3.org/1999/XSL/Transform"
14 →   xmlns:xsi="http://www.w3.org/2001/XMLSchema-instance">
15   <xsl:output method="xml" encoding="UTF-8"/>
16   <xsl:param name="NameInstance" select="'D:¥Sample.xml'"/>
17   <xsl:param name="NameInstance2" select="'D:¥Sample2.xml'"/>
18   <xsl:param name="NameInstance3" select="'D:¥Sample3.xml'"/>
19   <xsl:param name="NameInstance4" select="'D:¥Sample4.xml'"/>
20   <xsl:param name="NameInstance5" select="'D:¥Sample5.xml'"/>
21   <xsl:param name="NameInstance6" select="'D:¥Sample6.xml'"/>
22   <xsl:template match="/doc">
23     <xsl:variable name="MainInstance" select="/"/>
24     <PATIENT-REFERRAL>
25       <xsl:attribute name="xsi:noNamespaceSchemaLocation">D:/xml_schema.xsd</xsl:attribute>
26       <xsl:for-each select="recode">
27         <PATIENT-INFO>
28           <患者>
29             <xsl:for-each select="漢字氏名">
30               <氏名>
31                 <xsl:value-of select="."/>
32               </氏名>
33             </xsl:for-each>
34             <xsl:for-each select="カナ氏名">
35               <カナ氏名>
36                 <xsl:value-of select="."/>
37               </カナ氏名>
38             </xsl:for-each>
39           </患者>
40           <患者.住所>
41             <xsl:for-each select="国籍本籍コード">
```

Example of the XSLT code which is obtained by the mapping of medical data elements
(C university hospital)

From a prototype start XML schema to a start XML schema

```
1  <?xml version="1.0" encoding="UTF-8"?>
2  <!--W3C Schema は xmlspy v2004 rel. 4 U (http://www.xmlspy.com) で生成されています-->
3  <xs:schema elementFormDefault="qualified" xmlns:xs="http://www.w3.org/2001/XMLSchema">
4    <xs:element name="T大">
5      <xs:complexType>
6        <xs:sequence>
7          <xs:element name="患者基本情報">
8            <xs:complexType>
9              <xs:sequence>
10               <xs:element name="基本情報レベル">
11                 <xs:complexType>
12                   <xs:sequence>
13                     <xs:element name="基本情報1レベル">
14                       <xs:complexType>
15                         <xs:sequence>
16                           <xs:element name="カナ氏名" type="xs:string"/>
17                           <xs:element name="漢字氏名" type="xs:string"/>
18                           <xs:element name="性別" type="xs:string"/>
19                           <xs:element name="生年月日" type="xs:string"/>
20                           <xs:element name="国籍・本籍コード" type="xs:string"/>
21                         </xs:sequence>
22                       </xs:complexType>
23                     </xs:element>
24                   </xs:sequence>
25                 </xs:complexType>
26               </xs:element>
27               <xs:element name="住所情報レベル">
28                 <xs:complexType>
29                   <xs:sequence>
30                     <xs:element name="郵便番号" type="xs:string"/>
31                     <xs:element name="住所1" type="xs:string"/>
32                     <xs:element name="住所2" type="xs:string"/>
33                     <xs:element name="電話番号1" type="xs:string"/>
34                   </xs:sequence>
35                 </xs:complexType>
36               </xs:element>
37             </xs:sequence>
38           </xs:complexType>
39         </xs:element>
40         <xs:element name="患者病名管理">
```

Portion of the start XML schema which is obtained by converted the prototype start XML schemer with the XSLT code
(C university hospital)

References

[1] Honda M, Yamanobe Y, Nakayama Y, Sudo H, and Yanase K. Development of regional medical information system -using XML technology- (in Japanese). Japan Journal of Medical Informatics 2005: 25(1): 1-5.
[2] Honda M, and Yamanobe Y. On the current problems of user authentication for EMR in HIS, MEDINFO 2004, M.Fieschi et al.(Eds), Amsterdam:IOS Press, 1644, 2004

Acknowledgments

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●e-mail:m-honda@net.nagasaki-u.ac.jp

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Everyone's a winner, baby?

Sue Whetton[a], Jon Hilton[b]

[a] *University Department of Rural Health, Tasmania*

Abstract

Electronic health records have the potential to become the cornerstone of sustainable health services for the future. Before this can occur there are a number of risks that need to be managed. Existing risks relate to finding the balance between privacy and adequate access, and to developing systems that minimise the potential for unauthorised or illegal use of information. Current approaches, at least in Australia, are somewhat chaotic. Nevertheless, it is anticipated that these risks will be managed. Future risks are a cause for concern. As the electronic health record becomes more comprehensive and more accessible, there will be increasing pressure from a range of non-health care organisations for access to the information. The proposed uses for this information may not always be in the interest of the consumer. Health informatics professionals should be aware of this possibility, should contribute to any discussion around potential future use of health information and understand that the systems they help to build may be used in such a way that not everyone will be a winner.

Key words:
privacy, security, electronic record, risks

Introduction: sustainable health services

Health informatics has the potential to support dramatic and widespread changes to the structures and processes of our health care systems. Such changes are increasingly viewed as essential for the sustainability of health services in the future [1, 2]. It is a view shared by health professionals and consumers alike. A 1998 survey of patient satisfaction, sponsored by the Harvard School of Public Health, found that in each of three countries—the USA, Canada and Australia—79 per cent of the population said their system needs either 'fundamental change' or to be 'completely rebuilt'. The same sentiment was expressed by 89 per cent in New Zealand and by 72 per cent in the United Kingdom [3]

There are different ideas about how a fundamentally changed and presumably more sustainable, health care system will look and operate. Berwick [1] envisions a system that offers '24/7/365 access to help that is uncompromising, meeting whatever need exists, whenever and wherever it exists, in whatever form requested.' While this is more than most think possible, or perhaps even desirable, there is consensus that in a sustainable system, information is the key and that the increasing use of technological and other information and communications systems to access this information will fundamentally change the way health care services are structured and accessed. And for many, the electronic health record will be at the heart of these changes. It is the electronic health record that will finally deliver the health informatics promise of more effective and efficient health services, better quality care and long-term positive health outcomes for individuals and the community as a whole.

At the same time, this vision is tempered by the realisation that we need to manage the very real risks inherent in the implementation of an electronic health record. These can be considered as existing risks and potential future risks. Existing risks are widely discussed in the literature and relate to the need to maintain the privacy of the individual consumer while ensuring appropriate access for health professionals involved directly in the provision of health care or seeking access to data for secondary purposes. Existing risks also include those around the potential for unauthorised access and use of data from electronic records. Future risks refer to the potential for a broadening the range of legitimate uses of health data. Griener [4] suggests that we need to be vigilant and not assume that these will always be benign. In other words, although it is widely anticipated that mechanisms will be developed to effectively manage the risks and facilitate the benefits, we should not assume that everyone's a winner (baby).

Managing existing risks

Efforts to manage existing risks focuses on maintaining the privacy of the individual, ensuring appropriate access for authorised health professionals and developing mechanisms to minimise unauthorised access and use of data.

The sensitive nature of much health data and information means that privacy and confidentiality need to be stringently protected. The consequences of breaches of privacy and confidentiality can range from embarrassment arising from disclosure of sensitive information to serious discrimination, including bias by health carers, insurance organisations, and employers. Enquiries suggest that abuse of personal health information is not uncommon, and offenders are often organisations who should know better [5]. However deciding on what information should be kept confidential is not always straightforward. The purpose of

an electronic health record is to ensure that useful and relevant information is available for use by properly authorised people. This raises the question: *what is relevant?* While some (health professionals in particular), might answer 'Why, everything, of course', others will not be so sure. As the NSW Ministerial Advisory Committee observes 'Even seemingly innocuous information can be contentious. The fact that a person was treated in a particular hospital or location, such as a prison or sexual health centre, could indirectly reveal information about the person. Even though summary information such as name of hospital and health provider may not appear to be 'health information' as such, to the extent that it reveals something about a person's health status it may need to be treated with the same sensitivity as other health information [5].

Nor is there a straightforward answer to the question of who might be considered as 'properly authorised.' Everyone seeking access to information may consider themselves properly authorised. Patients may not agree and this gives rise to one more question: *Who decides these things?*

The health care environment comprises many stakeholder groups with different, sometimes conflicting views and priorities. This is demonstrated at the strategic level where the perceived relative importance of privacy and confidentiality varies between different stakeholder groups. A Report on Research Challenges in E-Health Technologies identified patient privacy as a primary issue for both research and the practice of health information management [6]. Yet health executives responding to the Commonwealth Fund International Health Policy Survey [7] viewed privacy concerns as less of an issue than start-up costs, maintenance costs and lack of standards (Table 1).

Table 1- Major barriers to greater use of computer technology

Per cent naming	*Aust*	*Can*	*NZ*	*UK*	*USA*
High start-up costs	84	84	93	69	71
Projected maintenance costs	49	42	32	52	27
Lack of uniform standards	49	35	50	31	44
Privacy concerns	20	26	7	8	17

Commonwealth Fund International Health Policy Survey

This suggests that there will therefore be situations when a balance will need to be struck between the priorities of different stakeholders. Unfortunately all groups are not equally represented in such discussions. More powerful groups are often able to exert more influence than marginal groups and consequently there may be situations where everyone is not a winner. Consider the following perspectives:

- Health Minister, Tony Abbott has put federal health IT bureaucrats on notice saying he expects tangible results within a year – specifically, a functioning electronic health record and accompanying smartcard system – or heads would start to roll [8].
- I am writing to question the need for or value to be gained from a privacy forum. There seem to be many other issues that are more pressing…We feel that most practitioners are very familiar with general privacy requirements… the problem is really only around how privacy is handled in the electronic referral environment [9].
- Sure there'll be breaches in privacy – but we can deal with those as they happen – the main thing is to get an electronic health record out there [10].
- It's very hard to retrofit and put privacy in at the end…we say build it in…Health information is seen as sensitive, so there are extra safeguards that apply to it… potentially there are a lot of bad outcomes if health information isn't appropriately looked after… [11]

Arguably, all stakeholder views should be able to be accommodated. However, if we consider the role and relative influence of the stakeholder groups, the reality is that some stakeholder views prevail, while others are marginalised.

- Governments pass legislation, establish policies and provide many of the resources to enable health care organisations to develop electronic health records, particularly where health care is partially or fully resourced from public funds. This translates into a significant ability to shape the views and activities of organisations and services.
- Senior management within health care organisations also set strategic directions that shape the development of electronic health records. Health care organisations seek to provide high quality, efficient services to the greatest number of consumers at the lowest cost. For private health care organisations, a profit margin may also be part of the equation. Health organisations have finite resources and many demands for these. The views of senior management will set parameters around the nature, scope and priorities of electronic health record projects. A focus on efficiency, technology or quality care will produce different issues and different outcomes.
- Health professionals are concerned with providing high quality care for their patients. They will therefore view the development of electronic records in terms of

relevance to, and effectiveness in furthering this goal. While clinicians support the principle of the right information in the right place at the right time, many are reluctant to give up their role as owner of the medical record and possibly arbiter of 'the right information in the right place'. The traditional status of the clinician in the biomedical model of health care bestows a considerable ability to influence discussion around this issue.

- Health informatics professionals are also able to influence the form and functions of an electronic record, but may temper their views for pragmatic reasons such as government support for their organisations. Alternatively, as a recent survey by the Health Informatics Society of Australia (HISA) suggested, heath informatics professionals may consider privacy issues to be important, but do not necessarily view the non-technical elements as being in their domain (One comment illustrating this point was: *The problem with the privacy debate is that the Australian government has not set up clear privacy legislation*.)
- Consumers are arguably the least influential stakeholder group. Horsfield and Peterson [12] suggest that consumers are not only marginalised, but also mediated – issues identified as of importance to consumers may reflect the concerns of the mediating group. Consumer issues currently tend to focus 'educating them' about the benefits of an electronic health record and the meaning of informed consent. Consumer representation at the strategic level of discussion and decision making is limited. While limited representation is better than none at all it is clear that consumer influence is somewhat less than many other stakeholder groups.

The challenge of obtaining a balance between privacy and security issues, and appropriate access to information by properly authorised individuals becomes more pressing and more complex as the increasing sophistication of electronic health records enables more and more information to be collected, stored and disseminated across departments and organisations. The complex mix of users and technical standards found in the health care environment make privacy, security and appropriate access significant challenges.

Responding to existing risks

The current approach to managing the need for privacy and authorised access includes a combination of legislation and professional self-regulation in the form of codes of ethics, supported by governance arrangements the development and use of electronic health records.

Unfortunately, legislation in Australia at least, is not straightforward. Table 2 shows the multiple jurisdictions each with their own complex legislation.

Table 2 - Privacy Specific Legislation and Administrative Instructions

Jurisdiction	Public Sector	Private Sector
Commonwealth	Privacy Act 1988 (Cth)	Privacy Act 1988 (Cth)
Australian Capital Territory	Health Record (Privacy and Access) Act 1997 (ACT) Privacy Act 1988 (Cth)	Health Record (Privacy and Access) Act 1997 (ACT) Privacy Act 1988 (Cth)
New South Wales	Health Records and Information Privacy Act 2002 (NSW)	Health Records and Information Privacy Act 2002 (NSW) Privacy Act 1988 (Cth)
Northern Territory	Information Act 2002 (NT)	Privacy Act 1988 (Cth)
Queensland	Information Standards 42A(Health)	Privacy Act 1988 (Cth)
South Australia	Code for Fair Information Practice	Privacy Act 1988 (Cth)
Tasmania	Personal Information Protection Act 2004 (Tas)	Privacy Act 1988 (Cth)
Victoria	Health Records Act 2001 (Vic)	Health Records Act 2001 (Vic) Privacy Act 1988 (Cth)
Western Australia	None	Privacy Act 1988 (Cth)

(Source: NEHTA's Approach to Privacy Version 1.0, July 2006)

Most Australian privacy legislation is built around a set of *privacy principles* with the concept of *informed consent* playing a major role in their application. Inherent in the privacy principle is the understanding that the right to privacy can never be absolute. No matter what the jurisdiction or type of information, there will always be situations that require a decision to be made around competing rights: while consumers of health care have a reasonable expectation that they should be able to control access to their information, this right may conflict with health care providers need to access accurate and up to date information, with the public health official's need for information to prevent or manage major public health risks or even with the government official enacting overriding legislation such as the National Security Information (Criminal and Civil Proceedings) Act 2004. This Act, a response to perceived security threats, is a suite of legislation that can lead to individual privacy being overridden by "the common good", while protecting the administration's right to privacy in.

Informed consent therefore clearly should include the understanding that this is so. It should also include the understanding that legislation is always subject to change,

Health informatics professionals should understand the complexities of informed consent and the possible consequences arising from the systems they help to create. Professional codes of ethics are intended to provide guide-

lines to this end. The IMIA Code of Ethics, for example, outlines a number of principles and rules for ethical conduct such as 'HIPs have a duty to ensure, to the best of their ability, that appropriate structures are in place to evaluate the technical, legal and ethical acceptability of the data-collection, storage, retrieval, processing, accessing, communication, and utilization of data in the settings in which they carry out their work or with which they are affiliated' [13].

To facilitate effective privacy-confidentiality-access of electronic health records, legislation and codes of ethics need to be supported by strong governance arrangements. The broader the reach of an electronic health record, the greater the number of individuals seeking access and the greater the amount of information stored in such records, the greater will be the need for strong governance. Current responses to the need for broad-ranging governance structures are many and varied, and generally ad-hoc, This is almost inevitable in a health care environment where the ultimate responsibility for maintaining privacy falls to the health care provider. Practitioners who work for a publicly funded health service will also be accountable to that service, which will be accountable to a funding body or bodies. Private providers may be accountable to insurers, shareholders, medical indemnity organisations. All of these layers of governance will be involved to some extent with the privacy aspects of a shared EHR. It is, however, leading to 'uncoordinated silos… governance by default where mechanisms are introduced one at a time to address a particular need' [14]. This does little to address the potential risks inherent in electronic health records.

These risks relate to processes utilised in the collection, storage and sharing of health information in electronic health records. While they pose a significant challenge, it is not unrealistic to expect that mechanisms will be developed to effectively manage them and thus deliver the promise of more effective and efficient health services, better quality care and long-term positive health outcomes for individuals and the community as a whole. Everyone will be a winner.

The same may not be true of future risks which relate to potential new uses of information contained in an electronic health record

Future risks

The majority of discussions around privacy, confidentiality and access to information focus on minimising the risk of unauthorised and illegal use of information contained within the electronic health record. These discussions are underpinned by the assumption that those determining appropriate and legal use will get it right, while at the same time begging the question of whether what can legally be done with information is always in the interests of the individual.

There is some concern, however, that this may not always be the case. As the electronic health record becomes more comprehensive and more accessible, it is suggested that there will be increasing pressure from a range of non-health care organisations for access to the information and that the proposed uses may not always be in the interest of the consumer [4, 6, 15]. Indeed, there have been incidents already that suggest this may be so. The West Australian police recently used Guthrie test samples to match DNA samples taken from a crime scene [16]. This may well appear to be a legitimate use of such material – we all want to see criminals apprehended. However, would this still be acceptable if content from medical records were provided to insurance companies or employers? The New South Wales Ministerial Advisory Committee on Privacy and Health Information [5] flagged this possibility when it suggested that 'there may be increasing pressure and demands placed on the information by non-health care bodies (for example insurers, employers, law enforcement agencies and some government agencies)'.

A recent report published in the United States included homeland security in a list of potential uses for an electronic health record [4], while comments on the proposed Australian Department of Human Services Access Card noted that 'the government had played a clever game of avoiding engagement on privacy issues' [17] and 'the more details that are settled, the more certain is the loss of control over our personal information' [18].

It can be concluded that health data that we are happy to share now may become a liability in the future.

While we are not advocating cessation of work on the electronic health record, these future risks are a cause for concern. Clearly, there is a need for a wider, fully informed public debate, one in which we, the health informatics community, have a responsibility to speculate, debate and engage both our own members and the wider community.

A requirement is an open and public discussion about the legitimate uses of health information. Many of the proposed secondary uses have a great initial attraction, but others clearly require that much greater deliberation be carried out in a public setting [4].

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Everyone's a winner, baby? (Risks relating to potential uses of health information in Australia)

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The vision

- There is a vision that the electronic health record may deliver the health informatics promise of more effective and efficient health services, better quality care and long-term positive health outcomes for individuals and the community as a whole

Reality check

- At the same time, this vision must be tempered by the realisation that we need to manage some very real risks inherent in the implementation of an electronic health record
- Privacy and confidentiality are significant issues that need to be addressed

The focus

- The majority of discussions around privacy, confidentiality and access to information focus on minimising the risk of unauthorised and illegal use of information contained within the electronic health record

Assumptions

- These discussions are underpinned by the assumptions that
  - Those determining appropriate and legal use of information will get it right
  - What can legally be done with information is always in the interests of the individual
- This may not always be the case

Demands

- The New South Wales Ministerial Advisory Committee on Privacy and Health suggested:
  - As electronic health records become more comprehensive and more accessible, there may be increasing pressure and demands placed on the information by non-health care bodies (for example insurers, employers, law enforcement agencies and some government agencies) [1]

One example

- The proposed uses of this information may not always be in the interest of the consumer
  - The West Australian police recently used Guthrie test samples to match DNA samples taken from a crime scene [2]
  - This may appear to be a legitimate use of such data – we all want to see criminals apprehended

Widening access

- Would it still be acceptable if content from medical records were provided to insurance companies or employers?
- Or even, as flagged in a recent report published in the United States, for homeland security and other surveillance activities? [3]

Consider

- We need to be aware that health data that people are happy to share now may become a liability in the future
- Many of the proposed secondary uses have a great initial attraction, but others clearly require that much greater deliberation be carried out in a public setting

Tackling the issues

- The consequences of these potential legitimate uses of data are not being fully discussed
- Comments on the proposed Australian Department of Human Services Access Card noted that
  - the government had played a clever game of avoiding engagement on privacy issues [4] and
  - the more details that are settled, the more certain is the loss of control over our personal information [5]

Our responsibility

- We are not advocating cessation of work on the electronic health record, but these potential uses of health information need to be considered
- There is a need for a wider, fully informed public debate
- It should be a debate in which we, the health informatics community, have a responsibility to speculate, debate and engage both our own members and the wider community

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The Solution for Consent Form in EMR System

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Abstract and objective

The EMR(electronic medical records) system is a motive to stir up the various issues which exist already in medical areas, such as the protection of the privacy, sharing of medical information, the law of the signature etc.

Among those issues, the management of various consent forms in EMR system is one of the problem awaiting solution. Consent form for operation and various procedures etc should kept several numbers of written signatures because it is basic document for problem solving with insurance company or legal problem. In Korea, the originality of consent form is kept by written signature or seal, so it is strictly required for all the consent forms legally. However, there has been no specific solution of this issue for the EMR system, because there is no same strategic solution as same as paper based consent form (PBCF). This research is for suggestion of safe strategic solution of consent form and its signature for EMR system.

Keywords:

consent form, EMR, digital pen

Introduction

The number of Medical Consent Form (MCD) has been increased continuously due to legal problem and unique Korean medical system, which is characterized by fee for services. So, many consent forms are required not only operation and procedures, even for the payment of medicine. So, consent form directly affect the financial management of hospital in Korea. Many hospitals and private clinics are implementing new EMR system to adapt new environment of medical system, however, there is no proper legal policy for managing consent forms' signature and digital consent file, yet. Therefore every hospital use paper based consent form for direct hand written signature and keeping original document, and then uploads consent form to EMR system by individual scanning. This makes job duplication and difficulties on managing consent forms of two different characteristics.

This study was postulated to suggest strategic stream of electronic signature based on the Electronic Medical Consent Form (EMCF), and verify its technical possibility based on the concept of originality, confidentiality, reproducibility of EMCF.

Methods

Severance Hospital's EMR system has been developed on the Environment of C#.NET and Windows XP with Microsoft Framework v. 1.1. And as materials for Client, on the basis of Windows XP environment, we selected digital pen as s signature image tool and make consent form by MS WORD.

The postulated steps are as followed:

1. Separation of Signature from Consent Form
2. Endowment of authorization of signature via image file
3. Combination of authorized signature and consent form
4. Creation of one XML documentation with signature image & Public certification key
5. Storage of XML file & Deletion of image file of signature

Result

The strategy is postulated on the same basis of paper consent form. The consent form was composed written part and signature part, which should kept image of signature or seal. The one time signature can makes one original consent form securely through above steps. This process can keep the current concept of consent form, so called originality and confidentiality. The digital pen can create hand written image for EMCF same as for the paper. The originality can be kept by separation, combination, and deletion of signature image, which was done by individuals. The confidentiality can be kept by creation of one XML document with Public certification and deletion of all the other files. For these procedures, there has been a development of new interface modules and UI, master tables for management consent form.

Conclusion

Our suggestion of new strategy and technical solution would give breakthrough to solve the issue of digital consent form with same approach of paper based consent form, especially in Korea. This process can keep the originality, confidentiality, and reproducibility of ECMF.

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MR Item as an Intermediate Terminology Between Terms and Clinical Document

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Abstract

Medical Record System is changing from paper document to electronic document. New era of electronic medical document system needs the basic terminology, however, it is difficult to realize Electronic Health Record (EHR) system through current terminology system. For the connection between terminology and clinical document (CD), the Medical Record (MR) item was innovated as a new concept. The basic concept and result of MR item is discussed.

Keywords:

terminology, EHR, MR item, CD

Introduction

The Clinical Document (CD) is a document that contains whole information derived from the process of interaction between patient and medical professionals. This kind of stored data should not be changed and interpreted differently as times go by. So, the structured terminology system has been developed, such as UMLS, SNOMED-CT, etc. However, authors find that terminology itself can not describe the interrelated characteristics of CD. We need more properties for the term and CD to express in reality. As an intermediate concept, so called MR item was used between terminology and CD.

Methods

All data was retrieved from the Electronic Health Record (EHR) system of one hospital located Seoul, Korea. The hospital has 2,100 beds, 2,500 clinicians, and 54 medical departments. All content item of CD were collected from 950 paper based CD. All items divided and subdivide by its usage and properties according to its own individual meaning. For this process, document analyzing tool was developed by the methodology of construction of database. This tool involves the variables of code, name of CD, type, unit, division, item group, and sub-item, etc. The collected data was transformed into Excel and MS SQL database to differentiate and extract same meaning in similar CD, same item from different CD, similar structure of items from different CD. The final items were managed by the MR item registration module.

Results

950 paper-based CDs were collected and analyzed. 63,232 terms are collected. The extracted final term with meaning properties, named MR item, are 13,287. Each MR item has 32 meaning variables, such as Type, Character Length, TxtBaseData, Numeric Base Data, Unit, Button Y/N, Action, Multi Line Y/N, Attribute, Width, Height etc. All clinical departments created 1,200 CDs through combination of MR items before implementation of EHR system. Continuous revision of MR item has been done for 1 year after implementation. 9,488 (41.7%) of MR items have been added (total 22,775) and 240 (1.8%) MR items have been changed.

Discussion

The priority of issue was how to create the vast of electronic CD easy to use and accurate to descript. The SNOMED CT has properties of term and concept as its characteristics. This enables to use one concept into several expressions. The other characteristic is the relation definition between terms. These characteristics enable the fine and self-controlled expression of clinical phenomenon. However, it can not express the objective of CD, the usability of CD. As an example, the item ‘admission path’ can be a same item in admission record and triage record of emergency room. if we hypothesize that this item is essential (should be recorded) item in admission record and is optional item in triage note, the SNOMED CT can not express this property, regardless of the content of record. This kind of property is significant for the working process in the real. This is a reason why the CD needs exchangeable property of meaning. It involves data type such as text, numeric, date, time, and etc. Also it involves the properties of check box, radio box, dropdown list, triggering event, whether or not to store in DB, and etc. These properties can be granted to MR item. The essentiality of ‘admission path’ could not be granted at the term level, instead it can be granted at higher level, MR item, in our

system. This intermediate concept of level can facilitate the usability of electronic CD and will maximize the efficiency of work process through CD.

The initial number of MR item has been increased continuously and only 1.8% of MR item has been changed. This means self-development and it would give maximum utility of EHR system.

Conclusion

The MR item, as an intermediate concept between terminology and clinical document, would facilitate the usage of clinical document and implementation of EHR system.

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Functional Analysis of Health Information System in Public Health Centers Focusing on Health Business Programs

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Abstract

The purpose of this study is to analyze the functionalities of Health Information System in Public Health Centers focused on Health Business Program. Field research was performed in accordance with the business guidelines of the Ministry of Health and Welfare. After analyzing the users' requirement and the functionalities of the system, we suggest a model of functionalities for interoperable EHR system. This will help to promote application of health information system and to improve efficiency of Public Health Centers.

Keywords:

Health Information System, public health Centers, health business program, health electronic health record

Methods

There were many Health Business Programs in Public Health Centers. To analyze function, we had to choose several Health Business Programs, which were considered as a important business and each had different work processes.

Nine Health Business Programs which recognized as key Health Business Programs in Public Health Care were selected.

Then, they have classified into following three categories: The First includes the Health Business Program which was managed by the local Health Information System. Second category includes the Health Business Program which was not managed by the local Health Information System but was managed by web system in common. Consequently, the personnel in charge of Health Business Program can't manage the cases by using their own Health Information System. Third category includes the Health Business Program has no Health Information System, so it was performed manually.

The methods of this study are as follow.

Analysis of the work process

Questionnaires and field interview survey were conducted at six Public Health Centers in Korea. And people in charge of each health business program named business manager were interviewed. After their work processes were inspected carefully, the functions of health information system and works performed manually using MS Excel or Word were investigated.

To show the functionalities, Unified Modeling Language (UML) was used, which showed the work process functionally.

Analysis the system of health business programs

The functions of business process of Health Information System that the manager use were analyzed. Functions were categorized into following three: mega process, major process and sub process.

Results

Analysis the work process

The health business managers perform the work of Health Business Program. They register the clients in Health Business Program and perform it. For example, they visit client's home and provided health care service. They also support the medical finance to the clients that allowed to reimbursement. And then the business managers report the results and statistics to the superior part . By these process, the clients are managed.

In short, it was analyzed that they have three mega processes. We called these functions as "registration", "acting" and "management"(Figure 1).

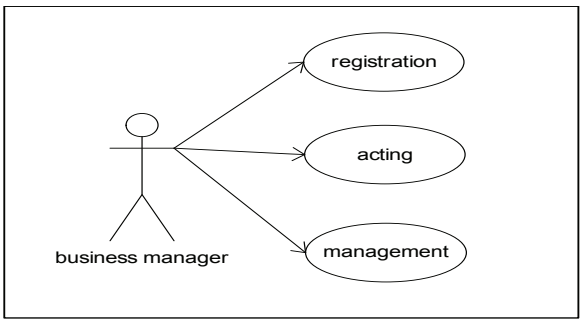

Figure 1 - Usecase Diagram: Health Business Program

Each Mega process was analyzed more detail level as following usecase diagram.(Figure2, 3, 4)

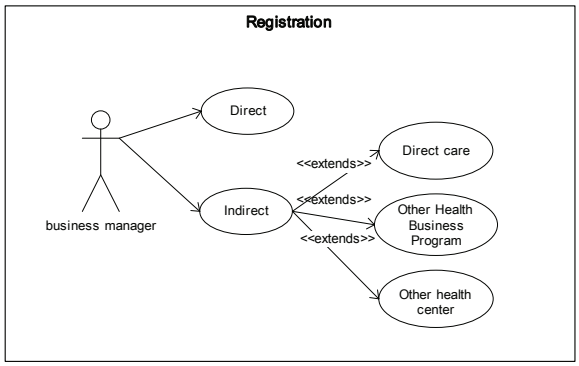

Figure 2 - Usecase Diagram: Registration

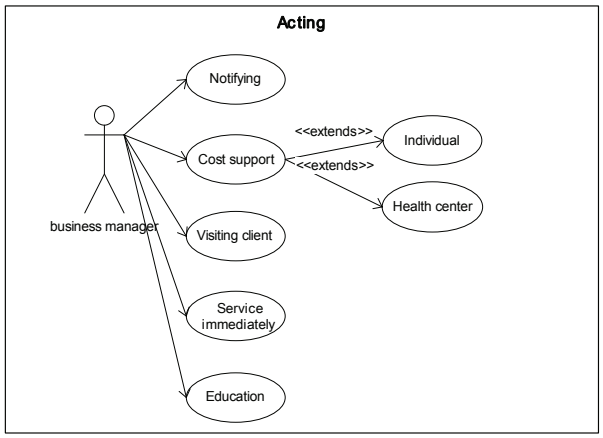

Figure 3 - Usecase Diagram: Acting

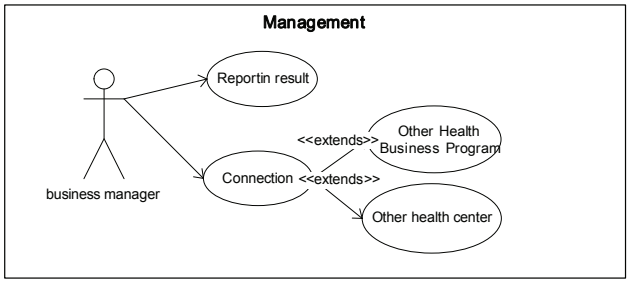

Figure 4 - Usecase Diagram: Management

Analysis the system of Health Business Programs

In Health Business Program, Health Information System hardly has been developed . Even in the case that the Health Information System has been developed, the business managers rarely use Health Information System., because the Health Information system in Public Health Centers couldn't support the functions that can interface among other Health Business Programs, and communicate between Public Health Center and other Health Centers. They are the most important functions for the business managers to perform their work. The functions of interface also are the core functions for the interoperable EHR system.

So, several symbols are marked. A Mark "" means that the function was performed by using Heath Information System in Public Health Center. A Mark "" means that the function was performed by using website in common system. Finally a mark "" means that the function doesn't have any Health Information System, so business managers performed manually.

Health Information System should be developed reflecting the end users' requirements. Our study could be helpful to engineers who develop Health Information System , so they could have a good understanding of medical domain. And that can help to reflect the users' requirements. Furthermore, the Health Information System would be adopted various Health Business Programs. Eventually these make increasing the efficiency of the user's business and make sure the implementation of interoperable Electronic Health Record System.

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Functional Analysis of Health Information System in Public Health Centers Focusing on Health Business Programs

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Abstract

- The purpose of this study
  - is to analyze the functionalities of Health Information System in Public Health Centers focused on Health Business Program.
  - Field research was performed in accordance with the business guidelines of the Ministry of Health and Welfare. After analyzing the users' requirement and the functionalities of the system, we suggest a model of functionalities for interoperable EHR system.
  - This will help to promote application of health information system and to improve efficiency of Public Health Centers.

Methods (1)

- There were many Health Business Programs in Public Health Centers.
  - To analyze function, we had to choose several Health Business Programs, which were considered as a important business and each had different work processes.

- Nine Health Business Programs which recognized as key Health Business Programs in Public Health Care were selected.

Methods (2)

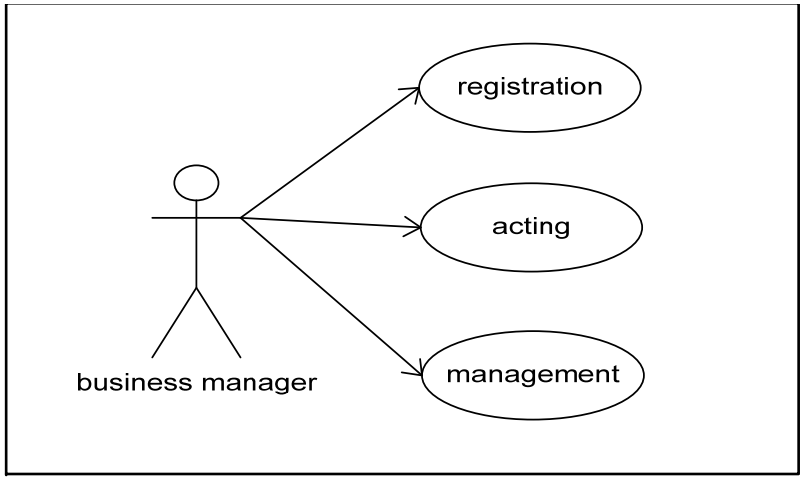
- Then, they have classified into following three categories:
  - The First includes the Health Business Program which was managed by the local Health Information System.
  - Second category includes the Health Business Program which was not managed by the local Health Information System but was managed by web system in common. Consequently, the personnel in charge of Health Business Program can't manage the cases by using their own Health Information System.
  - Third category includes the Health Business Program has no Health Information System, so it was performed manually.

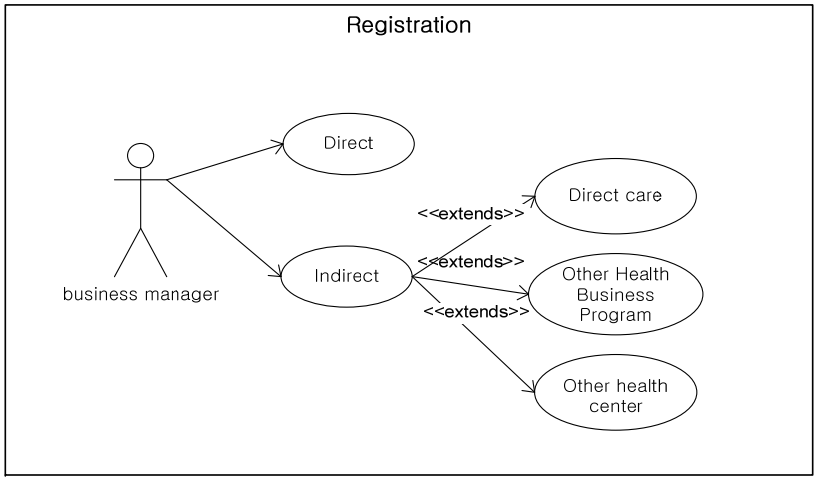
Methods (2)

- Analysis of the work process
  - Questionnaires and field interview survey were conducted at six Public Health Centers in Korea. And people in charge of each health business program named business manager were interviewed. After their work processes were inspected carefully, the functions of health information system and works performed manually using MS Excel or Word were investigated.
  - To show the functionalities, Unified Modeling Language (UML) was used, which showed the work process functionally.
- Analysis the system of health business programs
  - The functions of business process of Health Information System that the manager use were analyzed. Functions were categorized into following three: mega process, major process and sub process.

Results(1)

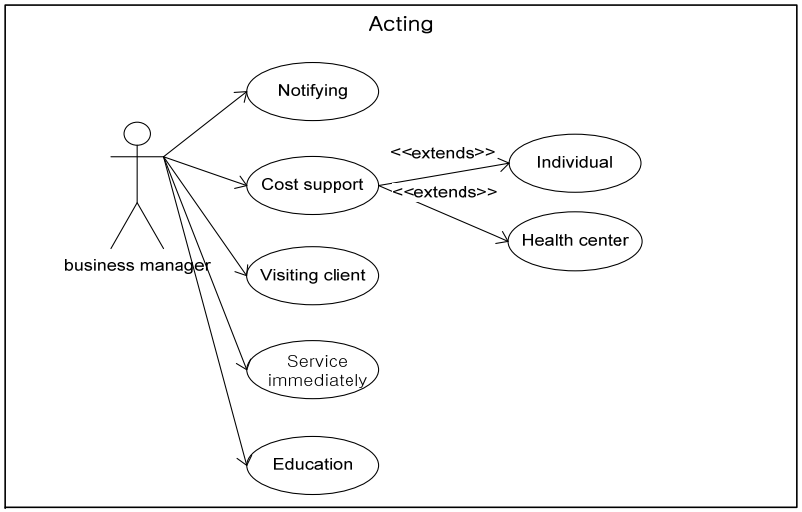
- Analysis the work process

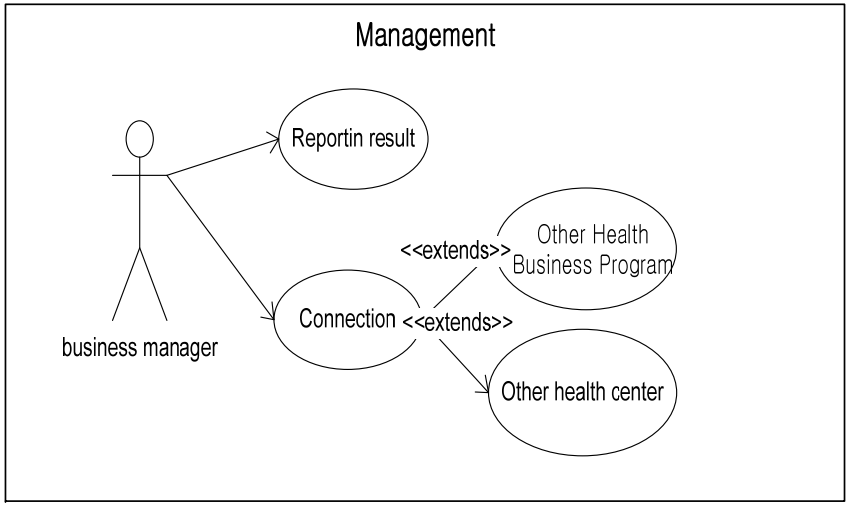




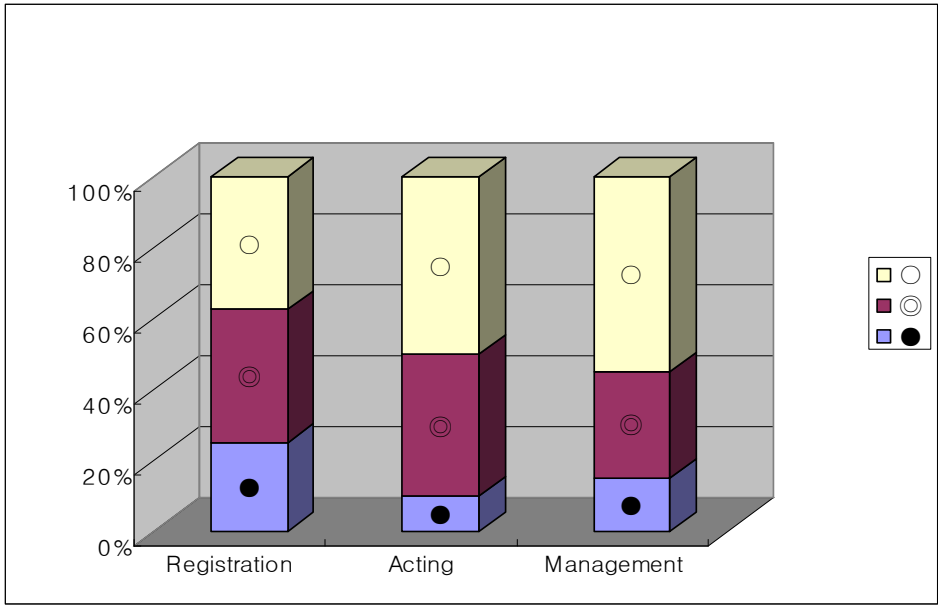
Results(2)

- Analysis the work process





Results(3)



Rate of functional using the Health Information System
(Sub process level)

Conclusion(1)

- Health business programs in public health center are recognized recently as essential activity of information system in Community Health. But actual condition can not support the effective management because there is little information system developed efficiently. From now on, establishing a health information system will be demanded for EHR system implementation.

- Health Information System offers an important infrastructure of efficient delivery and use of healthcare services. To develop the information system, it is important to develop a strategy covering the scope of work processes, public and private activities and adequate use of resources.

- So, in this study, we analyzed the function of Health Information System in Public Health Centers focused on Health Business Programs, which are recognized some core businesses in Public Health Centers.

Conclusion(2)

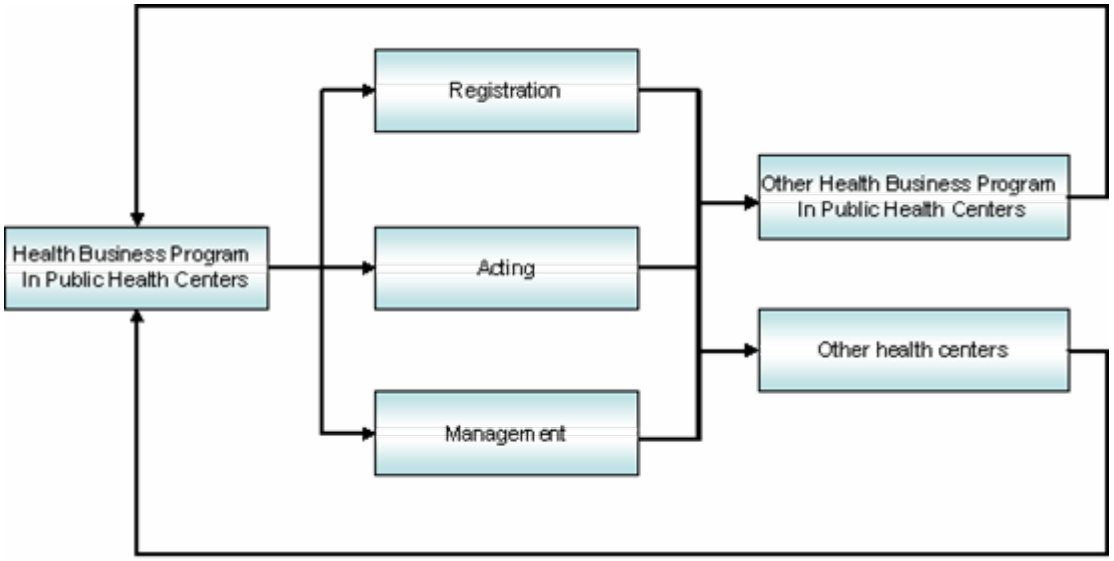
- In Public Health Centers, there are many different Health Business Programs. The Health Information System that supports the Health Business Programs was not integrated into a interoperable EHR system, but it has each Health Information System or has no Health Information System. This is why the functional analysis of Health Information System is significant.

- We showed that it lacks for interoperability on relations with the Systems of other Health Business Programs and the Systems in other health centers.

Conclusions(3)

- For the EHR functionality, health information systems should include functions we suggested. The model for interoperable EHR system will be derived.(Figure 6)

- *Figure 6. Model for interoperable EHR system in public health programs*



Conclusion(4)

- Electronic Health Record (EHR) systems need to offer a flexible framework for recording the consultation process, and accommodate the individuality of the clinician.[5]
- Health Information System should be developed reflecting the end users' requirements.
- Our study could be helpful to engineers who develop Health Information System , so they could have a good understanding of medical domain. And that can help to reflect the users' requirements. Furthermore, the Health Information System would be adopted various Health Business Programs. Eventually these make increasing the efficiency of the user's business and make sure the implementation of interoperable Electronic Health Record System.

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Preliminary Design of the Interoperable EHR Data Architecture in Korea

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Abstract and objective

Today, interoperable EHR architecture is being developed by key advanced countries but at present time, it remains as a high level conceptual model. In Korea, the center for interoperable EHR is currently developing Interoperable EHR architecture[1] to implement efficient national healthcare information network (NHIN). This study presented preliminary level design to define data architecture of interoperable EHR. To this end, the data model derived from this study should be in accordance with international standards such as HL7 Reference Information Model or openEHR Archetype Model.

Keywords:

National Healthcare Information Network, interoperable electronic health record, data architecture

Introduction

International standards related with interoperable EHR are focused on lifetime health record and ensuring interoperability, their difference depends on the use of information model for EHR. According to the experience of countries including US, UK, Australia and Canada, various approach methods have been adopted. Research aiming to obtain semantic interoperability of EHR solution based on standardized terminology is underway, however none have been introduced in detail regarding health and medical related data actually exchanged between EHR solutions yet. The purpose of this study is to define the information to be shared in EHR architecture and to select data elements for providing the NHIN service.

Methods

At first, we surveyed and analyzed the shared clinical information elements in several domestic and foreign studies. In domestic studies conducted in 2000 and 2003 as part of a healthcare information project, standardized data elements were proposed for clinical information exchange among hospitals. Then we added the data elements abstracted from international researches, HealthConnect in Australia[2], Continuity Care of Record (CCR) in US, and the Japanese Set of Identifiers for Medical Record Information Exchange (JMIX) in Japan. In addition, we carried out research on the scope of clinical data exchange between the main hospital and the branch hospital in Korea and found out how they exchange patient referral and result for referral, discharge summary, clinical finding, and medication information. Secondly, clinical information was classified and derived from requirements in EHR business architecture. Also general requirements and information to support data domain classified from the EHR infrastructure were extracted. Lastly, we classified these data elements from above two steps as common and essential data elements.

Results

The sharable data elements in EHR system were suggested in two aspects. One is for the essential 27 data elements including patient demographic information and clinical information such as chief complaint, lab findings, principle diagnosis, etc. regarding discharge summary. The other is 29 information scopes and 377 data elements to exchange healthcare information. The result does not confirm EHR data architecture as the data model for Korea but proposes data items for shared clinical information through verifications made by expert group and survey on domestic medical institutions in the future. Furthermore compliance with international standard shall be considered and ultimately the logical level shall be detailed.

Acknowledgment

This study was supported by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare in Republic of Korea (A050909).

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[1] Center for Interoperable EHR, EHR Architecture Conceptual Modeling V1.0. Korea, 2006.
[2] Linda May, Eric Browne, Lorraine Rayson, Lorraine Anderson, Stephen Chu, Part B – Health Event Summaries, HER Lists and EHR Views. Clinical Information Project in DoHA(Department of Health and Ageing), 2004

Preliminary Design of the Interoperable EHR Data Architecture in Korea

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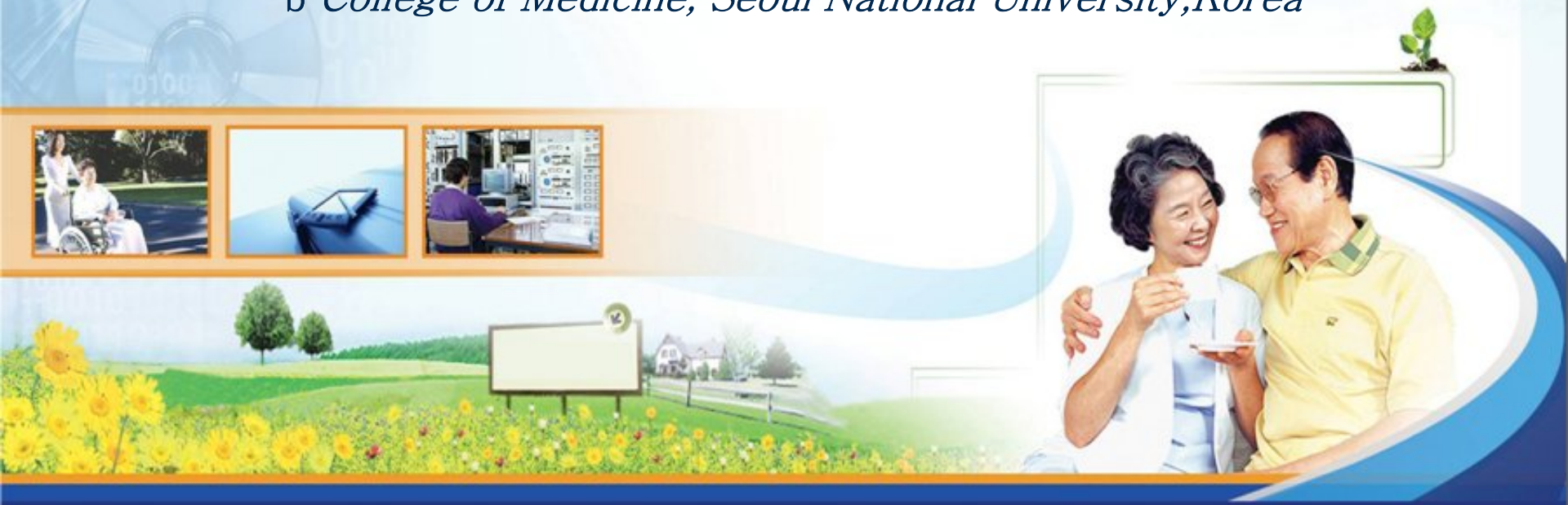
b *College of Medicine, Seoul National University,Korea*



Center for Interoperable EHR

Content

Abstract and Keywords

Abstract

Today, interoperable EHR architecture is being developed by key advanced countries but at present time, it remains as a high level conceptual model. In Korea, the center for interoperable EHR is currently developing Interoperable EHR architecture to implement efficient national healthcare information network (NHIN). This study presented preliminary level design to define data architecture of interoperable EHR. To this end, the data model derived from this study should be in accordance with international standards such as HL7 Reference Information Model or openEHR Archetype Model .

Keywords

National Healthcare Information Network, Interoperable Electronic Health Record, Data Architecture

Introduction

- Providing Lifetime EHR for ensuring consumer rights and improving self-care through Korea National Health Information Network
- Ensuring interoperability through International standards related with interoperable EHR
- But,

  according to countries such as US, UK, Australia and Canada, various approaches and information models for EHR have been adopted.
- Also,

  none have been introduced in detail regarding the actual clinical information that needs to be exchanged between medical institutions yet.

Methods

Approach → Survey & Analysis → Classification & Propositon

1 Survey and Analysis

- The shard clinical information elements in domestic studies
- The shard clinical information elements between domestic hospitals
- The shard clinical information elements in foreign studies

2 Classification

- From requirements in EHR business architecture
- From general requirements in EHR infrastructure
- Compared with shared items throughout the previous studies

3 Proposition of the sharable data elements

- The essential data elements regarding discharge summary
- The common data elements to exchange healthcare information

Methods

Approach → Survey & Analysis → Classification & Proposition

Survey and Analysis

Domestic Studies

- "Information Strategic Planning for Sharable Clinical Information" (1999)
- "Study on forming the basis of sharable clinical information" (2003)

Exchange Between Domestic Hospitals

- Surveyed on the scope of clinical data exchange between the main hospital and the branch hospital in Korea :

  Seoul National University Hospital, Inhwa University Hospital, Samsung Seoul Hospital, National Health Corporation Ilsan Hospital

Foreign Studies

- Abstracted form international researches :

  HealthConnect in Australia, Continuity Care of Record in US,

  The Japanese Set of Identifiers for Medical Record Information Exchange in Japan

Methods

Approach → Survey & Analysis → Classification & Proposition

Classification

Key Business Requirements

- Lifetime Health Record
- Sharing of Clinically Relevant Information
- Sharing EHR Information across regions and institutions
- Support of Potential Services
- Privacy and Security
- Consumer Consent

Requirements In EHR Infrastructure

- EHR shared support service
- EHR access support service
- Terminology & medicine supplies service
- Repository management services
- Registry management service
- Internal & External linking services

Comparison Between Surveys

- Considered the requirements mentioned above
- Compared between domains of clinical information derived from previous studies
- Compared between data elements derived from previous studies
- Classified and derived the shared data from the three steps mentioned above

Methods

Approach → Survey & Analysis → Classification & Proposition

Proposition

The essential data elements

- The essential data is related to the discharge summary.
- The essential data is necessary to exchange health information to a minimum.

The common data elements

- The common data is derived from the repetition of the same terminology in the previous surveys.
- It is sure that the common data will need to improve healthcare delivery and the interoperability among different information systems or hospitals to the maximum.

The essential 27 data elements regarding discharge summary

Data Items for Shareable EHR

Information Groups	Detailed Data Items	N
Demographics	Patient Name, National UID, Birth Date, Gender, Address, Phone No., Mobile No.	7
Medical Institution	Hospital Name	1
Medical Record Management	Patient ID	1
Medical Staff	Specialist, Physician, Signature, Medical License	4
Discharge Summary	Admission date, Discharge date, Admission Dept. name, Discharge Dept. name, Chief complaint & Symptom, Diagnostic findings, Name of procedure & operation, Treatment result, Principal diagnosis, Other diagnoses, Codes of diagnoses, Discharge medication, F/U plan	14
Total : 5 Groups		27

Results

29 information scopes and 377 data elements to exchange healthcare information

Data Items for Shareable EHR

Information Groups	N	Information Groups	N
Demographics	15	Puerperal History	18
Occupation	1	Review of System	15
Guardian	1	Physical Examination	15
Death registration	11	Prescription	15
Consent	11	Referral/Consultation	19
Access to Medical Records	6	Diagnostic Lab Test	23
Medical Institution	4	Diagnostic Imaging	12
Medical Record Management	1	Medication	18
Insurance	5	Discharge Summary	13
Medical Staff	9	Emergency	20
Problem List	16	Operation	45
Immunization	13	Transfusion	9
Environmental Risk Factors	8	Diet/Nutrition	11
Past Medical History	17	Other Treatments	6
Prenatal History	20	Total : 29 Groups	377

Detailed Data Items

Examination Name, Examination Date, Reading date, Reading result, Comments, diagnosis, Name of referring Dept, Name of referring physician, Code of diagnosis, name of radiologist, Imaging

Order date, Commercial name, Chemical name, Drug code, Physician name, Problem ID, Prescription rationale, Order status, Dosage, Dosage unit, Administration route, Administration area, Interval & Frequency, Administration precaution, First administration date, Last administration date, Indicated diagnosis for drug

Admission date, Discharge date, Admission Dept. name, Discharge Dept. name, Chief complaint & Symptom, Diagnostic findings, Name of procedure & operation, Treatment result, Principal diagnosis, Other diagnoses, Codes of diagnoses, Discharge medication, F/U plan

Discussion and Conclusion

- The purpose of this study is to propose data elements for providing the NHIN service.
- The proposed data elements are classified and derived from many researches in domestic and foreign countries, such as Korea medical ISP for sharable clinical information, data for exchange between hospitals in Korea, HealthConnect in Australia, and Continuity Care of Record in US.
- These data elements are valuable and important in terms of interoperable EHR. Also, They will be utilized for defining a conceptual data architecture that is an initial step of interoperable EHR architecture at the national level in Korea.
- Future work will be proceeded with verification by surveys and close examinations from experts.

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[1] Center for Interoperable EHR, EHR Architecture Conceptual Modeling V1.0. Korea, 2006.

[2] Linda May, Eric Browne, Lorraine Rayson, Lorraine Anderson, Stephen Chu, Part B – Health Event Summaries, EHR Lists and EHR Views. Clinical Information Project in DoHA(Department of Health and Ageing), 2004

- Acknowledgement

This study was supported by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare in Republic of Korea (A050909).

Plan of Interoperable EHR in Korea

Ein-Jeong Hwang, Myoung-Ju Jeon, Young-Hwan Choi, Yoon Kim*

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College of Medicine, Seoul National University, Korea*

Outline

- Common Scenario
- Purpose and Method
- Interoperable EHR Architecture
- Future Plan

Purpose of Common Scenarios

Explain the relationship between the typical healthcare scenarios supported with EHR system and the deliverables of research projects carried out by CiEHR

Projects of Headquarter

- NH-ICT Plan
- EHR Architecture
- Integrated Terminology Model
- CDSS

Projects of Sub Teams

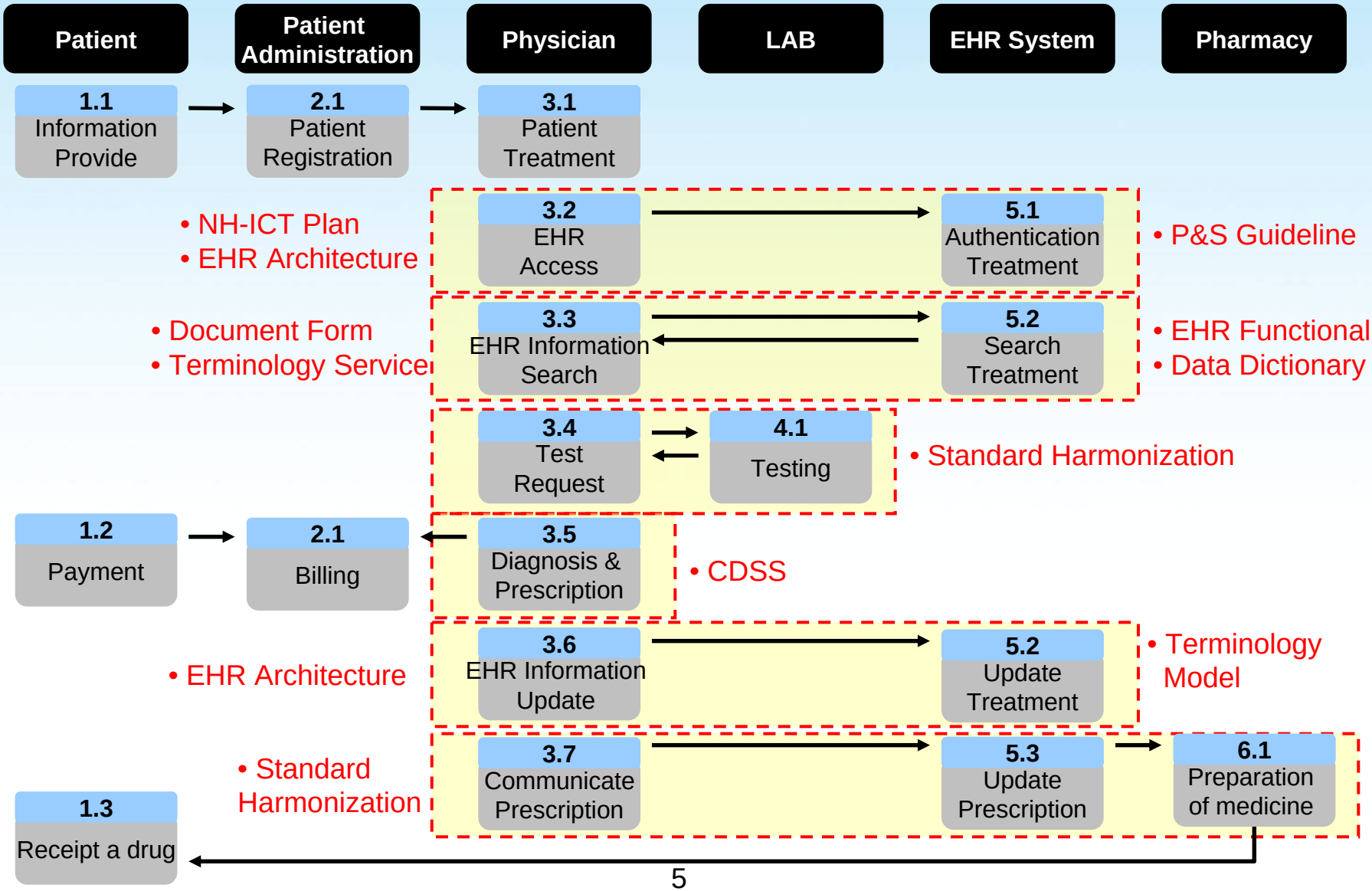
- EHR Functionality
- Data Dictionary and Document Form
- Standard Harmonization for Interoperability
- Terminology Service
- Private & Security Guidelines

Interoperability of Medical Record & Outpatient Clinic

1. Patient Mr. Kim visits Internal Medicine Department of HanGook Hospital.
2. Mr. Kim sees Dr. Lee after registering at the Patient Administration Department.
3. After receiving authentication for accessing EHR system, Dr. Lee accesses Mr. Kim's medical record in the hospital to review his past medical history.
4. Dr. Lee reviews recent information related to examination and test results of Internal Medicine Department.
5. Upon reviewing the EHR, Dr. Lee notes that Mr. Kim has been diagnosed for gastritis previously from another hospital and is allergic to 'A' medication.
6. Dr. Lee recommends and orders a gastroscopy to Mr. Kim for more detailed examination.
7. After completing the test, Dr. Lee makes the diagnosis, recurrent gastritis, to Mr. Kim.
8. Dr. Lee prescribes medication for the recurrent gastritis.
9. Mr. Kim pays the medical fee at the patient administration department of HanGook Hospital. He designates a pharmacy nearby his home to collect his medicine.
10. Mr. Kim collects his medicine prepared and ready for him at the designated pharmacy and returns home after paying for the medicine.

Common Scenario A – Workflow

Interoperability of Medical Record & Outpatient Clinic



Approach for Interoperable EHR

Business Architecture	**Framing Interoperability Business Scenario**	▪ General interoperable EHR scenario ▪ Emergency interoperable EHR scenario ▪ Bio-Surveillance scenario
	Definition of Interoperability Use-case	▪ Document EHR workflow about scenario ▪ Definition of EHR event and action
Purpose: Complement to EHR architecture using EHR use-case based on interoperability scenario		
Application Architecture	**Mapping of EHR Function and Application**	▪ Definition of EHR function using EHR event ▪ EHR application mapping based on the EHR function
	Major Decision Subject of EHR Architecture	▪ Patient Identifier ▪ Data Storage Format ▪ Adaptor System
	Definition of EHR Deployment Model	▪ Deployment of EHR service ▪ Deployment of EHR repository ▪ Definition of EHR deployment model
Purpose: Derive EHR function that support EHR business architecture. Definition of EHR deployment model based on analysis of considerable matters on EHR architecture.		

Framing Interoperability Business Scenario

Interoperable Business Scenario

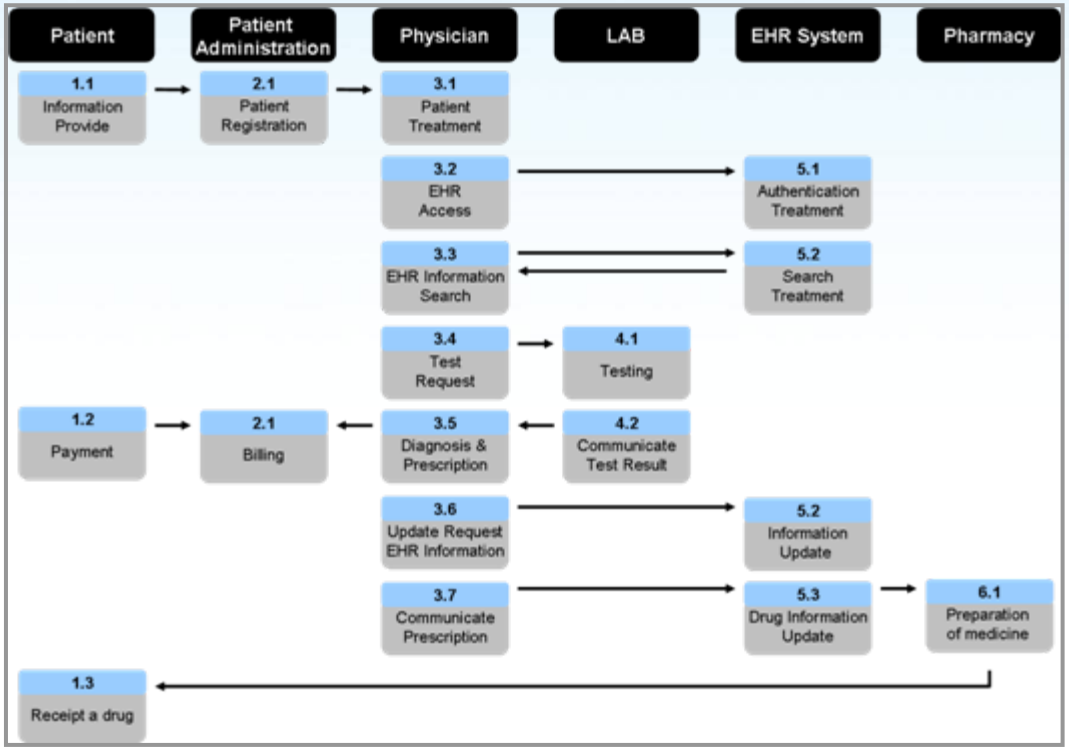
- A definition of scenarios in 3 main areas (the general interoperable EHR, emergency and Bio-Surveillance)
- 5 detail scenarios regarding general interoperable EHR.

EHR System Workflow

- A definition of a workflow between EHR system and major actors based on the scenarios.
- Description of how the EHR system works in order to realize each scenario.

Scenario of outpatient interoperability

Patient Mr. Kim visits Internal Medicine Department of HanGook Hospital. …



Events and Actions of EHR System

Derive event and action of EHR system: Bio-surveillance

- Definition of EHR events between actors and actions of the events
- Events and actions are connected with requirements of EHR function on EHR service

1.1 Surveillance Agency

- 1.1.1.0 Surveillance Policy Making
  - 1.1.1.1 Surveillance Target Selection
  - 1.1.1.2 Surveillance Policy Publication
- 1.1.2.0 Surveillance Policy Complete
  - 1.1.2.1 Policy Canceling Information Transmit
- 1.1.3.0 Surveillance Information Access
  - 1.1.3.1 EHR Service Registration
  - 1.1.3.2 EHR Service Access
  - 1.1.3.3 Surveillance Information Search
  - 1.1.3.4 Surveillance Information Download

1.2. IT Administrator

- 1.2.1.0 HIS Function Setting for Policy
  - 1.2.1.1 Event Registration / Cancellation
  - 1.2.1.2 Data Type Registration Process

1.4 EHR Service

- 1.4.1.0 User Management
  - 1.4.1.1 Grant EHR User ID
  - 1.4.1.2 Grant EHR Service Access Authority
- 1.4.2.0 Bio-Surveillance Access Control
  - 1.4.2.1 User Access Permission
  - 1.4.2.2 Reply Search Request
  - 1.4.2.3 Access Log Management
- 1.4.3.0 Report Management
  - 1.4.3.1 Terminology Mapping
  - 1.4.3.2 Form Creation
  - 1.4.3.3 Report Form Management
  - 1.4.3.4 Surveillance Information Transmit
  - 1.4.3.5 Transmit Log Management
  - 1.4.3.6 System Linking
- 1.4.4.0 Bio-Surveillance Information Mgt
  - 1.4.4.1 HIS Save Request Process
  - 1.4.4.2 Save Request Error Management

EHR Functions and Services

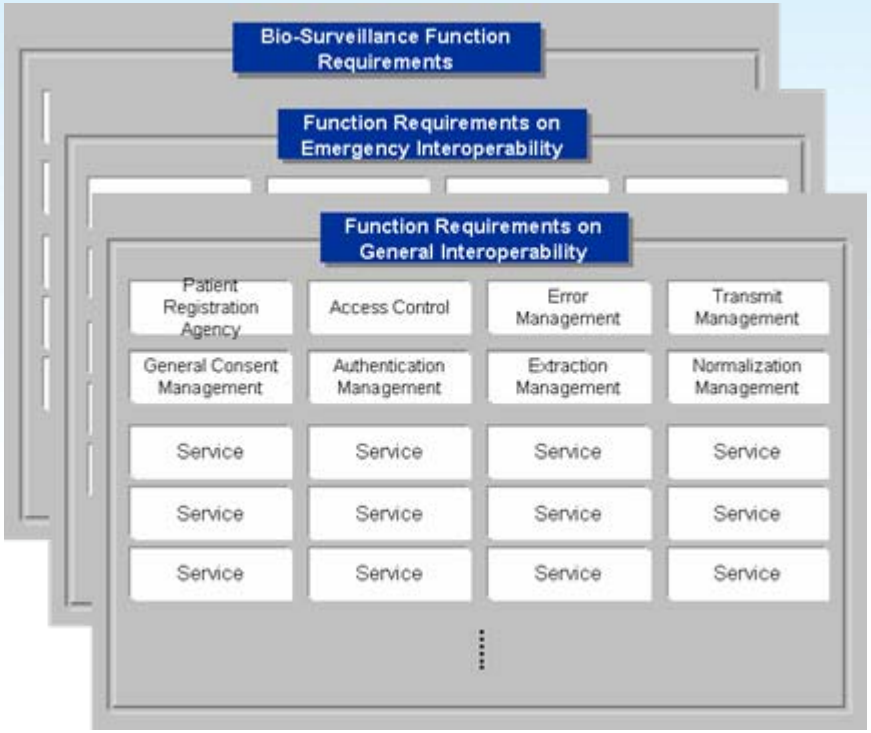
EHR Functional Requirements

- Derive EHR functional requirements from EHR actions of scenarios
- Definition of EHR service from EHR function Requirements.

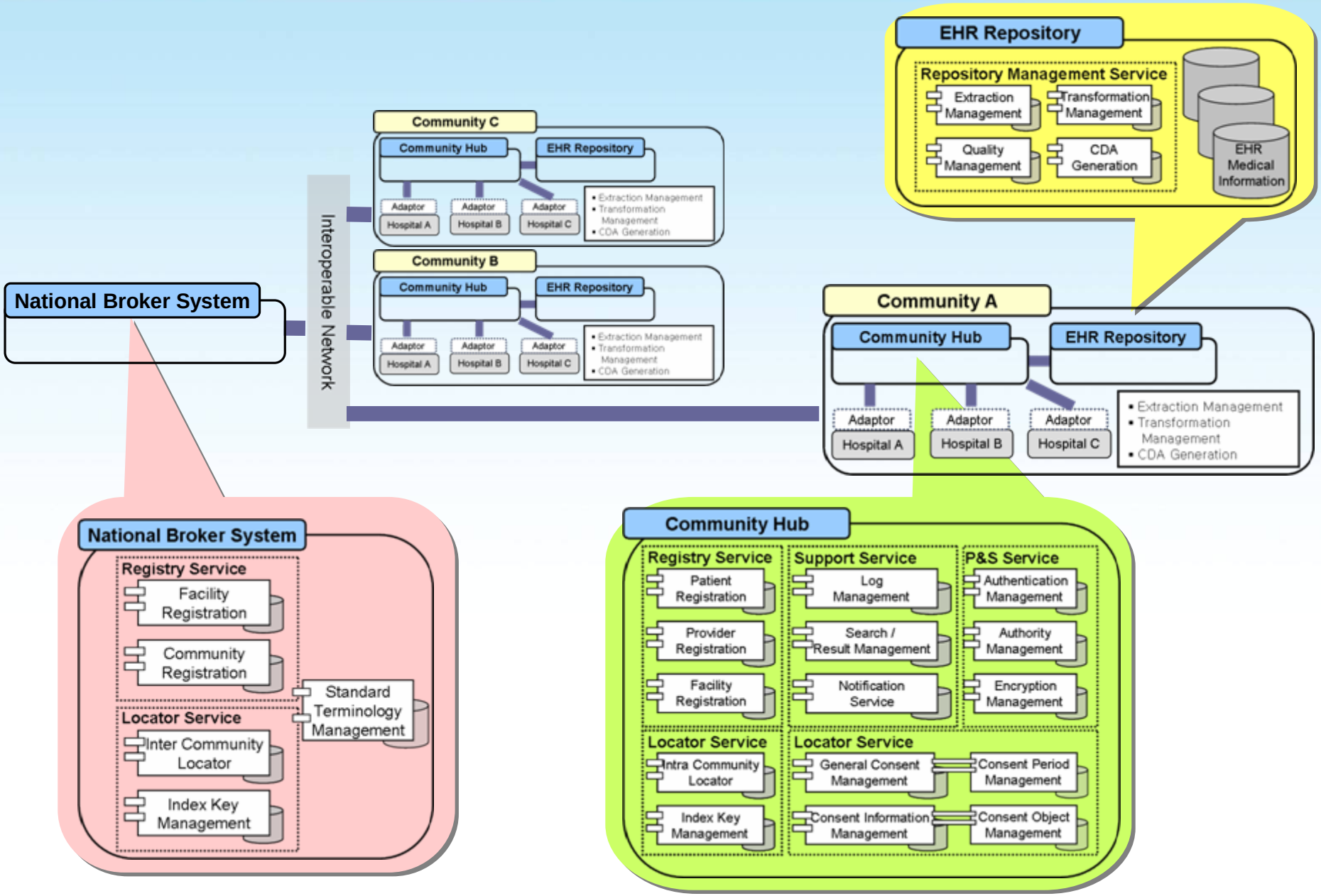
Event	Action	Functional Requirements	Functions
Request for search of patient record	Verification Query	EHR system requires error verification function of query to search EHR information.	Error Management
		EHR system requires correct result transmit function of search query.	Search and Provide Result
	Authentication and Verification of Provider	EHR system must involve function providers authentication .	Authentication Management
	Permission of Medical Record Transmit	EHR system must verify authenticated user and patient consent and permit transmit information.	Authority Management
	Transmit Patient Medical Information to Provider	EHR system must have extraction function from EHR repository.	Extraction

Definition of EHR Service

- Definition EHR services on each scenarios



EHR Deployment Model



Overall Plan of EHR Architecture

Conceptual and Logical Architecture of Interoperable EHR for Safe Management of Life-time Healthcare Information

EHR Architecture Framework	Interoperable EHR Architecture	EHR Architecture Guideline
Architecture Models	Business Architecture	Public Health Information Service
Architectural Deliverables	Data Architecture	Connection to Interoperable EHR
	Application Architecture	

2006	2007	2008	2009	2010
Public Health Center	Public Medical Institutions	PHR	Lifetime Health Record	Data Warehouse Bio-surveillance

References, Acknowledgments

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Acknowledgments

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Child Leukemia Management System - A Pilot EHR Application Based on the *open*EHR Architecture

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Abstract

The openEHR foundation has developed an innovative design [1,2] for interoperable and future-proof Electronic Health Record (EHR) systems based on a dual model approach with a stable reference information model complemented by archetypes for specific clinical purposes

This paper presents an early implementation of openEHR specifications based on the requirement for a dedicated EHR to manage child leukemia treatment, which would enable an overview of all key data on given therapy and relevant observations.

It seems possible to build an EHR application with dedicated purpose on a generic EHR architecture. The two-level modelling and archetypes based EHR architecture seems to be useful for its potentials to improve EHR interoperability and sustainability.

Keywords:

Electronic Health Records, archetypes, *open*EHR, child leukaemia

Introduction

The collaboration with the pediatric oncology department of the Karolinska University Hospital, Sweden was started in 2004 to investigate a new type of IT solution for the management of chemotherapy for children with Lymphoblastic Leukemia in maintenance stage. We selected to test the two-level modeling approach, developed by the *open*EHR foundation and also the basis for the new CEN and ISO 13606 EHR communication standards. Such systems are totally configurable by the clinical content specifications, a.k.a. Archetypes, therefore very adaptive and sustainable.

However, when this project was started there was no previous implementation of *open*EHR in the Java programming language which we wanted to use for several reasons. We therefore had to start by the implementation of all of the core specifications of *open*EHR before we could build the specific leukemia application with its user and other interfaces. This implementation of the *open*EHR specifications later became the reference implementation in Java as reported elsewhere [3].

Methods

The system was implemented in Java programming language and built according to the design specifications from *open*EHR, namely the Reference Information Model (RM) and Archetype Model (AM). Since there was no existing Java implementation at that time, the team started from scratch and made initial implementation of the RM, AM and Archetype Language (ADL) parser. A layered approach has been used in the system design (Figure 1).

The presentation layer of the application is web-based. It is based on an open source Web application framework called Maverick [4]. The screen forms are generated using XML from the application with XSL transformation.

The business layer consists of two sub-layers, one generic EHR services layer and the other more Leukemia treatment related and less generic application specific layer. The generic EHR services provide common features that are necessary for any serious EHR applications for managing health records with considerations on, e.g. security and clinical terminologies.

The clinical requirement specific to Child leukaemia treatment management are modelled as archetypes, which contain detailed knowledge on how to represent observations necessary for monitoring patient that is undergoing chemotherapy in leukaemia maintenance stage. These include list of lab investigations, observation on adverse events, evaluation by the clinician, and finally medication about oral chemotherapy.

The persistence layer utilizes an Object-Relational Mapping tool called Hibernate [5] and a Relational Database Management System product MySQL [6]. The system is deployed as a J2EE application on a JBoss Application server [7].

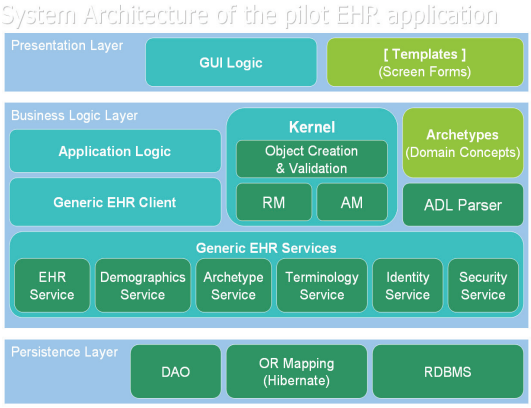

Figure 1- System Architecture of the pilot EHR application

Results

The Leukemia management system has been developed and is currently in the test phase. It records both demographic and clinical data for child leukemia treatment management. It renders all the information for a given patient and time period to a table or a diagram which gives the doctor an overview facilitating adjustment of oral chemotherapy. The clinical part of the system is totally driven by a Leukemia treatment archetype. Major part of the software has been donated to the openEHR Foundation and adopted as the Reference Implementation in Java [3, 7]. The implementation experience has been summarized in the openEHR Java Implementation Specification [8].

Discussion

The two-level modeling and archetype based EHR architecture used by this EHR application seems to be useful. It makes the system adaptive towards clinical requirement changes therefore more sustainable [9]. The separation between EHR system and EHR representation also improve the EHR interoperability [10]. But it also poses new challenges, e.g. term bindings between EHR data and external terminologies [11] and auto-generated screen forms based on archetypes [12, 13].

Conclusion

The fact that the Leukemia treatment management system is built on top of the *open*EHR architecture components proves that it is possible to build domain specific EHR applications in Java based on the generic design of *open*EHR with the two-level modelling approach. This work also led to the launch of the *open*EHR Java Reference Implementation Project and release of the core components as open source.

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Child Leukemia Management System
A Pilot EHR Application Based on the *open*EHR Architecture

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b Department of Medicine, Karolinska Institutet, Sweden

Introduction

- Collaboration with pediatric oncology department of the Karolinska University Hospital, Sweden
- Based on requirement for an integrated ICT support for child Leukemia treatment management
  - Auto-entered lab investigation results
  - On-going medications on oral chemotherapy
  - Observations on adverse-events
  - High-level overviews of records for given patient including all observations, adverse-events and medications
  - Clinical evaluation and adjustment of medications
  - Possibility for integrating decision support systems
- Testing two-level modelling and archetypes based EHR architecture

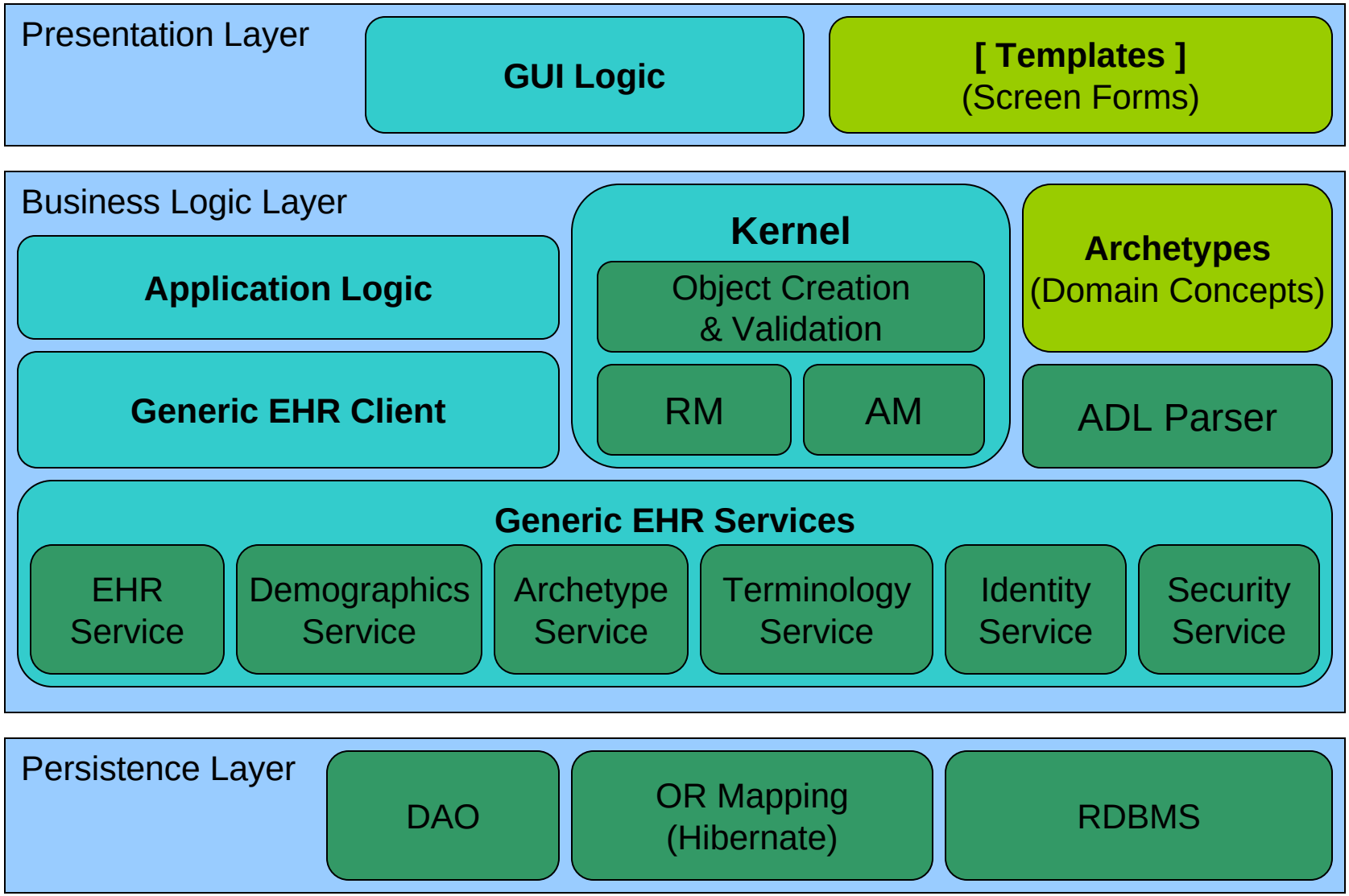
Methods

- Generic EHR system based on openEHR design specifications
  - Java implementation of the openEHR Reference Models and Archetype Model
  - Generic EHR Services
  - Application features: graphic or table overviews
- Clinical requirement modeled in archetypes
  - lab investigations
  - adverse-events
  - Overall evaluations
  - Medications: oral chemotherapy

Software methods

- Presentation layer
  - Web-based front-end using model-view-controller framework Maverick
  - Auto generated screen forms using XSLT transformation
- Business logic layer
  - Generic EHR services wired up using Spring Framework
  - Deployed in JBoss Application server
  - JAXB for XML data binding
  - JavaCC for producing Archetype Definition Language (ADL) parser
- Persistence layer
  - Hibernate for Object-relational mapping
  - MySQL as DBMS

System Architecture of the pilot EHR application



The main EHR archetype

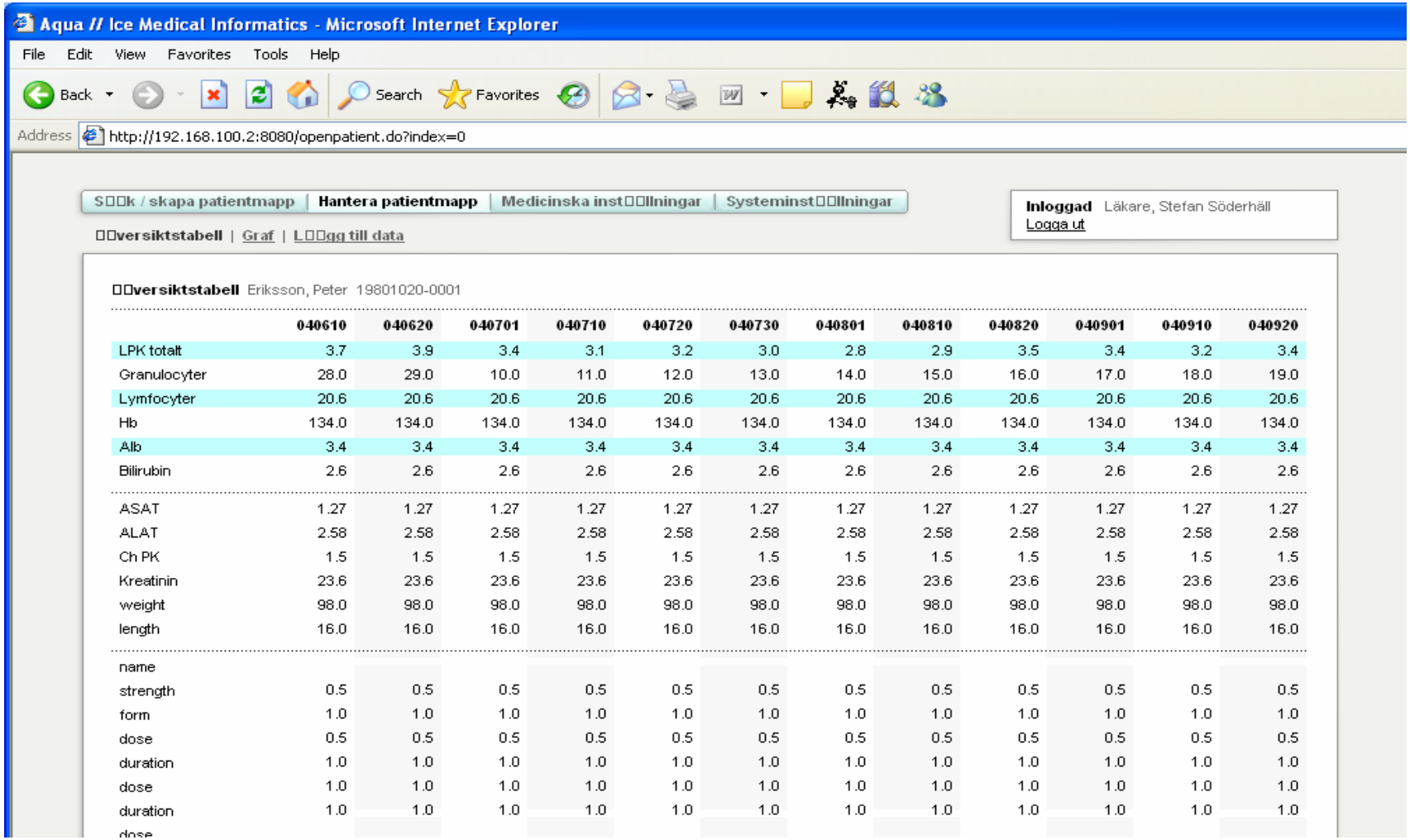
-EHR-COMPOSITION.leukemia_treatment.v3.adl - Eclipse SDK

Search Project Run Window Help

InspectorTest.java | Inspector.java | Occurrence.java | InspectionResult.... | TestClass.java | ArchetypeID.java | openEHR-demograph... | ope

```
22    rights = <copyright to ICE Medical Informatics, all rights reserved>
23
24  definition
25      COMPOSITION[at0000] matches {
26          content cardinality matches {*; ordered} matches {
27              SECTION[at0001] occurrences matches {0..1} matches {       -- observations
28                  items cardinality matches {*; ordered} matches {
29                      OBSERVATION[at4000] occurrences matches {0..1} matches {       -- observation for length and weight
30                          data matches {
31                              SINGLE_EVENT[at4001] matches {
32                                  origin matches {yyyy-mm-dd hh:mm:ss}
33                                  item matches {
34                                      ITEM_LIST[at4002] matches {
35                                          representation matches {
36                                              Cluster[at4003] matches {
37                                                  items cardinality matches {*; ordered} matches {
38                                                      ELEMENT[at4004] occurrences matches {0..1} matches {     -- weight
39                                                          value matches {
40                                                              DV_QUANTITY matches {
41                                                                  magnitude matches {|>0.0|}
42                                                                  units matches {"Kg"}
43                                                              }
44                                                          }
45                                                      }
46                                                      ELEMENT[at4005] occurrences matches {0..1} matches {     -- length
47                                                          value matches {
48                                                              DV_QUANTITY matches {
49                                                                  magnitude matches {|>0.0|}
50                                                                  units matches {"M"}
51                                                              }
```

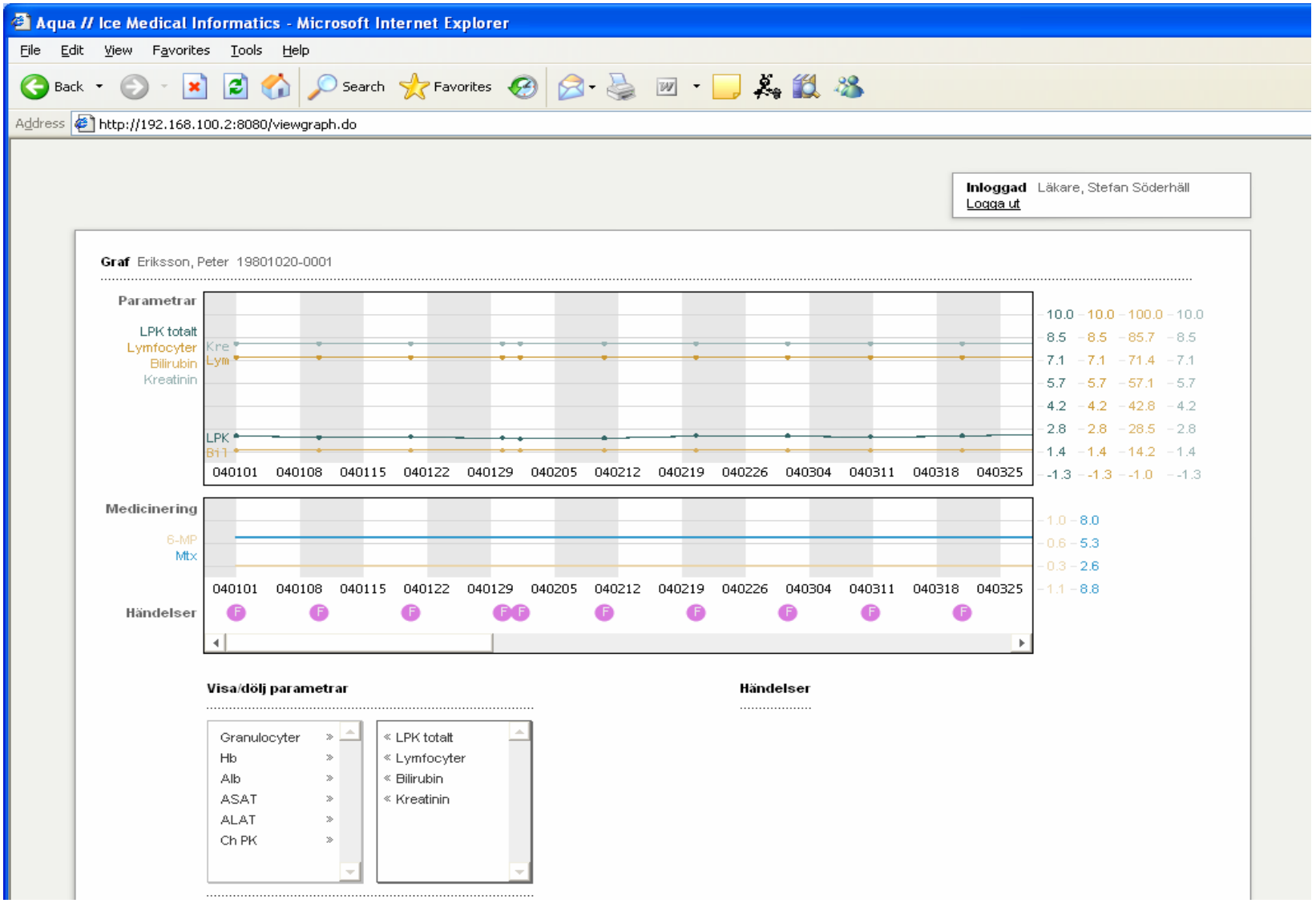
The table overview



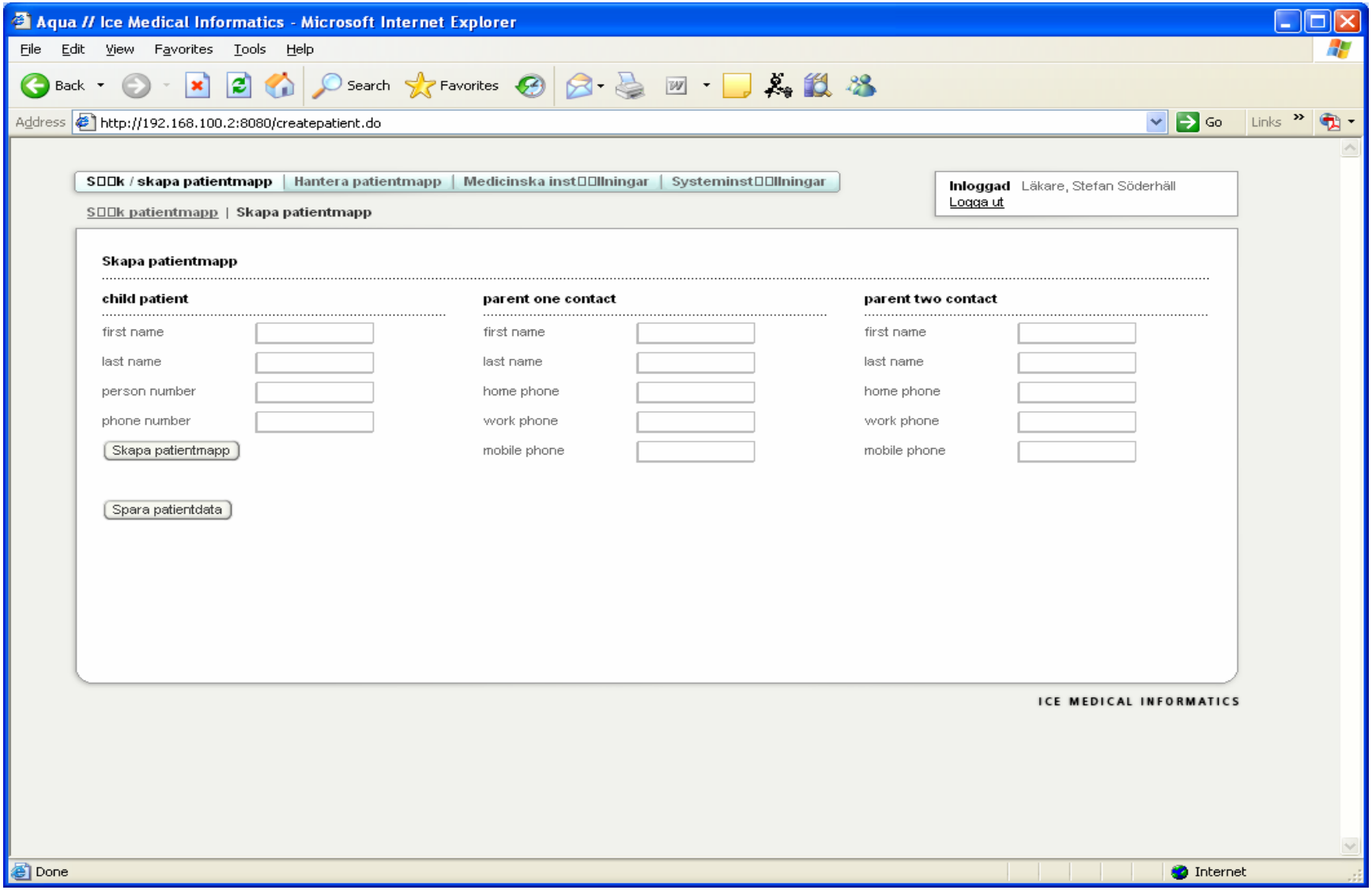
□□versiktstabell Eriksson, Peter 19801020-0001

	040610	040620	040701	040710	040720	040730	040801	040810	040820	040901	040910	040920
LPK totalt	3.7	3.9	3.4	3.1	3.2	3.0	2.8	2.9	3.5	3.4	3.2	3.4
Granulocyter	28.0	29.0	10.0	11.0	12.0	13.0	14.0	15.0	16.0	17.0	18.0	19.0
Lymfocyter	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6	20.6
Hb	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0	134.0
Alb	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4	3.4
Bilirubin	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
ASAT	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27	1.27
ALAT	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58	2.58
Ch PK	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
Kreatinin	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6	23.6
weight	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0	98.0
length	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0	16.0
name												
strength	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
form	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dose	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
duration	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dose	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
duration	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
dose												

The graph overview



Auto-generated screen form based on demographics archetype



Discussion

- Two-level model and archetype based EHR Architecture – a paradigm shift for building EHR applications
- More adaptive EHR Systems
  - Detailed clinical requirement modeled as archetypes unforeseeable by EHR developers
  - Generic EHR systems driven by archetypes authored by clinical professionals
  - Challenges
    - auto-generated screen forms based on archetype
    - Scalable persistence layer for fine-grained objects
    - integration between archetypes-driven part and non-archetypes-driven part of the system
- Improved EHR Interoperability
  - EHR models based on standards
  - Machine interpretable archetypes
  - Towards semantic interoperability by sharing meaning of expressions and terms thru bindings between EHR nodes and terminologies
  - Challenges
    - archetype governance
    - term bindings between EHR nodes and terminologies
    - effective EHR query based on archetypes

Conclusion

- Two-level modelling and archetypes based EHR architecture seems to be useful
- EHR independent EHR representation improves EHR interoperability
- Possible to build EHR applications for specific need based on generic EHR architecture

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We would like to thank the openEHR community for their contributions to the open source project.

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Plan of Interoperable EHR in Korea

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Abstract

This study describes the plan of development of interoperable EHR as the core element of National Information Network (NHIN) Framework in Korea. At the present time center for interoperable EHR is try to preparing architecture for EHR implementation. The EHR architecture could be composed of EHR functionality, data dictionary, standards, and Privacy and Security and these are essential elements for interoperable architecture design and Healthcare Information Technology (HIT) adoption of hospitals.

Keywords:

interoperable EHR, National Information Network, Healthcare Information Technology

Introduction

The aim of EHR implementation in Korea includes a Healthcare Information Technology (HIT) adoption of public hospitals and an interoperable EHR. Architecture for EHR implementation includes primary and secondary users' requirements, To-Be model related to EHR system functionality, standard documents, guideline of healthcare information exchange, and privacy and security.

Methods

In 2007, the plan of EHR architecture is aimed for implementing logical level. The steps of implementation are follows. First, the analysis of requirements for primary and secondary users as a clinical information exchange for patient care and a use of policy decision-making and research etc., respectively) and current status of general circumstance should be done. Second, EHR functionality with the work process To-Be model in the middle and large-sized hospitals is produced. Third, data dictionary will be structured by analyzing clinical documents of public hospitals. Standard clinical documents will be defined by users' agreements and then will be modeling CDA (Clinical Document Architecture)-based document structure. After third step, EHR functionality and stand clinical document will be matched.

Fourth, for implementing EHR services we will design a technical architecture for application architecture and technical standard. The shard EHR data (Laboratory, medication, health summary, image) has written scenarios and use case. Lastly, we make a Standard and Privacy and Security (P&S) guideline for interoperable EHR. In order to interoperable EHR, it is necessary to standard and P&S. Figure 1 shows the fundamental connection design for implementing EHR logical architecture.

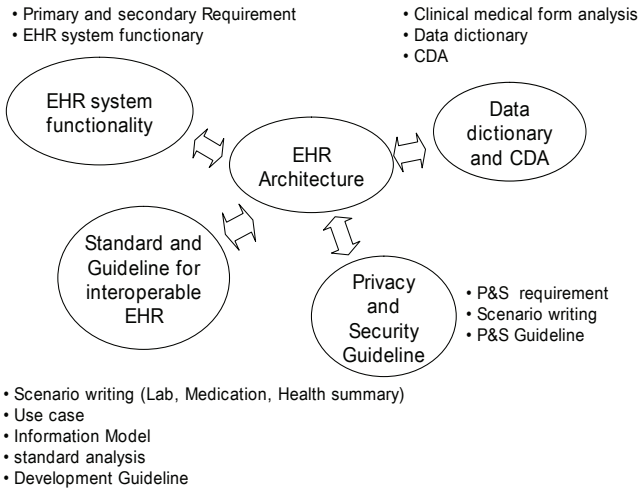

Figure 1-Fundamental connection design for EHR logical architecture

Results

This study presented a plan of implementing for EHR logical architecture. From now on, a more prescriptive approach will be needed to solve this EHR architecture.

Acknowledgments

This study was supported by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare in Republic of Korea (A050909).

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Development of Critical Pathway System based on Hospital Information System

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Abstract and objective

Usefulness of Critical Pathway (CP) method is widely recognized. However, there are still few examples of utilizing information technology for CP. We developed Electronic Critical Pathway System (e-Path) based on our Hospital Information System (HIS). Users can place orders from the e-Path and records made on e-Path are automatically transferred to Electronic Medical Record. Variance analysis and clinical assessment can be done by this system.

Keywords:

Critical Pathways, Hospital Information System

Introduction

Critical pathway (CP) is a useful tool for improvement of quality and efficiency of medical care. So far, more than 100 paper-based CPs have been prepared in Osaka University Hospital. There are some dissatisfactions in paper-based CPs. Entry columns are too small for daily record, so that doctors have to do a lot of redundant office duties such as order entry, nursing instruction and chart entry. Information of the patient is dispersed; coherence becomes tend to be lost in paper-based CP, which becomes the result where the advantages of CP are impaired. We developed e-Path which is well linked to MIS to solve these problems.

Description of e-Path

Overview

In our e-Path, a course of medical treatment can be divided into some periods (steps), in every period, orders are fixed and at the time of step end outcome assessment is done.

Our e-Path system consists of three parts: Path Editor, Path Entry and Path Application. First, users register s new CP in advance, various order information as well as nursing plan and nursing instruction can be set in the system. After a CP is applied to a patient by Path Entry, a concrete plan is displayed in overview form. With Path Application, the orders are processed by step. These consecutive records are recorded to the progress note of the Electronic Medical Record automatically.

Path Editor, Path Entry and Path Application

Path Editor is a system to design a new set of CP. First, base date such as admission day and day of surgery is set. Then what order should be placed on the relative day counted at the base date, and what nursing plan should be done is registered. Further, the item which is not order item such as verification matter and schedule of explanation can be registered. Variance which is expected in each CP is registered to the list in advance. The outcome of each step can be set, and the assessment item that is the condition to have to fill the outcome be set.

A patient is selected from the list in HIS, and a CP is applied to the patient concerned is selected. Some small adjustment can be made such as rescheduling surgery date due to holiday.

Path Application is a body of our e-Path System. All orders prior registered within current step are transferred ordering server and nursing plan is placed. Order correction can be made. There are check boxes to check non-order items when they are processed. In order to advance to the following step, outcome item must be achieved. When variance that should deviate from CP is occurred, the variance is registered, and CP is discontinued. After CP ends, the evaluation of the entire CP can be registered.

Integration with the Electronic Medical Record

Most information such as e-Path entry information, orders, outcomes, assessments, variances, non-order items, comments can be seen in progress notes or flow sheets in EMR. It is also possible to add and various records from the progress note as usual.

Results

The e-Path was introduced to respiratory ward in June 2006. Between June 1 and November 30, total number of cases is 52. Final evaluation had been done in 26 cases, 24 cases (92%) were appreciated that e-Path is effective.

Some disadvantages of e-Path have been point out. Individual order correction is more difficult than paper-based CP. Since medical documents of our institution have not fully computerized yet, staff still have to do redundant paperwork.

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The Need of an Electronic Version of Child Health Record. Development of Child Health Record Web Application, Pilot Phase

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Health Informatics Laboratory, Faculty of Nursing, National and Kapodistrian University of Athens, Greece

Abstract

Young children's health care is both an important and a complex need and it is related both to the surveillance of their physical and their psychological development. These data are mainly recorded in special booklets whose publication is under the supervision of the Ministry of Health. The Health Informatics Laboratory of the Faculty of Nursing of the National and Kapodistrian University of Athens, in an attempt to improve the process of obtaining data and the recording conditions of the aforementioned data, created the "Child Health Record Web Application" program. This is an electronic version of the Child Health Booklet (CHB), which is aimed at both parents and doctors, and which will contribute to the formation of health policies by the National Health System. The "Child Health Record" is an application that is accessed with a Web browser over the Internet. The program is at an early, trial stage, during which evaluations and views by a sample of possible future users are being assembled.

Keywords:

Medical Records Systems, computerized, child, internet

Introduction

The value and significance of preventive medicine is a generally accepted fact in the field of professional Health Care. Preventive medicine is advantageous in relation to therapeutic medicine since it has a greater influence on illness rates [1]. In paediatrics, more than any other medical specialty, preventive medicine has an especially significant place. Periodic preventive health surveillance takes up about 33% of the working time of the primary care paediatrician. This has the goal of preserving and improving child health [2].

In light of the obvious need for a program of systematic health inspection for children, the Ministry of Health has applied the institution of Child Health Booklet since 1976 [3]. In 1989 it established a program of child health inspection made up of pre-established clinical preventive examinations, whose results are noted in set individual health reports included in the CHB [4].

Many studies have concerned themselves with the evaluation of the CHB use in all these years [3], [5]-[9]. As a summary of these we can state that, despite the fact that the CHB has been introduced to everyday medical action, both parents and health professionals consciously or unconsciously ignore the greater part of its purpose with the result that the important value of the information it may carry with it, is lost. Far from the purpose it was designed to serve, the CHB is frequently just used as a vaccinations record card.

The reasons for CHB misuse go deeper than mere ignorance and should be sought out mainly in the areas of ergonomic value, availability and the principles of its design in general.

The need of an electronic version of the CHB

The CHB is a medical document, in which is recorded particular information concerning the child's health. In effect, it is part of the child's medical record. The well known and proved disadvantages of a manuscript health record, which are overcome by an electronic form, as well as the many advantages that the latter carries with it, are especially relevant in the case of children's health records.

The fact that children need to be treated differently from adults by medical professionals is one that cannot be ignored. Correspondingly, a child's health record partly differs from an adult's health record. There are special characteristics indispensable to an electronic system that seeks to support children's medical treatment. The fulfilment of these prerequisites – in addition to the basic fundamentals that apply in the case of adults – will result in the realization of all the advantages of an E-version of the CHB. There are differences in the following areas between a child's and an adult's health record:

1. Type of data (development information, newborn's name, special paediatric glossary, range of normal rates per age, time of birth).
2. Data processing (vaccinations, special requirements for instructions to the parents, standard reports).
3. System design (special issues of confidentiality, paediatric work conditions, family links, connections with the national district offices) [10].

Materials and methods

Description of the construction

The web page contains basic information regarding the CHB. It aims to draw the interest of health professionals, students in Health faculties and parents. It exists in a Greek and an English language version.

The electronic address of the web page is as follows: http://www.childhealthrecord.com. The apposite screen analysis is 1280X1024 pixels (Figure 1).

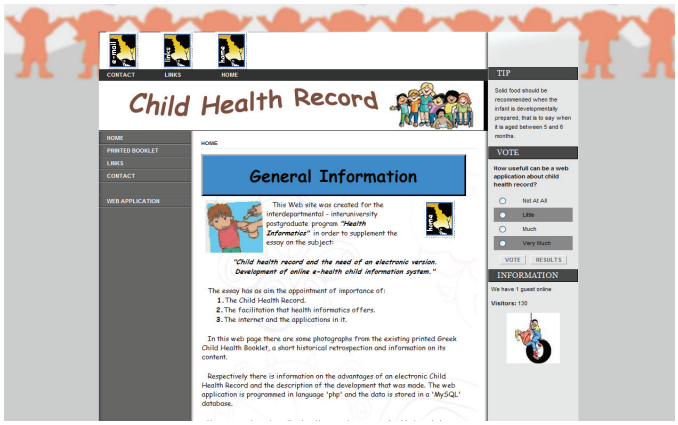

Figure 1- The first web page of the English version of the site

The creation of the application was done in PHP programming language, which has a high compatibility with the MySQL database. This language was used because it is considered as having the most advantages among programming languages such as ASP, Java [11]. JavaScript code was also used.

The application's graphics are HTML pages, frequently combined with CSS. The tables of the database – planned previous to programming – were created representing the subject of the data.

The application's window is of sized 780X600 pixels. The window does not demonstrate the menu and toolbars that normally go with the web browser.

Actors

The application users are divided in three roles. The user might be a parent, who will only be able to browse information, a doctor, who may browse and edit information and the administrator, who will be able to add or delete children in addition to the above uses.

Entrance to the application is enabled through inputting the username and password that the user is required to type on the application's first page.

Contents

All screens were designed in such a way as to be pleasant to look at and easily read in the analyses used by today's majority of monitors. The site has created a friendly 'environment', since it is not only aimed at health professionals in search of an ergonomic site, but also to parents, who are to make up the majority of the site's users.

In almost all of the sites 'screens' there is a right-hand button named 'information', which directs the user to information or groups of information that are mainly directed to parents, explaining the contents and answering questions. The 'information' pages are connected to the initial report pages so that each time the information connected to the relevant data of the application appears.

The thematic units developed are those that exist in the printed version of the CHB, updated and completed. Each unit appears in the form of a 'tag' and navigation is enabled through a bar at its lower part (Figure 2).

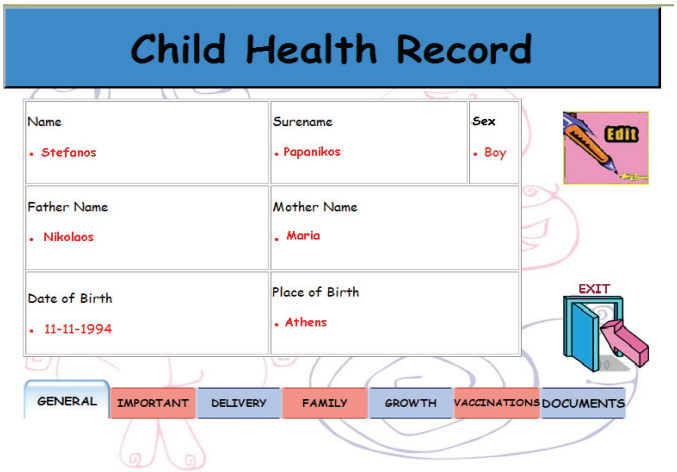

Figure 2 -"General" tag of the web application

Initially, there is the general information – demographic data concerning the child (Name, Date of Birth etc).

A separate 'card' is devoted to important information of which the doctor should be aware, such as allergies, enzyme deficiencies, serious illnesses and conditions.

Next, follow information concerning pregnancy and delivery (time, problems).

The parents' personal data and any chronic health problems are mentioned in detail.

The development card contains a powerful tool which enables the appearance of the child's somatometric data on the growth chart which presents the normal rates (Figure 3). In this card there is also contained information on the first infant examinations, psychokinetic development sup-

ported by images showing the attained abilities and dental problems.

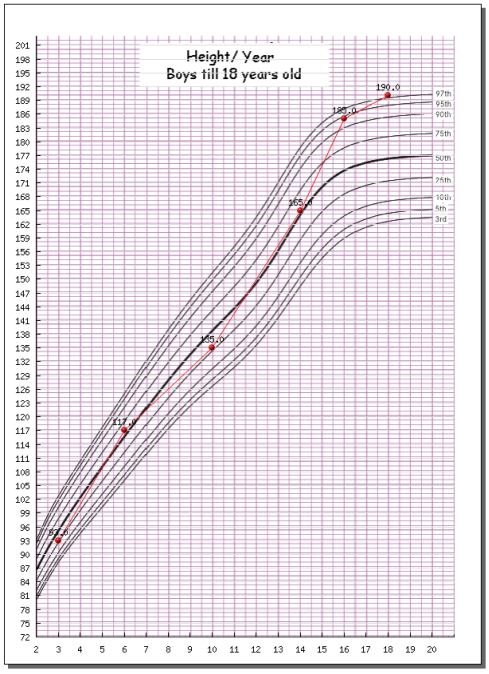

Figure 3 - Height growth chart for a boy (3 to 18 years old)

The vaccinations card, which demonstrates, in concentrated form, the diagram of compulsory vaccinations in Greece could not have been omitted from this card. There is also space for other vaccinations and for recording the date and type of the next planned vaccination (Figure 4).

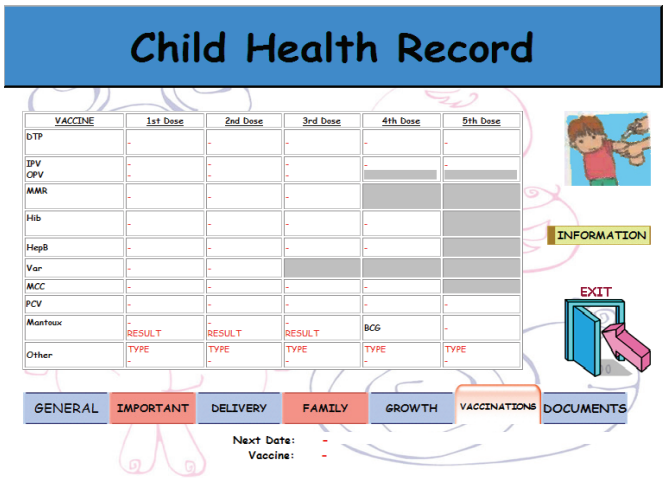

Figure 4 - Vaccinations card

The final card demonstrates three documents that need to be completed for the child's registration at school or the district office and during intervallic check-ups. They can be completed and printed electronically.

The doctor may alter the information by pressing the 'EDIT' button, which only appears if the password given belongs to a doctor. The rates for the relevant fields at the given time appear and the doctor is not obliged to re-enter all the data if s/he only wishes to change one. During the filing process, the process of selection is made easier as the doctor is requested to choose out of prepared answers that exhaust all possibilities (for example, sex: BOY/ GIRL). The input of all dates is done through an electronic calendar. During the input of a vaccination the doctor is requested to choose the vaccine and the dose. If the combination is wrong, the system will indicate the fact.

The date of birth is processed so that the child's age may be found and certain functions calculated automatically, such as the automatic choice of the correct category for filing the development data (A, B newborn examination, 0-36 months or 3-18 years).

The doctor – and the parent – is enabled, by pressing the 'information' button, to see the time-plan of the child's vaccinations and the period in which the child will be at the time will be highlighted in yellow, through an automatic calculation based on the date of birth.

In the same way, sex defines which development diagrams will be chosen and presented to the user. If sex has not been filed, the user will be requested to indicate sex.

Finally, the administrator will be able to view, analyze and make copies of all tables included in the database. The most important of these are the tables showing who entered the site and when, the changes s/he made and when s/he left the site. Apart from this, however, there are two buttons for the simplification of routine tasks, such as the addition of a new child or the deletion or edition of the data of another. During the addition of a new child to the database, two passwords are agreed upon, one for the parents and one for the doctor. The same combination of username as that of another child is forbidden, as also the identical passwords. In deletion-edition, there is a search filter for the child, who can then be deleted or its data edited.

Evaluation

A questionnaire containing 15 evaluation questions was created and 100 students from the faculty of nursing were asked to use the application and answer the questions as future health providers, parents and health system managers. The questions requested of the students to evaluate the application regarding completeness of the contents, availability, speed, safety, ergonomic value, possible contribution to health, general impressions and to add a comment. Each question had a scale of 5 answers with 1 as the lowest level and 5 as the highest level of achievement.

Pre-evaluation by possible users may have much to offer as far as improvement and completion of the application are concerned, prior to the distribution of the application to real users.

Results

The outcome is well presented in Table 1.

Table 1 – Answer averages (approximated)

Question	Answer as health provider	Answer as parent	Answer as manager
Availability	5	5	5
Usability	3	4	4
Data Presenta-	4	5	4
Browsing	3	4	4
General Content	4	5	4
Medical Con-	4	5	5
Vaccination	5	5	5
Information	4	5	4
Other content	5	5	5
Retrieve Speed	3	3	4
Store Speed	3	-	4
Security	3	2	4
Electronic	5	4	5
Contribution to	4	5	5
General Impres-	4	5	5

Discussion

The choice of the critical sector of the paediatric health record brought us face to face with three groups of people using it: the parents, the health professionals and the health system managers. The results of the pre-evaluation can be easily explained by analyzing the views, expectations and reservations of each group separately.

The parents' views

The children's parents are well aware of the fact that health care is made up of many and complex information drawn from various sources and they have certain worries regarding the way in which the data concerning the health of their children are filed. Parents are well aware of the need for regular health checks, evaluation, vaccination and preventive services for their children and there is a general acceptance among them of electronic systems for the coordination of health care.

However, families with multiple sources of health care are quick in realizing that access to and movement of information may become problematic, with delays and difficulties in ER, specialized surgeries, public hospitals etc. Parents also report that frequently they themselves have to act as mediators between the suppliers for test results, clinical instructions, pharmaceutical prescriptions and in general for all information concerning the past, in a struggle to keep at bay the possibility of unsuitable treatments due to lost information.

Many parents worry that easy access to their children's health records is not available and they often report reactions to wrong medicines as examples of things that could be avoided through an electronic system. Parents are also aware of the importance of timely vaccinations, as they are conscious of the fact that the challenge lies in changing the progressively more complex programs of archive conservation required for the introduction of medical care in schools.

A small, but often effusive percentage of parents appear to be suspicious of large, centralized data systems in private, and even more so in public hands. So parents want to actively hold and manage their child's medical record themselves, and request access to recordings as well as the right to insert their own comments. Some parents are further concerned with the fact that data are given to employers, parents that have not been granted child custody etc, and they request the deletion of certain information.

All parents hold the view that there should be a way in which they may be informed in simple words on the various matters connected to childcare. They are asking for an information system, which will supply them with expert information and advice on such topics as breastfeeding, nutrition, correct child development etc [12].

The health professionals' views

Electronic health records exist so as to transport data to and from the suppliers of health services. Doctors, understandably give more thought to the information that they should receive than to the information they are requested to disclose. They recognize, nevertheless, the needs and expenses of both centralized and decentralized channels. They would rather have access to an efficient, friendly, flexible, reliable incremental source of all they should know, as well as an incremental, economical 'device' for passing on data.

They believe that such a health information system would be able to give them fuller and more reliable information regarding vaccinations, medication and certain examinations and for extra-medical services that their patients receive. The system should also enable them to send this information to colleagues, schools etc. They require from

the system to automatically produce notifications, parent reminders, diagrams showing the gaps in immunization, notifications regarding critical laboratory rates or allergies to medicine and other important data. The doctors always have the most important share in the quality of care, but they know that these systems can improve this quality even further in everyday practice.

An information system like the one described above facilitates the securing of quality in medical practice. This, however, can turn against professionals as much as it acts favourably towards them. The profiles of clinical efficiency for the medical practice in a number of areas – such as the immunization percentages and screening tests – become higher and more sensitive, both for professionals and outside observers, such as insurance companies and health authorities. Doctors are sometimes worried that this data will be used to evaluate their work but without any consideration of the complex needs of the children under surveillance or of the working environment. In addition, the economic data are usually made accessible to insurance companies as well and these latter may discourage any new investments.

The doctors and the rest of the medical staff are also quite suspicious of large systems of electronic data, after years of disillusionment with older systems. They either had had to turn vanguard staff to people responsible for the difficult and painful task of recording data in an electronic form, or they never used the system. All this constitutes doctors suspicious towards new, demanding electronic systems in their offices.

Health Systems

Public health is part of both the distribution of information and the application of the population based policies and operations. As dispensers of paediatric services, public health programs share many of the hopes and qualms related to electronic versions of CHB. The public health sector is responsible for comprehensive preventive services as well as for the surveillance of patients, the regulation of health care and the state collection and analysis of health data. Each of the above has specific needs for information, which would be better collected if the electronic CHB had been in use.

The first objective of an electronic health data system is the reinforcement of the preventive health services for children, usually in the form of vaccination archives. The advantages of an electronic form include the system for newborns' screening tests, the evaluation of diet and the other services and these make the electronic version a much richer source of data for community practices, management and leadership of public health.

The allocation of licenses to suppliers of health services to children, such as paediatric clinics and private surgeries, is not subject to any form of control or monitoring. An overview of clinical data for each supplier would allow a health control panel to focus more on the quality and the outcome based value of health care provided, rather than spending itself on inspection raids.

Apart from the roles mentioned above, the health system also runs population based operations, in cooperation with community and private health care, such as the goal setting health promotion and the regular control of disease, which allow access to health care, health awareness at the workplace and the differences in the health level of minorities. Each one of these projects has a strong stem in childhood illnesses and could use the population's clinical data in order to improve the planning and evaluation of a program [13].

Conclusion

The transition to an electronic version of CHB can contribute significantly in the promotion of children's health and of society's health in general and can become a powerful tool for parents, professionals and state health planning.

In Greece, as in many other countries, the traditional, manuscript health records are still preserved. We believe that through the present study we can contribute to the acceleration of the changes towards an e-health system for children.

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A Survey on Shared Electronic Health Record Architectures in Europe

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Abstract

The EU e-Health action plan has initiated activities across Europe for e-Health and the creation of Shared Electronic Health Records (SEHR). Most of the member states are preparing or already have roadmaps and programs. Information on these activities, especially on the more technical aspects, is of great importance for informed decision making but very hard to find – due to the early stages and transitory phases in which those programs are currently in, with communication being considered no priority. To gain first hand insight, a survey was conducted amongst active experts in the field of SEHR, identified by having given topical presentations at selected international conferences in 2006. The survey was conducted online, with 35 participants (19.4 % of all approached) answering the questionnaire on general e-Health strategy, the SEHR program in general and technical aspects of the program. Of the participants, 80% know of an SEHR program in their country they could answer questions on. The majority judges the programs to be in their early stages and is sceptical against official statements for program completion timeframes. Trans-national (EU level) interoperability is only seen by 56% of the participants as an issue. The Internet protocol is exclusively seen as means of transport for the exchange of SEHR data. The majority foresees a mostly decentral federated architecture with central patient index, but federated metadata registries and data repositories for the SEHR. HL7 V3 CDA, DICOM and IHE XDS achieve highest ranking as standards and technical frameworks for realization of the SEHR. SEHR projects currently are in an early stage where specifications are not finalized and still subject to change. Research and pilot projects, that have in some cases been initiated more than a decade ago, are present in some countries giving directions for how pervasive solutions could work and have to be incorporated into future infrastructures.

Keywords:

electronic health records, e-Health, IHE, system architecture

Introduction

In its 2004 e-Health action plan [1], aligned with the eEurope action plan [2], the commission of the EU set ambitious goal to establish a European e-Health infrastructure until 2009. Several measures were defined, amongst them the development of national or regional roadmaps for e-Health by each member state by the end of 2005, the definition of a common approach to patient identification and interoperability standards for health data messages and electronic health records by the end of 2006, the deployment of health information networks for e-Health in the period 2004-2008, the provision of online services such as teleconsultation, e-prescription, e-referral, telemonitoring and telecare by the majority of European health organisations by the end of 2008, and a baseline for a standardised European qualification for e-Health services in clinical and administrative settings by the end of 2009.

This has sparked substantial activities among the EU member states, with a large variety of national and regional projects being started (see for instance [3] for the work on e-Health strategy in Austria).

One of the key elements for e-Health strategies is to establish a Shared Electronic Health Record (SEHR) for all citizens, meaning that elevant health related data for citizens is electronically shared across different providers in all the sectors of healthcare. Substantial benefits in terms of quality and productivity in a collaborative care setting are enabled by such infrastructure [4] and seen as indispensable in the future health system [5]

Even though the commission has also agreed in the e-Health action plan, that it will publish a study on the state of the art in deployment, examples of best practices, and the associated benefits biannually in the period 2004-2010 for benchmarking already resulting in valuable studies eg. in the e-Health ERA project [6,7,8], it is still very hard to find information on the functional and technical approaches pursued in the member states in the establishment of shared electronic health records. Studies on certain aspects of shared electronic health records with special focus on EU-wide interoperability like the one on patient summaries conducted in the e-Health ERA project [9] have become available, but also here, only 9 official state-

ments (by the national Ministry of Health or the national e-Health competence centre) were received and issues of health record system architecture were not considered.

Methods

Since information on the various approaches to these technical aspects are of great interest for those contributing to SEHR projects themselves, and currently reports are rarely available, a survey with this focus was made amongst those experts working on SEHR projects to collect their opinion on the scope and status of these projects. It is also interesting to see how e-Health strategies an SEHR programs are viewed by national experts, sometimes in disagreement with the statements of national strategies.

For the recruitment of participants for that survey, persons were identified who had either authored or co-authored papers related SEHR given at various conferences[1] in 2006 (to ensure that they are currently actively involved in this field) or who are representatives of national competence centres for e-Health. Additionally, the national representatives of EFMI (European Federation of Medical Informatics) were approached. Since the survey was conducted online, 180 persons were invited via email to participate on Nov 2 2006. With a reminder after one week, the survey was answered by 35 participants (19.4%) unt it was closed on Nov 20 2006.

Scope of the survey and participation

The online survey was composed of 23 questions in there groups: general questions on the e-Health program, questions on the SEHR program, questions on the SEHR architecture and functionality.

The 35 participants were from 18 countries – mostly European, with additional participation from Russia and Israel (5 from AT and NO, 4 from DE, 3 from IT, 2 from CH, DK, EE, SE, and 1 from FI, FR, GR, IL, IS, LT, PL, PT, RO, RU).

The participant judged themselves mostly as competent or very competent to answer the survey (Table 1):

Table 1 – Competence of participants

How competent do you feel to make statements on the national eHealth strategy with regard to shared electronic health records in that country?	participants
very competent (ie. actively involved in the national e-Health effort)	16 (46%)
competent (ie. expert on the subject with good insight into the national e-Health effort)	9 (26%)
slightly competent (ie. involved in certain aspects of the national e-Health effort)	9 (26%)
not competent (ie. not involved with the national e-Health effort)	1 (2%)

Of those 28 participants who stated there is an SEHR program in their country, their involvement with this program was characterized as described in Table 2:

Table 2 – Involvement in SEHR program

How are you involved with this SEHR program?	participants
Decision maker	3 (11 %)
Consultant	10 (36%)
Program team member	4 (14%)
Member of a stakeholder organization of the program	3 (11%)
Other - not directly affiliated with the program	8 (28%)

Since there were several participants from some of the countries, the agreement between those participants from the same country on selected questions could be determined to have a measure for the reliability of the survey results. The agreement was determined as the percentage of participants from one country giving the top ranking answer for one of 7 selected questions[2]. Taking the arithmetic mean of these values, an overall agreement of 79% was found. This indicates that there is generally a good consensus accurately reflecting the e-Health situation, but it also shows that there is a certain controversy in the expert opinion caused mainly by the transitory phase in which most of the countries are with respect to their e-Health programs (eg. the Austrian participants disagreed if there is an Austrian e-Health strategy – the strategy was completed by an expert group in December 2005 [3] but has not yet been official adopted by the Ministry of Health). It was noted by several participants that the sur-

1 The conferences considered are: Nordic e-Health Conference 2006 (Copenhagen, DK), EU e-Health Conference 2006 (Malaga, ES), e-Health Benchmarking 2006 (Hall, AT), Telemed 2006 (Berlin, DE), EuroPACS 2006 (Trondheim, NO), ICICTH 2006 (Samos, GR), MIE 2006 (Maastricht, NL), GMDS 2006 (Leipzig, DE), MIR 2006 (Budapest, HU).

2 Questions: Is there a national e-Health strategy in your country? When was it formulated? Estimate for the completion of SEHR program? Trans-national interoperability considered? Basis for patient identification? Basis for health professional identification? Network infrastructure?

vey does not allow to describe the transition phase in which some projects currently are and the coexistence of regional and national programs for SEHR within one country.

General results on e-Health strategy and the SEHR program

The initial question of the survey was on the existence of a national e-Health strategy in the respective country. A majority of 83% of the answers was positive (with disagreement from the Austrians whether the current document on the e-Health strategy can be considered official, and uncertainty from the Norwegians whether there is an official e-Health strategy in their country). Only PL, PT, RO, RU were definitely negative. This result is in good agreement with [8], where it is stated that 21 out of the 25 EU member states (84%) report having adopted a national e-Health roadmap (unfortunately, [8] is not specific with regard to the countries).

The time of formulation of the e-Health strategy was given as indicated in Table 3:

Table 3 – National strategy

Time of formulation of the eHealth strategy	participants
Currently being formulated or in draft status	6 (20%)
Formulated/last updated 2006	8 (27 %)
Formulated/last updated 2005	6 (20%)
Formulated/last updated 2000-2004	7 (23%)
Formulated/last updated before 2000	1 (3%)
Uncertain	2 (7%)

The agreement amongst the participants from one nation is not very good for this question – for Austria there is only 50% agreement, with one group stating that the 2005 strategy paper is the strategy, the others considering this preliminary and seeing the strategy currently being formulated.

With respect to the existence of a national SEHR program on which they can make statements on, 57% of the participants gave a positive answer (details in table 4). This is in good agreement with [8], where electronic health records are claimed to be on the e-Health roadmaps of 14 (of 25) European member states. For Austria, we see disagreement among the participants if there is one national program or several regional programs aligned with the national strategy – and one participant reports on a research focused program.

Table 4 – SEHR program in strategy

Type of program	participants	countries
national level public sector program part of national e-health strategy	15 (43%)	AT(2), DE(2), DK, EE, FI, IL, IT, LT, SE
regional level public sector program aligned with national e-health strategy	2 (6%)	AT(2)
regional level public sector program independent of national e-health strategy	2 (6%)	RO, PL
national level private sector program	0 (0%)	
regional level private sector program	1 (3%)	PT
research focused preparatory program	8 (23%)	AT(1), CH, DE(2), GR, IT, NO(1), RU
No SEHR program	7 (20%)	CH, FR, IS, NO(4)

Also for Germany, one part of the participants makes statements on the national program (which is currently not specific about SEHR but focused on e-prescription [10]), the other on research projects. Among the participants from Norway, one reports on a research program for SEHR, whereas the others see no SEHR program in their country. The vast majority sees national level public sector SEHR programs in their countries. Private sector SEHR programs are very rare.

Table 5 – SEHR timeframe

SEHR timeframe	According to official statements	According to private opinion
2006/already available	3 (12%)	1 (4%)
2007	4 (15%)	2 (8%)
2008	5 (19%)	1 (4%)
2009	1 (4%)	5 (19%)
2010	5 (19%)	7 (27%)
2011	0 (0%)	1 (4%)
2012 or later	1 (4%)	8 (31%)
No statement	7 (27%)	1 (4%)

The high percentage of research focused programs mentioned shows that SEHR is still very much in a transitory state, with concepts still being formulated. The names of

the SEHR projects given by the participants are listed in table 6.

The timeframe for the completion of a working SEHR with advanced functionality and coverage is seen fairly sceptical by the participants, with their private opinion being far behind official statements (table 5), with the majority seeing the completion of the SEHR project beyond 2012.

Table 6 – SEHR projects

Project name	Country	inhabitants covered
RTS-Rede Telemática da Saúde	PT	150
Electronic health certificate project (preliminary)	RU	
National EPR service	FI	5 million
bIT4Health, Telematikinfrastruktur und elektronische Gesundheitskarte	DE(4)	80 million
Israel National EHR Program	IL	5 million
Estonian Digital Health Record	EE	1.4 million
National e-Health System (NESS)	LT	3.5 million
Research and development programme for electronic health record, Norwegian University of Science and Technology (NTNU)	NO(1)	
Silesian startup project for national EPR	PL	Currently 5 million (of 39 million planned)
National IT Strategy for the Health Care Service 2003-2007	DK	5 million
"Sanità Elettronica 2010" (e-Health 2010)	IT	60 million
ELGA (Elektronische Gesundheitsakte), eHI (eHealth Initiative)	AT(4)	8 millions
MediNET	RO	200.000
National patient summary	SE	9 million

The current percentage of completion of the project is generally seen to be in the very early stages (with very good agreement among participants from one nation), with only the small scale Portuguese project claiming imminent completion (Table 7). Even the representatives from Denmark, well known for its avant-garde position in e-Health and SEHR, claim only to be between 25% and 50% complete.

Table 7 – Percentage of completion

Current percentage of completion of SEHR	participants
0% - 25% (preparatory phase)	16 (61%)
25% - 50% (pilot projects)	9 (35%)
50% - 75% (full rollout)	0 (0%)
75% - 100% (finishing)	1 (4%)

Special results on the technical aspects of the SEHR programs

The question, if trans-national (especially European-level) interoperability was a concrete issue in the SEHR project was surprisingly negated by 37% of the participants (56% were positive, 7% uncertain), which shows the importance of EU initiatives to foster interoperability.

The means for patient identification are given (in very good agreement amongst the participants) in Table 8

Table 8 – Means of patient identification

Means of patient identification	participants
Patient health chipcard or identification token	9 (32%)
eGovernment citizen chipcard or identification token	1 (4%)
Unique national citizen identification number	11 (39%)
Unique national patient identification number	3 (11%)
Social insurance number	0 (0,0%)
Master Patient Index systems for the federation of patient data between healthcare organizations	0 (0,0%)
Not decided yet	3 (11%)
Uncertain	1 (4%)

National citizen identification numbers are the top means of identification, with patient chipcards coming next (also in [8], it is stated that health cards are on the roadmaps of 10 of 25 European countries). The social insurance number is nowhere used for patient identification.

The means to identify health professionals are given in table 9.

Table 9 – Means of health professional identification

Means of health professional identification	participants
Health professional card	14 (52%)
Identification token stored on some other medium	0 (0%)
User accounts maintained in the SEHR or connected systems	7 (26%)
Not decided yet	5 (18%)
Uncertain	1 (4%)

The health professional card is clearly predominant, but also in national projects (Estonia and Lithuania), user accounts maintained in the SEHR or connected systems serve as means for user identification (and access control).

With regard to the network infrastructure and protocols used for access to the SEHR, the Internet protocol is clearly undisputed. A secluded intranet is the prime choice, but also encrypted connections via the public Internet are considered (see table 10).

Table 10 – Type of network infrastructure

Type of network infrastructure	participants
Secluded Intranet for the Healthcare sector based on Internet Protocol	13 (52%)
Secluded network for the Healthcare sector based on some other protocol	0 (0%)
Public Internet with appropriate encryption	9 (36%)
Uncertain	3 (12%)

For the additional services that are to be offered together with the SEHR for patients and health professionals, the results are shown in figure 1.

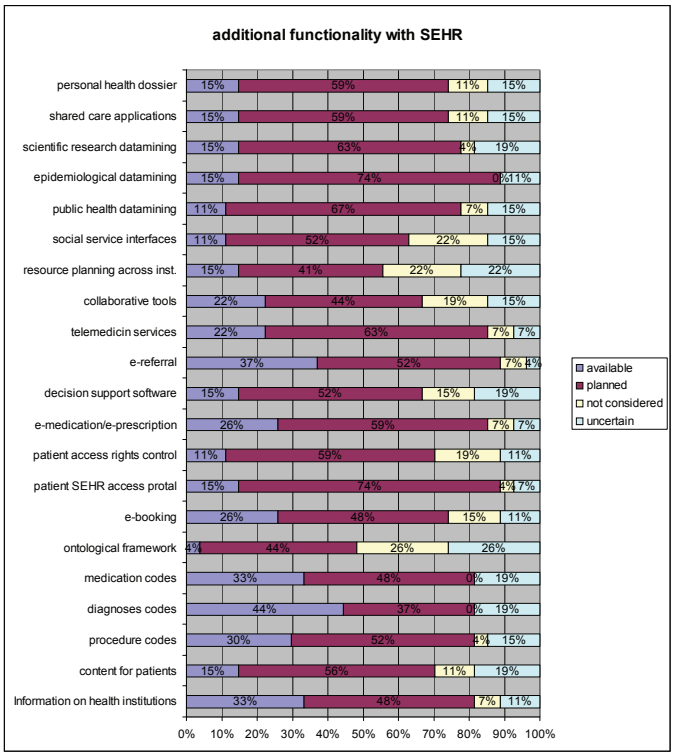

Figure 1 – Additional services

Among the currently available functionalities, common nomenclatures for diagnoses, medication and procedures, e-medication/e-prescription and e-booking along with information on healthcare institutions are predominant. Patient portals are mostly being planned, with various participants stating that functionality for patients to control access rights to their health record data is not considered. Complete ontological frameworks are considered least important.

For the central question for this survey, the design of the SEHR architecture, the participants were given the choice between 5 different designs, ranging from a completely centralized approach for the storage of all SEHR data to completely unfederated decentralized SEHR:

- Completely central architecture (with limited number of national data centres): Central Patient Index; Central Metadata Index and Patient Summary Data Repository; Central Repository for full SEHR data
- Mostly central architecture (all core data stored in limited number of national centres): Central Patient Index; Central Metadata Index and Patient Summary Data Repository; Decentral Repository for full SEHR data
- Mostly decentral federated architecture: Central Patient Index; Decentral Metadata Index and Patient Summary Data Repository; Decentral Repository for full SEHR data

- Completely decentral federated architecture (federation of RHIO's with cross community data access): Decentral Patient Indices; Decentral Metadata Index and Patient Summary Data Repository; Decentral Repository for full SEHR data
- Completely decentral unfederated architecture (unfederated RHIOs): Decentral Patient Indices without cross enterprise federation; Decentral Metadata Index and Patient Summary Data Repository; Decentral Repository for full SEHR data

The results found are given in Table 11:

Table 11 – Architecture type

Architecture type	participants	countries
Compl. central architecture	1 (4%)	FI
Mostly central architecture	6 (22%)	AT(2),DK, EE,GR,LT
Mostly decentral federated architecture	9 (33%)	AT(3),CH,DE,EE,RO,SE
Completely decentral federated architecture	3 (11%)	DE,IT(2)
Completely decentral unfederated architecture	1 (4%)	IL
Other/not yet decided	5 (19%)	DE,DK,NO, PL,RU
Uncertain	2 (7%)	NO,PT

Only one participant from Finland sees the national SEHR effort directed towards an all central architecture. The mostly central and mostly decentral architectures prevail – for pragmatic reasons (eg. the amount of actual EHR data that would have otherwise to be stored centrally).

Table 12 – Regulation for data in SEHR

Regulation for data in SEHR	Participants
National regulation exists	4 (15%)
Regional regulation exists	2 (7%)
National regulation is planned	12 (44%)
Regional regulation is planned	1 (4%)
No regulations are planned - agreements between healthcare will do	5 (19%)
Uncertain	3 (11%)

The situation with not yet final specifications for SEHR architectures has its impact on the disagreement between the participants (in Austria, the e-Health strategy prepared by the e-Health Initiative favours a mostly decentral architecture, whereas the preliminary results from a government commissioned feasibility study tend towards a mostly central architecture).

Regarding the question, whether there are regulations on what data items are to be published into the SEHR, the participants gave the answers in table 12.

The data items considered to be available via the SEHR (currently or in the future) were named to be:

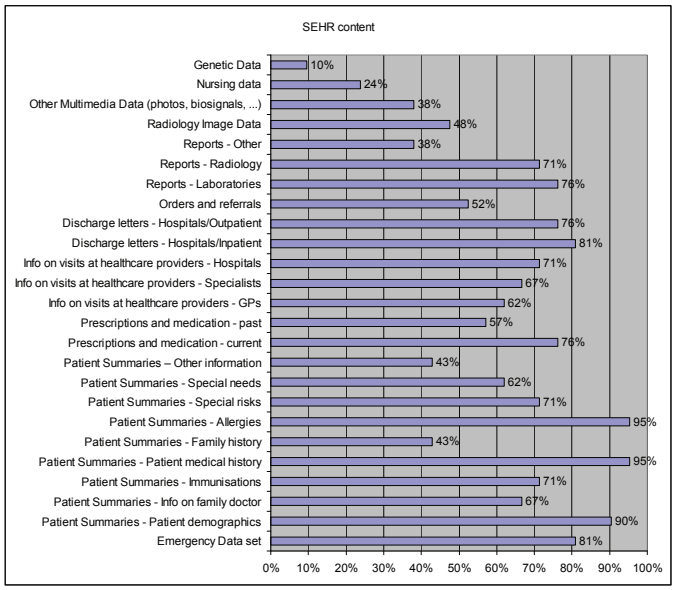

Figure 2 –Data items in SEHR

For the Israeli program, it was mentioned that a unified discharge summary based on HL7 V3 CDA was considered and confidential information on sexual abuse might also be part of the SEHR.

On the question regarding the standards and technical frameworks considered for the content and the communication of the SEHR, the participants gave the priorities listed in Figure 3. The participants see a clear prevalence of HL7 CDA (eg. over CEN 13606) for the SEHR content. IHE XDS is also very popular as a set of protocols for access to SEHR data – but only slightly in advance over CEN EN 13606 EHRCOM, in which's scope transmission of healthcare information is also contained. Even though CEN EN 13606 will be a harmonized European standard once completed, the HL7 CDA as ANSI and ISO standard has good reception since its adoption by industry is much better. The good acceptance of ICD and ICMP does not come as a surprise. SNOMED CT is very well considered with 42 %. The popularity of DICOM can also be seen. For Denmark, it was pointed out that the national B-EPR standard which is akin to CEN 13606 is being used. For Italy, the compliance of the SEHR with the "Sistema Pubblico di Cooperazione (SPCoop, Public Cooperation System)" as a national standard was noted. This compilation gives an impression of the importance of various standards, technical frameworks and nomenclatures in the eyes of experts in the field. Since in most cases, the SEHR programs are

still in their very early stages with room for adaptation driven by the national experts, possible directions for the adoption of standards can be seen, where there are no binding regulations yet.

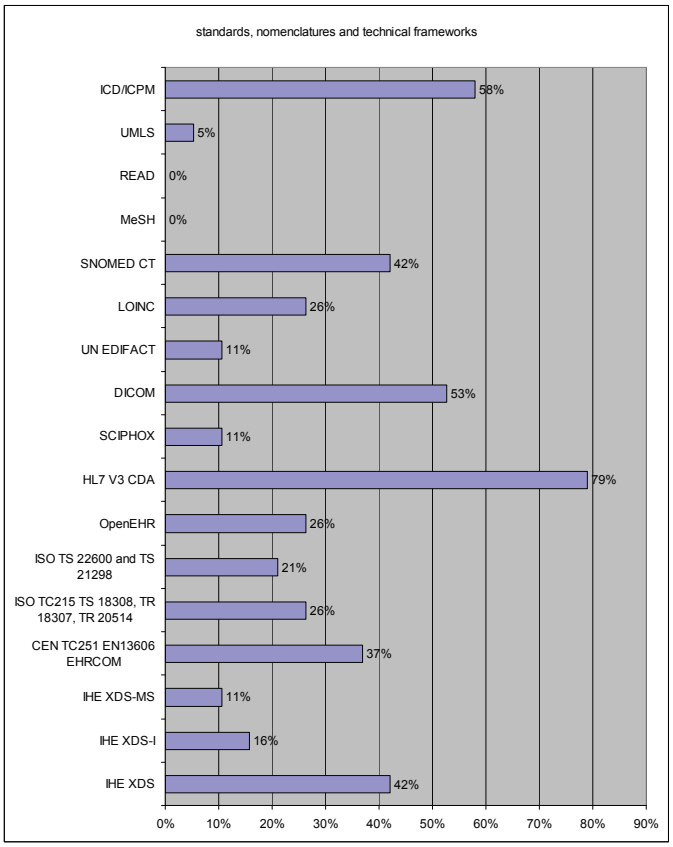

Figure 3 –Standards and technical framework

Conclusion

Contrary to the approach in [9], not national governments or e-Health competence centres were approached with questions on the technical aspects of the national SEHR programs but experts working on these projects. This brings in a certain bias from the individual viewpoints of these experts, but also "official" statements by government institutions (Ministry of Health, national competence centres) do not have to reflect the situation indisputably – apart from being very hard to obtain on a technical level. Looking on the agreement between multiple participants from one nation, it can be seen that there is generally good consensus on the main technical issues. Most disagreement comes from early stage of the programs and transitory phase from pilots and basic infrastructure to full SEHRs. The SEHR programs are in an early stage where specifications are not finalized and still subject to change. Research and pilot projects, that have in some cases been initiated more than a decade ago, are present in some countries giving directions for how pervasive solutions could work and have to be incorporated into future infrastructures. Regional and national activities coexist to form together the SEHR functionality. National approaches are fairly different across Europe and trans-national interoperability is not seen as a core issue. Industry standards and initiatives (HL7 CDA, DICOM, IHE) are most influential amongst the experts and thus have the potential to lead to basically similar and interoperable architectures for SEHR across Europe. The European standardization effort (CEN EN 13606) is not seen as so important. For the SEHR architecture, most participants foresee a mostly decentralized design with central patient index, but distributed metadata registries and data repositories. The Internet protocol is undisputed as basic transport medium – where secluded intranets as platforms for the utilization of the SEHR are predominant over encrypted communication via the public Internet. Chipcards are seen as one of the main means for patient identification for the SEHR, and health professional cards are rated top for identification of healthcare professions. The timeframe for completion of the SEHR programs is seen by most experts in their private opinion more sceptical than in the official statements, foreseeing completion mainly in a timeline 2010 or later.

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Data protection in shared health records: requirements and challenges

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Introduction

With the advent of computers and computer networks, collecting and storing all clinical information about a patient in electronic files became reality [1].

An electronic health record (EHR) system offers improved access to patient-specific information and has major benefits in terms of the quality of health care and the quality of life of clinicians in practice [2].

The internet has offered us the capability to access medical information from anywhere, anytime, transforming the patient-doctor relationship, particularly with respect to sharing decision making between patient and doctors [3].

Privacy, Confidentiality and Security

Rindfleisch distinguished among privacy, confidentiality and security in protecting health care information [4]:

- **Privacy**: The right and desire of a person to control the disclosure of personal health information.

- **Confidentiality**: The controlled release of personal health information to a care provider or information custodian under an agreement that limits the extent and conditions under which that information may be used or released further.

- **Security**: A collection of policies, procedures, and safeguards that help maintain the integrity and availability of information systems and control access to their contents.

Electronic health records characteristics

Fritsche et al. noted that collection of comprehensive and valid scientific medical data through EHR should be [1]:

- Easy to install and maintain thus being less expensive.
- Time-saving for the medical staff (users) in their daily work.
- Able to store all medical information (including picture etc.) in retrievable format.
- Able to provide data validation by repeated use of the data in patient care.

Electronic health records characteristics

Shortliffe and Fagan argue that there are at least four major issues that have consistently constrained the efforts to build effective health record systems [2]:

- Standards are needed in the area of clinical terminology;
- Concerns about data privacy, confidentiality, and security;
- Challenge of data entry by physicians;
- And difficulties related to integration of record systems with other information and data in healthcare settings.

Electronic health records requirements

The basic requirements of shared health records are:

- Comprehensiveness
- Confidentiality
- Accessibility
- Liability
- Authentication
- Flexibility
- Permission
- Accessibility in emergency cases
- Maintaining Integrity of the health record

Electronic health records requirements

There are some legal Issues regarding health records such as:

- Jurisdiction
- Legally valid agreements
- Legal implications of shared practice of medicine
- Patient's right to review and release their records

Achieving Privacy in Electronic health records

In some cases to protect privacy and confidentiality, EHR data must be:

- Anonymised, and
- De-identified.

Anonymisation usually involves stripping patient identifiers (name, address, social security number, hospital record number, etc.) from records or substituting a false identifier for the real identifier [5].

De-identification entails removing the specific identifiers listed in the privacy rule and determine there is no other information that may identify the individual [6].

Current and future challenges of data protection in shared health records

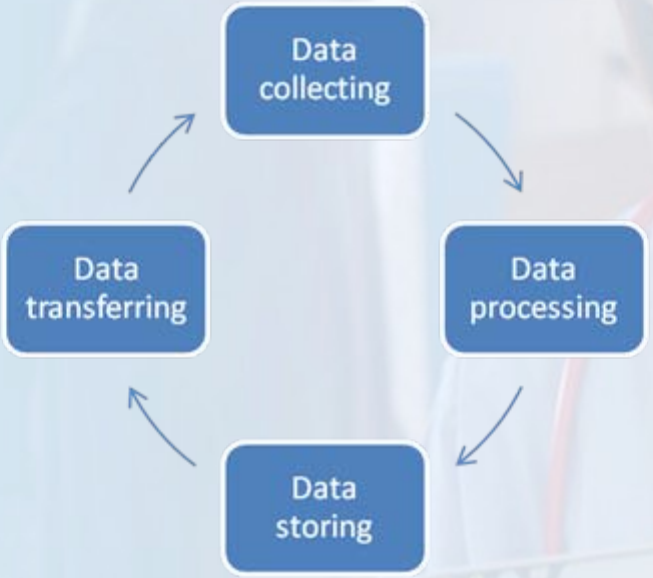
- Some patients and doctors have expressed concerns about the use of the new technology in shared health care record services. Most of these concerns are related to data protection and confidentiality issues.

- Some issues should be considered while moving from a paper-based record system to a computer-based one, such as the needed time of transmission, resources, management and administration tolls and staff, and basic technology infrastructure [2, 7].

- Some people will find ways to get secure information by exploiting human weakness to bring pressure to bear on someone with legitimate access to health information [7].

Current and future challenges of data protection in shared health records

Data could pass through four stages:



Data protection abuse could happen in any of these stages.

Conclusion

- The concept of security is intrinsically correlated with other aspects of EHR, including legal, technical, social, political and financial. The nature of these relationships between security and other issues depends on the specific user of the electronic patient records.

- The advanced technologies needed for implementing secure systems almost always make the use of the system more complex for the users. This complexity can reduce the benefits of using new technology and limit its advantages. The grand challenge for the future will be to provide a secure and at the same time user friendly electronic health record system.

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Information Extraction from Medical Notes

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Abstract

Health providers tend to prefer free text when describing drug dosages prescribed to their patients. However, unstructured text is not amenable to large scale analysis such as data mining. In this paper, we explore four methods that automatically identify drug, dosage,and method of delivery information from transcribed physician notes.

Our final method uses just one extraction heuristic, and achieves an average precision of 96.74% on a training set and 96.70% on the test set and average recall of 69.48% on the training set and 79.72% on the test set. These results suggest that a small number of heuristics can provide accurate extraction of drug, dosage and method of delivery information in medical notes.

Keywords:

information science, medical; Clinical Laboratory Information Systems; information extraction

Introduction

Health professionals need the flexibility of unstructured text to express their diagnoses and treatment strategies. Thus, the presence of unstructured text is inevitable, but, for data mining, information systems are required to convert the unstructured text to a structured representation for analysis.

There are two key approaches used to extract information from unstructured medical text: supervised learning, and a knowledge-based approach. Successful supervised learning models that have been demonstrated on biology include maximum entropy models[1], hidden Markov models[2], naïve Bayes, and decision trees[3]. In contrast to supervised learning, a knowledge based approach does not require labeled examples. Instead, dictionary lookups and heuristics help in extracting key facts from text. Successful implementations of knowledge-based approaches can be found for medical literature[4][5], radiology[6], and histopathology[7].

Materials and methods

The data used in these experiments comprised narrated notes for 12,222 patients in the University of North Carolina at Chapel Hill (UNC) hospital system. The notes were transcribed and anonymized prior to our analysis as part of a parent UNC DEcIDE project. The goal in the parent project is to identify treatment and outcome patterns for newly diagnosed patients with type II diabetes mellitus, some of whom have cardiovascular comorbid conditions. The parent project had access to both structured and unstructured data, but, our experiments consider only the patient note.

Method 1, the first experiment, used a subset of diabetes drugs to trigger the text extraction. This experiment used the GNU Awk (gawk) script language. We worked closely with experts from the DEcIDE team who were familiar with drugs commonly used to treat diabetes. The output from this experiment was used for discussion with the DEcIDE team, and was instrumental in the design of future methods.

Our goal in Method 2 was to provide DEcIDE team members information to help them identify patients who already had diabetes. The script identified sentences that contained (a) the word "diabetes," (b) drugs commonly prescribed for diabetes, or (c) the word insulin. The input to this method was the result of a program that split notes into separate sentences.

The first two experiments revealed a surprising degree of regularity in the way physicians described the drug and dosages prescribed. Our goal in Method 3 differed in two ways: (1) identify *any* drug, and (2) focus on the drug *and* the amount of drug prescribed. Thus, Method 3 moves the trigger term from a drug to an amount and dosage combination.

We used enhanced grep (egrep), a UNIX text processor for Method 3. We added a UNIX C-Shell (csh) script to the framework, which enabled us to modify and document the regular expression more easily than in previous methods.

We constructed a training set comprised of 30 notes we selected at random from the complete set. Based on the training set, a single regular expression was selected for the final experiment. It ultimately identified words at least 4 letters in length, followed by a numeral or a number, and a unit of measurement. Parameters such as how the drug is to be taken and the frequency of the dosage will be extracted.

Results and discussion

We applied the script for Method 1 on the complete set of 12,222 patients. The script output included the patient ID, the date of treatment, and 50 characters before and after the drug that triggered the extraction. Our goal with Method 1 was to verify the text processing pipeline, which worked as expected.

Method 2 was applied to records belonging to 1,933 unique patients identified by the DEcIDE researchers. A test set of 166 patients was chosen randomly. The third author, using the criterion of successfully detecting diabetes patients, evaluated the results of this set manually. The method was found to have a precision of 61.33% and recall of 77.13%. The relatively low precision and recall were because our script did not account for negation. The most common error was family history of diabetes as opposed to diagnosis.

Our goal with Method 3 was to identify prescribed drugs and corresponding dosages. We also extracted the drug's prescribed frequency and method of delivery, if available. Drugs without dosages tended to refer to the patient's reaction, allergies, or other factors unrelated to current prescriptions.

A machine learning approach inspired our evaluation of the regular expression used in Method 3. We created a training set by selecting 30 random patient notes from the complete set. We then wrote the regular expression based on notes in the training set. Once the expression was complete, we selected an additional 40 patient notes at random to form a test set. We checked to see that the training and test sets were similar and found an average of 4.83 drug dosages per patient. A test set was derived from a random set of 40 patient notes, with an average of 3.78 drugs per patient.

The error analysis of the training set in Method 3 revealed that the most important factor is detecting a number followed by an SI unit. The analysis also revealed several legitimate dosages in the notes that Method 3 did not detect. The primary error in recall was due to unexpected units of measurement in the text. The second most important factor was correctly extracting the drug name. Three key reasons caused the drug extraction to fail:

1. The drug name did not precede the dosage.
2. The drug contained multiple words.
3. Short drug names. Method 3 requires that a drug name be 3 or more characters long.

We developed a fourth and final regular expression based on the underlying causes of error in Method 3. We made the following changes to Method 4:

1. Added floating point (decimal) numbers,
2. Improved the set measurement units used to trigger the heuristic, by expanding the list of SI units and added apothecary units, and
3. Removed unnecessary delivery abbreviation.

Without any background knowledge of drug names, Method 4 performed surprisingly well on drug extraction for the training and test sets (see Table 1). An informal analysis showed that drugs paired with dosages were usually associated with current prescriptions rather than drugs used previously.

Table 1 – Method 4 Detailed Training and Test Set Results

	Training		*Test*	
	Precision	***Recall***	***Precision***	***Recall***
Drug	86.96%	82.76%	86.81%	82.78%
Amount	100.00%	91.39%	100.00%	96.08%
Method of delivery	100.00%	62.03%	100.00%	91.89%
Prescribed frequency	100.00%	41.73%	100.00%	48.15%
Average	**96.74%**	**69.48%**	**96.70%**	79.72%

Precision for drug amount was 100% for both training and test sets because the method uses an explicit pattern match on the unit of measurement and its quantifier. The prescribed frequency recall, while low (41.73%/48.15%), is on par with other methods, as is the method of delivery in the training set (62.03%). This is due to variances in how the notes report frequency. We are continuing to work on methods to improve the currently low retrieval rate of prescribed frequency.

Conclusion

Our results show that a single extraction rule achieves precision of 96.72% and recall of 74.60% on a set of randomly selected notes. Precision was lowest for drug extraction (86.81%), and consistently high (100%) for amount, method of delivery and frequency. Recall was 44.94% for the prescribed frequency, but remained high for the other data.

Our final method ran at a rate of 24-26 notes per second with an Intel Pentium 4 2.0 GHz processor. This suggests that a single well defined extraction rule would scale well to larger numbers of notes, and result in precision and recall that are competitive with systems that employ deep natural language processing methods. Further research that characterizes high precision rules is critical if we are to

move towards a completely generalizable and scalable model of information extraction from medical records.

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Information Extraction From Medical Notes

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Motivation

- Medical Notes
  - Thousands of medical notes in any hospital system
  - Unstructured text not amenable for data mining
- Goal :
  - Accurately extract information from each note
    - Drug
    - Dosage
    - Method of delivery

Materials

- Data Set
  - Transcribed dictated notes
  - 12,222 patients in UNC Hospital
  - Anonymized
- Part of UNC DEcIDE project
  - Identify over-dosage of diabetes patients
- Gold standard
  - structured data sets
  - Physician annotated

Method Summary

Method	Trigger	Output
1	Drug name	± 50 chars from drug
2	Drug name or 'Insulin' or 'Diabetes	•Sentence •Trigger
3/4	Word > 3 letters & Number & Measurement Unit	•Drug •Amount •Method of delivery

Example – Method 1

- Trigger: drug name

Trigger: Drug name

We will begin the patient on her home dose of **Glucotrol**, 5 milligrams PO QD and we will give sliding scale insulin as needed.

- Output: 50 characters either side of drug

We will begin the patient on her home dose of **Glucotrol**, 5 milligrams PO QD and we will give sl

50 Character limit

Example – Method 2

- Trigger: drug, ‘diabetes’, ‘insulin’

Trigger: ‘diabetes’

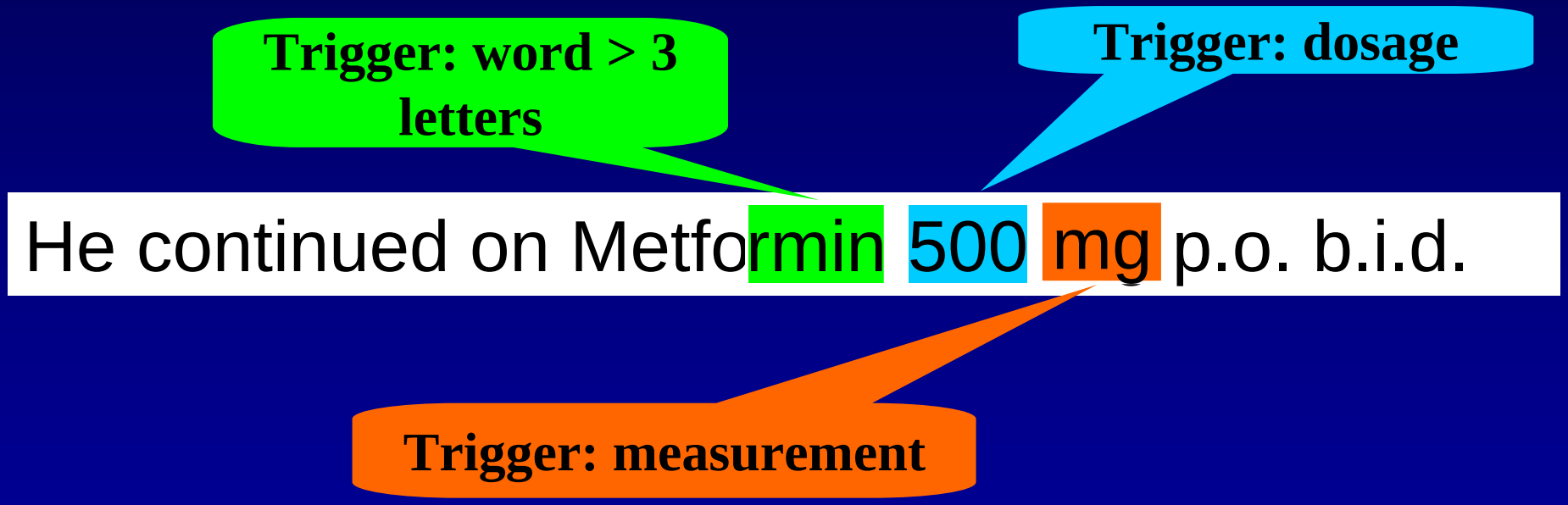
The other diabetes related medications are Actos 45 mg and Lantus at bedtime 20 units.

Trigger: Drug name

- Output: Entire Sentence

Example – Method 3/4

- Trigger: word > 3 letters, dosage, measurement

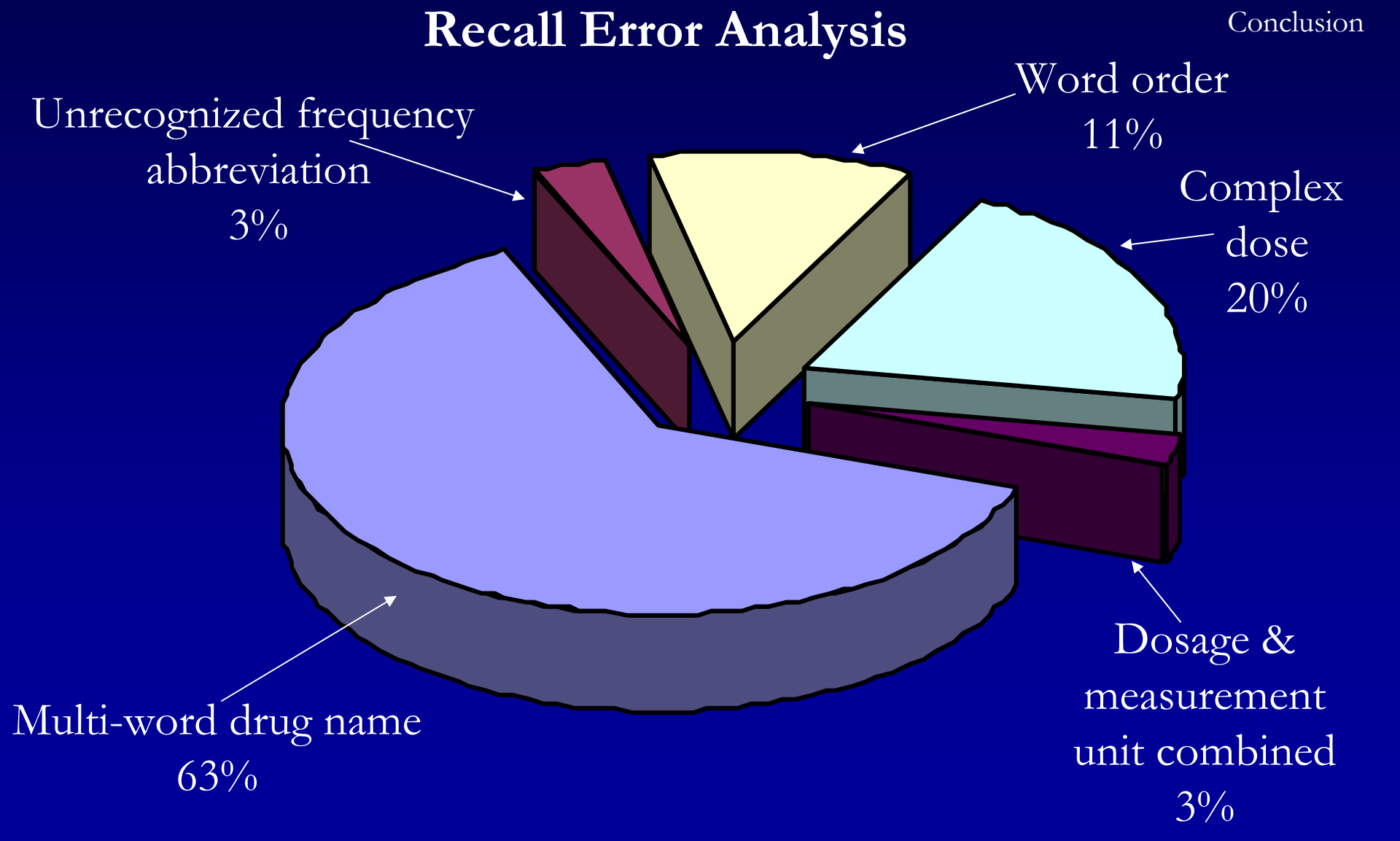


- Output: Drug, dosage, unit, delivery, frequency

Method 3/4 – Advantages

- Processing Speed
  - 24-26 patient notes/sec
  - Pentium 4 2.0GHz processor
- Drug name not used in trigger
  - Identifies new drugs
  - Missing or obscure drugs do not lower performance

Method 4 Limitations



Results of Method 4

	Training Set		Test Set	
	Precision	Recall	Precision	Recall
Drug	86.96%	82.76%	86.81%	82.78%
Amount	100%	91.39%	100%	96.08%
Method of Delivery	100%	62.03%	100%	91.89%
Prescribed Frequency	100%	41.73%	100%	48.15%
Average	**96.74%**	**69.48%**	**96.70%**	**79.72%**

Conclusion

- Average F-Measure (Test Set)
  - Drug 84.80%
  - Amount 98.04%
  - Method of Delivery 95.95%
  - Prescribed Frequency 74.06%
  - **Average** **88.21%**
- Scales well : 24-26 patient notes/sec

Questions or Comments ?

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Developmental Context: Evolvement of the EHR Systems in the Russian Federation

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Abstract

Today's milieu of healthcare information systems on the post-USSR territories is a loose alloy of the inherited pre-perestroika structures with the modern healthcare governance initiatives, against the background of the rapidly developing private sector in the medical IT-industry. By providing a general picture of the diverse infrastructure that the new IT-systems of today rely on for better care delivery, we have tried to outline and accentuate the following: a growing degree of awareness of the need to develop this sector, to eliminate the inefficiencies of the triple-channel system of care budgeting, with each of the three elements – the Social Insurance Fund, the Obligatory Insurance Fund, and the Pension Fund of the Russian Federation – often serving literally the same means, and the developmental context for the formation of a nation-wide system of the personal socio-medical records in the Russian Federation.

Keywords:

medical record systems, computerized; academies and institutes; social security; insurance; funds; public health; data collection; registries; Russia; Russian Federation; Moscow; center, academic medical; pensions; retirement benefits; international health problems.

Introduction

In the Russian Federation, electronic medical records as such have been first delved into in the mid-sixties. That is when the first Russian works on information technologies in healthcare were published. The era of the seventies was marked with the first IT-systems applied at medical organizations, followed by the first corporative clinical information systems.

In the late seventies the USSR had its first computerized analytical centers at both national and regional levels. The systems primarily tended to the state's needs in aggregating medical statistical data.

These analytical systems matured through the 80s into the 90s, and at the moment the USSR ceased to exist in 1991, the network, comprised of these centers, was devoid of its vertical administrative support structure. From then on they went through a number of transformations to become the medical information-analytical centers as we know them today.

Today more than 40 constituent territories of the Russian Federation have their own medical information-analytical centers. Other territories of the Russian Federation have their own medical statistics bureaus within their healthcare governance structures. The Russian Academy of Medical Sciences, the top-level executive organ in medicine for the whole Federation, established its own Medical Center for Information and Analysis as a not-for-profit, non-governmental organization in 1997. Its primary function was registration of the data related to the high-cost federal budget care delivery and scientific research in the field of public healthcare (see Figure 1 and 2).

Current context

There evolved, and are functional, ten systems that register personalized information about the population of the Russian Federation (see Figure 1). All ten systems formed in different historical periods, vary greatly as to the motives for their establishment and are supported by different resources.

The State Automated System "Elections" [1] provides for personalized registration of all voters across the territory of the Russian Federation. All the voting-age citizens of the Russian Federation are registered by the computerized Information System which collects the following data: full name, date and place of birth, sex, citizenship, place of residence, and type of the identification document. Every citizen has the right of full access to his or her personal file.

The Visa and Passport Service within the Ministry of Internal Affairs that collect all personal data related to issuing passports and granting Russian citizenship.

The Civil Registry Office registers all the personal data pertinent to institution of marriage.

There are more than 800 clinical information systems across all the medical organizations in Russia today [2]. The non-state structures that form their own databases of socio-medical nature for the purpose of conducting their own business are various insurance companies and retirement funds, medical organizations, medical information-analytical centers, such corporations of the national scale as JSC Russian Railways, and JSC Gazprom, etc.

Seven of them are of the socio-medical character.

Figure 1 – current systems for the personalized registration of data in the Russian Federation

Taking into account their technical, human, and financial resources, three of them are capable of becoming system generators for a common system of the population data registration based on personal health records. All three are also public services – three of the government-established non-budget funds: the Pension Fund of Russia, a block of 91 Funds of the Obligatory Medical Insurance, and the Social Insurance Fund. There are rapidly developing mechanisms of exchanging information between all of them (see Figure 2).

The Social Insurance Fund [3] pays for medical care rendered to the disabled citizens, patient transfer to the organization where they have been referred to receive expensive hi-tech services, long-term care facilities for senior citizens, resort spa-and-rehabilitation packages, medical leaves, pregnancy and maternity leaves until the child reaches the age of 3 years old, and occupational disease and incapacitation compensations. This Fund, with its structure, resources, and mechanisms, has been inherited from the former USSR.

The Fund of Obligatory Medical Insurance [4] is a new formation (founded in 1993). It finances medical care rendered to the citizens of the Russian Federation within the framework of the State social guarantees toward free medical care provision. It has a system of registration of the personified data on services rendered.

The Pension Fund of the Russian Federation [5] collects the data on all the retired and working-age citizens – all employers are obligated to report to the Fund the number of their employees and the amount of their wages. Apart from that, there is a well-established data link for information exchange between the Fund of the Obligatory Medical Insurance and the Pension Fund for the purpose of providing medical care and medications to the retired. The key element of the Pension Fund is its unique system of the social security numbers that it assigns to each citizen of Russia. This number has a counterpart within the structure of the Obligatory Medical Fund and its 90 territorial branches – the unique number of the personal insurance police. As there is no federal-level uniformity amongst the subsystems (every Obligatory Medical Fund of each region has its unique ways of assigning numbers that evolved historically), it is considered highly desirable and productive to merge all the Obligatory Funds around the stem of the Pension Fund with its social security numbers identification system.

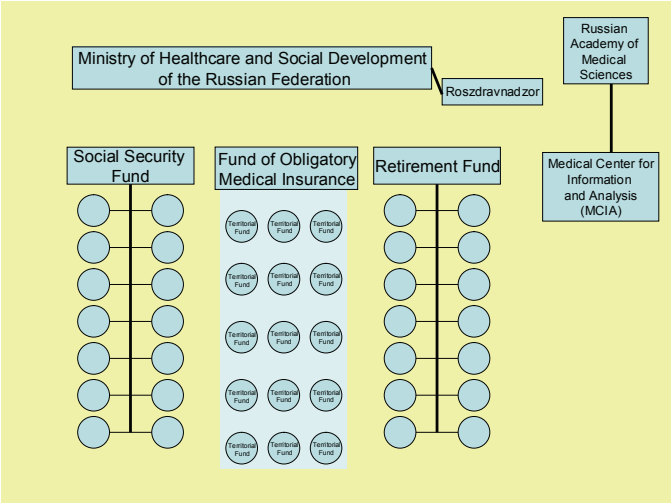

Figure 2 – Three existing systems capable of becoming central in the national health information system

Licensing, supervision, and control functions are carried out by the federal executive organ in the system of healthcare and social guarantees – ROSZDRAVNADZOR [6] as a federal service within the Ministry of Healthcare and Social Development of the Russian Federation.

The national system of the personified socio-medical data registration is in its stage of active development. There is an evident need to define a nation-wide approach, to develop normative rules and creation standards, to actualize the system of aggregating, processing, and maintaining personified data of socio-medical character on the basis of personal socio-medical records.

In order to achieve a high level of interoperability and general performance with a national model, it is necessary to accept and adopt international guidelines, classifications and protocols of exchanging and safeguarding information.

Consolidated efforts of the information and communication technologies of the country should be directed at developing a national system in the nearest future. The "rules of the game" are a pre-requisite for this step – there

should be an architecture design as well as normative rules for establishing a national system of the socio-medical data with the basis on the personal socio-medical records.

A national system for the personified registration of the socio-medical data is developed and structured with the aim of improving social care delivery and making social care more accessible, extending the nations' life-expectancy, and improving its health. In this capacity, the system will become a fundamental element of the national priority project in healthcare.

Rapid evolvement of the global tendencies in public healthcare is inevitable, so is the quantitative aggregation and qualitative advancements in the development of the world-wide clinical databases (applied medicine, etc.). Russian model of the system for the personified socio-medical data registration is technologically the most advanced on the post-USSR territories. For the purpose of registration of the personalized socio-medical data it is necessary for the European, North-American and Russian systems to be maximally synchronized for best results.

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[2] http://www.armit.ru
[3] http://www.fss.ru
[4] http://www.ffoms.ru/ffoms
[5] http://www.pfrf.ru
[6] http://www.roszdravnadzor.ru

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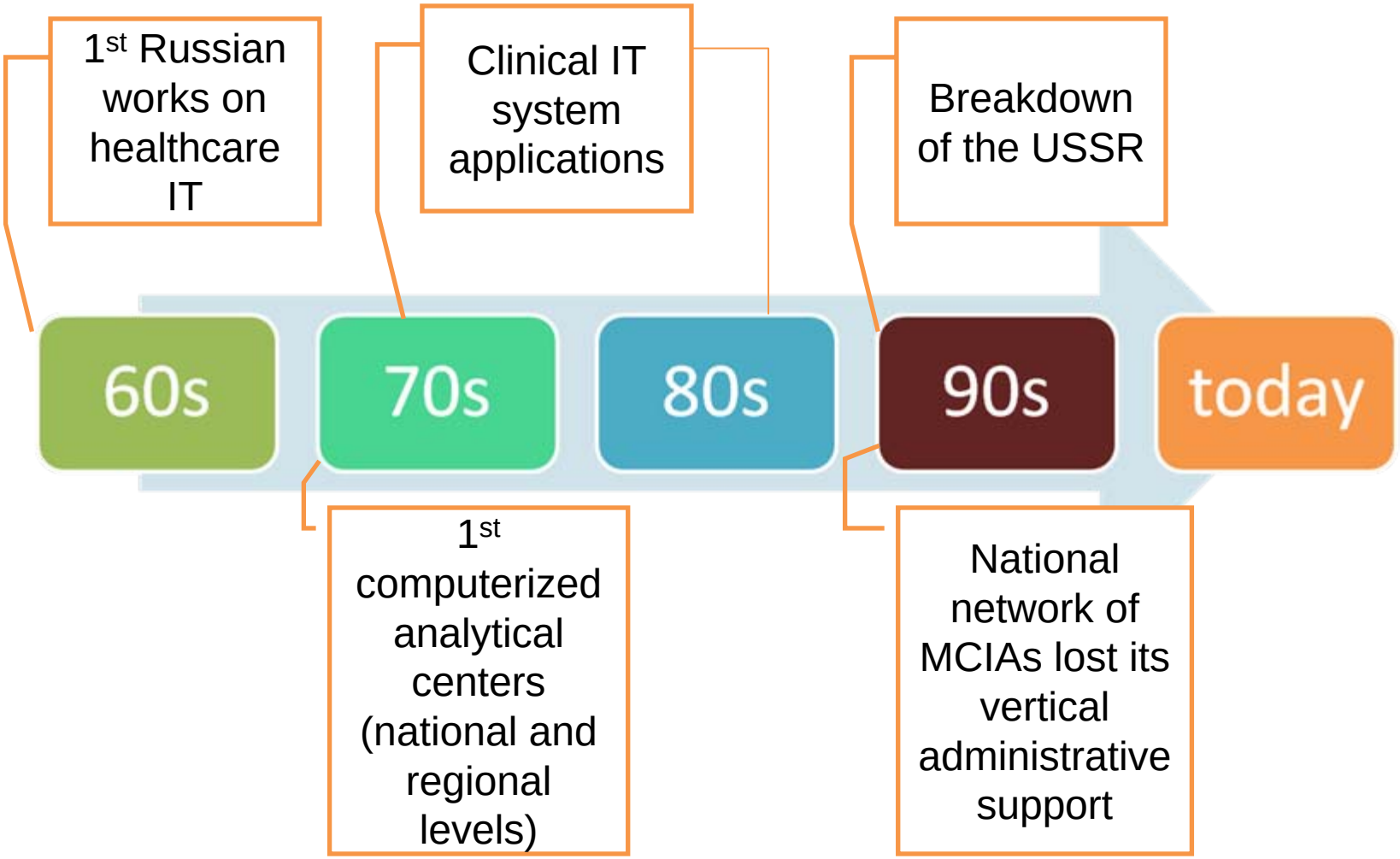
Developmental Context: Evolvement of the EHR Systems in the Russian Federation

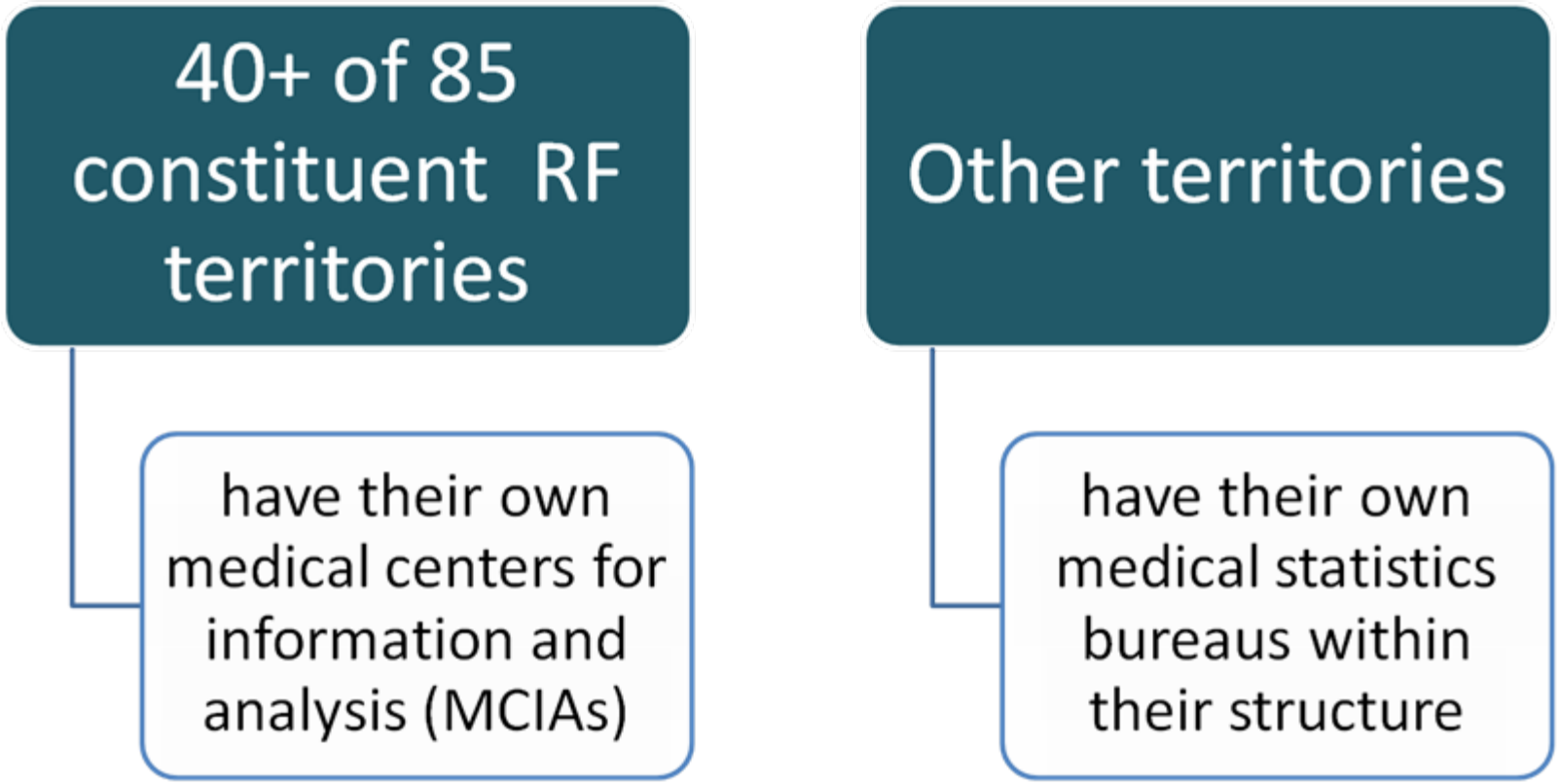
Petr P. Kuznetsov, MD, MS, Andrey P. Stolbov, MS, Vadim V. Budenkov, Konstantin J. Chebotaev

Medical Centre for Information and Analysis of the Russian Academy of Medical Sciences

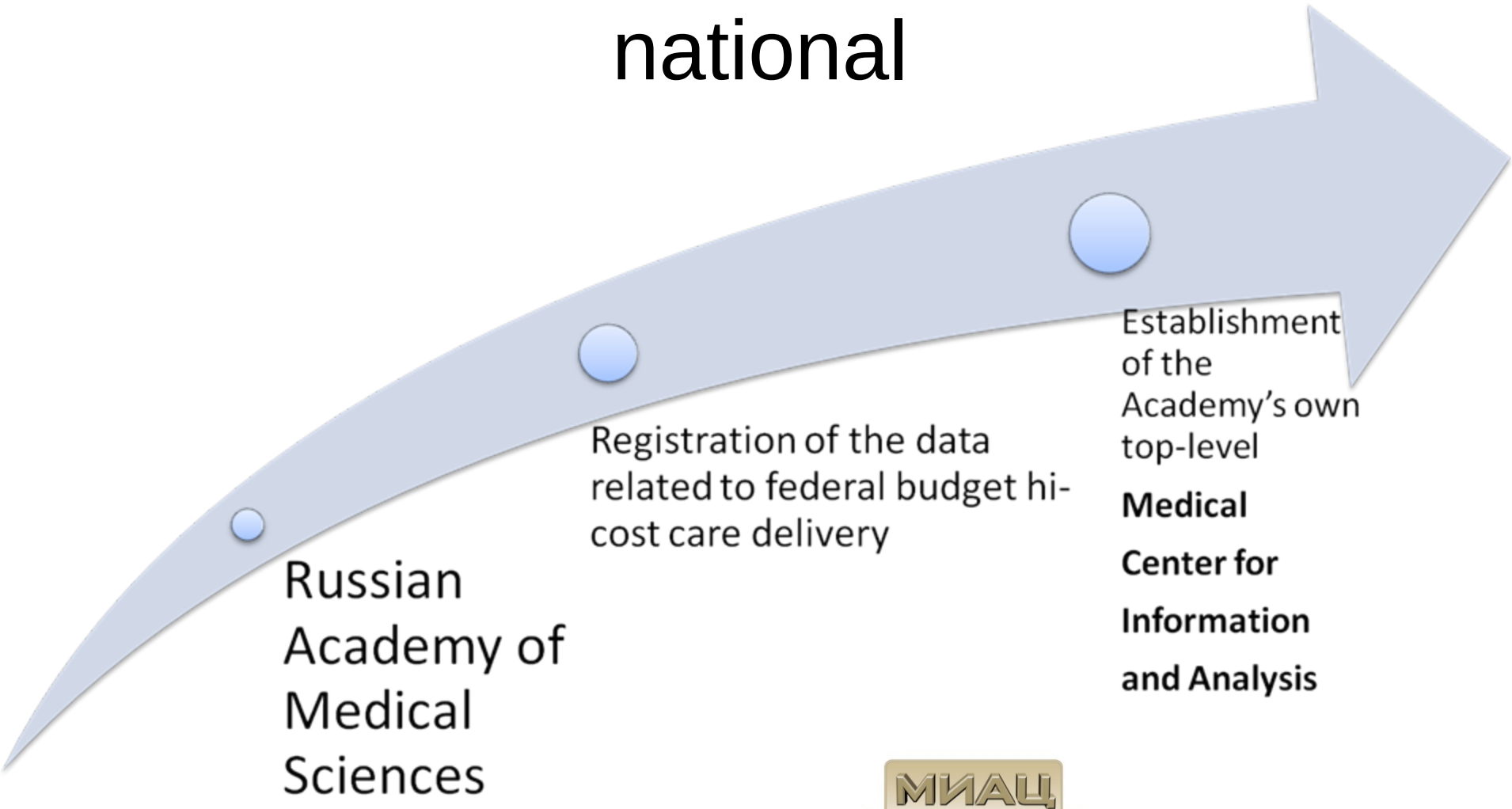
USSR: EHR evolvement chronology



- **MCIAs today**


40+ of 85 constituent RF territories
have their own medical centers for information and analysis (MCIAs)
Other territories
have their own medical statistics bureaus within their structure

Top level medical statistics: go national

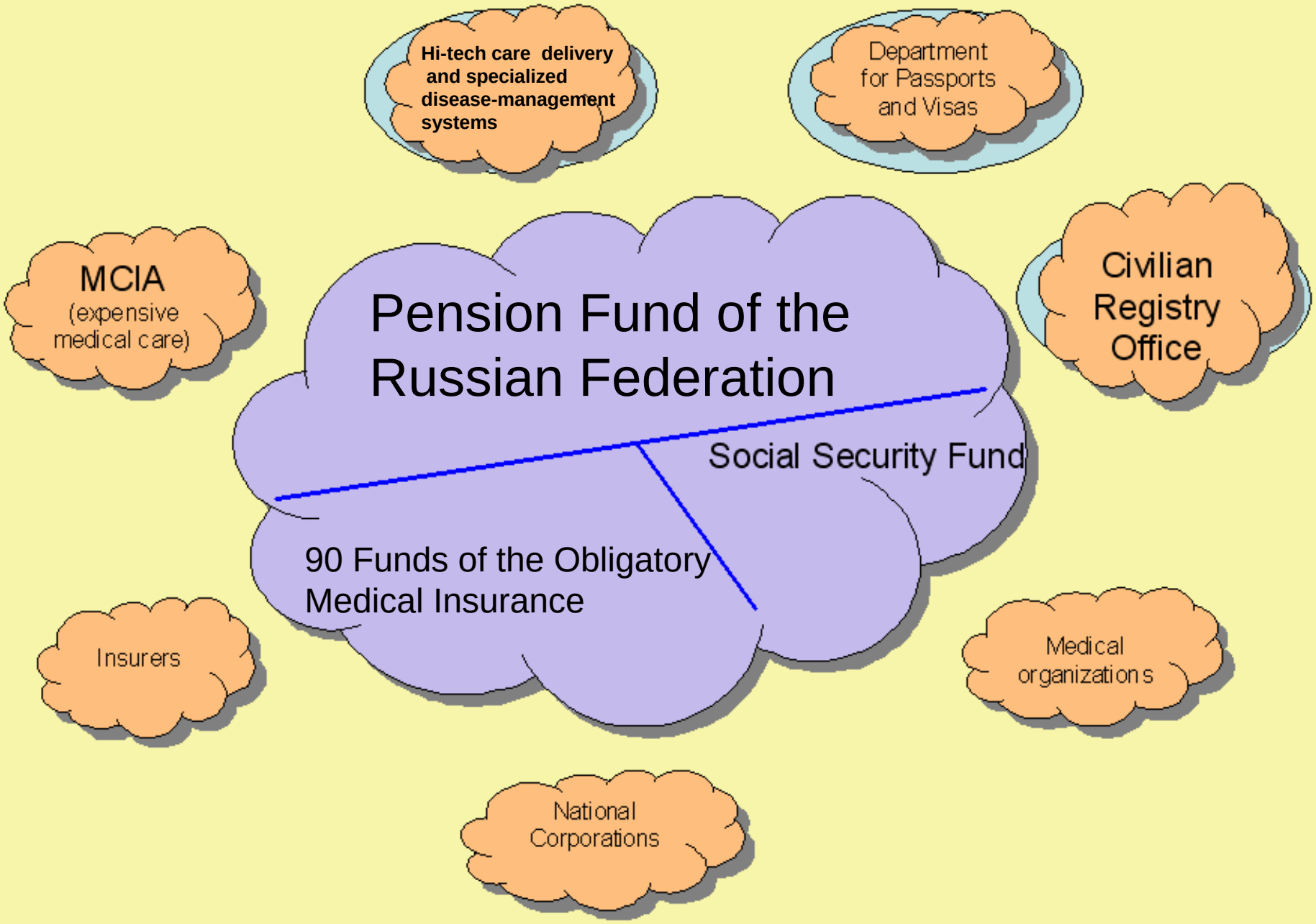


МИАЦ РАМН

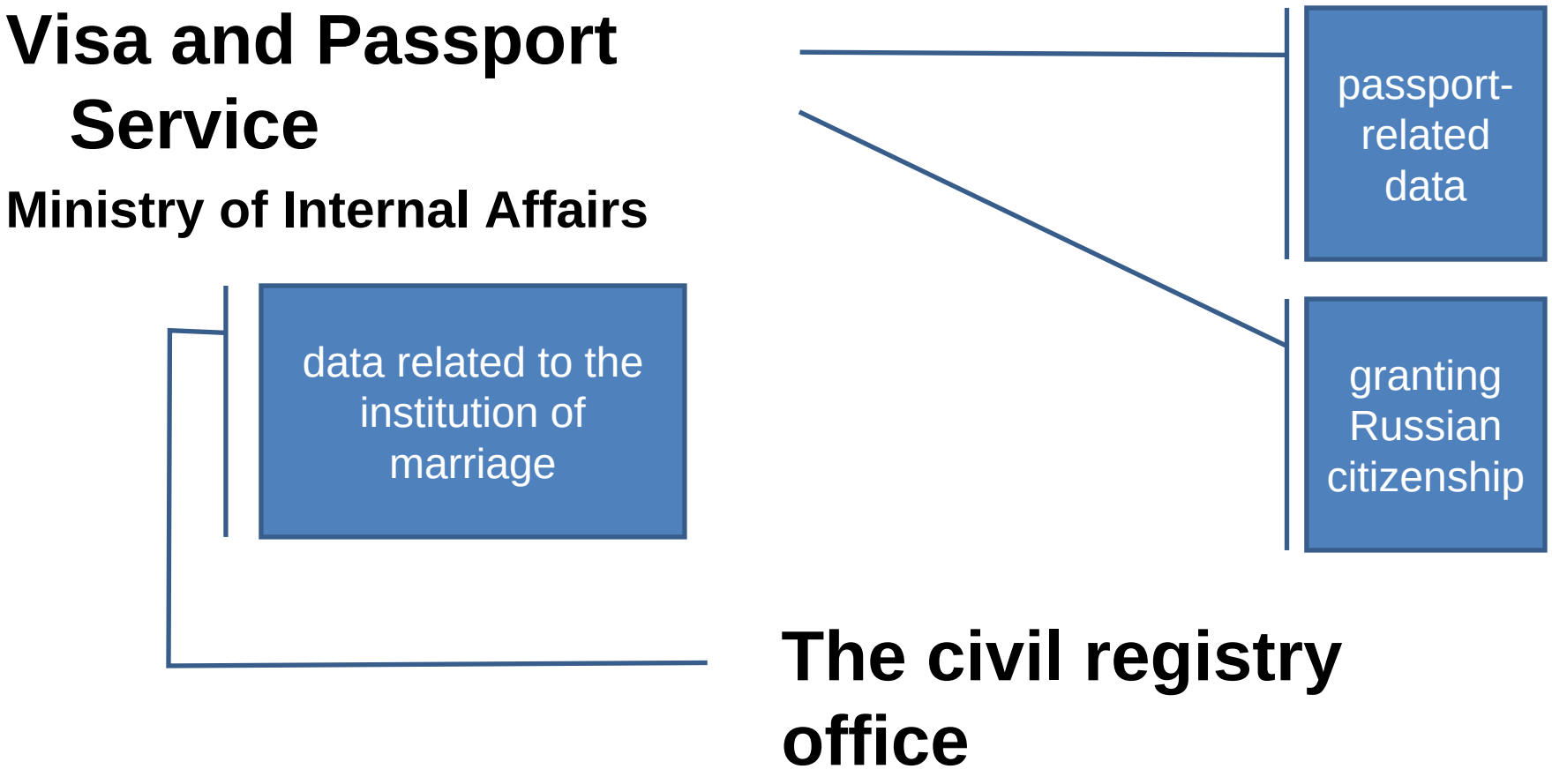
MCIA RAMS

Not-for-profit Non-governmental

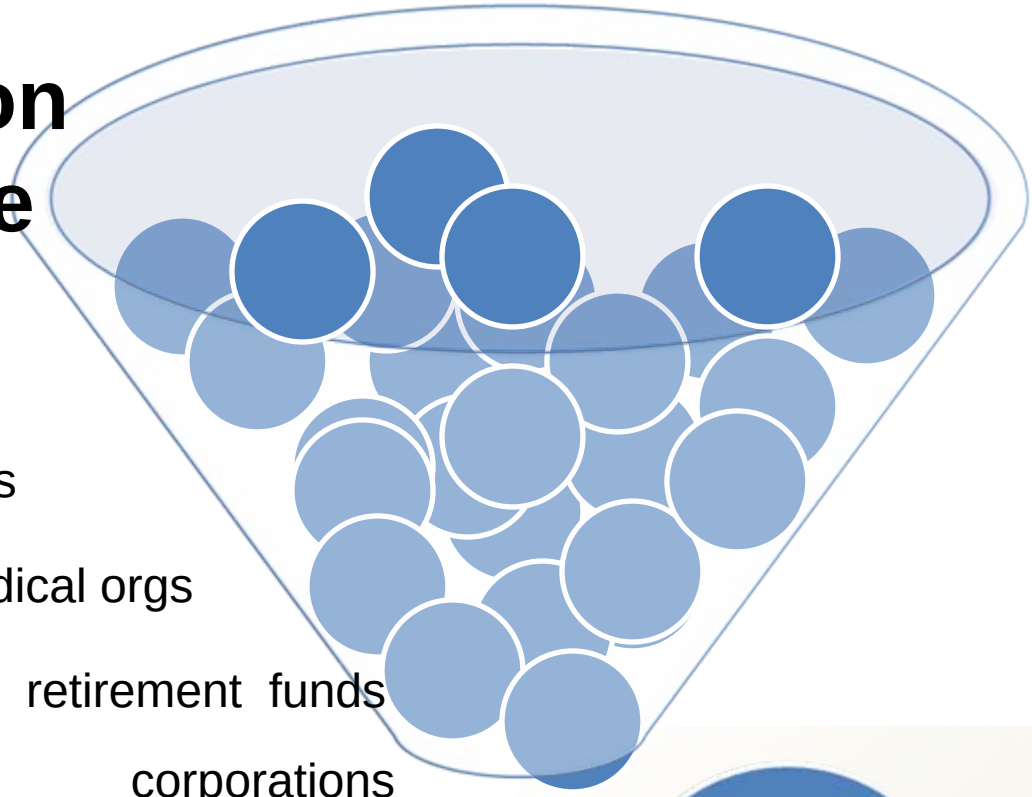
10 systems that register personalized population data in the Russian Federation



Top 10 i-systems: ID agencies



~800 information systems in the country

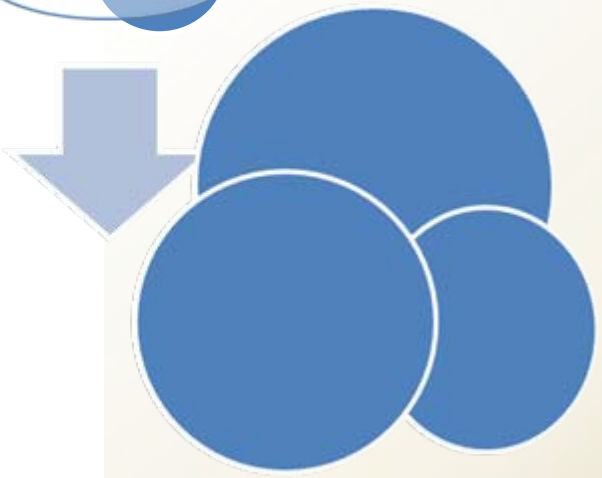


insurers

medical orgs

retirement funds

corporations



3 systems

most potent of becoming system-generative elements

all 3 are government-established, non-budget funds

The Social Insurance Fund

USSR inheritance

P

A

Y

O

R

disabled citizens

rehab

medical leaves

occupational diseases

patient transfer to POS for hi-cost care

incapacitation compensations

pregnancy and maternity leaves

The Fund of Mandatory Medical Insurance

Founded in 1993

P A Y O R

today:
records for
140 million
Russian citizens

free medical care provision
within the framework of
the social guarantees by
the State to the citizens of the
Russian Federation

The Pension Fund of The Russian Federation

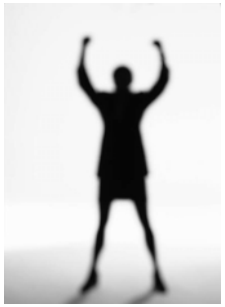
Founded in 1993

PAYOR

pension plans

unique ID

unique ID



BEFORE 2004

NOW

unique ID

universal
Social Insurance
ID number
ACROSS ALL SYSTEMS

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Provider actions in response to drug alerts generated in the Composite Health Care System

Fola Parrish, Nhan Do, Nancy Orvis

Department of Defense, TRICARE Management Activity, Falls Church, Virginia, USA

Background

- Composite Health Care System (CHCS) is an integrated enterprise computerized provider order entry system (CPOE) used by the US Department of Defense

- CHCS is deployed at over 500 medical treatment treatment facilities worldwide

CHCS

- CHCS performs medication order checks for:
  - drug to drug interaction
  - drug to allergy
  - drug dosage
  - drug duplication
  - drug under-utilization
  - drug over-utilization

Study Objective

- To assess provider actions in response to drug alerts generated in the CHCS

Method

- Survey of prescribing providers was conducted at two military treatment facility (MTF) clinics:
  - Military Family Health Clinic at the Bethesda National Naval Medical Center
  - General Medicine Clinic at Walter Reed Army Medical Center

Survey Participants

- Physicians (17)
- Physician assistants (5)
- Nurse Practitioners (6)
- Dentist (1)
- Pharmacist (1)

Demographics

Gender

- Male 15 (50%)
- Female 15 (50%)

Specialty

- Family Practice/Family Medicine 19 (63.3%)
- General Internal Medicine 5 (16.7%)
- Pediatrics 2 (6.7%)
- Other 4 (13.3%)

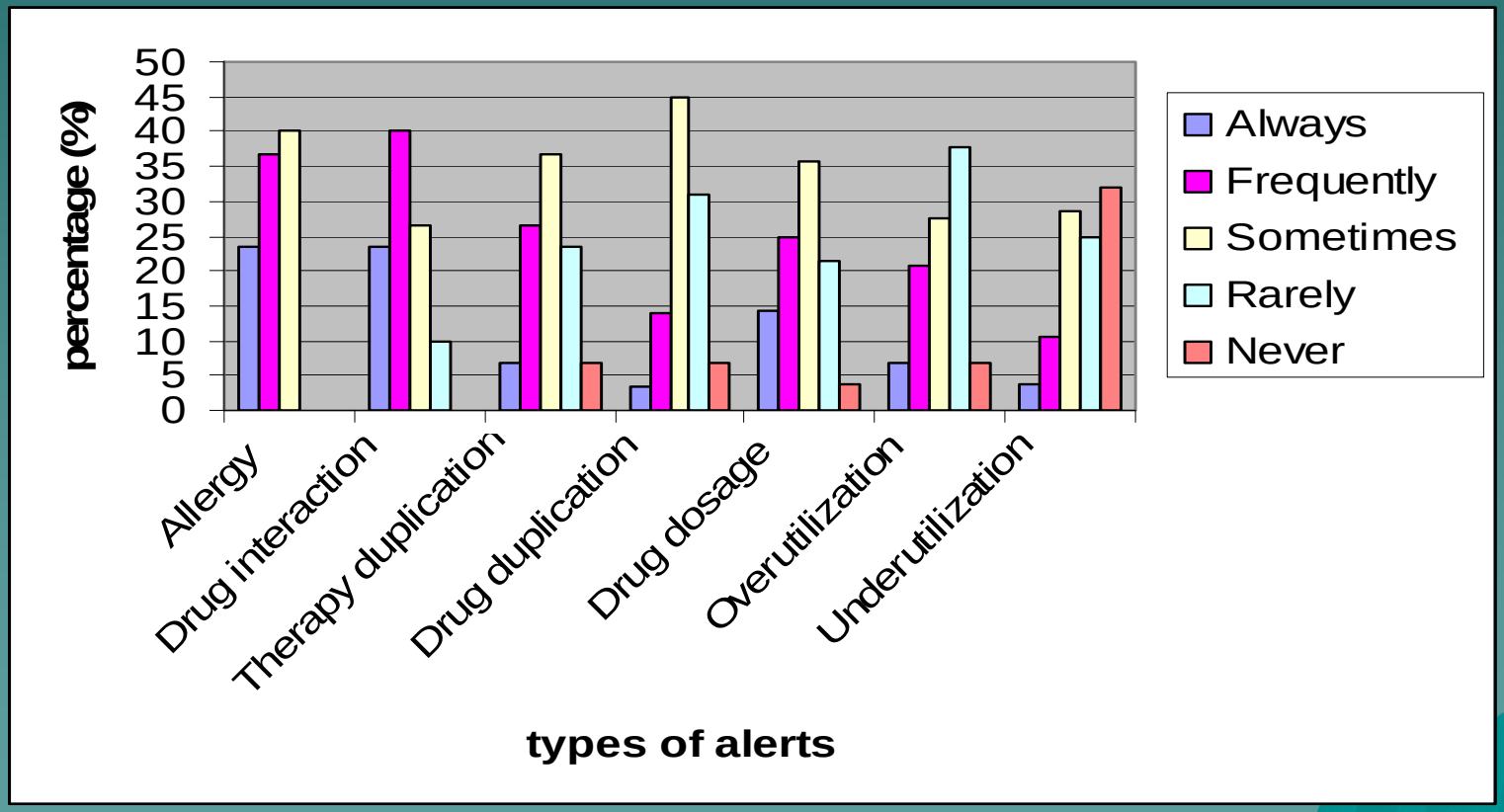
Usefulness of alert types

Type of Alert	Always N (%)	Frequently N (%)	Sometimes N (%)	Rarely N (%)	Never N (%)	Total N (%)
Drug-allergy	7 (23.3)	11 (36.7)	12 (40.0)	–	–	30 (100)
Drug–drug interaction	7 (23.3)	12 (40.0)	8 (26.7)			30 (100)
Therapeutic duplication	2 (6.7)	8 (26.7)	11 (36.7)	7 (23.3)	2 (6.7)	30 (100)
Drug duplication	1 (3.5)	4 (13.8)	13 (44.8)	9 (31.0)	2 (6.9)	29 (100)
Drug dosage	4 (14.3)	7 (25.0)	10 (35.7)	6 (21.4)	1 (3.6)	28 (100)
Drug over-utilization	2 (6.9)	6 (20.7)	8 (27.6)	11 (37.9)	2 (6.9)	29 (100)
Drug under-utilization	1 (3.6)	3 (10.7)	8 (28.6)	7 (25.0)	9 (32.1)	28 (100)

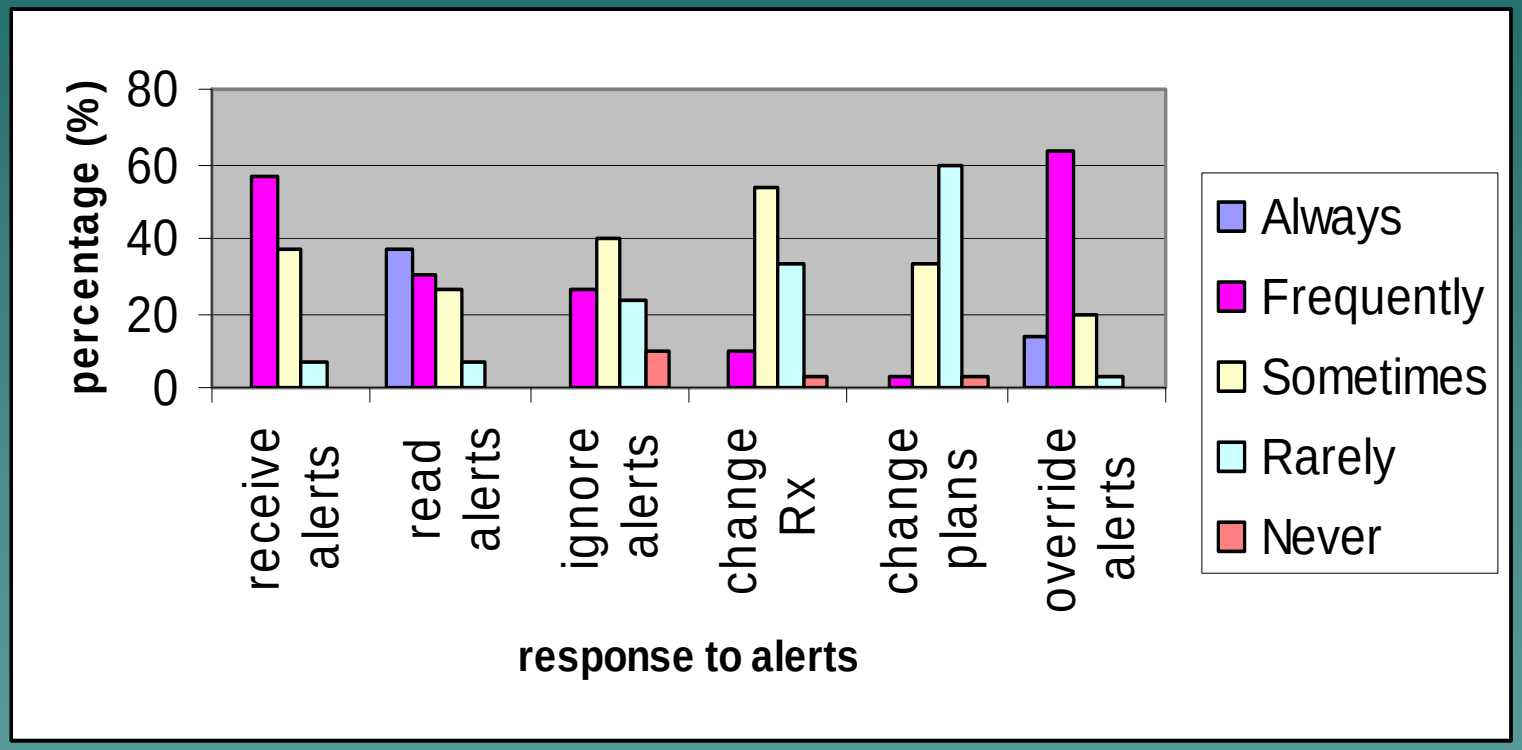
Provider actions to alerts

Provider action	Always N (%)	Frequently N (%)	Sometimes N (%)	Rarely N (%)	Never N (%)	Total N (%)
Receive alerts	–	17 (56.7)	11 (36.7)	2 (6.7)	–	30 (100)
Read alerts	11 (36.7)	9 (30.0)	8 (26.7)	2 (6.7)	–	30 (100)
Ignore alerts	–	8 (26.7)	12 (40.0)	7 (23.3)	3 (10.0)	30 (100)
Change prescription	–	3 (10.0)	16 (53.3)	10 (33.3)	1 (3.3)	30 (100)
Change / monitoring plans	–	1 (3.3)	10 (33.3)	18 (60.0)	1 (3.3)	30 (100)
Override alerts	4 (13.3)	19 (63.3)	6 (20.2)	1 (3.3)	–	30 (100)

Usefulness of alert types by percentages



Provider response to alerts by percentage



Conclusion

- Providers frequently do not consider alert warnings or messages in_making their prescribing decisions

- Eliminating specific alerts can improve system integrity and increase provider acceptance

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Provider Actions in Response to Drug Alerts Generated in the Composite Health Care System

Fola Parrish, Nhan Do, Nancy Orvis

Department of Defense, Tricare Management Activity, Falls Church, Virginia, USA

Abstract

Computerized provider order entry combined with clinical decision support systems can alert prescribers to significant drug interactions, but growing evidence indicates that most providers often override these drug alerts. We conducted a survey of military prescribing providers in order to better understand their perceptions and actions in response to the drug alerts generated in the Composite Health Care System (CHCS). The majority of providers found certain types of alerts such as drug-drug interaction (63%) and drug-allergy alerts (60%) to be more useful than drug underutilization, drug over utilization, and drug duplication. More than three-quarters (77%) of providers indicated that they frequently overrode drug alerts during the medication ordering process. The results of our study suggest problems with the specificity and sensitivity of the alerts generated in the CHCS.

Keywords:

drug interactions, drug-allergy interactions, drug alerts, clinical decision support, medication errors, computerized provider order entry, CPOE

Introduction

CHCS is the computerized provider order entry (CPOE) system used by the Department of Defense (DoD) in over 500 medical treatment facilities (MTFs) worldwide. CHCS is integrated with clinical decision support systems and performs order checks for drug-allergy, drug-drug interaction, drug duplication, drug dosage, drug underutilization and drug over-utilization.

Methods

The questionnaire was given to prescribing providers at two busy military health clinics and to participants of a monthly workgroup meeting. Providers were required to indicate their agreement or disagreement to each statement or question on a five-point Likert-type scale.

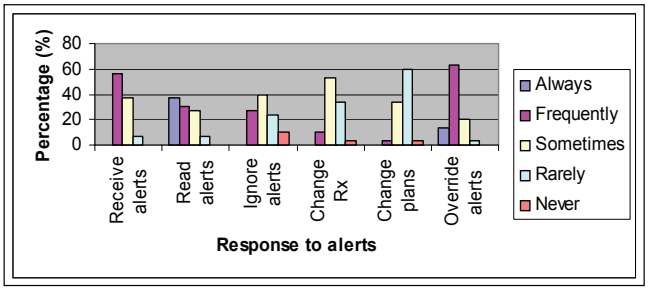
Results

Of the 32 questionnaires distributed to providers, 30 (94%) were completed and analyzed for this study. Demographically, survey participants were evenly divided between male (50%) and female (50%), and almost half had used the CHCS for over ten years (45%).

Providers found drug-allergy (60%) and drug-drug interaction (63%) alerts to be the most useful types of alerts while drug underutilization (57%), drug over-utilization (45%), and drug duplication (38%) alerts were found to be rarely or never useful.

More than half of the providers (57%) indicated that they frequently received drug alerts. A significant number of respondents (77%) admitted to always or frequently overriding drug alerts, 67% admitted to always or frequently reading drug alerts, and 27% admitted to frequently ignoring drug alerts (see Figure 1). Overall, 37% of physicians rarely or never changed their initial prescription decision based on the drug alert they received, and 63% rarely or never changed a patient's clinical or monitoring plans because of a drug alert. This could indicate that providers do not consider drug alert messages or warnings they receive in making prescribing decisions.

Figure 1 - Provider response to drug alerts



Conclusion

The high frequency of alert overrides expressed by providers may reflect problems with the sensitivity and specificity of the alerts generated by the system. Eliminating specific alerts or alert types that providers do not find useful can improve system integrity and increase provider acceptance of the CPOE. The findings of this study are consistent with results from studies conducted in civilian and private health care institutions.

Does Integrated EHR System Assure Safety Patient Management?

Kiyomu Ishikawa[a], Hidehiko Tsukuma[a], Norikazu Iwata[a], Takeshi Tanaka[a], Hisashi Ohmichi[b], Yoshimasa Umesato[b], Hitoshi Terasaki[b], Nakao Konishi[c],Akie Kawamura[d], Kayo Sakata[d], Teruko Sainohara[d], Miyuki Sugimura[d], Reiko Umemoto[e], Masashi Tooya[f]

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[f] *Department of Safety Management, Japan Council for Quality Health Care, Tokyo, Japan*

Abstract and Objective

To argue about a recent attack towards a policy to develop integrative networked Electronic Health Record (EHR) system as a basis for cooperation among care teams and with patients and in support of care for patient safety in Japan.

Keywords:

Electronic Health Record (EHR) system, Data use, Patient Data Protection, Confidential Information, Disclosure.

Introduction

Though the EHR is expected to decrease the variation in record quality, there is still no consensus on its social role. The idea that it is just the computerized version of the paper record still prevails. In our view, it will be necessary to develop it beyond that into the key medium for interaction of specialists in medical care.

Methods

As the basis for our work, two questionnaire surveys were executed by the author headed commission developing policy for Health Record structure and its computerization (E-Chart Taskforce). One survey assessed the attitudes towards a next step of EHR system in the Hiroshima university hospital and its affiliate hospitals. The other survey assessed the current state of safety management of EHR systems in the hospitals certified by Japan Council for Quality Health Care (JCQHC).

Results

The survey of the above hospitals showed that most have computer supported administrative procedures, but only few computer-based health records. The attitudes of the Hiroshima EHR users show that while they expect efficiency and quality improvements, there is also apprehension that the system in use might lower practical efficiency and compromise patient safety. Accordingly, health recording requirements and storage policy have been restructured and communicated to the hospitals.

Conclusion

Despite our effort to reflect the care process in the system operation, the current system in the opinion of medical staff is so complicated and unusable that it might impinge on operational efficiency and threaten patient safety. We are guided by the notion that the standardization of the EHR will lead to standardizing the safety of the healthcare process.
In order for the standardized EHR to become the basic medium for the interaction of specialists and patients in the practice process, we have to comprehend the EHR from the perspective of safety and quality of healthcare and reevaluate its computerization to arrive at a better blueprint for the next generation health system, which is worth while to disclose for patients.

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A Security Infrastructure for Shared Electronic Health Records - Role Based Access Control as IHE XDS Extension towards End-to-End Security

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Abstract

In an aging society with continuously increasing number of multi-morbid patients rising costs of the health care system are expected. The availability of relevant medical data across institutional boundaries is expected to improve quality and efficiency in health care services. In this work an IHE-XDS compliant architecture for Shared Electronic Health Records with a concept for End-to-End security is described. Therefore a security model with Role Based Access Control mechanism (RBAC) has been designed.

Keywords:

Computerized Medical Records System, community care networks, computer security

Introduction

In an aging society with continuously increasing number of multi-morbid patients rising costs of the health care system are expected. The electronic processing of medical data, which is expected to improve quality and efficiency of health care services [1] will lead to an increasing amount of medical data exchanged across institutional boundaries [2, 3].

A variety of existing standards for Shared Electronic Health Records (SEHRs) have been analyzed and the IHE Cross Enterprise Document Sharing Profile (XDS) turned out to offer a high level of interoperability while providing concrete recommendations for implementation [4]. XDS does not specify the underlying network architecture, nor are security aspects addressed.

End-to-End security, in contrast to Point-to-Point security, allows secured information to be transmitted via intermediate nodes without breaking security. Therefore securing of information, such as encryption and digital signing is handled by communicating applications and not by the network protocol as performed for Point-to-Point security.

According to national and international rules and regulations data security is a vital aspect of SEHRs. Medical Data GRIDs seem to be appropriate to address both, interoperability required by the IHE XDS profile and demands for End-to-End security regulated by the Austrian federal law for health telematics. This approach is currently beeing developed in health@net, a large scale project for trans-regional interconnection of major health care actors in Western Austria (about 700.000 inhabitants, 1600 GPs, 12 hospitals including one University Hospital).

Materials and methods

In an initial step functional requirements for a SEHR have been analyzed [5]. Based on this analysis a technical specification has been elaborated as requirements document. To ensure the highest possible level of security and data protection, functional requirements have been analyzed along with security requirements for trans institutional workflows in a SEHR.

Therefore a methodology known as SECTET is used to develop UML models that specify workflows between the participating partners. A starting point is the document model that defines the basic objects that are managed and exchanged by the system. In parallel a role model is developed that reflects the permissions and capabilities of the users of the system. These models guide through the elicitation of security requirements [6].

IHE – XDS (Cross Enterprise Document Sharing)

The IHE Cross Enterprise Document Sharing Profile (XDS) provides an architectural approach for document sharing in heterogeneous health care environments [4].

At the Document Source medical documents are produced, which are then stored at the Document Repository and made available to the end user (Document Consumer). The Document Registry is for indexing and search functions, the PatientID source provides a unique patient identification.

Medical Data GRIDs

The architecture is designed to be highly scalable and secure, to offer standardized interfaces and provide for interoperability across institutional boundaries. For this

reason an architecture following the blueprint of Medical Data GRIDs, that is an adaptation of Data GRIDs [7] to the requirements of the medical domain, seems to be most appropriate.

Role Based Access Control (RBAC)

Role Based Access Control is a concept for specifying and enforcing enterprise protection policies, where users can be assigned roles and individual roles can be assigned access permissions [8]. RBAC is a concept successfully used in various access control systems.

Architecture

Currently an open source prototype architecture based on the IHE XDS specification is being developed. The architecture and specific modifications necessary to meet legal and organizational requirements are described as follows.

To ensure greatest possible flexibility and scalability, a distributed approach following the above introduced paradigm of Medical Data GRIDs was chosen and implemented using widespread Web service technology. Services are implemented in the Java programming language with Tomcat as application server and Apache Axis as Web service framework.

The core architecture consists of independent services responsible for storing documents and corresponding meta data, security features, unique patient identification and service discovery according to the IHE XDS specification. In Figure 1 the IHE-XDS reference architecture is shown along with the services implemented in the prototype architecture. To guarantee a high level of security beyond simple transport layer security, Role Based Access Control as a security concept has been implemented.

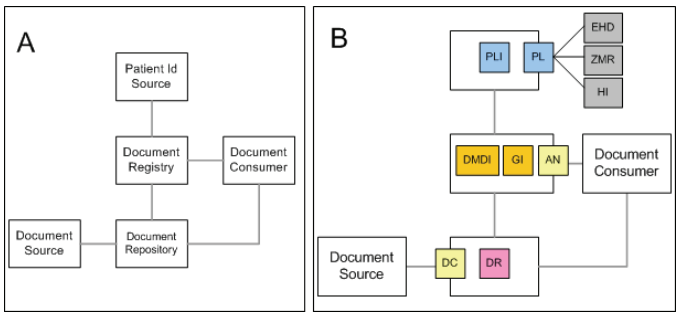

Figure 1: Health@net Architecture based on the IHE-XDS reference architecture. In (A) the IHE-XDS reference architecture is shown. In (B) specific adaptations for the health@net prototype architecture are described. Document Clearing (DC), Document Repository (DR), Document Meta Data Index (DMDI), Global Index (GI), Access Node (AN), Patient Lookup Index (PLI) and Patient Lookup (PL). Governmental services for obtaining patient identification

Core functionality is provided by the three service groups (IHE XDS Actors). Document Repository, Document Registry and PatientID Source. Medical documents remain stored in the organization where they have been produced in the Document Repository (DR). The Document Clearing service (DC) is responsible for converting documents from a proprietary format to the Clinical Document Architecture (CDA) format [9] internally used as data standard for interoperability. Local patient identification is mapped to the internally used unique identification.

The Document Registry service provides functionality for document search, per-document access permissions, a link to the physical location at the Document Repository as well as a service discovery unit. This service group comprises three services: Document Meta Data Index (DMDI), which holds search relevant meta data as well as document based access permissions.

The Global Index (GI) is responsible for finding Meta Data Index services that hold document meta data for a specific patient identified by the unique PatientID. Document consumers are only permitted to access the architecture via a gateway with well defined interfaces, provided by the Access Nodes (AN).

The PatientID Source service group provides for unique patient identification across institutional boundaries, independent form patient's nationality. The Austrian legal situation and the fact that a unique patient identification does no (yet) exist requires different services, partly provided by the Austrian government to be integrated in the architecture.

A Patient Lookup Index (PLI) is used as interface for other services (mostly DC and AN) to obtain a unique patient identification based on demographic data. A Patient

Lookup service (PL) is used to obtain this identifier transparently for the architecture from different governmental person ID sources.

Security Concept: Role Based Access Control (RBAC)

According to functional and technical requirements Shared Electronic Health Records have to fulfill highest possible security and privacy demands. Therefore fine-grained access permissions for all patient related information is required.

Well known information security techniques to ensure confidentiality, integrity, availability and authenticity are mandatory but there are still more domain specific requirements coming from patients, medical professionals or even from both. The following important aspects have been identified and can be found in the list below.

- 4 – eyes – principle (Doctor needs the patients attendance in order to access his health record). Exception: Patient can access and eventually modify his own data. Exception: Emergency access (special logging and informing of the patient).
- Possibility for the owner (patient/citizen) to completely lock/hide certain entries.
- Possibility to delegate time limited access to a doctor and possibility to delegate proxy access to family members.
- Encrypted communication and authentication based on digital certificates (mutual authentication of services).
- Austrian health insurance chip card (e-card) as digital ID-card for authentication with personal health record.

Based on those requirements a hierarchic two level security model has been elaborated as outlined in Figure 2.

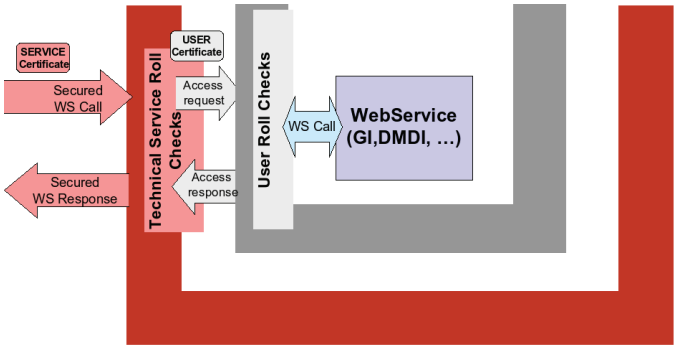

Figure 2 - Two level role check model. In the external level static service roles are checked, in the internal level dynamic user roles. For further details refer to the text.

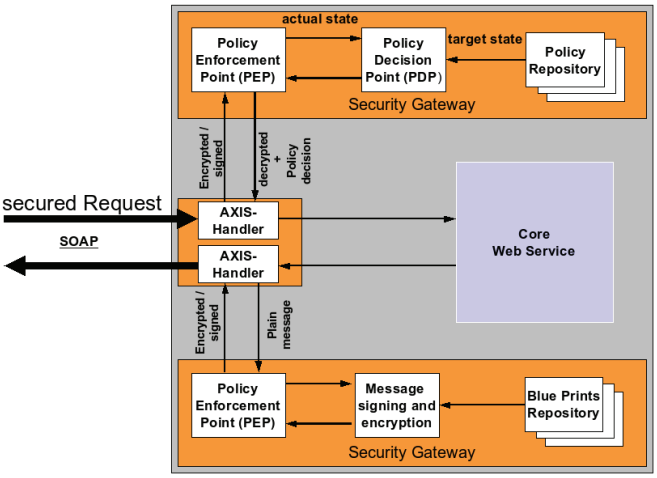

Figure 3 - Policy based security model. The middle part of the figure represents Axis Handler and Core Web Service. Decryption and verification of received messages is shown in the upper part. Encryption and signing of transmitted messages is described in the lower part of the figure. For further details refer to the text.

Level 1: Service role checks:

Each web service has to ensure, that it can only be called by registered and entitled Web services. The calling service has to send a certificate which the called service has to check. Therefore each Web service gets supplied with a service certificate signed by a trusted certification authority and stating out its role. Once a called Web service properly identified the role of the calling service it is compared to the locally configured policies in order to decide whether the call should be permitted or not.

Level 2A: Static user role checks:

After the service role check succeeded, permissions of the user that actually started the request have to be analyzed. As the Electronic Health Record will include different types of documents with different access rules they have to be checked as well. A pharmacist, for example, must not be able to see any discharge letter but, in turn, has to be able to access a patient's prescriptions. Therefore the same role based mechanism as already used in level 1 is applied.

At the time a user account is created, an appropriate user certificate is issued defining the user's profession and effective permissions (assignment procedure of permissions is beyond the scope of this work). When accessing a patient's health record this certificate is checked against the pre-configured policies of the corresponding Web service. For example: In case a user requests access to a patient's prescriptions and the user is assigned the role pharmacists, access will be granted.

Level 2B: Dynamic user role checks:

Furthermore it is important to check dynamic user roles. An authenticated pharmacist, for example, who is correctly trying to access patient's prescriptions should only be permitted to access the information if the consent of the patient is present. Again the same role based check method is applied. In Austria each citizen already has a unique health insurance smart card (e-card) with crypto card functionality. The certificate on this card (and the associated pin-code) can be used to check whether the patient has given his consent while a medical professional is trying to access his health record. Only if the patient's consent can be verified, access will be granted.

In the role based access control mechanism on each level of the security hierarchy actual permissions have to be checked. Therefore each Web service is configured with a set of policies. As the service is called from outside, an inspection is carried out whether the call confirms to the local policies and, only if so, the the requested Web service can be invoked. In case a request does not comply with configured policies the request gets rejected and logged.

For each request a state is extracted which is compared to local policies. If an adequate policy can be found where that the actual state matches the target state, a positive acknowledgment is generated and access is granted.

Implementation using Web Service Security

The security infrastructure is being implemented using Web Service Security Extensions. The Apache Web service framework Axis permits so called “Axis handlers” to be registered with the framework in order to extend it's functionality. In the architecture security functions are integrated via Axis Handlers.

This concept does not require Web services to be designed with security aspects in mind. The RBAC based security infrastructure is pluggable via the Axis handler.

The security gateway depicted in Figure 3 uses policies to map roles to access permissions. The figure describes how received data are decrypted and validated (upper part) and how send data are encrypted and signed (lower part).

Service roles and user roles are defined in the Policy Repository and can be changed dynamically. The procession of a received SOAP message is initially intercepted by the Axis handler and forwarded to the Policy Enforcement Point (PEP).

The actual state (e.g. current role of calling user and requested action) is then extracted and transmitted to the Policy Decision Point (PDP). The PDP searches for a policy in the Policy Repository which defines the requested action as permitted for the respective user. If a corresponding policy is found access is granted, the message decrypted, verified and returned to the Axis handler, which finally forwards the call to the original Web service.

Transmitted messages are processed in a similar workflow. The message is intercepted by the Axis handler and forwarded to the PEP. At this stage the message is signed and encrypted for the receiving service according to the policies in the Blue Print Repository. The Axis handler, as a last step, transmits the secured message to its destination.

The security model described in Figure 3 is the technical implementation of the two level role check model described in Figure 2.

Discussion and outlook

Currently a prototype implementation of the IHE-XDS compliant architecture with the role based access control methodology has started. The development of the network architecture follows an iterative approach which we have chosen to gradually adopt the architecture to evolving requirements of the major players. In this article the first prototype architecture is described including role and context based authorization system to provide for End-to-End security. A prototype is currently being released, which will demonstrate the conformance of the security mechanism to the above mentioned requirements.

The IHE IT Infrastructure Technical Framework [4] does offer Profiles for security, such as the Audit Trail and Node Authentication Profile (ATNA) and the Cross Enterprise User Authentication Profile (XUA). The first covers service authentication only on transport layer (without End-to-End focus), audit and centralized secure logging. The latter covers secure user authentication in trans-institutional context. XUA is not final yet, but the introduced RBAC based approach is expected to be seamlessly integrated in the XUA Profile.

Motivated by the above mentioned drawbacks (XUA is not final and ATNA only provides Point-to-Point and not End-to-End security) the RBAC based security infrastructure has been developed. Point-to-Point security allows secure information to be transferred between precisely two networked nodes. End-to-End security, however allows secure information, dedicated for a specific application, to be transmitted via an arbitrary number of intermediate nodes.

Currently static service role checks (level 1) and static user role checks (level 2A) are implemented. For dynamic user role checks (level 2B) further research concerning the application of attribute certificates is needed. Level 2B checks are expected to be integrated in the next software release, scheduled for the summer 2007.

Although the architecture is based on Medical Data GRIDs, in the prototype phase GRID middleware such as the GLOBUS Toolkit 4 [10] have not been used because requirements for Medical Data GRIDs, as outlined above, are currently not satisfactorily covered. Nevertheless GRID middleware provides interesting features particularly in the field of authentication and distribution of digital certificates. The adaptation of those concepts is planned for the next prototype.

The implementation closely sticks to the IHE XDS specification. Changes concerning the patient identification have become necessary to reflect the requirements of the Austrian federal law for health telematics. However, before IHE XDS based Shared Electronic Health Records can be used in production environment several technical and organizational aspect have to be solved.

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Data Integrity Management for Medical Image Data Archive Using Digital Signatures and Time-Stamp Certificates

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Abstract and objective

Medical image data archives have been introduced at Innsbruck University Hospital in 1997 using write-once media (CD-R) for long term storage. Due to increasing data volumes, a migration of the archived data to high capacity magnetic tape storage media was necessary. To fulfil the requirements for guaranteed integrity and non-repudiation of the archived data, an additional data integrity layer was added to the commercial PACS software product to add digital signatures to the archived data and time stamp certificates. A time stamp server software suit had been developed by the hospital IT team for that purpose in 1999, issuing more than 2.4 million certificates since. The data integrity layer proved essential in early detection of a severe hardware malfunction in the tape archive system, which resulted in corruption of archived data in December 2000.

Keywords:

PACS, medical archives, time-stamping, data integrity

Introduction

The guarantee of data integrity in archiving medical data is a prime concern. Usually, this is resolved by using unalterable (write-once) media like WORM, CD-R, DVD-R etc. The first choice of archive media for the PACS introduced at Innsbruck University Hospital in 1997 was CD-R jukeboxes, and image data was only stored in one copy. Due to the fast growing volume of data archived, a decision to change to higher capacity magnetic tape media had to be taken in 1999, also to allow for duplicate archive copies of data to prevent data loss in case of media corruption (actually, in the course of data migration of 1.8 TB of compressed image data in 1999, one CD-R medium - from a total of 4.800 - was found to be corrupt, resulting in the loss of 157 imaging studies). To fulfil the requirements for guaranteed data integrity and eliminate the potential for subsequent alteration of archived data (non-repudiation) when using rewriteable media like magnetic tapes, an additional data integrity layer was added by the hospital IT team to the commercial PACS software product. This data integrity layer is a set of scripts that scan the PACS database for trigger events for archiving and retrieving imaging studies and provide the corresponding fundctionalities by interfacing to the archive management software of the magnetic tape archive. The archiving script scans the database for imaging studies due to be archived, then one by one collects together all image files of this study, and adds a digitally signed "study summary files" to the data set to be archived that allows to validate the integrity of the archive data (in subsequent retrievals) and also requests a time-stamp certificate from a time-stamp server for this archive data set, as a guarantee that the given data set was present at the specified point in time (and not foisted later in a possible fraud attempt).

Methods

To enable the commercial PACS product to use a tape archive system for long term archiving (instead of the CD-R jukeboxes), a software layer was developed by the hospital IT team to connect to the archive management software system. It was decided to archive image data in packages containing one imaging study each (ranging up to Gigabyte size for large CT exams). A study summary file is created for each study, representing an enhanced directory listing of all image files in the study, containing filename, creation date, file size and an MD5 hash of the image file itself (the MD5 hash algorithm was chosen for its fast execution time essential for the hardware available back then). This study summary file is digitally signed with a server specific private key (controlled by hospital IT staff). On retrieval of the archived data set at a later point in time, the signature of the study summary file is verified and the content of the study summary file is cross checked against the retrieved image data – allowing to detect any alteration in the image data files.

This still leaves open the possibility for manipulation by the hospital IT team in control of the signature keys. To eliminate this potential security breach, a digital time-stamping service was developed by a member of the hospi-

tal IT team in early 1999 as a Java application running under Linux. This service has been continuously operational since, issuing more than 2.4 million time-stamp certificates, one for each imaging study archived.

This time-stamping server receives request for issuing a time-stamp certificate via a proprietary TCP/IP socket based network protocol (standards for time-stamp certificate formats and request protocols have only been defined years later [1]). This usually contains an SHA1 hash of the actual data that is to be time-stamped (in our case, an SHA1 hash of the study summary file). The certificate issued is a text data set that is signed by the time-stamping system with its own private key. It is comprised of the data to be time-stamped (the SHA1 hash), the UTC time-stamp, a sequence number, and a hash of the previously issued certificate. This linear linking scheme is the simplest way to guarantee a tamper-prove sequence of time-stamp certificates. It is impossible to alter one of the certificates at a later point in time (even when in control of the signature key), because this would require changing all subsequently issued time-stamp certificates as well. To render even this impossible, once a month, the most recently issued time-stamp is send to a broader group of people to make it publicly known (publishing it in a printed periodical with wider circulation was also considered).

Results

The time-stamping system started operation in May 1999 and was first tested, when 1.8 Terabyte of losslessly compressed image data were migrated from 9 CD-R jukeboxes to the tape archive system in a 2 month effort in the summer of 1999. The dual archiving of data and the digital signature based data integrity layer proved enormously valuable, when a sporadic hardware defect occurred in the tape drives (or rather a SAN fibre channel gateway device) used in the tape archive system, corrupting part of the image data files.

In December 2000, when retrieving imaging studies from the tape archive the data integrity checks comparing data retrieved with the MD5 hash information from the data summary files stored along with the actual image data showed signs of data corruption and caused the hospital IT staff to initiate a problem analysis with the hardware vendor, which proved to be very difficult due to the erratic nature of the hardware defect. After lengthy analysis and due to the fact, that corrupted data sets could be easily identified, the problem could be tracked down and data recovery procedures were initiated.

The time-stamping service has been operating flawlessly since 1999, issuing a total of 2.4 million time-stamp certificates until now. Apart from the incident with data corruption, no data integrity problems ever occurred.

Conclusion

Ensuring data integrity and guaranteeing non-repudiation for magnetic tapes as long term archive medium for large volume medical image data using digital signatures and time-stamp certificates has proved to be a viable and cost effective solution and has been operational at Innsbruck University Hospital from 1999 on. More than 2.4 million imaging studies have been archived and digitally time-stamped. The inhouse development for the time-stamp server proved to be very stable and has been continuous in operation for 8 years. Nevertheless, the linear linking scheme used to generate a tamper-prove sequence of time-stamps has deficits in the verification process [2] and more efficient schemes have been proposed [3]. Due to the absence of standards available at the time of implementation of the time-stamp service, the protocol for requesting time-stamp certificates had been defined in a proprietary way. Subsequently, standards have become available [1]. And open source implementations for time-stamping services are now also available drawing on these standards (see [4] and [5]), which have the additional advantage to be able to utilize commercial Hardware Security Modules (HSM), which guarantee the tamper-prove generation of time-stamp certificates in hardware. Even though the utilization of time-stamps is undisputed, a new standard compliant system with improved security (eg. by using HSM and new secure hash algorithms) can be seen as a requirement for the new medical image and documents archive system, to which the PACS image data has recently been migrated. Anyhow, digital signature legislation limits the validity of digital certificates (the Austrian "Signaturgesetz" sets a maximum of 5 years for the validity for qualified certificates [6]), and thus a renewal of the signatures on the archived data sets has to be considered, best performed along with a periodic active rearchiving on new media to protect against data corruption due to media ageing.

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De-Centralized Network System For Sharing Electronic Medical Records

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Abstract

Collaboration among medical specialists is necessary. Some regional medical collaboration systems have been developed using centralized models. The centralized model network determines collaboration within the network and cost too much. Therefore, we have preliminary developed a de-centralized medical collaboration system to overcome this barrier to collaboration as sustainable network. This model has some capability to establish sustainable medical network.

Keywords:

de-centralized communication, open source software, electronic medical record, internet, P2P

Introduction

Medical professionals collaborate via referral letters. There are some systems that enable the sharing of electronic medical records (EMR), within a wide area network, using a centralized model[1-5]. However, such models limit the communication and collaboration of EMR to within the network (Figure 1). If we wish to refer a patient to another doctor in such a model, we must confirm whether the doctor belongs to the network or not. Therefore, the centralized model network encloses medical specialist within its network and constitutes a barrier to medical collaboration. Consequently, the centralized model does not match real medical relationships.

Therefore, we preliminary developed a medical-record-sharing system using a de-centralized network to construct de-centralized network which connect every hospital seamlessly (Figure 2).

The aim of this project was to develop collaboration software that seamlessly communicates electronic medical records to other professionals using a de-centralized network.

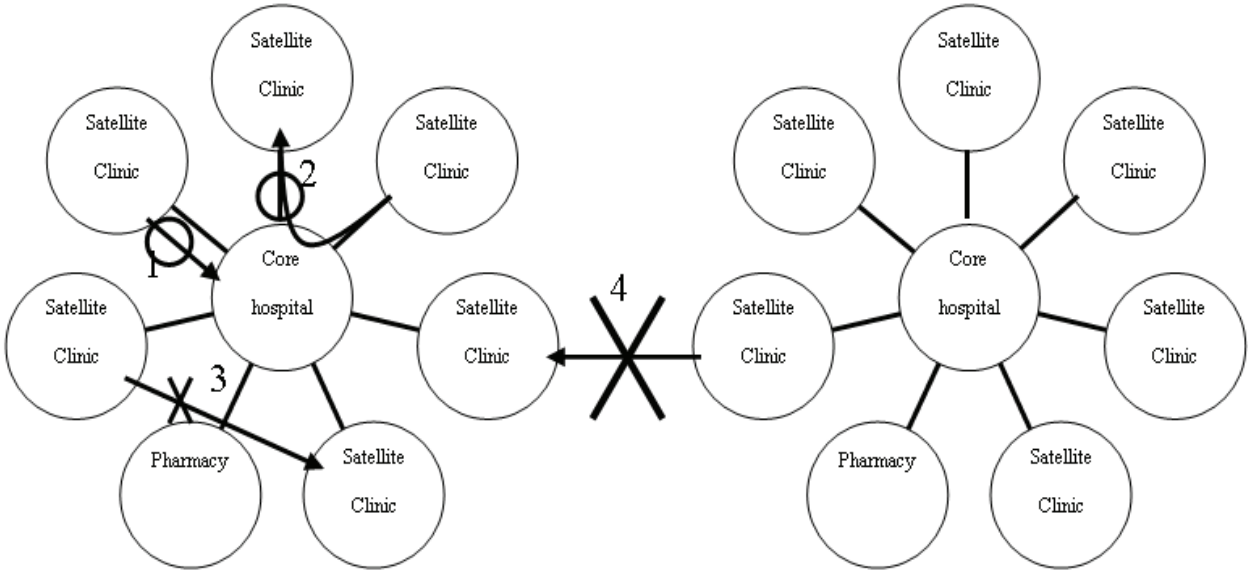

Figure 1 - Typical centralized network model. In this model, a satellite participant can refer a patient from the satellite to the central hospital (arrow 1) or to another satellite via the central hospital (arrow 2). However, a participant cannot refer a patient to another satellite directly, or to another network (arrow 4)

Methods

The system was separated into three modules: the medical referral letter editor, peer-to-peer (P2P) communication, and message management modules. We adopted Java as the development language and developed it using Sun Java 2 Standard Edition Software Development Kit (J2SE SDK) 1.4.2[6]. We used JXTA 2.1[7] as the P2P framework to construct de-centralized network, Eclipse 3.2.1[8] as the integrated development environment (IDE), and Concurrent Versions System (CVS) [9] to administer the source code. The CVS repository is placed on Sourceforge.jp and can be viewed at http://cvs.sourceforge.jp/cgi-bin/viewcvs.cgi/mega-net/.

Medical referral letter editor module

The patient referral letter implements a graphical user interface (GUI) to edit the message. The information in each message is stored as a Java instance and contains the patient's name, birthday, sex, age, diseases, clinical course, past history, family history, medications taken, and notes. After editing the message, it is sent to a medical specialist by the P2P communication module and stored by the message management module.

P2P communication module

For the implementation of this module, refer to the programmer's guide for JXTA[10]. This module includes the following features:

- Create or join PeerGroup with secure authentication.
- Extend PeerAdvertisement with hospital (institute) name, address, doctor's name, doctor's speciality, telephone number, and FAX.
- Publish and discover the extended PeerAdvertisement in real time.
- Connect peer to peer via an encrypted pipe.

The peer discovery algorithm is distributed hash table model implemented with JXTA. A PeerAdvertisement is generated when instantiating a group on a peer, and contains all the necessary parameters, including the participant's medical information in XML format. PeerAdvertisement propagates within PeerGroup, which can connect segments within a secure network cloud, and requires password authentication to join.

Each peer propagates its organization information and doctor's information within this securely protected PeerGroup to be identified. The participant sends an electronic referral letter to the other who could join this network with this authentication, on demand. The PeerGroup provides an encrypted pipe for peer-to-peer connections and sends a ciphered message with patient information using the TLS 1.0 protocol[11] to provide security against Internet sniffing.

When a message is received, this module decrypts the message and stores it on a local hard disk using the message management module.

Message management module

Each electronic medical referral letter is serialised as a Java instance. The serialised instance is saved and loaded on a local disk via a Java stream. This module stores messages that are sent and received via the P2P communication module. The messages are listed in a table and can be viewed as three windows, similar to the layout in MS-OutLook. This module also manages other items to extended PeerAdvertisement described before.

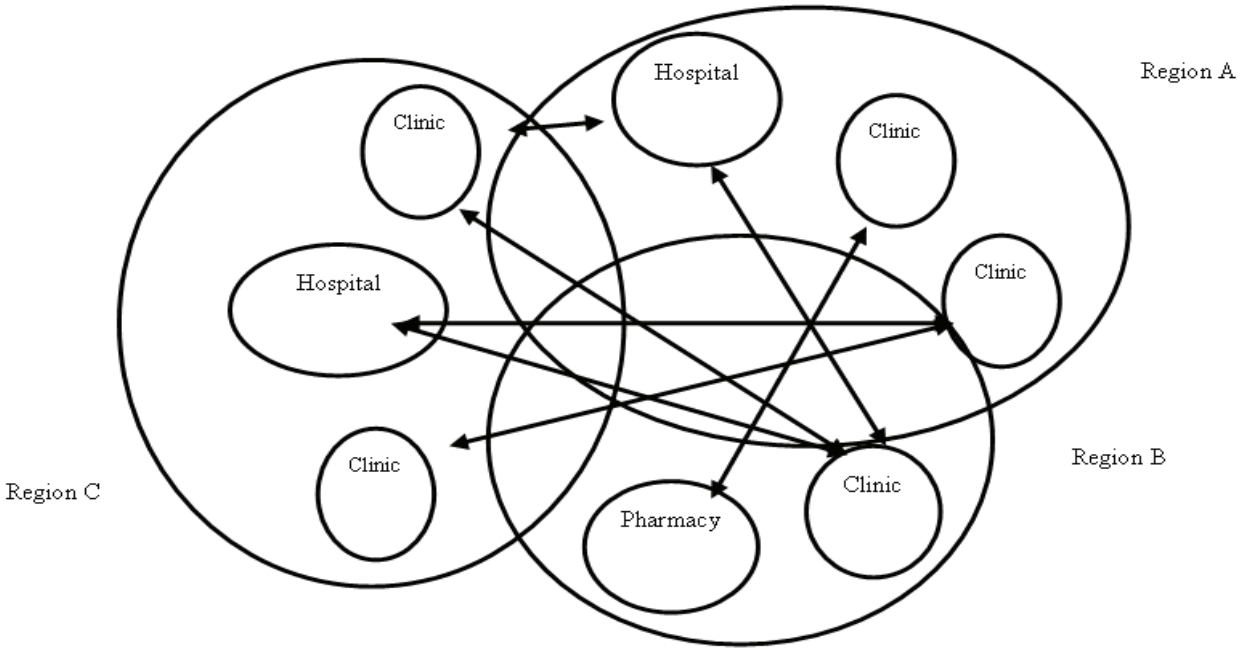

Figure 2 - De-centralized network model. In this model, a participant can make seamless referrals to other participants beyond the region

Results

Our system can successfully transfer encrypted electronic medical referral letters to doctors via a P2P network.

It takes about five minutes to configure this system for use after downloading it. Since there is no server, a client only needs to configure for his / her network. The configuration needs the P2P setting and user information. The only cost to join this network is that of downloading it.

Writing a referral letter

This system finds peers automatically. Information on peers can be viewed in a list window. The list shows the doctor's name, specialty, and organization name. The recipient of the letter can be chosen from this list.

The user can edit a referral letter with a GUI. After editing it, the message is sent to the selected peer instantly and saved on a local hard disk.

Message management

This system receives messages automatically. Messages are saved in two folders: 'sent' and 'received'. The list of messages can be viewed by GUI.

Discussion

As this project is a work in progress, many problems remain to be solved. Nevertheless, this system offers tremendous benefits that can make up for these problems. This paper discusses these problems and invites interested parties to join the project.

The most significant problem in setting up a health care network is that of interconnecting the centres within the network[12]. Each physician should be able to determine which medical specialist to collaborate with, rather than having this decided for him or her by the network architecture. In our de-centralized model, medical professionals can introduce patients to specialists outside the regional network system, as they deem appropriate.

Network model	Development	Maintenance (Server)	Maintenance (Participant)
De-centralized	$60,000	$0	$0
Centralized	$2,000,000	>$100,000/year	>$1,000/year

Table 1 - Cost of the network (Estimate based on other medical record network services which developed by the fund of national funds in our country.)

However, this system has critical problem that cannot send message to off-line participant, although in centralized system, server stores the message for off-line participant. To resolve this problem, we are now refactoring this system for off-line participant by queuing message on local until the participant is on-line to be send message.

In addition, since this system runs on Java VM, it does not depend on a specific operating system (OS). Therefore, this system has few restrictions, not only in terms of medical use, but also in terms of the computer environment.

One remarkable advantage of this system is its total cost (Table 1). In Santa Barbara County, US, P2P based medical system project also reported that it succeeded to reduce total cost of medical communication [13]. There is no cost for a network server with this system. Since we used open source products, we saved development costs. There is, in addition, no cost or fee for participants who wish to join this network. This constitutes a major advantage, as compared to other systems.

As contrast with centralized model, de-centralized network is looser combination with each information system. In general, tight information integration, which shares the same database, is easier to develop than loose one. If chronologically ordered data are needed (laboratory data centre, for example), centralized model is superior to the looser data integration[4]. Therefore, we have to develop some tight information combination interface to the other system that can apply under the open source license.

However, since our source code is open, others can adapt it to the communication module of their hospital information system. Our licence permits the use of our source code in proprietary software.

This system is robust against malicious Internet attack because the target is so widely distributed; this means that an attacker cannot jeopardize the entire system. Even if an attacker cracks the system of one participant, the other participants can still communicate with each other. While it has a lot of merits for medical specialist that EMRs are distributed and available like notorious file sharing systems, patient privacy issue does not allow it. Therefore, we decided security policy that peers can only send EMR to the associated doctor to refer a patient and the documented agreement of patient for transfer is necessary to transfer his / her record, and cannot issue query to the other peer to get unrelated EMRs. Under this policy, the risk of information leakage should be minimal because each participant only stores information on his / her own related patients.

This method does not conflict with inter-network communication, such as IHE-IDX. Peer-to-peer communication system can easily be adapted to organization-to-organization communication.

Although this system has some merits than the other system, legal issues has raised on P2P system. In Japan, P2P file sharing system named Winny caused many security issues that leak significant confidential matters on many personals, companies, and government (such as military matter). The author is accused in a court, whether to develop P2P software is guilt or not. This project is faced in the trouble that we cannot continue our development until this legal issues is clear.

Moreover this system has many technical issues on security and the other field, but we think it is only the technical issue that is able to be resolve. Therefore, we are trying to reconstruct this application over web-based framework, which can disclose electronic medical record to the consumer or the other healthcare provider with strict security for fair use.

Conclusion

We have preliminary developed a de-centralized collaboration system that can transfer electronic medical information seamlessly. As compared to other systems, our system has fewer restrictions, is inexpensive, and can be used to construct a robust network. Furthermore, our open source software has the potential to evolve, which will allow any remaining problems to be overcome in the near future. This system has the capability to enrich medical practice but has been faced to the legal issue.

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De-centralized network system for sharing electronic medical records

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Introduction

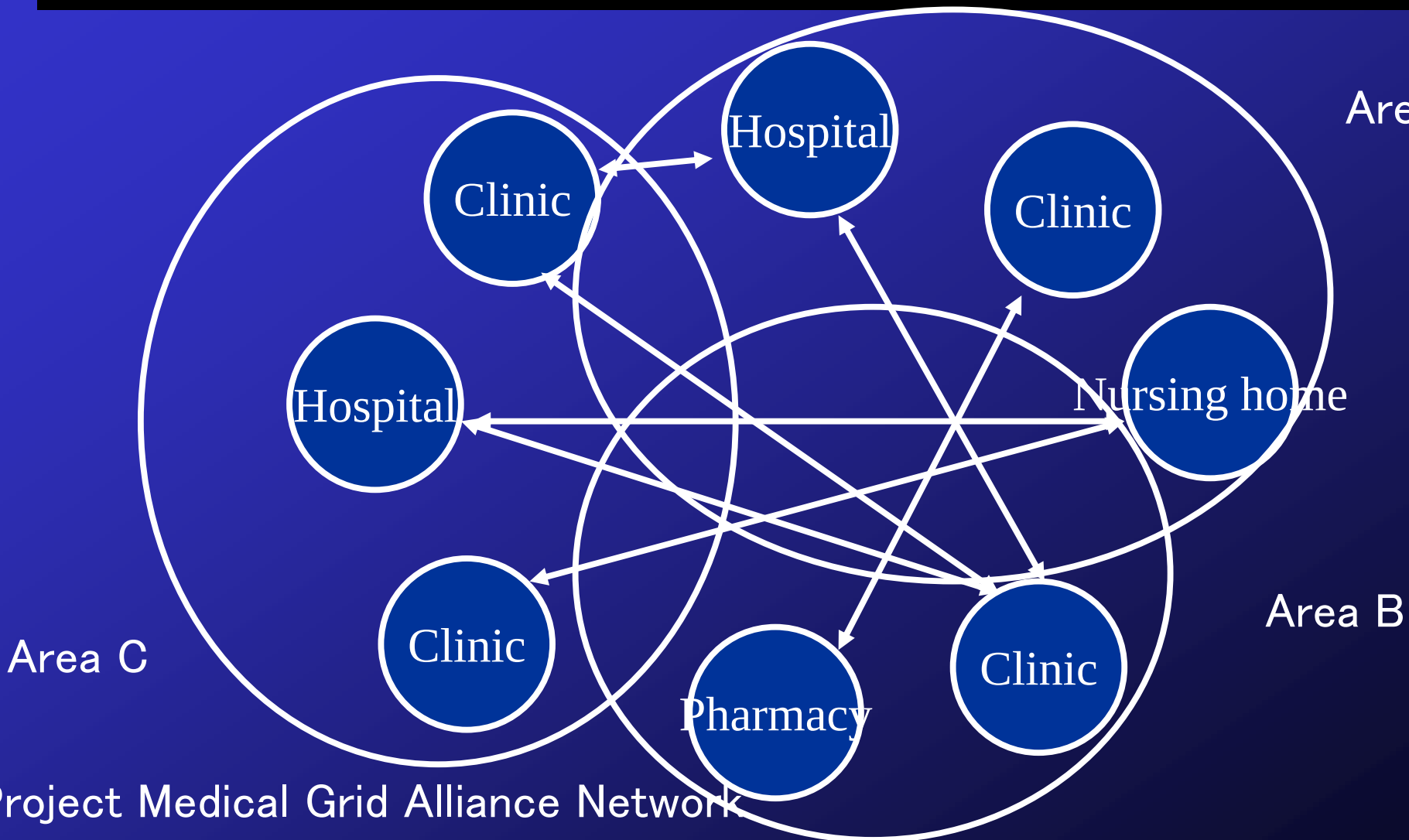
- Inter-hospital relationship
  - –Specialty, intensive care, collaboration
- Share electronic health/medical records
  - –Regional Healthcare Information Organization
  - –EHR
- Is centralized model(Client/Server) suitable?

Regional Healthcare Information Organization(C/S type)

Problem of C/S model

- Mismatch of relationship
  - Relationship is not only limited in organization, but also spread in mutual trust.
- Compatibility among systems
  - Incompatible format
  - Closed architecture
- Administration cost
  - Server, security, software, line
  - How it cost? Is it sustainable?

De-centralized model



Project Medical Grid Alliance Network

Methods

- Development environment

  Java2 SDK 1.4.2, JXTA 2.1, Eclipse 3.2.1, CVS for source code repository
- Software design
  - –Divided three modules, Referral letter editor module, Message management module, P2P communication module
  - –Referral letter editor
    - GUI editor for referral letter
  - –Message management
    - Message saved as Java instance
  - –P2P communication module
    - Search and manage participant healthcare provider by JXTA Framework 2.1, which is open source P2P framework.

Result

- Development
  Total 8547 line, 3packages, 49 classes.
- Software deployment
  Takes about 5 minutes
- Encrypted P2P communication
  - Transfer referral letters to each participant via encrypted pipe, by P2P technology
- Open source
  - We issued software repository on Sourceforge.jp.
    http://cvs.sourceforge.jp/cgi-bin/viewcvs.cgi/mega-net/

Screen snapshots

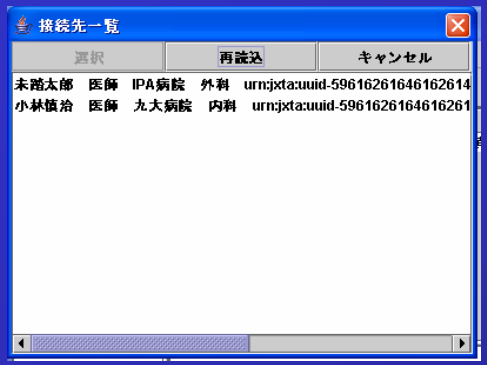


Figure 1. List of healthcare providers

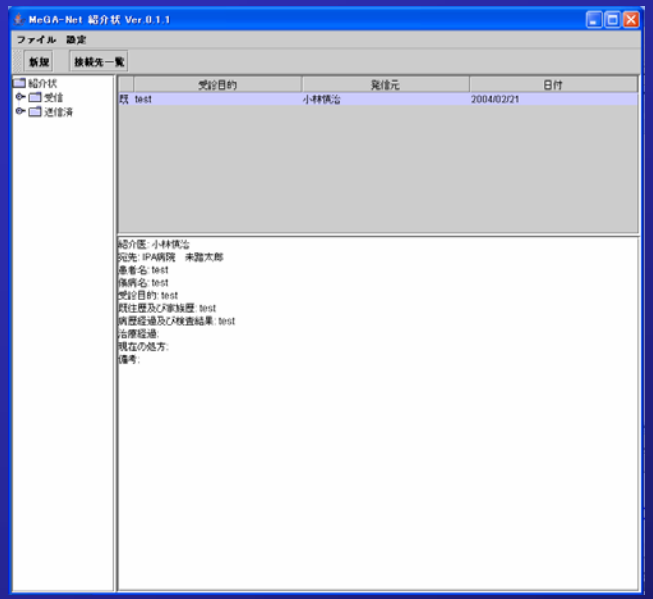


Figure 2. Referral letter management window

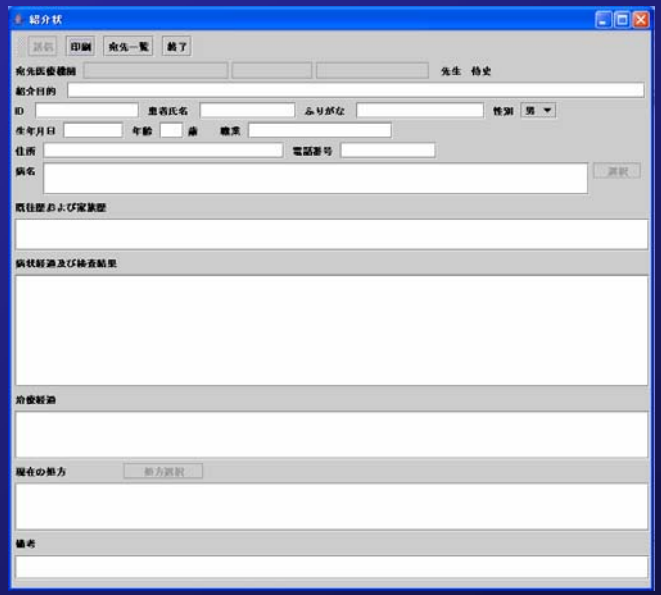


Figure 3. Referral letter editor window

Discussion 1

- Robustness
  - Peer-to-peer communication does not depend on a specified network route, but on duplicated route.
  - Attacker cannot crack entire network. される。
- Information leakage
  - Information is encrypted and transferred directly to each other to protect leakage by the third party
- Authentication
  - JXTA PSE(Personal Security Environment) authentication system implements PKI based authentication.

Discussion 2

- Cost
  - Reduced development cost by using open source software
- Deployment
  - No server setup, client setup only

Model	Development cost	Server maintenance cost	Client maintenance cost
De-centralized	$60,000	$0	$0
Centralized	$2,000,000	>$100,000/year	>$1,000/year

Conclusion

- We have preliminary developed a de-centralized collaboration system.
- As compared to other systems, our system has fewer restrictions, is inexpensive, and can be used to construct a robust network.
- This system has the capability to enrich medical practice but has been faced to the legal issue.

Acknowledgement

- This projected was supported by a grant under the Exploratory Software Project FY2003(IPA, Japan).
- This software has been supported by Sourceforge.jp as development platform.

http://cvs.sourceforge.jp/cgi-bin/viewcvs.cgi/mega-net/

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The Development of Automatic Triage Score Messaging System at Emergency Department: Using Modified Canadian Triage and Acuity Scale (MCTAS)

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Abstract

Triage is an essential component of emergency department (ED) patient management. Canadian Triage and Acuity Scale (CTAS) is a well known triage scale as a reliable tool for rapid patients assessment. The CTAS was modified and implemented to Asan Medical Center through electronic medical record (EMR) systems since April 2006. Automatic PDA messaging system of triage score to emergency medical staff was also developed. Local EMR database, the existing call system, and a new triage messaging interface were integrated. The system was designed as follows: Triage Nurses input modified CTAS score of a patient to nursing information sheet of EMR. If the modified CTAS level is critical, the triage score and other patient important information are instantly transferred to PDA phones of on-call staffs, and if patient's modified CTAS level is not critical, such information is transferred after 2 hours via reservation messaging process. This system is good for emergency communication and can be applied to other critical diseases as well like acute coronary syndrome.

Keywords:

triage, emergency, PDA computer, computerized medical record systems

Introduction

Triage is a critical reference when assigning emergency department (ED) patients' treatment priorities and treatment areas. Also, it is an assessment tool determining the time of stay at ED, and patients' expected outcomes. Canadian Triage and Acuity Scale (CTAS) is a 5-level triage system and is accepted as a more reliable tool than 3 or 4 level triage systems for rapid patient assessment at ED [1].

Asan Medical Center (AMC) is the Korea's largest tertiary referral hospital with 2,200 beds. Every day over 200 patients visit emergency room from all regions of Korea. Overcrowding is always a big threat for a critically-ill patient, because emergency personnel can not contact with him directly and instantly after his visit to ED [2].

AMC has been used other types of triage scale, such as AVPU (Alert, Verbal, Pain, Unresponsive) scale, Glasgow coma scale, Revised triage scale. These scales are simple and easy to use but sometimes inaccurate. These are composed of subjective measurements like blood pressure, mental status, etc.

So, after some modifications of the triage level, CTAS was introduced at AMC. Modified CTAS (MCTAS) scoring system was implemented to EMR system of ED. Automatic PDA messaging system of triage score was implemented for user's convenience and for the rapid triage information transmission. The developmental process and the architecture of the system were reviewed.

Methods

CTAS had been modified by five certified emergency nurses (CENs) and an emergency medical professor since December, 2004. The maximum reassessment time was shortened to one hour from two hour and the CTAS level of trauma patient was elevated a level higher [3]. These modifications were made after discussions of CENs and an emergency medical professor. Before the introduction of MCTAS, CENs had been used MATS (Modified Asan Triage Score) scale as an objective triage scale. The comparison study of the usefulness of two triage scale showed that MCTAS was more reliable than MATS in indicating the severity of condition of ED patients [3]. After then, MCTAS and its basic information were implemented to the EMR system on March 10, 2006. The user interfaces of MCTAS were developed after several times of discussions with the EMR developer team.

The automatic PDA messaging system of MCTAS was implemented with two purposes. The first one was to establish early and direct call system for emergent patients (MCTAS level I, II), the second was to alert on-call emergency staffs the delayed dispatch decision for non-emergent patients. The activation rules, contents of messages, message recipients were decided by emergency medical staffs. Automatic messaging service was started since March 17, 2006 after triage messaging interface was developed. The rules were adjusted twice, and a reservation messaging process was introduced after 3 months of the installation to serve the second purpose.

Results

The instant messaging system was implemented at first for high levels of CTAS: If a CEN inputs patient's triage score into a nursing information sheet window and restores it after other information inputted, the automatic triage messaging process is activated. If a patient's triage score is 1 (resuscitation) or 2 (emergent), EMR server sends it with patient dataset (e.g. patient's ID number, treatment area, chief complaint), and on-call staff's PDA number to SMS (short message service) server instantly through a triage messaging interface. After then, SMS sever sends the whole package of information to a PDA phone of an on-call staff within local wireless network area. If less emergent scores (3-5) are entered, the automatic triage messaging process is not activated. If a triage score of patient is changed to 1 or 2 during ED stay, this information is also automatically transmitted to on-call staff by above process.

The reservation triage score messaging system was implemented 3 months later: If less emergent patient (MCTAS score; 3~5) stays at ED more than 2 hours, reservation call is sent to on-call staff with the same dataset as above. This system was introduced to alert on-call emergency staffs the delayed dispatch decision for non-emergent patients and to solve overcrowding. However, too many messages were transferred to on-call staffs after reservation call system started. Because there are many patients with cancer and cardiovascular problem at AMC, patients could not be discharged easily with laboratory or imaging results only. The process was changed that the reservation call is sent to on-call staffs for only selected patients (fast-track area).

Discussion and conclusion

The overcrowding of ED is a common problem in Korea. This makes it difficult to assign patients proper priority for treatment based on the severity of their condition [3]. Triage is the process of quickly sorting and assigning the right patient to the right resources in the right place at the right time [4]. For this purpose, a comprehensive five-scale triage system has widely been accepted over other scaling systems as the most effective triage tool in ED.

Authors used CTAS for automatic triage messaging system after some modification. This system does not send all triage score of ED patient. The first consideration is a critically-ill patient. For this kind of patient, this system is an excellent communication tool between nurses and emergency medical staffs or between emergency residents and on-call staffs. This messaging system can replace paging system or notifying system in ED, especially for CTAS level 1 patient. Do we need to communicate with a colleague on the phone for the patient on resuscitation?

The reservation messaging system needs more evaluation. Too much PDA messages can be regarded as spam messages. The time limit, patient selection, and triage scores must be considered to change to reduce reservation call messages.

The automatic triage messaging system must be evaluated based on user's satisfaction, (system's) effectiveness, and patients' conditions in future studies. The optimum numbers of messages per day for emergency medical personnel are needed to investigate because more processes can use this automatic paging system. And the regulation of SMS messaging process must be established.

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The Development of Automatic Triage Score Messaging System at Emergency Department: Using Modified Canadian Triage and Acuity Scale

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Nursing Department, Asan Medical Center [c]

I. Introduction (1)

❖ **Triage ; Emergency patient**

1. Critical reference ; priorities
2. Assessment tool ; outcomes

❖ **Emergency Department (ED) of AMC***

1. Overcrowded ; > 200 patients / day
2. High portion of Critical ill patients

   ICUs ; 12 ICUs, 170 beds

*; Asan Medical Center

ASAN Medical Center

I. Introduction (2)

- EMR implemented Triage Scales
  AVPU scale*, Glasgow Coma Scale (GCS),
  Revised Triage Scale (RTS)
  -> Easy but inaccurate

- Automatic messaging system
  Effective & rapid paging system
  -> More objective triage scale
  -> Consensus between emergency staffs

*; Alert, Verbal response, Pain response, Unresponsiveness

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II. Methods (1)

Canadian Triage & Acuity Scale (CTAS)

1. 5-level triage system
   a reliable & objective tool
2. Modified CTAS (mCTAS)
   December, 2004 -> March 10, 2006
   retriage interval, higher level for trauma
   5 CENs*, 1 emergency professor
3. mCTAS ; EMR_ER
   trends, basic information

* ; certified emergency nurse

ASAN Medical Center

II. Methods (2)

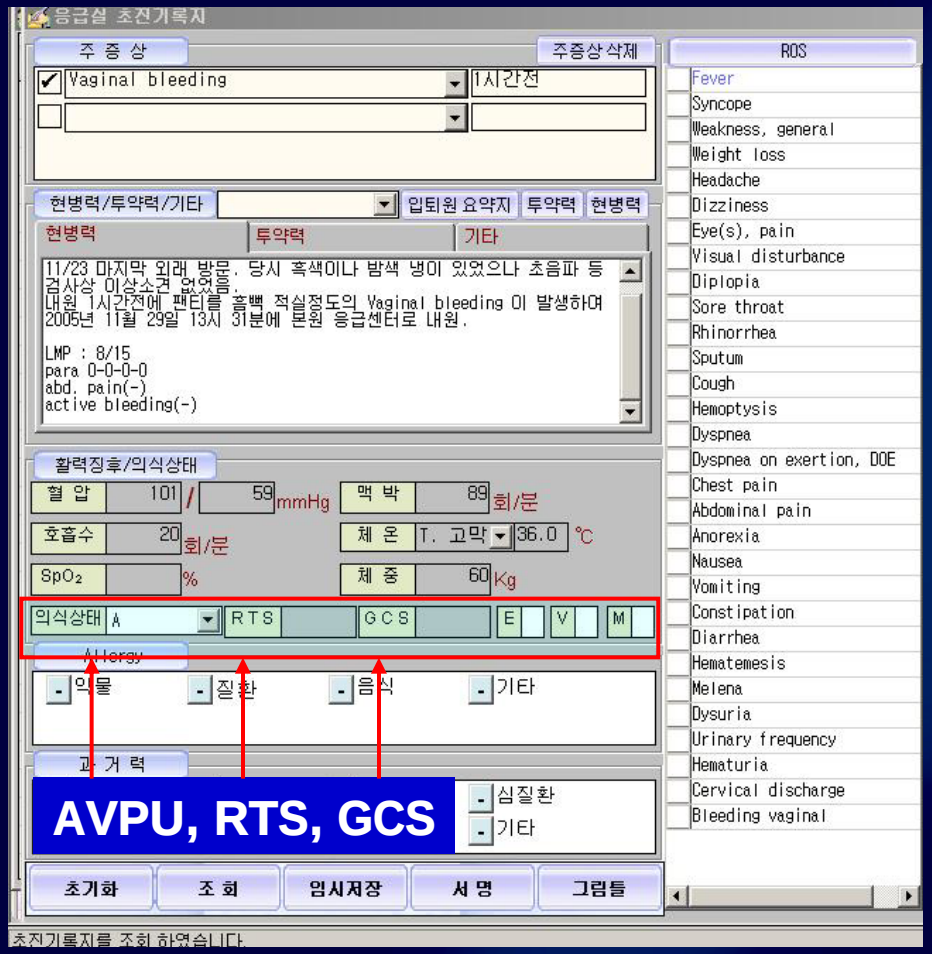
Automatic Messaging system ; mCTAS

- Since March 17, 2006

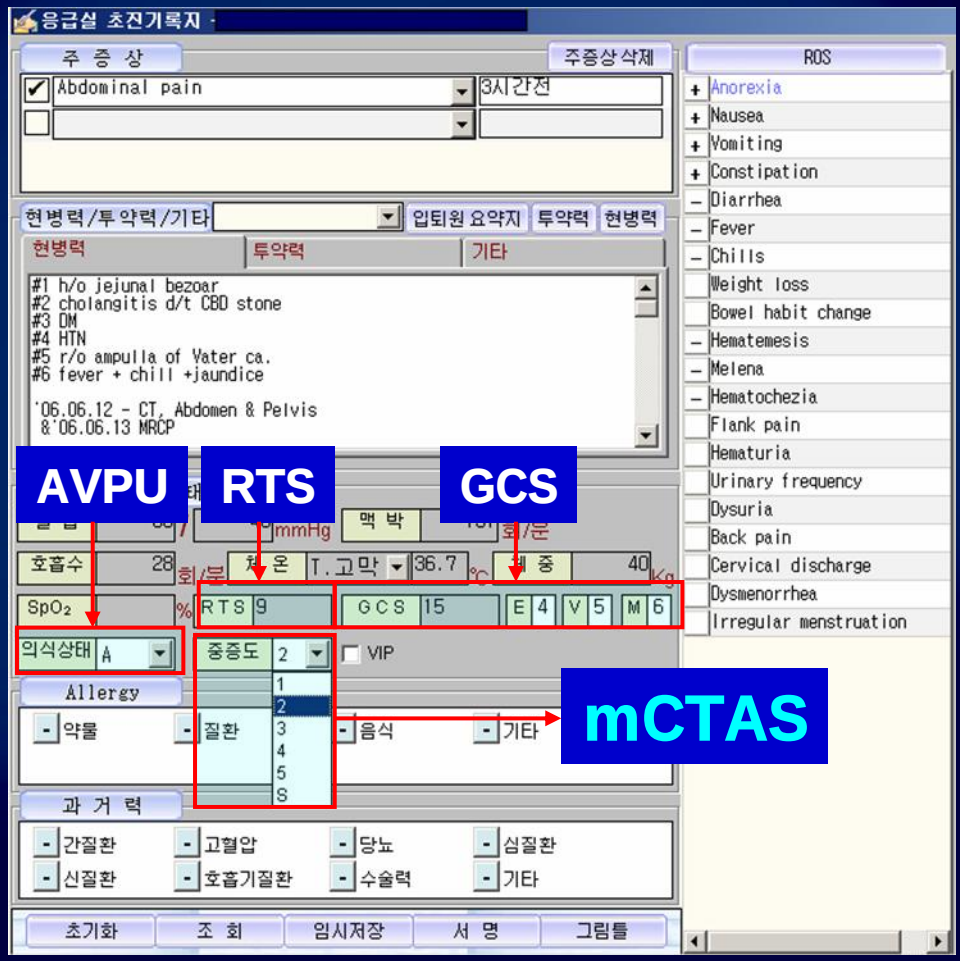
1. **Messaging rules**
   Level I, II ; instantly SMS activation
   Level III~V ; “reservation call”
2. **Contents of messages**
   Patient ID & name, chief complaints, triage level, treatment area
3. **Message recipients**
   On-call emergency staff, senior residents

III. Results (1) ; mCTAS EMR_ER

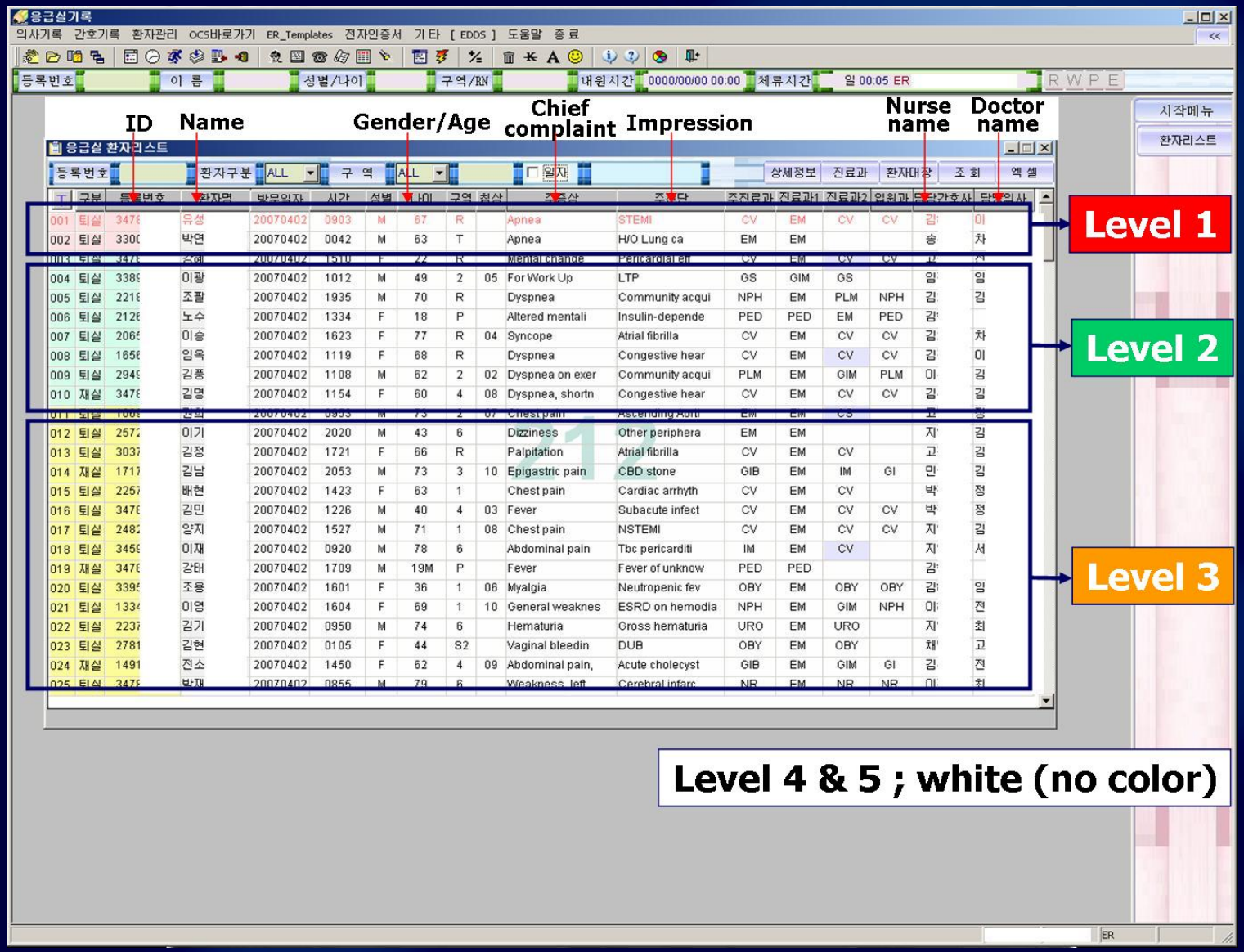
Doctor's initial note before mCTAS



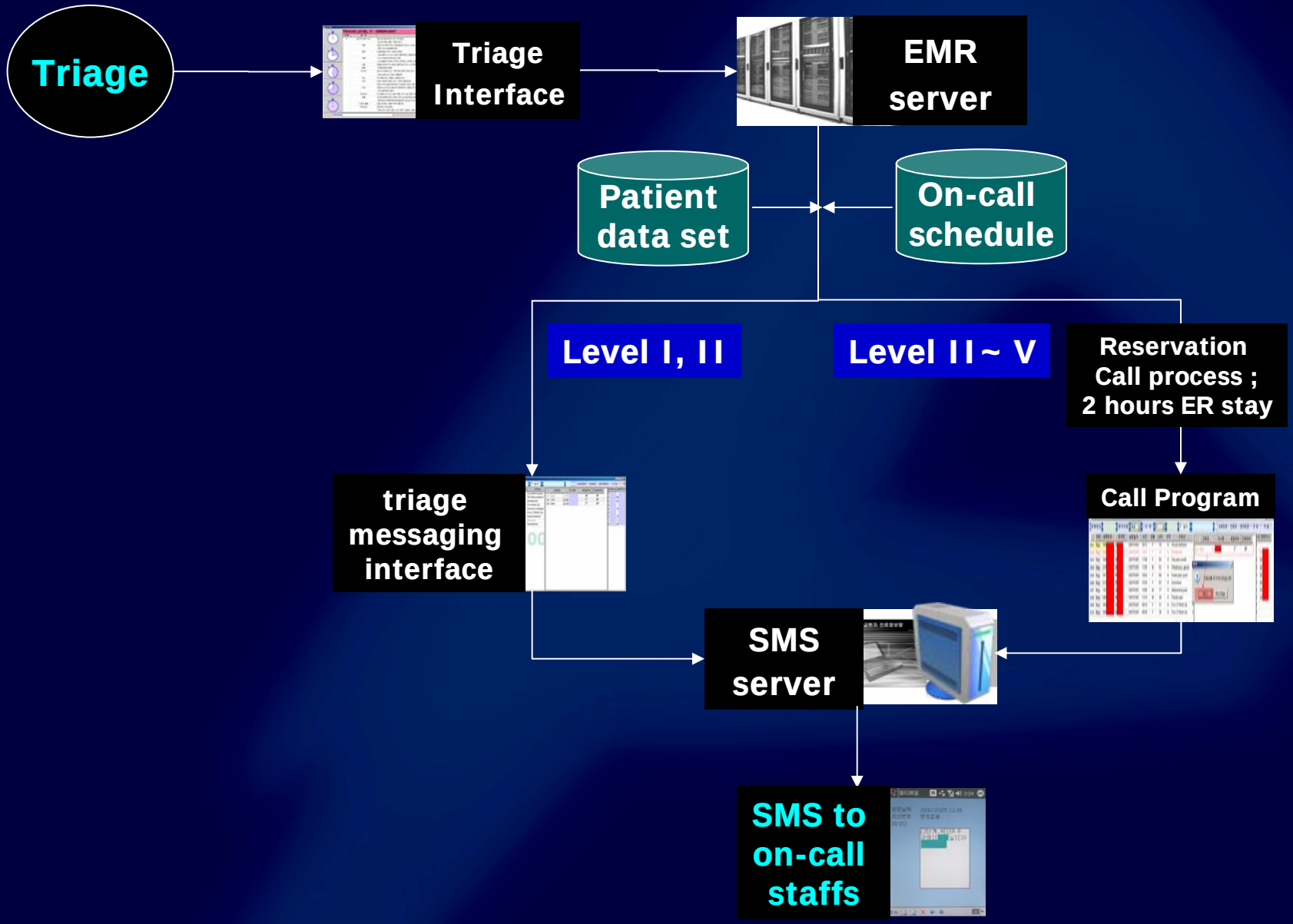
Doctor's initial note after mCTAS



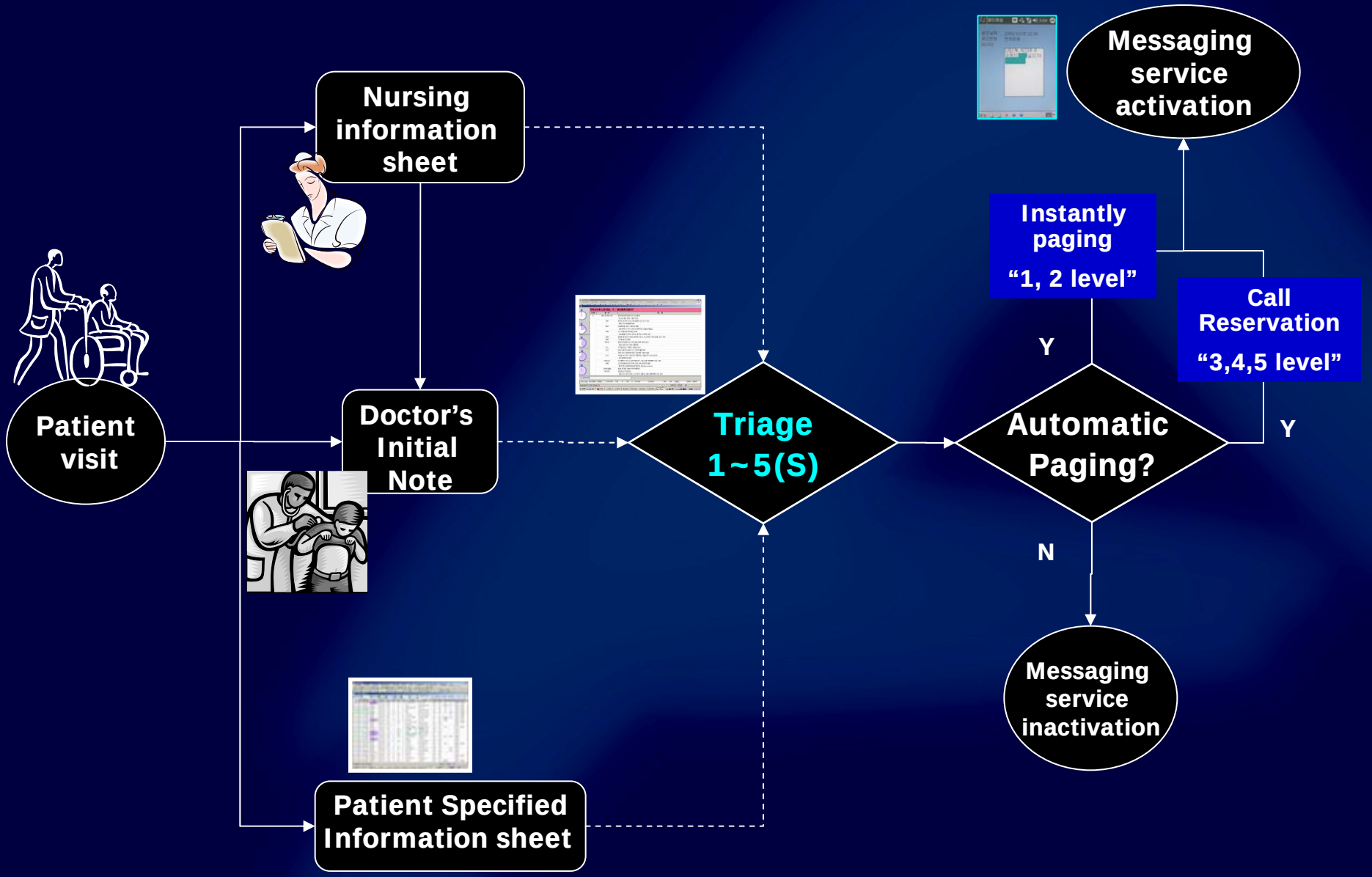
III. Results (1) ; mCTAS EMR_ER



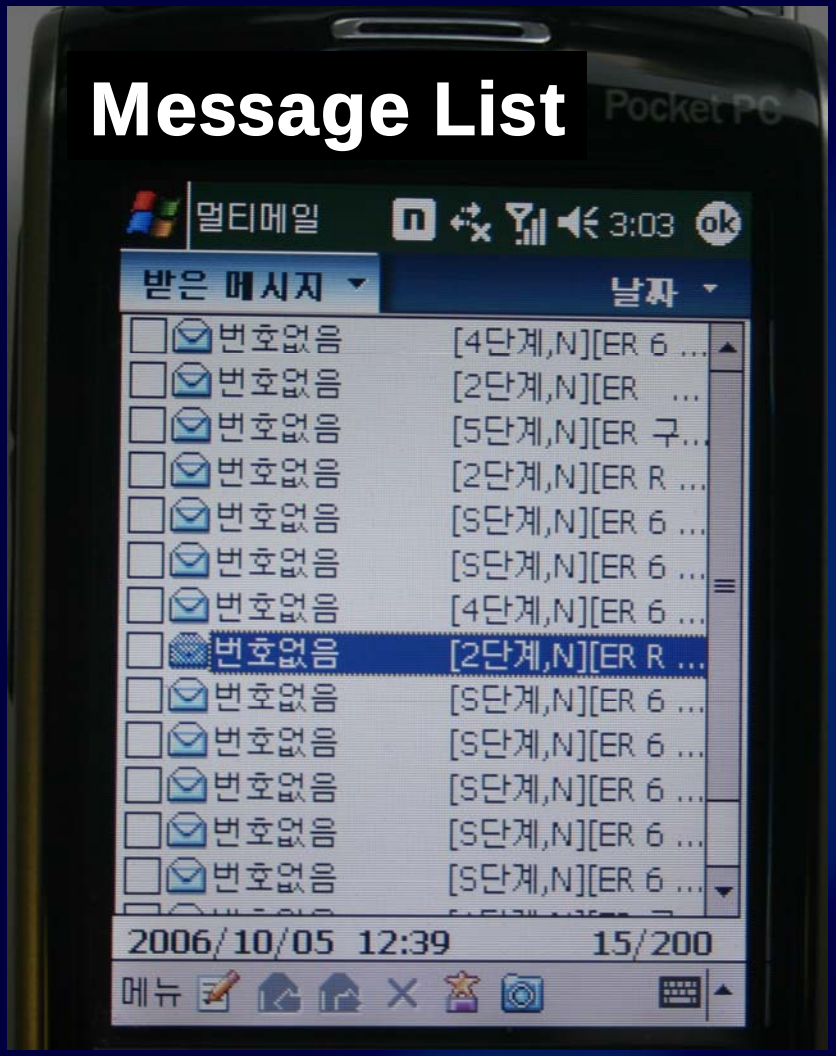
III. Results (2) ; Messaging Architecture

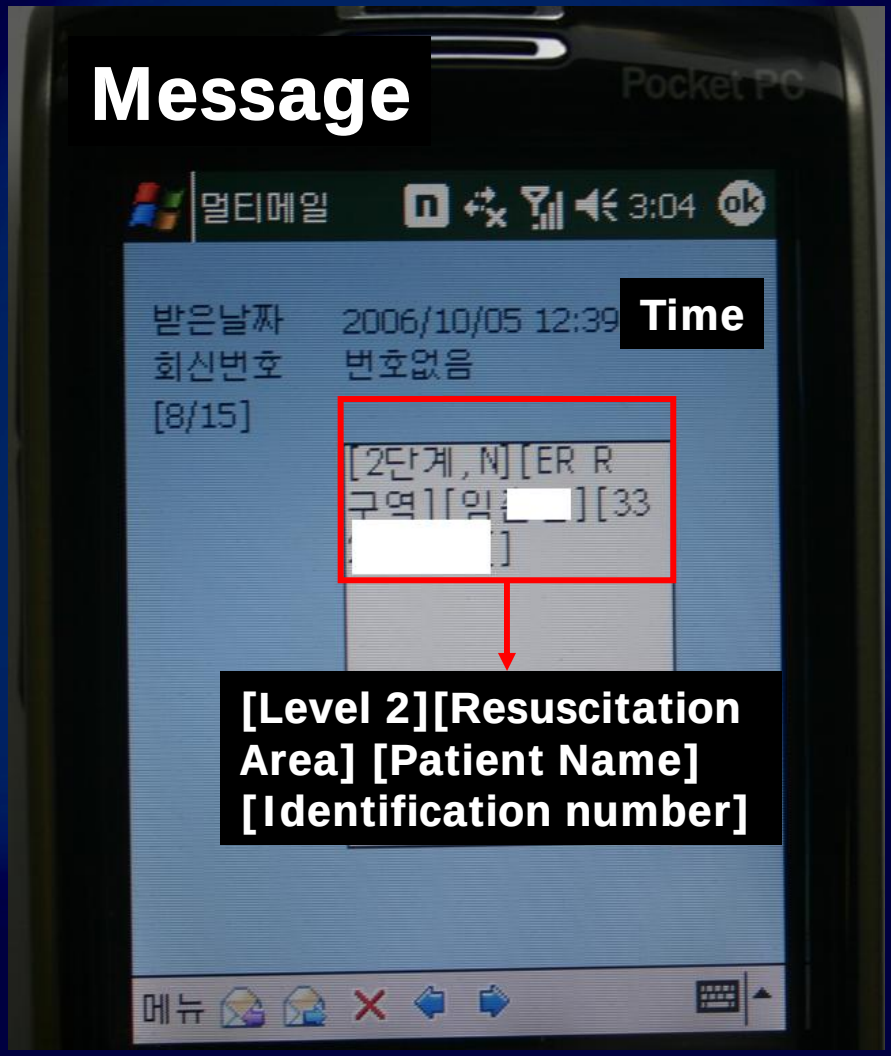


III. Results (2) ; Messaging Flow



III. Results (3) ; Triage SMS





IV. Conclusion

Automatic Triage messaging system

1. Effective & rapid paging system
Level Ⅰ, Ⅱ

2. The large number of messages
; Level Ⅲ~Ⅴ
-> Limitation of messages

3. User's satisfaction, patient outcome

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Derlet RW. Overcrowding in emergency department: increased demand and decreased capacity. Ann Emerg Med 2002;39:430-2.

Fernandes CM, Tanabe P, Gilboy N, Johnson LA, McNair RS, Rosenau AM, Sawchuk P, et al. Five-level triage: A Report from the ACEP/ENA Five-level Triage Task Force. J Emerg Nurs 2005;31:39-50.

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A Sustainable, Multi-Organizational Model for Decision Support During Public Health Emergencies

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Abstract

In an effort to provide decision support during times of public health emergencies, Regenstrief Institute, Inc. and the Indiana University School of Medicine, in partnership with the county and state health departments, created a sustainable model to deliver information to health care providers and public health personnel. The model leverages extant systems and processes, including active disease monitoring through electronic laboratory reporting and syndromic surveillance, delivery of health information via the Indiana Health Information Exchange, and evidence based utilities and blog technology to create a public health utility with disease-specific information and epidemiologic reporting requirements.

Keywords:

disease outbreaks; bioterrorism; information dissemination; decision support systems, clinical

Introduction

Just-in-time knowledge at the point of decision making is critical to improving health care outcomes. This is especially true when crucial public health decisions must be made in response to a bioterrorist event or an emerging pandemic. However, the ability to access needed information has been extremely problematic because of the different levels of connectivity and training available to public health workers and health care providers across large areas.

To address this issue a partnership was formed among the Indiana State Department of Health and the Marion County Health Department, the Indiana University School of Medicine Libraries (IUSML) and the Indiana Health Information Exchange to establish a cost-effective model for both alerting health care providers and public health workers to developing threats and providing them the needed information for both treatment and reporting.

guidelines and the required reporting of the specified

Methods

The model, predicated on an earlier construct [1], was built on three existing programs. The Regenstrief Institute, Inc. in conjunction with the Indiana Network for Patient Care and the Indiana State Department of Health developed an automated electronic system for reporting notifiable conditions [2] and a state-wide syndromic surveillance system [3]. I3, the Indiana IAIMS (Integrated Advanced Information Management Systems) Initiative, through the Indiana Health Information Exchange and its DOCS4DOCS utility, provided a framework to notify health care providers about real or suspected public health emergencies. [4] The IUSML offered evidence based decision support using Web technologies.

The goals of the project were to insure rapid notification of public health problems to a large yet targeted group of health care providers and to provide access to quality filtered knowledge supporting treatment guidelines and reporting requirements. Because the eventual objective was to operationalize the model for long term adoption, it was essential to develop sustainable methods.

Automated electronic laboratory reporting of notifiable conditions uses LOINC test codes and HL7 messaging to provide timely information to local and state health departments regarding the potential for a public health event. Notifiable conditions from laboratories around the Indianapolis metropolitan statistical area are reported to the health departments. The enhancement model facilitates provider notification and the creation of decision support information.

The Indiana Health Information Exchange maintains a master list of clinical contact information in the central Indiana region. This "master physician index" enables the rapid notification of health care providers about emerging public health threats, and communications can be targeted to specific locations and/or clinical conditions. This insures a higher level of relevance of the warning for the provider. Simultaneously, the IUSML is contacted about the suspected problem and receives information concerning proposed optimum treatment and management condition.

The IUSML is responsible for searching for current evidence about management of the condition and creating a web presence containing this information in a format effective for users. In addition, reporting requirements and links to the health department web sites are included. To insure sustainability, a blog utility was chosen because the technology facilitates document creation and maintenance, is familiar to most users, and provides built-in searching functionality.

In addition to the reporting and management information for health care providers, a listserv is maintained for notification of public health workers. The health departments have their own systems for notifying their affiliated sites, however the notification of access to knowledge-based information is handled by the IUSML once the Blog site has been updated and approved.

While much of the information about emerging public health events comes from the electronic surveillance functionality, the public press also reports events of public health significance. Although press accounts commonly describe incidents in specific locations with little potential to spread, decision support may be beneficial for these events and the web site is updated as the need presents itself.

Results

As of November 2006, there were thirteen public health events that prompted creating knowledge support on the web site. The mechanism for the notification of health care providers has been developed using extant resources but has as yet to gain widespread adoption, not because of the technology but because of organizational issues.

The process for the notification of public health workers was implemented with the second public health event posted and, as a result, the utility has achieved wide spread use. Anecdotal responses to the initiative have indicated that the Web site has provided critical information managing both health care conditions and epidemiologic reporting.

Discussion

By using three extant processes, active surveillance through electronic laboratory reporting, DOCS4DOCS delivery of information to health care providers, and the evidence-based medicine services of the IUSML, a sustainable model was developed to deliver decision support information to targeted health care providers and public health workers during instances of public health events.

The technology and processes were easily adapted to meet the needs of the health departments and system users. However, organizational issues regarding the health care provider notification component have precluded the full operationalization of the system. It is anticipated that these issues will be resolved within the next year and that the system will be fully implemented. However, the public health worker notification and the creation and use of the Blog utility have proven to be an effective means to providing decision support during times of emerging infectious diseases and bioterrorism events.

Conclusion

Emerging public health crises require coordination of information from a variety of sources and targeted provision of quality filtered knowledge to a wide range of health care workers. Access to evidence is critical to the management of the events for both the population and individual patients; collecting information to monitor the impact of the occurrences contributes to the knowledge base and helps mitigate future occurrences. Using extant technology and promoting organizational partnerships can offer a sustainable model to enhance responsiveness to these events.

Acknowledgements

The authors performed this work at the Regenstrief Institute for Health Care and the Indiana University School of Medicine and they were supported in part by the National Library of Medicine, grant number GO8 LM008232-02.

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The Interface Software Design:Information System of Emergency Medical Care For Disaster In Indonesia

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Abstract

Information systems have an important impact on emergency situations, especially during disasters and effective connections are required for networking between disaster affected areas, field hospitals and emergency departments. Critically ill patients are the first priority during transport, and in addition, the vital signs should be hemodynamically stable and frequently reported from the disaster affected area and during transportation until arrival in the emergency room. Since the geography of Indonesia includes many mountainous areas, this tends to hamper networking, meaning communication infrastructures have not yet covered all areas and districts of Indonesia.

In this article, we propose the creation of a communication network system using radio VHF (very high frequency) as a wireless connection from disaster affected areas, field hospitals and emergency rooms. The use of this prototype would be relatively cheap for developing countries like Indonesia. During this simulation, we operated the reporting system during a landslide that occurred in Garut County, West Java and which needed to be reported to the Dr. Slamet General Hospital, Garut and also to the Hasan Sadikin General Hospital in Bandung as the medical command control centre in the West Java province. The software interface design was created as required to monitor the report systems of the patient's vital signs, hemodynamically and the wound state while in transit.

Keywords:

information system, vital signs, hemodynamic, disaster, software interface

Introduction

After the landslide occurred in Garut county West Java, Indonesia, the victims had to be evacuated to the nearest hospital emergency department as soon as possible. Initial checks were made for vital signs and hemodynamic stability to ensure it was possible to evacuate them to the emergency department. At the time, despite the numerous patients on the field, we used triage to determine whether the patients had to be evacuated or not. Since geographical conditions also presented obstacles during evacuation, coverage allowing reports to be made via network communications was not possible in the disaster area. Although wireless mobile phones could be used for communication, these tended to function poorly, since the BTS (base transmission stations) in the vicinity had already been damaged due to the natural disaster. Meanwhile, the medical team had to report to the hospital while transporting the critically ill patients.

There were 50 victims at the location, who were classified using green tags (non emergency), yellow tags (emergency but non critical), red tags (critically ill) and black tags (deceased). Approximately 10% of the 50 patients had red tags and needed advanced treatment in the local emergency room (disaster area vicinity) or even evacuation to the top referral hospital. We usually have many problems during transport due to unpredictable patient conditions, and despite hemodynamic stability while going to hospital, conditions sometimes worsen during evacuation.

In the clinical scenarios above, if a health information exchange network were installed within the disaster affected area, with Dr. Slamet General Hospital as the front medical post (the emergency room nearest the disaster area), and Hasan Sadikin General Hospital as the top referral hospital in West Java province, thus enabling data exchange from one to another, and if the hospitals were readily available and ready to receive critically ill patients, this may enhance information systems carrying clinical transfer data and patient consultation and result in a more efficient workflow for the medical and paramedics crews (Fig. 1).

This article will describe the background and motivation for current local health information efforts on the disaster in Indonesia and also how to create an interface design which represents a form of transport for critically ill patients suitable for a developing country like Indonesia.

Discussion of certain issues that may be required can be addressed to the emerging local health service, as well as that concerning some of the specific issues that are likely to affect emergency case management in the referral hospital.

Background

Geographical location and geological condition of Indonesia have made this country one of the most potential countries but at the same time prone to disaster such as earthquake, tsunamis, floods, landslides, cyclones, and volcanic eruptions. In general, disasters occur every year. Even in recently years, disasters have become more frequent and taken place one after another.

No	Type of disaster	Event	People affected
1	Flood	229	416
2	Landslide	106	201
3	Fires	91	26
4	Earthquakes	27	47
5	Typhoon	42	3
6	Volcanic eruption	13	0
	Total	687	2,409

Source: BAKORNAS PBP, 2004

Table 1 - Type and time disaster occurrences in 2003

When earthquake and tsunami disaster happened in Aceh last year, more than 200.000 people died, all of main infrastructure in most of Aceh area was down fall includes telecommunication. Red Cross and army are first institution which arrives in location instantly after information had been validated.

Medical care is normally established at the first opportunity, but limited facilities and support and the lack of adequate facilities in medical care units means victims may perish. In this case, we should have a solution to support the exchange of information between medical care units in disaster areas with the principal hospital and logistic units situated elsewhere.

This project promotes a system for the data communication exchange with a multi-barrier. Where geographic conditions make it particularly difficult to deliver data, and telecommunication networks are especially distant, the courier transmission and synchronized data could represent the best alternative technique to keep the system working. However, the system includes a solution to reduce the time required for courier delivery – namely, to use radio frequency as the data transfer medium.

Material and methods

Emergency medical care information system (EMCIS) is a communication system for emergency situation by using VHF radio technology to deliver low speed data, voice, and image from disaster areas to the center of disaster management system. In this case, the EMCIS Project designed a VHF modem, a protocol communication for the VHF modem, and a software application for delivering medical information.

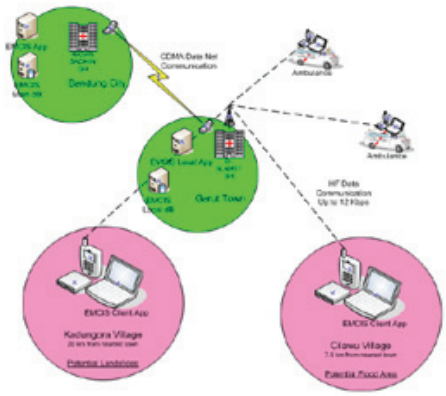

Figure 1 - Network communication and reporting system

Design software interface

On this software interface was designed as needed for critically ill patients. The requirements are user friendly, easy to understand, data entry can be done as quickly as possible, possible for consultation by using instant messenger and must be able to cover patient's conditions reporting whether live threatening or not.

Design input starts by that user needs and translating that data into the engineering terms. Defining design input is not as simple a task as it sounds. The needs itself based on the critical ill patient requirements that can represent the conditions during transporting. Ensuring that adequate safety is built into the interface design and often several trials must be done to reach the best requirements by doing many simulations.

Each patient has their own characteristics of the injury, even if they have the same injury but the problem might be different. There are many parameters for critically ill patient so perhaps need plan for updating design input interface as new information crops up during design.

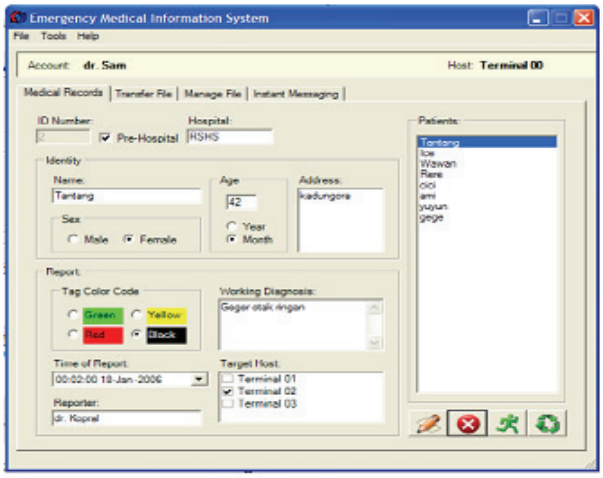

Figure 2 - Main design of EMCIS

In order to focus on how best to support interface design, Westudied the monitoring critical ill patients to find out what kind of parameters that used in emergency room or intensive care unit and suitable for all stages of critical patients. We also collected what is the proper parameter that can be used for live saving and transporting, and what vital sign liked and disliked about critically ill patients. Furthermore we must know when do we have to set the patient in the rest condition of their metabolic system so that the oxygen demand might be in minimum state in order to keep patient a live during evacuation. Using this information, we designed concept to support the core engine for transferring data and making consultation among paramedics in the field and the expert in the hospital. The Clinician that we have discussed has an average of over 10 years experience working with critically ill patient in the intensive care unit or emergency. They work for Hasan Sadikin General Hospital-University of Padjadjaran School of Medicine that focus on areas such as emergency room (ER), intensive care unit (ICU), recovery room (RR), and even operating room (OR). In addition, they have an expert in the critically ill patient caring background.

Almost of the medical staff in that field have the same idea about the parameter for monitoring the patient. The main parameter for the critical patients are chief complaint, level of consciousness, pulse rate, respiration rate, blood pressure (Fig. 4) and location/status of the wound (Fig. 5).

Based on this parameter, the patient will be given tag such as red, yellow, green and black. It is very important because the priority of actions is just depending on this tag. First priority is red tag because this is really critically ill patients and life threatening. Second one is yellow tag where the patient in emergency case but not critical. Green tag is only maybe have a small wound and black is deceased. (Fig. 2).

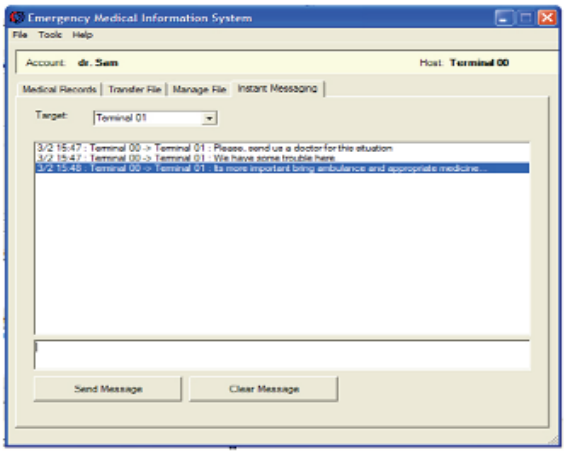

Figure 3 - Instant messaging

During the early stages of interface design we performed the simulation inside the hospital by using radio communication. Some reported that the patient was getting worse hemodynamically or vital sign unstable and then must give the responses and support to the patient. The design that we make based on that simulation so that we made the sketches interface tools, such as multi tab (Fig. 2), and then break down into specific one in every tab. In this part we viewed the general information of the patient (victim) such as identity, report and list of victims. The identity was so simplify in order to make an easy way for data entry during disaster. It only takes a little typing and a click on the box according to the condition. The explanation of interface must be recognized by user as simple as possible and tested with users before building a prototype. In the early stages of design is critical and might be something happen so that simulation must be done as much as possible two or three times a week in emergency room.

A user will interact with the application mostly through forms, so by the simulation hopefully can decrease the error. Whether you are an experienced user or just new comer on using computer, this interface will provide you an easy way for entry data as essential information to the patient, expertise and hospital.

The other facility on this application is instant messaging (Fig. 3). Through this option, paramedics are possible for consultation and transfer file. Even though only small data that can transfer like small size picture but it is very useful on disaster area whereas infrastructure communications collapse.

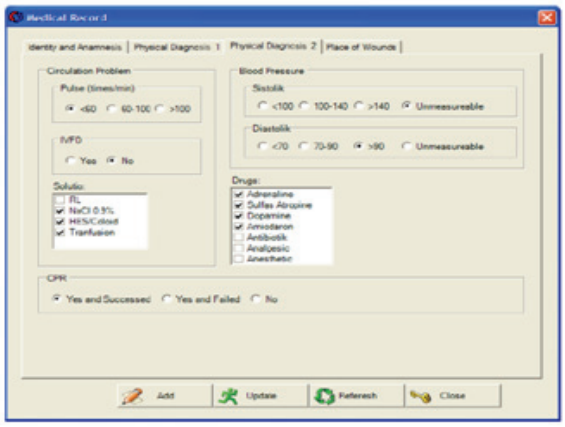

Figure 4 - Physical diagnosis

The other important things are also the actions during the evacuation. After classified into red, yellow and green tag we must do something. For example if the blood pressure decrease, pulse rate increase and location of wound might broken main artery so causing bleeding then we have to give solution and drugs to keep the patient survive. In this case the user is just click the box, what kind of solution and drugs that had been given and then reported to the hospital (Fig. 4). Every patient will have their own data and reported to the referral hospital frequently.

Location of wound in disaster area was needed due to most of the patients are trauma cases. It might have open or closed wound, contusion or fractures, active or occult bleeding so that can describe on the picture by clicking in the box. Every box on the picture represents the main common artery which may cause the active bleeding like on the upper and lower extremities. There is a special case on chest and abdominal trauma because it may cause of massive bleeding even it closed wound. In the chest wound sometimes pneumothorax can happen and it is one of life threatening case so that the paramedics must do something like needle decompression even in the transport (Fig. 5). All organs in the thoracic cavity are related with airway, breathing and circulation which may cause life threatening if we do not do something aggressively.

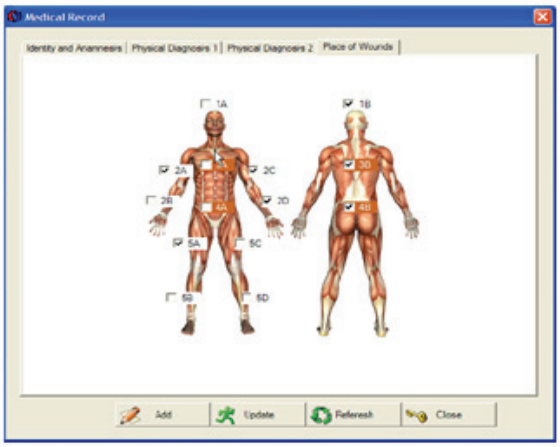

Figure 5 - Place of wound

Discussion

An interface design must reflect both user requirements and a means of communication with the software. A user friendly design is vital as an input maker and each input action will become part of a valued patient database. The interface design component must also be guaranteed to correspond to the bidirectional exchange of communication and data during transport. When interfaces are designed, the composition combines not only user requirements, as the input data maker, but also the environment of critically ill patients. Whatever the patient's condition, they generally have equivalent parameters when life threatening events occur. There are also specific cases, namely head trauma, thoracic cavity trauma and abdominal trauma, where closer attention is vital because if life saving intervention is performed as rapidly as possible, the patient will improve dramatically. For this design feature, a survey was conducted regarding the types of parameter and limitations of the interface design on critically ill patients by performing a simulation evacuation within the hospital. The conclusion was that vital signs, hemodynamic stability and the location of wound/s represent the whole spectrum of patient conditions. The other inputs include therapy while in transit, which can be performed by providing the solutions and/or drugs required in resuscitation. This means a hospital doctor avoids providing over-therapy in solutions or drugs when the patient arrives in the emergency room and will only administer advanced treatment, such as resuscitation surgery, in the event of internal bleeding and/or in an intensive care unit facility. This will allow optimum treatment to be given to patients. Although there are several means of treatment in the hospital, the challenge is how to ensure the patient survives while in transit. With this in mind, the software will be part of pre-hospital care in the field or an medical data information system.

Acknowledgements

The authors would like to thank Setyo Budi Agung, Hariyo Santoso, Andri Qiantori, Samudra Prasetyo from Telkom Risti and Harry Prihanto from BPPT Indonesia for their supporting on this paper.

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Requirements of Linkage with Triage-Tag Information and Electronic Health Records Available in a Huge Disaster

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Abstract and objective

To support transporting victims and patients efficiently in a huge disaster, the authors propose a regional information system sharing real-time acceptance information of hospitals, which is linked with a regional EHR system. Using the simple model of regional EHR with triage-tag information, the authors discuss requirements to distribute real-time acceptance information of hospitals. In the system the flow of triage-tag ID and EHR ID information has a crucial role.

Keywords:

medical records systems, computerized, hospital information systems, disasters, rescue work

Introduction

In a huge disaster, hospitals outside of damaged zone have to accept not only victims but also diseased patients due to destructions of equipments in hospitals and hospital themselves in a damaged zone, as in the case Hanshin-Awaji earthquake on 17 January 1995, by which 64 hundreds people died and 40 thousands injured: In this case the number of transported diseased patients from the damaged zone to outside hospitals was greater than that of victims in the first two weeks [1].

By lessons of Hanshin-Awaji earthquake, a triage-tag standardized by Japanese Fire Defense Agency has been used generally. In the case of leaving the metals in Amagasaki which is the first case of major incident in Japan after the earthquake, nevertheless, the identification and finding location of victims are pointed out as problems. [2]

The authors has been developing the information system in Hiroshima region supporting rescue teams by sharing real-time acceptance information of hospitals of this region with bringing a wide area disaster in view, which nevertheless depends on inputs of hospital administrative [3]. To obtain more correct information of acceptance even in a huge disaster, and to support the identification and finding location of victim, we propose a new model of information system connected with personal information of victims and patients.

Methods

We suppose the model system as following: In one administrative district named region A, a regional EHR system can be used with everyone living there; in which a disaster information center with an information system stands: These systems work under these conditions;

a) Both the EHR system and disaster information center system (DIC) have independently data centers far from this region connected with computer networks each other, which can work in a situation of huge disaster in this region.

b) All (heli)ambulances in the region can communicate with DIC by wireless transmitters, by which they can share acceptance information (maximum and occupation numbers of beds) of each emergency hospital in the region by a network connection between the EHR system and DIC.

c.) All hospitals and clinics in the region have each permanent ID numbers of them on the EHR system.

d.) Computer terminals in all the hospitals and clinics can communicate with the EHR data centers above mentioned without faults of power supplies or computer network.

e.) Every patient in the region has an ID of the EHR system, all of whose hospital records with IDs of hospitals can be retrieved by their ID on EHR.

We next suppose a zone in the region, in which a huge disaster happens: We assume following conditions in this situation:

1.) Computer terminals in all the hospitals outside the zone can communicate to the EHR system.

2.) All the emergency hospitals outside the zone can provide their acceptance information to DIC.

3.) All the victims should be triaged and tagged with permanent IDs: Other information standardized by Japanese Fire Defense Agency than a triage-tag ID should be recorded at each triage steps.

4.) Disaster Medical Association Teams (DMAT) have already been to the zone, and the (heli)ambulances have been ready to transport victims or patients

from the zone. In this situation, victims of disaster could be triaged four times; 1) in tagging a triage-tag at a place he/she rescued; 2) before a medical treatment by DMAT; 3) Before transporting to the outside region; 4) Before a medical treatment in the emergency hospital.

5.) All diseased patients transported from the hospitals or clinics in the zone should be triaged before a medical treatment in the emergency hospital.

Under these assumptions, we organize along a timeline from a rescue to a hospital admission of victim or patient, and consider on requirements of cooperation between the EHR system and DIC to update acceptance information in real-time and to find locations of victims and patients

Results

Primary information in each triage step is shown in the table 1. Since a value of priority on a triage-tag can be varied, acceptance information of the hospital can be determined. In addition, we have to consider patients or victims not transported by (heli)ambulances who can come to a hospital without tagging of triage-tag. Thus, we can obtain most correct information at the fourth triage step before a hospital care. As almost all patients might have EHR-IDs which warrant continuous hospital cares and identifications, it is convenient to input EHR-IDs instead of triage-tag IDs. Since all hospitals have terminals for the EHR system, and since an admission recorded by a triage/EHR-tag ID means an occupation of acceptable bed, the above information can be input from the terminals and used for hospital cares. The locations of them are automatically obtained by input of above information.

Due to these reasons, the requirements are following; 1) the EHR system have to obtain a triage-tag or EHR ID with triage information (priority) of victim or patient and hospital IDs in triage before hospital cares; 2) the EHR system sends the above information; 3) the DIC system can renew acceptance information and locations of victims and patients according to data from the EHR system and distribute to (heli)ambulances (see Fig. 1 and 2).

Discussion and future remarks

Using wireless devices like RFID for identifications [4], hospitals can easily input IDs to renew acceptance information. Mobile devices to input pre-hospital information (symptom, pollution, etc.) and information of transporter (ID of heli/ambulaces) could be helpful for preparations in hospitals and precise trace of victims.

Acknowlegement

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Steps of triage	Information on Triage-tag				Use of Info.
In tagging	ID of tag				#
	Place of accident	Situation of Insury			
		Polition (Chem., Bio., Rad.)			*
	Common in each steps.	Triage officer			
		START infor.	Priority		*
			Symptom(degree of Insury, disfunction of organ, etc…)		
Before treatments					
			Vital signs	Respiration rate	
Before Transportation				Heart rate	
				Level of consciousness	
Before hospital care.		Medical treatments			
		Others		Age	
				Alergy	
				Medication	
				Past history	
				Last meal time	
				Effect of medical treatments	
	Location of victim	Transporter			#
		Hospital name			*, #

Table 1 - Primary information in each triage steps. Asterisks mean information to renew acceptance information. Sharps mean information for location of victims or patients

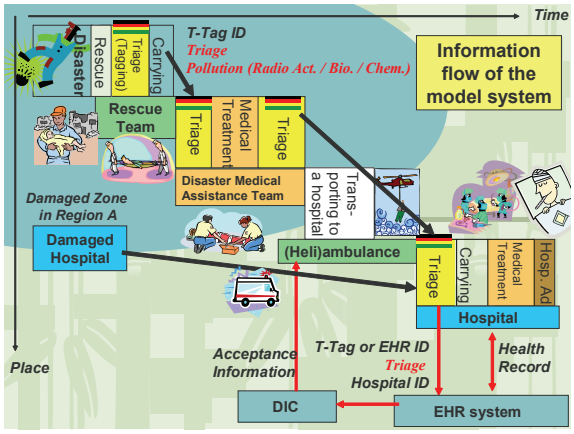

Figure 1 - Information flow of the model system

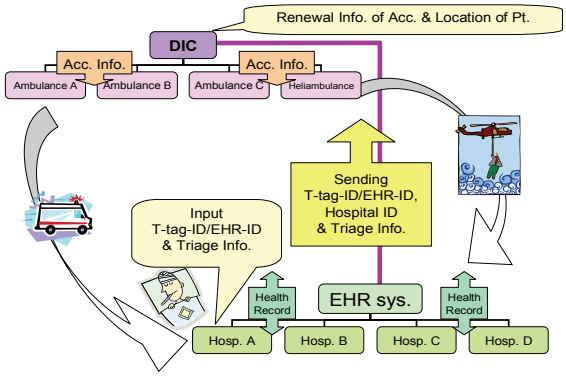

Figure 2 - Information flow between DIC and EHR systems

Requirements of Linkage with Triage-Tag Information and Electric Health Records Available in a Huge Disaster

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Hiroshima University Hospital, Hiroshima, Japan.

**Information Media Center, Hiroshima University, Higashi Hiroshima, Japan.*

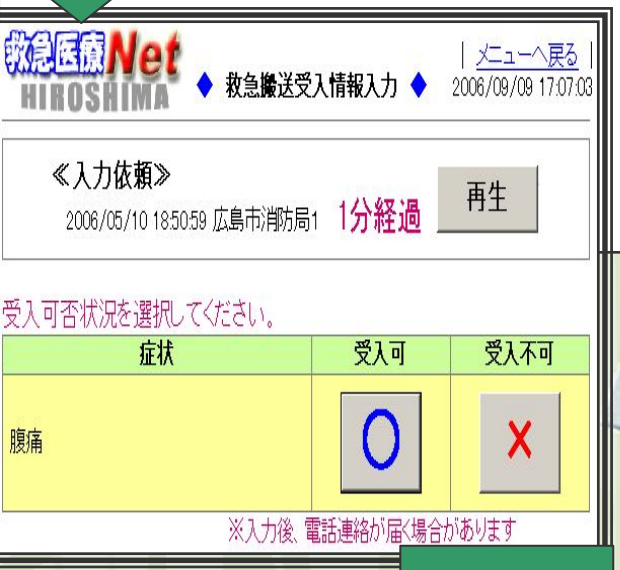
Introduction

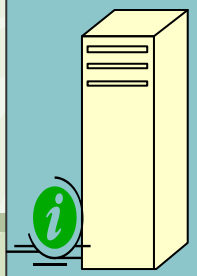
- In a huge disaster, hospitals outside of damaged zone have to accept not only victims but also diseased patients due to destructions of equipments in hospitals and hospital themselves in a damaged zone, as in the case Hanshin-Awaji earthquake on 17 January 1995, by which 64 hundreds people died and 40 thousands injured: In this case the number of transported diseased patients from the damaged zone to outside hospitals was greater than that of victims in the first two weeks [1].
- By lessens of Hanshin-Awaji earthquake, a triage-tag standardized by Japanese Fire Defense Agency has been used generally. In the case of leaving the metals in Amagasaki which is the first case of major incident in Japan after the earthquake, nevertheless, the identification and finding location of victims are pointed out as problems. [2]
- The authors has been developing the information system in Hiroshima region supporting rescue teams by sharing real-time acceptance information of hospitals of this region with bringing a wide area disaster in view, which nevertheless depends on inputs of hospital administrative [3]. To obtain more correct information of acceptance even in a huge disaster, and to support the identification and finding location of victim, we propose a new model of information system connected with personal information of victims and patients.

Acceptance Information of Emergency Hospital

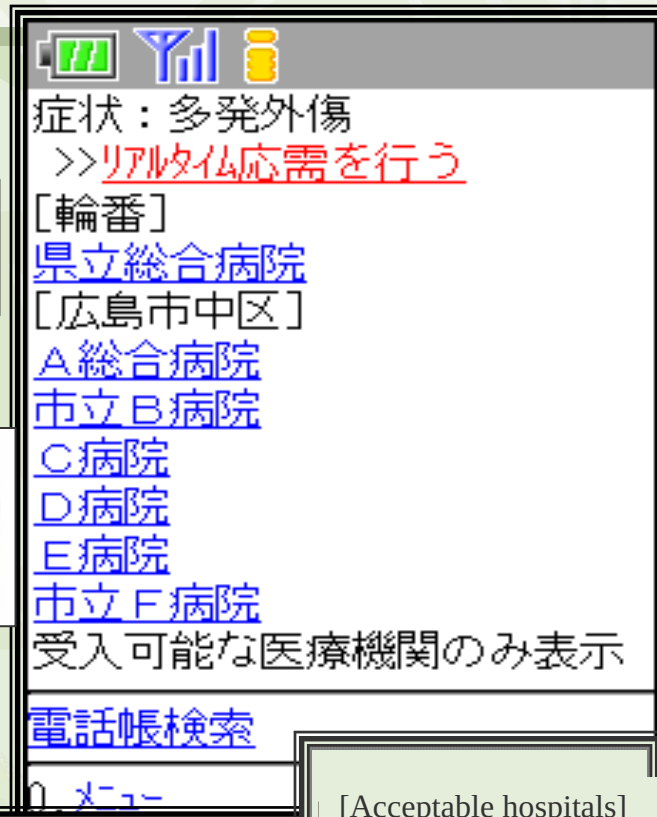
Mobile terminal on Ambulance.

Input acceptance

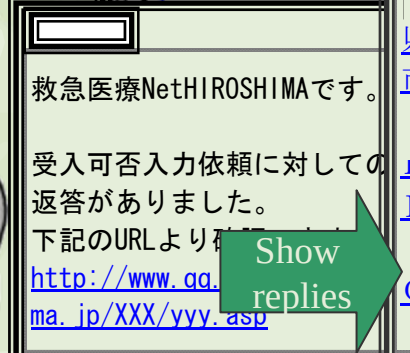




Call Hospitals



Present DIC system in Hiroshima



Call back

Method (1)

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a) Both the EHR system and disaster information center system (DIC) have independently data centers far from this region connected with computer networks each other, which can work in a situation of huge disaster in this region.

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c) All hospitals and clinics in the region have each permanent ID numbers of them on the EHR system.

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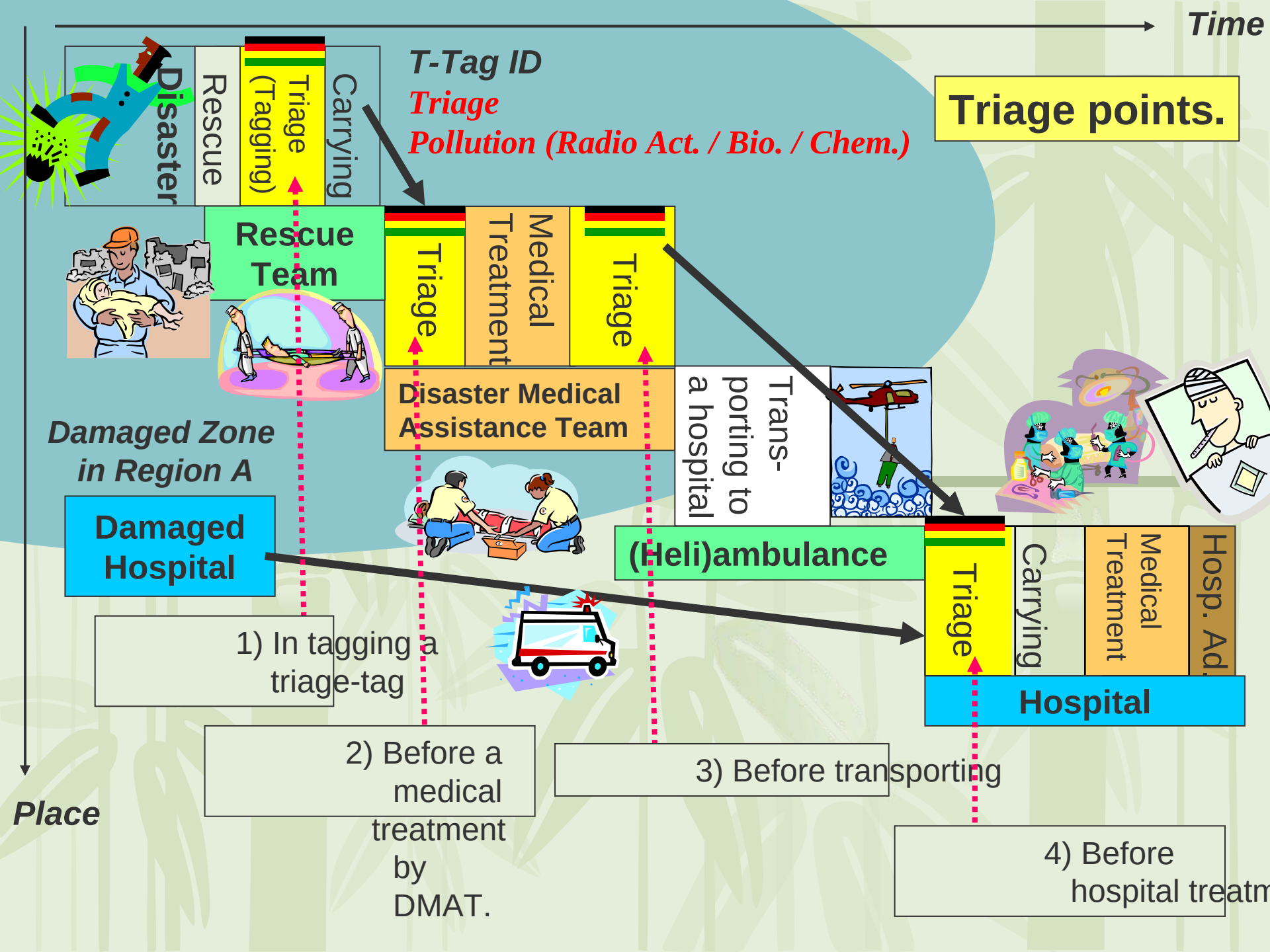
e) Every patient in the region has an ID of the EHR system, all of whose hospital records with IDs of hospitals can be retrieved by their ID on EHR.

Method (2)

- We next suppose a zone in region A, in which a huge disaster happens: We assume following conditions in this situation:

1. Computer terminals in all the hospitals outside the zone can communicate to the EHR system.
2. All the emergency hospitals outside the zone can provide their acceptance information to DIC.
3. All the victims should be triaged and tagged with permanent IDs: Other information standardized by Japanese Fire Defense Agency than a triage-tag ID should be recorded at each triage steps.
4. Disaster Medical Association Teams (DMAT) have already been to the zone, and the (heli)ambulances have been ready to transport victims or patients from the zone. In this situation, victims of disaster could be triaged four times;1) In tagging a triage-tag at a place he/she rescued; 2) Before a medical treatment by DMAT; 3) Before transporting to the outside region; 4) Before a medical treatment in the emergency hospital.
5. All diseased patients transported from the hospitals or clinics in the zone should be triaged before a medical treatment in the emergency hospital.

- Under these assumptions, we organize along a timeline from a rescue to a hospital admission of victim or patient, and consider on requirements of cooperation between the EHR system and DIC to update acceptance information in real-time and to find locations of victims and patients.


Time
Disaster
Rescue
Triage (Tagging)
Carrying
T-Tag ID
Triage
Pollution (Radio Act. / Bio. / Chem.)
Triage points.
Rescue Team
Triage
Medical Treatment
Triage
Disaster Medical Assistance Team
Trans-porting to a hospital
Damaged Zone in Region A
Damaged Hospital
(Heli)ambulance
Triage
Carrying
Medical Treatment
Hosp. Ad.
Hospital
1) In tagging a triage-tag
2) Before a medical treatment by DMAT.
3) Before transporting
4) Before hospital treatm
Place

Results

- Primary information in each triage step is shown in the table 1. Since a value of priority on a triage-tag can be varied, acceptance information of the hospital can be determined. In addition, we have to consider patients or victims not transported by (heli)ambulances who can come to a hospital without tagging of triage-tag. Thus, we can obtain most correct information at the fourth triage step before a hospital care. As almost all patients might have EHR-IDs which warrant continuous hospital cares and identifications, it is convenient to input EHR-IDs instead of triage-tag IDs. Since all hospitals have terminals for the EHR system, and since an admission recorded by a triage/EHR-tag ID means an occupation of acceptable bed, the above information can be input from the terminals and used for hospital cares. The locations of them are automatically obtained by input of above information.
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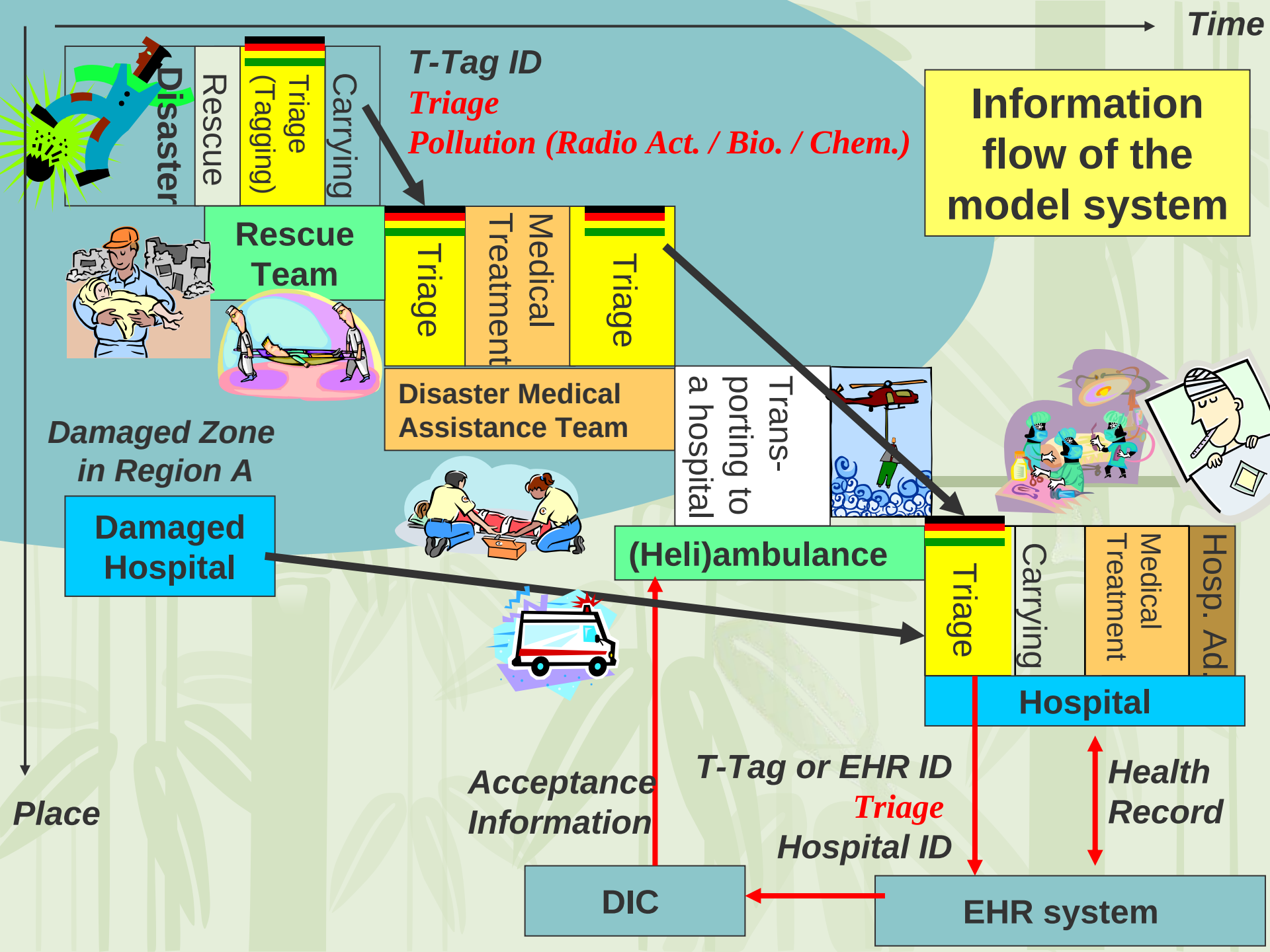
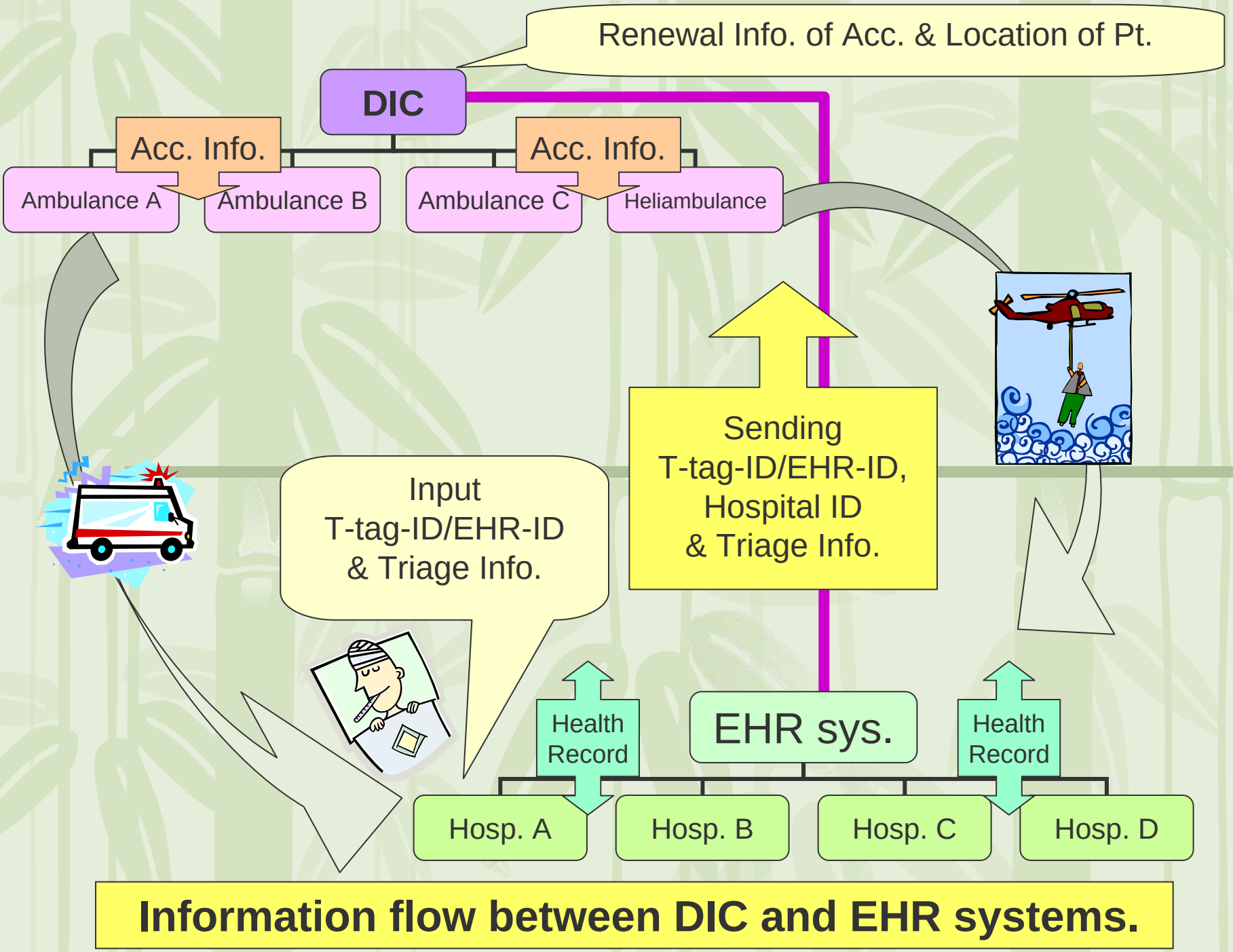
Primary information in each triage steps

Steps of triage	Information on Triage-tag			Use of Info.
In tagging	ID of tag			#
	Place of accident	Situation of Insury		
		Polition (Chem.、Bio.、Rad.)		*
	Common in each steps.	Triage officer		
		START infor.	Priority	*
			Symptom(degree of Insury, disfunction of organ, etc…)	
Before treatments				
Before Transportation			Vital signs: Respiration rate	
			Vital signs: Heart rate	
			Vital signs: Level of consciousness	
Before hospital care.		Medical treatments		
		Others	Age	
			Alergy	
			Medication	
			Past history	
			Last meal time.	
			Effect of medical treatments	
	Location of victim	Transporter		#
		Hospital name		*, #

*: Information to renew acceptance information.
#: Information for location of victims or patients.


Time
Place
Disaster
Rescue
Triage (Tagging)
Carrying
T-Tag ID
Triage
Pollution (Radio Act. / Bio. / Chem.)
Information flow of the model system
Rescue Team
Triage
Medical Treatment
Triage
Disaster Medical Assistance Team
Trans-porting to a hospital
Damaged Zone in Region A
Damaged Hospital
(Heli)ambulance
Triage
Carrying
Medical Treatment
Hosp. Ad.
Hospital
Acceptance Information
T-Tag or EHR ID
Triage
Hospital ID
Health Record
DIC
EHR system



Information flow between DIC and EHR systems.

Discussion and future remarks

- Using wireless devices like RFID for identifications [4], hospitals can easily input IDs to renew acceptance information.
- Mobile devices to input pre-hospital information (symptom, pollution, etc.) and information of transporter (ID of heli/ambulaces) could be helpful for preparations in hospitals and precise trace of victims.

- Acknowledgement

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Customized Early Warning System Based on HTN for Home Healthcare Model

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Abstract and objective

We adopted hierarchical task network (HTN) planning in a customized early warning system for home healthcare model. It is necessary to design a customized early warning system for the patients who were in various health states, because regular or irregular report format and alarm delivery systems were diversified according to severity of health state. HTN planning is suitable for use of constraint programming so as to effectively prune the search space during the search for solution. An efficient and scalable information control is presented by use of HTN. The paper also briefly deals with a process strategy for the early warning system.

Keywords:

Hierarchical Task Network, Emergency Response, Home Healthcare Model

Introduction

As the elderly population and the demand of well-being life increasingly grow, IT-based technology allowing bio-signal measurement and assessment at home have been focused nowadays. The elderly or citizen can be efficiently controlled with respect to health status parameters which act as input features in the early warning system for health status.

Methods and results

The early warning system developed by Home Healthcare Management System Research Center (H2MSRC) in Yonsei University adopted HTN planning in order to efficiently design the planning of emergency response because of extendible, intelligible, and easily communicated properties. Events derived from 7 objective status parameters measured from 4 types of sensor devices and 3 subjective parameters results in customized emergency response according to the formalized I-planning domain model. (Ref. figure 1)

Conclusion

HTN planning was practically adopted in our early warning system for Home healthcare model and revealed the intelligent and collaborative planning ability.

Acknowledgment

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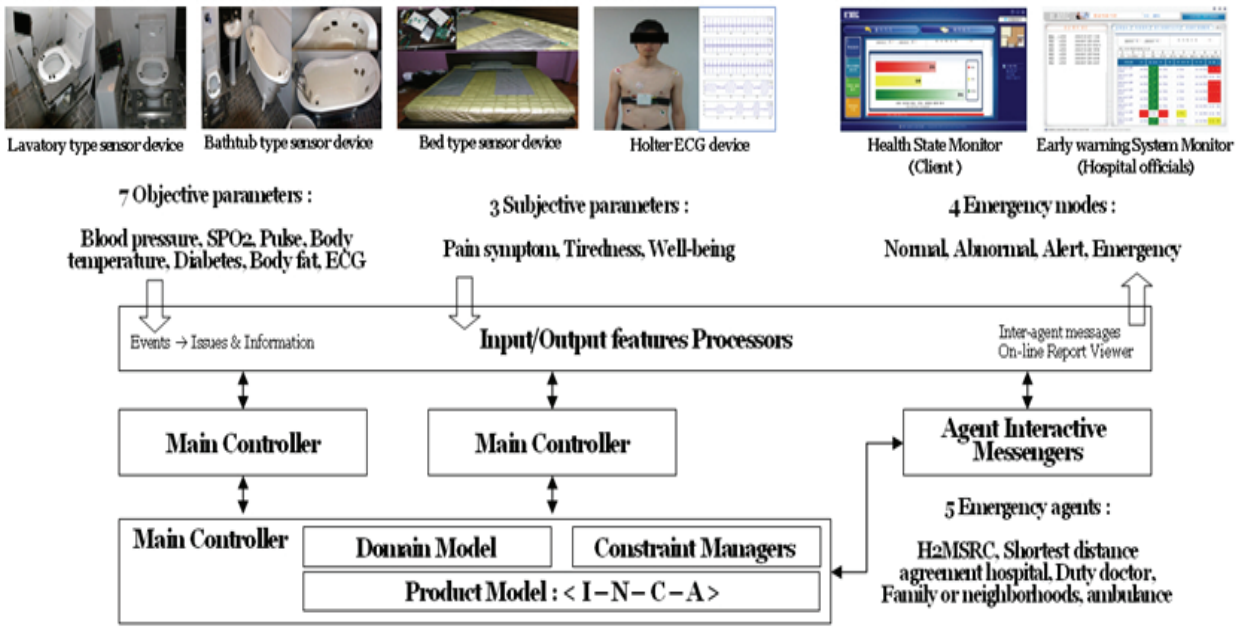

Figure 1- Events diagram of the customized early warning system based on HTN Planning

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"Toughclinic" – Modern Medical Informatics Under Extremer Conditions

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Abstract

The care of seriously injured persons or victims of catastrophes in the medical way like in environmental conflict areas or in the administrative way like in a refugee camp often has to be guaranteed under bad conditions. Paper based documentations are easy to implement and to use, but they underlie known disadvantages. With the system "TOUGHCINIC" as an electronic file for exceptional circumstances emergency patients, victims or refugees can be set up very fast. Any facts can be documented in special adapted input and edit mask; digital photos can also be added. The software components are able to be adapted locally.

A wireless cross linking of many individual and extremely robust notebooks without central infrastructure is possible. A breakdown of a laptop or a component does not affect the others. The used applications in reach are automatically adapted with the others and therefore they get always an actual database. After the returning of an employee the data synchronization will be done automatically.

The three principles are the simple handling and the possibility of total configuration by non technical personnel in the case of need, the extremely fast operational readiness as well as the toughness under extreme environmental conditions.

Keywords:

medical records systems, computerized; developing countries; war; disaster help; aid, first

Introduction

The care of seriously injured persons or victims of catastrophes often has to be guaranteed under bad conditions. A save, simple and fast support of the real care is not only medically, e.g. in environmental crisis area, but also administratively necessary for a big amount of affected people in refugee camps.

Paper based documentations can be easily adopted and used, but they underlie significant and also known disadvantages. The material is not resistant, copies are not automatically updated if the original or one of the copies are changed, automatically analysis for example for stock administration (re-order, consumption analysis) or warning notices (immunisation status, dual-physicals) are not implemented and it is in principal only a limited structured documentation possible.

Because of many reasons computer based documentations were in this kind of operation not advisable. The standard hardware is under difficult extremely environmental conditions not reliable. Computer solutions often demand expert-knowledge and cabling on-site additional logistical problems e.g. in camps. Qualified personnel, who has to leave the base for a short time for working, e.g. to accomplish immunisations at nearby locations, could so far badly profit of networked knowledge. Furthermore available software solutions are too complex for the fast and uncomplicated access by international personnel, the features and installations of regular hospital information systems are often unsuitable.

The identification and registration of patients, victims or refugees are often only based on central kept paper lists or on handed out identifier for particular persons (e.g. wristlets). The control and administration of such lists or identifiers is connected with difficulties and time delay especially for searching, because of the typical handling to have either an actual list on a central location or part-actual lists on different locations.

With the planed system TOUGHCLINIC patients, victims and refugees can be registered fast. It supports a medical and/or administrative all-embracing care. The development of this system has started and is described in the following.

HL 7 as a communication standard [1] and communication server as technological middleware platforms are today in many hospitals central components of the hospital computing and from this surrounding hardly to think away [2]. In many hospitals single departments communicate electronically with purchased software products already so called hospital information systems. This is what Waegemann calls as "automized medical record (system)" [3].

If hospital information systems shall conform to the displayed definitions and requirements, it seems apparent that neither hospital information systems nor electronic patient records can be bought as a finished product. Rather the declaration of Van der Velde is true, which calls hospital information systems as a "conceptual bound", in which single appliances develop and can be integrated as an acting whole system [4]. The system TOUGHCLINIC offers such a bound.

Materials and methods

Necessary equipment

About 50 percent of all damages of notebooks go back to transport accidents like falling down or effects of pushing. Screens, cases and hard disc drives are the most affected. Especially the expected environmental conditions like aridity or clamminess, also extreme temperatures and in dealing with technical applications in limited situations let notebooks not appear as adequate equipment in areas of catastrophes or crisis.

Special notebooks e.g. Toughbooks of Panasonic have a special mechanical protection. The cases of these notebooks are manufactured of a magnesium alloy. Warp resistant magnesium alloys at all screens avoid warps or breaks. The hard drives are saved against vibrations. Because of their flexible bearing, connecting plugs resist extreme pressure. Furthermore keyboard and touchpad are sealed against entering fluid. Dust and dirt can not enter. The use of latest touch screen technologies allows although in direct sunlight a high-contrast screen. The specialised notebooks are up to the MIL standard MIL-STD 810F for shock-proof and up to norm IP54 for water and dust protection.

Also the photo industry made progress and offers digital cameras like Olympus µ720SW or Pentax Optio Wpi, which are useful for the project TOUGHCLINIC because of their attributes like waterproofness and resistance for sand and dust by special seals as well as their small dimensions with simultaneous simple usability.

Computer language and architecture

In principal an enlargement of the project is possible, so that the fixed centre in the (first world) home countries always stays well informed about the actual data. This can be useful for automatically ordering or for global forwarded medical consultant requests. In this case, it would be an online available data base. This is not planed in this project, but could be already considered in planning stage. To not eliminate later synergies, a computer language like Java should be used [5]. Java works with the concept Write Once, Run Anywhere. This means that a program programmed in Java has to be compiled theoretically just one time and it runs on all other systems, which has a Java Runtime Environment. This JRE exists for all-around used operating systems like Microsoft Windows, Linus, Solaris, Mac OS X, AIS and many more. In addition there are the JRE not only for server- and desktop operating systems but rather for many other embedded systems like mobile phones, PDAs and also smartcards and other technical platforms, like car and TV. The independence of platforms ends for those systems for which a so called Java Virtual Machine does not exist.

There are many frameworks in uses to achieve an isolation of the systems components and to advance the use of "best-practice" [6].

Java encloses also industry standards for data persistence and network communication. The architecture of TOUGHCLINIC bases on a three-tier-model with the typical tiers: data management, business logic and presentation [7]. Each upper tier can access directly to the underlying tier.

A data base system which uses only a few resources is required for saving the appliance data. This DBS has to be easy to install and to administrate and it also has to support transactions at the same time [8]. HSQLDB and Java DB are two effective and perfected Java data bank systems, which achieve these requirements [9]. Furthermore both systems support the Embedded-Modus in which the DBS is incorporated into the Java appliance so that an exact installation and administration of the data bank system is not necessary anymore. To be transparently for the user it persist only one appliance which has to be started.

One of the central functions of the application is to exchange local data with every reachable co-equipment (unit, implement, and device) and to synchronize one another. One possible method of resolution would be the application of *SyncML* (Synchronization Markup Language), which was defined by the *Open Mobile Alliance* (OMA) to serve exactly this purpose. SyncML-messages are XML-documents, which are exchanged via SyncML-protocol in-between the mobile applications. In doing so there is a difference between the representation protocol and the synchronize protocol. The SyncML representation-protocol defines the message-structure and also the different types of messages e.g. Add, Alert, Atomic, Copy, Delete, Exec, Get, Map, Replace, Search, Sequence and Sync. Furthermore it defines methods for the consistent appellation and identification of dataset, which are synchronized.

The synchronization-protocol focuses on the administration of the particular synchronization-connection. It defines the information flow between the SyncML-client and -server during the synchronization-process as well as the different types of synchronization, like disposable- or non-disposable-synchronization. During the implementation of the SyncML respectively one application takes the role of the Client and another one the role of the Server. The roles are negotiating again for every Synchronization-process. If there is requirement e.g. for a backup, it is possible to synchronize every applications with a central SyncML-Server.

The Java Foundation Classes is a comprehensive collection of GUI-components and Services, which makes the development of demanding graphic user interface possible. More complex components, which are exceeding the

functionalism of the standard components, can be developed via the Java 2D interface. Also three-dimensional issues can be solved with the Java 3D functional-library.

MANET-Radio communication network

So far in a traditional radio-network (Wireless LAN, WLAN) [6, 7, 8] it was only possible to connect one notebook with exactly one central router or exactly one additional notebook. This makes the whole communication very depending on the central architecture and a breakdown of the router would shut down the whole network immediately. Also the bandwidth is limited. More connected notebooks would reduce the flow-rate of data.

Special wireless networks, so called mobile ad-hoc networks (MANET) consider the individual, attending notebooks as a joint, which serve as a repeater to stay in touch with one or more other joints. The result is a network, which can overcome long distances, especially in uneven or challenging terrain. Furthermore MANETs are very reliable, because every node is connected with many other joints. If a joint breaks down out of the network e.g. because of a hardware failure or another reason, the surrounding joints search for an alternative route. Thanks to this still young technology a project like TOUGHCLINIC is practicable.

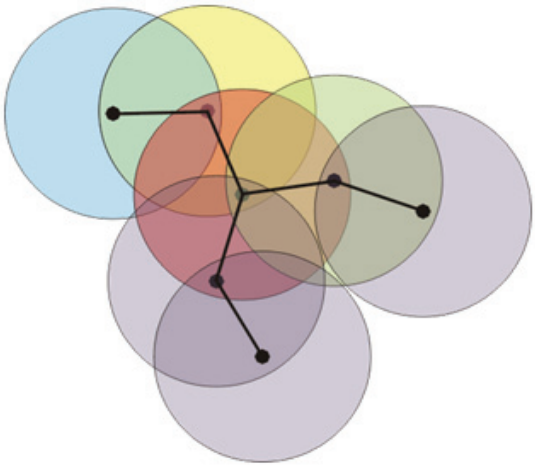

Figure 1- Schematic representation of a MANET-Wireless-Network

To make dynamic routing possible, every application has to send its routing information to every other application, with which one in makes a connection. To do this can be used e.g. the in the meantime fully developed Optimized Link State Routing Protocol (OLSR). At this distributed flexible process of routing, every Router knows the complete net-topology, so that they are able to configure from case to case the shortest way to the destination. Also the data-flow is not lowered because of more applications. It stays constant or even increases.

Structure of the electronic file and the form based additional documentation

Through the provision of a root-appliance and a (constructive) Plug-In-Architecture it is possible that new modules, e.g. (file-rider) in a patient record or also in an administration file, can be added and worked on fast and easy. A special component demonstrates a mechanism for the cognition and administration of Plug-Ins. Every installation of the TOUGHCLINIC can be arranged with a one sentence to Plug-Ins and consequently be arranged by IT-laymen. Because of the experiences of the submitter's institution it's easy to give a reasonable and still basic-documentation for a medicine and an administrative file.

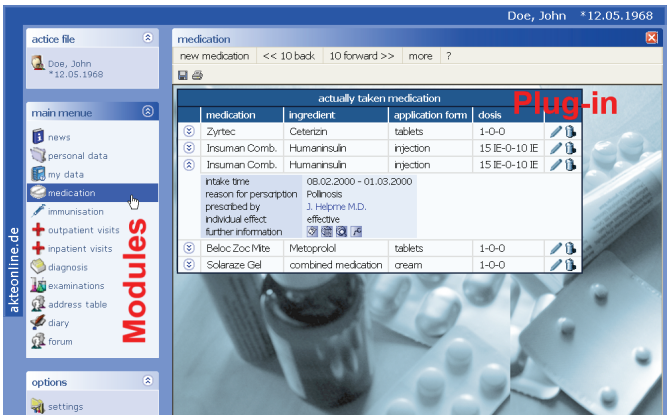

Figure 2- Presentation of modules and Plug-Ins with an example-screenshot of a consistent implementation of software in the system; akteonline.de"

The displayed file structure can include forms as basic modules. This very basic type of mask should be established and worked on by laymen on-site using a form-editor. A special component displays a mechanism for the cognition and administration of forms. Using the forms, the aim is achieved to cover as many as possible intended use, especially to cover the non-planable.

The operation of the system TOUGHCLINIC has to be possible in the English language and with international personnel. The difficulty of the language is not only limited on input and output. It is also included in the understanding and logic of the attendant persons. Some experiences show that for example support staff from different cultures approach problems in a different way than people from our culture. They could use the intended documentation and system functions for our culture, translated from 1:1 in their language, not in the expected way. Because of that preferably a lot of input and output possibilities should be structured in a selection or depend on

pictures. Graphic illustrations of body parts, which can be marked and annotated, could be a good example. These are available for every body part and can be put into the created forms.

Results

Using the system TOUGHCLINIC as here described, any circumstances can be securely documented in special adjusted input and output masks and digital pictures can be added. The software components are due to their modular construction also adjustable for the specific intended use on-site.

Through modern and only now available information technology a wireless networking of many individual, extremely tough and inconspicuous notebook computers without any infrastructure is possible. Breakdown of a notebook or a component does not have any influence on the others. It can be replaced directly by another one (without bothering about manually restoring or copying of data).

The used applications in reach are synchronized automatically with the others and so they receive always an actual dataset. This is also helpful, if notebooks will be launched outside the base. After the returning of the employee the data synchronization will be done automatically. In contrast to the existing W-LAN solutions there is no central hardware-effort necessary. Decoding is so efficient by now to avoid an interception of the content.

Because of the additional decoding of the individual datasets, a losing of one of the high-mobile workstation is limited to a financial loss.

The language barriers between employees from different countries are eliminated through the use of translation-patterns of the data masks, dynamic graphics, e.g. remarkable part of the human body rather than free-text-fields for localization-description.

The three principles of the system TOUGHCLINIC during the support of the medical and administrative care of patients, refugees and victims of catastrophes are very easy handling and the possibility of configuration by non-technical personnel in the case of need, the extremely fast operational readiness as well as the reliable service under extreme environmental conditions.

At the actual early status of development co-operations-partners for processing and use are sought-after, as well as sponsors.

Acknowledgments

Thanks to the potential project-partners Dr. Andreas Fabricius, Missionsärztliches Institut Würzburg (Germany) and Mr. Maurice Mars, University of KwaZulu-Natal (South Africa).

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A Composite Index for Evaluating Electronic Medical Records Systems: Work in Progress

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Abstract

As the number of hospitals using Electronic Medical Records (EMR) systems in Japan continues to rise, there is a need to develop an evaluation framework that can allow comparison of EMR effectiveness within and between hospitals.

Principal component analysis (PCA) was used to summarize survey data into a Composite Index (CI). Five constructs –system quality, information quality, service quality, use and user satisfaction were used to develop the CI. The process included formulating items for each constructs, condensing the data into factors relevant to the constructs and calculating the CI by summing up the product of each construct with its respective PCA score.

The preliminary results show that the CI can discriminate between hospitals that are in the same stage of IT maturity and that the ranking of the hospitals using the CI is strongly correlated with hospital's IT maturity.

The CI can be used as a diagnostic tool for hospitals that are implementing EMR systems as well as hospitals that want to benchmark their systems against other hospitals.

Keywords:

Hospital Information Systems, EMR Systems, evaluation, EMR System Composite Index,
Principal Component Analysis

Introduction

Recent research has shown that information technologies and electronic medical records (EMR) systems can improve adherence to clinical guidelines, patient safety, and the delivery of preventive health services, thereby potentially improving health outcomes for patients. Despite these evidences, wider adoption of EMR systems remains limited [1]. However, the government of Japan has initiated several programs that are likely to enhance wider adoption of these systems. For example, the government policy targeting at least 60% of hospitals with 400 beds or more to computerize their records by 2006 [2], the introduction of prospective payment system based on diagnosis procedure combination (DPC) [3] are expected to enhance wider adoption of EMR systems in the coming years.

As the number of hospitals using EMR systems in Japan continues to rise, there is a need to develop an evaluation framework that can allow comparison of EMR systems effectiveness within and between hospitals. In this paper we propose a framework for generating a Composite Index (CI) for evaluating the EMR systems effectiveness within and between hospitals. The framework involves: 1) identification of factors that contribute to the EMR systems effectiveness; 2) development of a set of measures that can be used to quantitatively score the EMR systems effectiveness based on the factors in 1) above; and 3) provision of an overall theoretical framework that incorporates these factors toward developing a CI for EMR systems.

Methods

Factors contributing to EMR systems effectiveness

Researchers from information sciences have long studied various factors that would impact the use of Information Systems (IS). Although there have been no comprehensive studies that would propose a general model for evaluating EMR systems effectiveness, the DeLone & Mclean's model [4] of IS success provides the most extensive and comprehensive framework for identification of factors contributing to the success of EMR systems. We adopted five constructs (Table 1) from the model, guided by the ability of the construct to be measured quantitatively using survey data and can be synthesized into a single composite score (CI) for evaluating EMR systems in a hospital.

Table 1 - Constructs used for CI computation

Constructs: Definition	Example items	# items	User group
System quality: Number of processes / activities that involve the use of computer-based applications	-Inpatient pre-admission -entering patient notes	269	CIO, CMO, CNO
Information quality: The value and usefulness attributed to the output of the EMR system by users	-get the information you need in time -the information content meets your needs?	23	Dr, NS
Service quality: The responsiveness of the systems staffs to users' requests, systems down-time and trouble-shooting of the EMR system.	-can you count on the system to be up and available? -the system subject to frequent system problems and crashes?	4	Dr, NS
Extent of Use: The extent to which users are using the EMR system	-centralized scheduling system for different outpatient clinics -check drug information (such as drug allergy and drug-drug interaction warnings)	68	CIO, Dr, NS
User satisfaction: The extent to which users felt that the EMR system is important in improving the quality of care they provide	-the quality of medicine has improved as a result of the EMR system? -Overall, are you satisfied with the EMR system in your hospital?	31	Dr, NS

[a] CIO = chief Information officer; CMO = chief medical officer; CNO = chief nursing officer; Dr = Doctor; NS = Nurse

Item generation

We compiled items measuring each target construct (Table 1) following an extensive literature review of studies assessing EMR systems effectiveness [5-8]. In order to improve the validity of the CI, multiple sources of evidence on the EMR systems effectiveness was needed. To this end, five user groups, namely, chief information officer (CIO), chief medical officers (CMO), chief nursing officer (CNO), doctors (Dr) and nurses (NS) were surveyed. The users surveyed were the most likely to be knowledgeable about the EMR systems in their hospitals and whose work is the most likely to be affected by the introduction of EMR system. Overall, five instruments targeting each of the five user groups were developed.

Data collection

Data were collected as part of a nationwide longitudinal study evaluating the improvement of quality of healthcare services as a result of the introduction of EMR systems. The present study was conducted during the second phase of the nationwide study and only 71 healthcare institutions (69 hospitals and two clinics) that had responded to the first phase of the study were targeted. In the first phase, 350 healthcare institutions out of 1522 hospital in Japan that had implemented computer-based patient care systems (especially EMR and physician order entry) were randomly selected to participate. The first phase of the study assessed the costs of computerization (both initial investment and running costs). The intention was to build a business model for EMR implementation. In the present study, questionnaires, together with a covering letter, were sent to 71 healthcare institutions. The hospitals were also asked to rank their EMR systems using the hierarchical scale (ranking from 1 as "least computerized" to 5 as "most computerized") developed by the Japanese Association of Healthcare Information Systems Industry (JAHIS) [9], as a measure of IT maturity. Data were collected over a period of six weeks starting the month of February 2006.

Data analysis and CI computation

Overall, 42 institutions (41 hospitals and 1 clinic) responded to the survey. For the purposes of this analysis, we excluded the clinic making the effective response rate to be 59.4% (41/69). The responding hospitals did not differ significantly with the non-responding hospitals on organizational characteristics such as bed size, ownership, age of EMR system and hospital category. We excluded hospitals where the entire user groups were not represented and where only less than 10% of Dr and/or 10% of NS responded. Based on the above criteria, only 20 hospitals could be included in the CI computation.

Data validation and CI computation

In calculating the CI, the process included data transformation, condensing the data into factors relevant to each construct, and calculating the CI by summing up the prod-

uct of each of the five constructs with their corresponding principal component analysis (PCA) scores.

In summary, data preparation involved condensing items that were on a scale of yes/no to distinct sections and recoding the negatively worded items of the Likert scales before carrying out factor analysis. Each of the resultant factors were analyzed for reliability using Cronbach's alpha. Items were deleted where necessary to achieve an alpha of at least .700. Factors with Cronbach's alpha less than .700 were excluded from CI computation. A PCA was conducted on each of the factors with Cronbach's alpha .700. The constructs scores were calculated by summing the product of each of the user groups' scores with the corresponding PCA scores. CI was then calculated by summing up the product of each of the construct scores with the corresponding PCA scores. A detailed description of the CI computation process is available from the first author (Otieno George Ochieng) on request.

Results and discussion

Internal consistency verification

Cronbach's alpha for the 5 constructs revealed an alpha of .717. However, service quality construct was found to be negatively correlated with the corrected Item-totals and suggesting that deleting it could improve the alpha to .843 (Table 2). The lack of positive correlation between service quality and the rest of the constructs could partly be due to the fewer number of items (Table 1) used in measuring it. Since we desired the model to be additive, we dropped the service quality construct from the final CI computation.

The composite CI for evaluating EMR Systems

Table 3 presents the CI for hospitals. The highest CI was recorded in hospital B34 (81.6) and the lowest in D14 (55.4). The average of the CI was 70.7. Dividing the range (81.6-55.4) of the CI into four equal parts reveals that 7 hospitals are in the top quarter and 4 hospitals are in the bottom quarter. The top 7 hospitals can be considered as outstanding performers in the effectiveness of EMR system while the last four hospitals still require concerted efforts to improve the effectiveness of EMR systems as measured by the CI. The table also presents scores for the constructs, which can serve to identify key areas that a hospital is under or over-performing. Generally, hospitals registered lowest score on the information quality construct. The least performing hospital –D14, registered lowest constructs scores in almost all the constructs.

Table 2 - Internal Consistency verification

	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's Alpha if Item Deleted
System	.550	.890	.667
Information	.845	.958	.549
Service	-.281	.224	.843
User satisfaction	.523	.935	.657
Use of EMR	.874	.928	.475

Validation

A literature search revealed no external standard that could be used to assess the criterion validity of the CI. We therefore, assessed only the construct validity of the CI using correlation analyses. The high correlation between the CI and the constructs scores may indeed represent accurate view of the level of EMR systems effectiveness in the surveyed hospitals (Table 4). The CI was also strongly correlated to IT maturity –a scale developed by JAHIS, thus confirming at once the construct validity of the CI.

Conclusion

This is the first study that attempts to develop a CI for evaluating EMR systems effectiveness. It proposes a framework for evaluating the EMR systems effectiveness of a hospital and identifies five constructs and surrogate measures that can be used in quantifying them. It then describes a procedure for calculating the CI for evaluating EMR systems effectiveness in hospitals. The CI is important because its level can be used as a strong predictor of how well a hospital can perform in the new healthcare environment. The CI can also provide policy makers with a detailed scorecard of their EMR systems relative to its peer counterparts. Further, a breakdown of the constructs' scores allow policy analyst to pinpoint areas of strengths and weakness, thus providing a balanced perspective in guiding a hospital through the computerization. The framework developed here should be viewed as both descriptive and diagnostic: Descriptive because it tends to explain the state of EMR system and diagnostic because it identifies problems areas.

Table 3 - The CI for EMR systems in the surveyed hospitals

No	Hospital Code	System quality	Information quality	Use	User satisfaction	CI	IT maturity
1	B34	86.9	60.3	73.8	62.1	81.6	4.0
2	D11	64.4	64.5	67.8	72.5	77.9	3.0
3	D23	84.5	55.9	70.8	57.0	77.2	5.0
4	D29	82.0	58.3	69.9	56.3	76.9	3.0
5	D40	86.1	54.0	71.7	53.2	76.4	4.0
6	C35	85.6	55.0	68.2	56.9	76.3	3.0
7	D20	79.3	55.3	68.4	58.3	75.3	3.0
8	B10	76.2	56.2	67.0	55.9	73.7	3.0
9	D24	72.8	56.2	64.5	60.6	73.2	3.0
10	D33	77.1	53.9	65.0	56.6	72.7	3.0
11	D37	80.6	51.7	67.1	51.7	72.3	3.0
12	D16	73.4	52.5	65.7	55.2	71.2	3.0
13	B43	75.9	51.3	65.5	52.6	70.7	3.0
14	D28	72.7	51.6	64.7	51.7	69.5	3.0
15	C22	73.4	51.2	59.1	51.8	67.7	3.0
16	D17	55.2	51.4	55.9	57.5	63.6	2.5
17	C38	61.1	48.4	51.1	53.2	61.5	2.5
18	C12	64.4	42.8	57.1	46.7	60.8	2.0
19	A27	66.7	44.1	51.4	46.9	60.0	2.5
20	D14	53.2	42.7	47.1	49.5	55.4	2.5

Table 4 - Correlation coefficients between the constructs, IT maturity scale and the CI

Constructs & IT maturity Scale	CI
System quality	.955(**)
Information quality	.893(**)
Use	.991(**)
User satisfaction	.802(**)
IT Maturity	.897(**)

** P-value<0.01 level (2-tailed)

We acknowledge some of the methodological limitations related to the computation of the CI. First, the hospitals selected are too few. Secondly, PCA technique based on correlation matrix was used, which tends to be unstable given the rapid pace of change in EMR implementation. However, PCA was the most scientific and credible method of combining data from different users with items on different scales.

Further work to validate the index is currently in progress.

Acknowledgement

This research was partly supported by the research grant from the Ministry of Health, Labour and Welfare, Government of Japan, number H17-Med-038. We are indebted to Prof. Hasegawa and Prof. Hosoi for their support in this study.

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A Composite Index for Evaluating Electronic Medical Records Systems: Work in Progress

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2. Background of the study

- As the number of hospitals using electronic medical records (EMR) systems
  - continues to rise, there is
  - A need for evaluation framework that
  - Allow comparison of effectiveness of EMR systems within and between hospitals

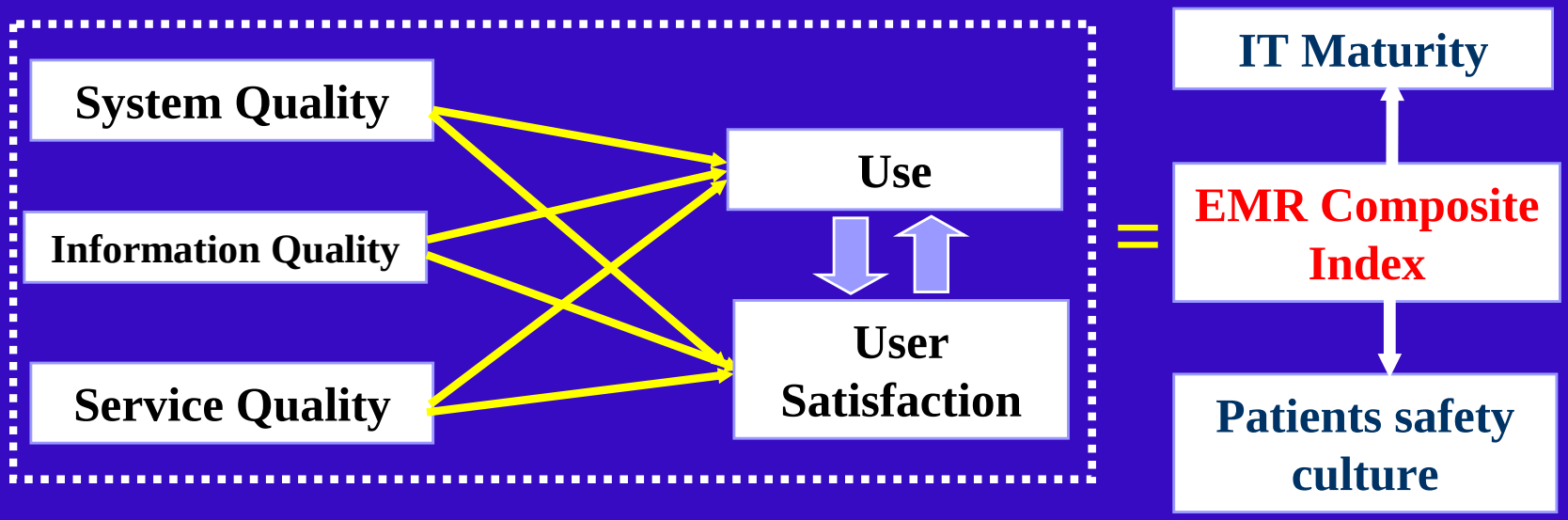
- Objective:

  To propose a framework for generating a Composite Index (C.I) for evaluating the effectiveness of EMR systems

3. The Framework:

- **Involves:**
  - Identification Constructs for EMR systems effectiveness
  - Identification of Items to measure the constructs
  - Calculating the Composite Index (C.I) for EMR systems effectiveness
  - Validation of the C.I

The Model



4. Methods I: Data collection

- 41from a total 69 (59.4%) hospitals returned questionnaires
- Data on IT maturity of EMR systems based on the JAHIS 5-level scale ("1" least computerized and "5" most computerized) and Patient safety culture were also collected
- 20 hospitals were selected for Composite Index (CI) calculation

  based on:

  - Whether all the 5 Target Group of users were represented
  - Whether at least 10% of doctors and /or 10% of nurses participated

5. Methods II: CI calculation

- **Principal component analysis (PCA) was the main analysis procedure because;**
  - **Items in the survey were not on the same scale**
  - **Different respondents were surveyed**
- **PCA was also used as a Data reduction and weighting process**

Benchmarking of hospitals

- **Data for the Composite Index was transformed using the "best performer" and "worst performer" approach**
- **To transform the data the following formula was used:**

$$r = 1-((Max-x) / Max) * F)$$

Where F = max / (max-min); x = original value; r = transformed value.

Thus for x = max, r = 1-0 = 1

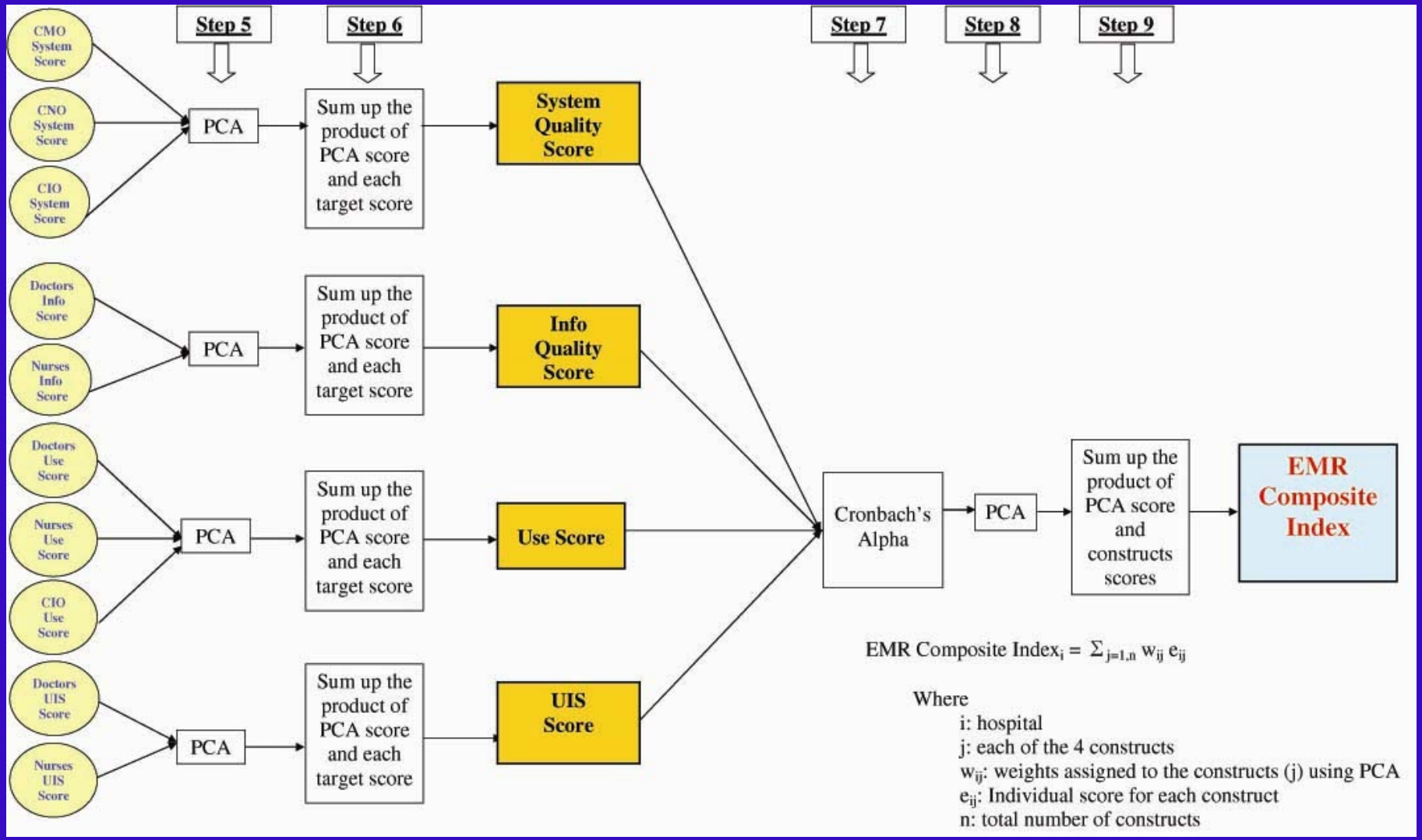
x = min, r = 1-1 = 0

6. EMR Composite Index Construction process

Constructs	No. Items	Scale	1st step	2nd step	3rd step	User group Scores
System quality Is checking drug allergy computerized?	269	Yes/no	Average	Cronbach's alpha	PCA	CIO, CMO, CNO
Information quality does the information content meet your needs?	23	5-point Likert	Factor analysis	Cronbach's alpha	PCA	Dr, NS
Service quality Is the system always up and running?	4	5-point Likert	Factor analysis	Cronbach's alpha	PCA	Dr, NS
Use How often do you use the system to check drug information?	68	5-point Likert	Factor analysis	Cronbach's alpha	PCA	Dr, NS
User satisfaction Overall, are you satisfied with the EMR system in your hospital?	31	5-point Likert	Factor analysis	Cronbach's alpha	PCA	Dr, NS

CIO-Chief Info Officer; CMO-Chief Medical Officer; CNO-Chief Nursing Officer; Dr-Doctor; NS-Nurse

7. EMR composite Index Calculation

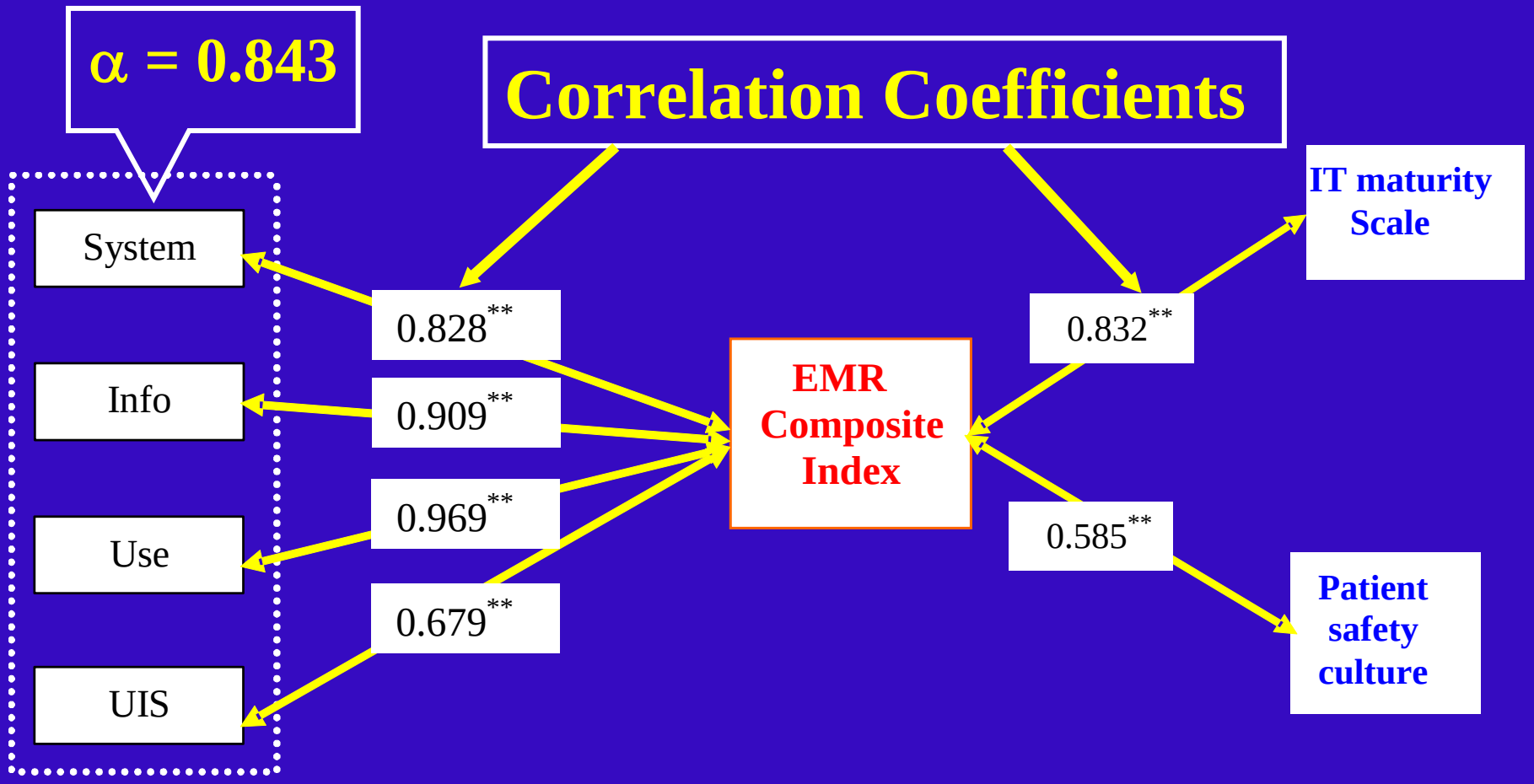


Info=information; use=extent of use of EMR system; UIS=user of information satisfaction

8. Results: EMR Composite Index (CI)

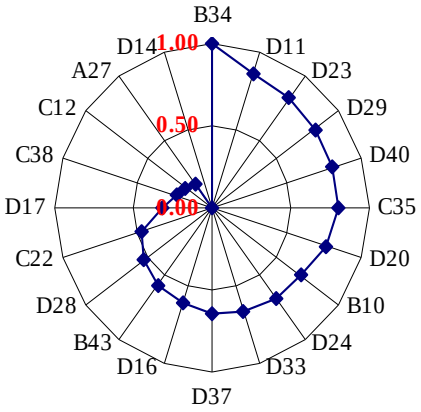
No.	Hospital code	System quality	Information quality	Use	User satisfaction	CI	IT maturity	Patient safety
1	B34	86.9	60.3	73.8	62.1	81.6	4.0	71.0
2	D11	64.4	64.5	67.8	72.5	77.9	3.0	75.1
3	D23	84.5	55.9	70.8	57.0	77.2	5.0	64.6
4	D29	82.0	58.3	69.9	56.3	76.9	3.0	76.4
5	D40	86.1	54.0	71.7	53.2	76.4	4.0	69.7
6	C35	85.6	55.0	68.2	56.9	76.3	3.0	67.7
7	D20	79.3	55.3	68.4	58.3	75.3	3.0	55.8
8	B10	76.2	56.2	67.0	55.9	73.7	3.0	72.5
9	D24	72.8	56.2	64.5	60.6	73.2	3.0	52.3
10	D33	77.1	53.9	65.0	56.6	72.7	3.0	43.5
11	D37	80.6	51.7	67.1	51.7	72.3	3.0	75.1
12	D16	73.4	52.5	65.7	55.2	71.2	3.0	64.2
13	B43	75.9	51.3	65.5	52.6	70.7	3.0	63.3
14	D28	72.7	51.6	64.7	51.7	69.5	3.0	59.9
15	C22	73.4	51.2	59.1	51.8	67.7	3.0	63.3
16	D17	55.2	51.4	55.9	57.5	63.6	2.5	63.3
17	C38	61.1	48.4	51.1	53.2	61.5	2.5	49.4
18	C12	64.4	42.8	57.1	46.7	60.8	2.0	55.6
19	A27	66.7	44.1	51.4	46.9	60.0	2.5	60.2
20	D14	53.2	42.7	47.1	49.5	55.4	2.5	63.3

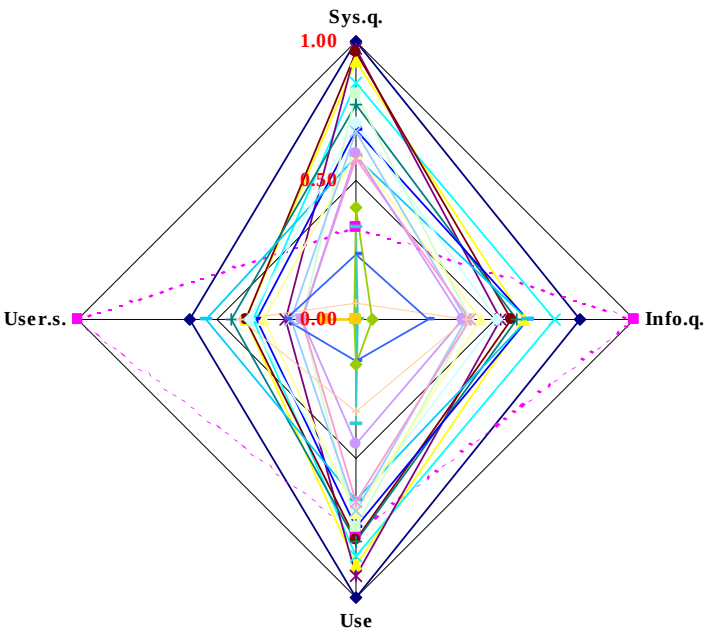
9. Validation of the CI



**p-value < 0.01 level (2-tailed Pearson correlation)

10. Benchmarking of the hospitals using CI





Sys.q=system quality; info.q=information quality; user s=user satisfaction

11. Discussion and conclusion

- These initial results show that:
  - The CI is internally consistent
  - has good construct validity, and
  - is sensitive to differences between hospitals

- Proposed a framework for evaluating effectiveness of EMR systems by;
  - Identifying relevant constructs, and
  - Describing a procedure for CI generation
- The CI can:
  - Provide a detailed scorecard for EMR systems, and
  - Allow analyst to pinpoint areas of strengths and weakness to guide computerization

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Collective Intelligence and a Sustainable Healthcare System

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Abstract

Collective Intelligence is Mother Nature's way of cooping with evolving complexities. For a sustainable healthcare system, we must cast a critical look at our traditional episodic based healthcare delivery model and focus more on disease prevention and chronic disease management. This in part is possible by way of having access to timely and accurate lifetime patient medical information. A National Health Information Infrastructure initiative is the catalyst needed for such dramatic changes in our healthcare system.

Keywords:

national health information network

Unsustainable healthcare system

The Centers for Medicare and Medicaid Services (CMS) recently released projected health care expenditures for the 2005 through 2015 period. [1] Total health expenditures are estimated to be $2.16 trillion in 2006, and are projected to rise to over $4 trillion in 2015. Per person health spending is $7,110 this year and is projected to increase to $12,320 by the end of the period.

Health spending continues to increase much faster than the overall economy (i.e., gross domestic product, or GDP). Since 1970, health care spending has grown at an average annual rate of 9.9%, or about 2.5 percentage points faster than GDP. [2] In recent decades, the growth rates for health spending and GDP have slowed, but health spending growth remains consistently above GDP growth. As a share of the economy, health care has risen from 7.2% of GDP in 1965 to over 16% of GDP today, and it is projected to be 20% of GDP just 10 years from now.

Despite such overwhelming expenditure:

- Medical errors is the third leading cause of death in the United States. [3]
- 250,000 people die in the U.S. each year due to surgical errors, mistaken diagnostics, incorrect prescribing, hospital-acquired infections and inadequate care.
- There are over 46 million uninsured persons in US. [4]

Clearly this is not a sustainable healthcare system. The time has come to take a few fundamental steps away from our traditional business and clinical models.

Business model

The current financial incentives in healthcare system undermine efforts to improve preventive and primary care, manage chronic conditions, and coordinate care. It is based on claim-based transaction model which forces providers to focus more on patient volume and less on healthy patients. Revamped payment models should reward more effective and efficient care, with focus on value. Indeed US government, health plans, employers, and "watch dog" groups are all moving towards the implementation of quality measures, public reporting of both hospital and physician performance, and the tying of those outcomes to reimbursement.

Clinical model

In a sustainable healthcare system healthy population is as important as individual patient treatment. More often, in the present hospital-based systems:

- Physicians and other clinicians sometimes provide patient care while lacking knowledge of previous medical history, resulting in both wasteful duplication and clinical decisions that do not take into account critical data related to patient health. In fact, studies show that paper hospital records are unavailable when needed approximately one-third of the time.
- Hospitals and physicians are often unable to obtain usable information that is essential to research breakthroughs in confusing particularities of individual patients or in avoiding preventable medical errors and malpractices.
- Public health agencies and providers are unable to exchange information critical to identifying, tracking, and responding to public health threats ranging from traditional epidemics to deliberate bio-terrorist attacks.
- Health services researchers do not have ready access to data required to develop improved processes of care, which would lead to improved health outcomes.
- Patients who wish to collaborate with their doctors in managing their own health have little information to work with. Meanwhile, private and governmental payers, as well as individual workers, and consumers, continue to bear the financial burden of clinical inefficiency.

Higher quality of care and efficiency is achieved when up-to-date best practice information is universally available replacing opinion-based decision-making to evidence-based decision-making. The constraining tunnel vision created by the present silos of clinical information must give way to a bird's-eye view of patient lifetime medical encounters.

Collective intelligence

By definition Collective Intelligence is an intelligence that emerges from the collaboration and competition of many individuals, an intelligence that seemingly has a mind of its own.

The field of collective intelligence is seen by many as primarily a human enterprise in which mind-sets, a willingness to share, and openness to the value of distributed intelligence for the common good are paramount. Participants are confident of their own abilities and recognize that the whole is indeed greater than the sum of any individual parts.

As complexity and crises increase, more people and institutions are recognizing that our collective intelligence - at every level and especially in its wiser forms - has tremendous potential to produce positive change and even turn major breakdowns and crises into evolutionary breakthroughs. [5]

Thus collective intelligence is a holy grail of social change and social creativity. If we could better understand how to support it, increase it and facilitate it, we would be more able to effectively co-create a better world. Doing that, of course, involves significant political, economic, social, cultural, organizational and spiritual challenges. But the rewards, when these challenges are successfully engaged, are tremendous.

Harnessing collective intelligence

As patients move through various episodes of care, it becomes evident that to enhance quality of care various stakeholders' business processes must be woven together into an integrative delivery mechanism. National Health Information Infrastructure (NHII) is a new paradigm for the achievement of real-time information integration. It is a platform for sharing information and knowledge appropriately so it is available to people when they need it to make the best possible health decision.

NHII includes not just technologies but, more importantly, values, practices, relationships, laws, standards, systems, and applications that support all facets of individual health, health care, and public health. It encompasses tools such as clinical practice guidelines, educational resources for the public and health professionals, geographic information systems, and health statistics at all levels of government, and many forms of communication among users. [6]

Concisely, National Health Information Infrastructure:

- is an initiative set forth to improve the effectiveness, efficiency and overall quality of health and health care,
- is a comprehensive knowledge-based network of interoperable systems of clinical, public health, and personal health information that would improve decision-making by making health information available when and where it is needed,
- is the set of technologies, standards, applications, systems, values, and laws that support all facets of individual health, health care, and public health,
- improves public health through advanced bio-surveillance methods,
- streamlines collection of data for quality measurement and research,
- is voluntary,
- is NOT a centralized database of medical records or a government regulation,
- is an information infrastructure, not information system,
- sits beside the legacy systems of providers, payers, etc,
- reduces local implementation barriers while making the meaning of content in local systems increasingly explicit with time,
- facilitates direct access to external information if permitted by patient consent,
- facilitates incorporation of practice guides,
- decouples the management of information about patients from the systems that automate practice.

To meet the Nation's health needs, the NHII must serve all individuals and communities equitably. The interconnections made possible by the NHII would allow information capacities that now exist or are developing in the health field to be put to fuller use.

Ready access to relevant, reliable information and secure modes of communication would enable consumers, patients, healthcare and public health professionals, public agencies, and others to address personal and community health concerns far more effectively.

NHII architecture

A successful NHII architecture must address three fundamental layers of (1) Systems Integration which is concerned with publication, description, and translation, (2) Organizational integration which deals with consensus, and credentialing, and finally (3) Semantic Integration which handles integration at business process level.

The overarching goal of adopting NHII is to achieve progressive homogeneity across the nation healthcare delivery system, respecting the federated environment, and a balance between what is common and what is decentralized.

Federated model

The interweaving fabric is based on an integrated but decentralized/federated delivery system, which maintains each organization's brand and identity. Its objective is not to impose uniformity throughout the System: instead it recognizes that the agility and autonomy are significant contributing factors to system's overall success.

Conversely, it also recognizes that more synergy needs to be leveraged across entities and that critical functions exist (such as common patient identification, providers registry, referral network etc.) where nation-wide consistency/commonality must be implemented to achieve a holistic healthcare system.

Therefore, NHII federated architecture is about relations between system parts, and between people. It recognizes organizational politics and admits conflict would better reflect reality than a model of unstinting cooperation and unfettered exchange of information. Federalism is preferred archetype, where potentially competing or non-cooperating parties are brought together by negotiation.

NHII federated architecture identifies closely related (people and supporting systems) activities in an organization, along geographical, process, or functional lines. It divides the organization into clusters (domains) with their own administrative and control mechanisms, and supporting systems. The internals of a domain are to be opaque to other domains. It lets domains communicate exclusively via messages to be placed on a federal nation-wide information highway guaranteeing message delivery. Data flow is only by a domain publishing, and other domains subscribing to, specified agreed upon information. A domain itself can consist of a federation; therefore, in this sense, this federation pattern is recursive.

NHII federated architecture is a direct response to the healthcare market challenges associated with fragmented provider structure and rapid changes of affiliation among providers. Independent clinics are constantly bought out or are forming to be more competitive. Physicians' affiliation to hospitals and health plans are constantly evolving. The overall framework supports a complex, adaptive system, which aims to create a global healthcare community by the physicians for their patients.

Governance model

NHII Governance Model defines the policies and practices all services should follow. With no clear guidelines on how an enterprise would govern its services, national initiatives would fail to deliver the results.

Governance is determined by the policies, rules, and regulations under which an organization functions, as well as the processes ensure compliance. While design-time governance deals with capturing information about services and policies, run-time governance enforces those policies during service discovery, management, and execution. For effective governance, a federated control within the NHII infrastructure is needed to ensure that organizational policies are consistently applied.

NHII governance model supports:

- Central registry to store all services, associated metadata, plus business and technical policies.
- Directory services that accurately certify, identify, and categorize clients and providers of health care services.
- Federated identity, verification, and authorization.
- Local, regional, and federal access control mechanism with fine-grain granularity.
- Audits and logging

Trusted third party

Following the successful Model of Internet's Domain Name System, there needs to be regional central authorities which facilitate interactions between stakeholders who both trust the third party. They need to use this trust to secure their own interactions.

Core services provided by the trusted authority include:

- PKI services for distributed authentication, identification, and verification of engaging partners.
- Registry and directory services that accurately identify clients (white pages) and providers (yellow pages) of healthcare services.
- Person meta-data object repository which keeps track of individual's lifetime encounters with the nation's healthcare system.
- Transactional queuing system to support asynchronous nature of healthcare processes.

Conclusion

The NHII would serve important national interests. *Implementation of the NHII will have a dramatic impact on the effectiveness, efficiency, and overall quality of health and health care.* Serious problems such as public health emergencies, medical errors, and health disparities could be addressed in a more timely and comprehensive fashion. Furthermore, even though NHII itself will deliver huge benefits, much like other public infrastructures such as roads, communications, electricity, etc. main outcomes will be derived by additional services. It will spawn new business activities that would otherwise be economically unfeasible.

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Online vs. Offline Quality Management in Diabetes Care: Impact On Process Quality

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Abstract

Process quality measures were compared between centers that perform quality management only offline, by means of paper based quarterly benchmarking reports, with centers that additionally performed online benchmarking with a web based application. In this observational study (164 centers with documented 60,859 patient visits) no differences in the rates of 9 recommended process quality indicators in diabetes care were observed between the two groups of centers.

Keywords:

Quality Assurance, Health Care, Internet, Diabetes Mellitus

Introduction

Number of persons suffering from Diabetes Mellitus is rising worldwide, mainly due to sedentary lifestyle and aging populations. Although effective treatments for Diabetes Mellitus are available, substantial proportion of patients does not receive recommended care.

Feedback of medical performance and benchmarking are considered to be effective methods of quality improvement [1, 2]. We developed and deployed BARS, a web-based system for data collection and benchmarking in diabetes care [3] in year 2002. Data can be collected either online, on paper forms or imported from EMRs. Using this software, paper based quality of care reports are produced quarterly and sent to all participants via ground mail.

In this poster, the impact of additional online benchmarking on process quality is examined.

Methods

Forum for Quality Systems in Diabetes Care (FQSD) is a voluntary quality improvement initiative active in Germany and Austria. FQSD members document pseudo-anonymized patient data annually on structured data entry forms, either on paper sheets or online. All centers (general practitioners and hospitals) that collected data receive quarterly non anonymized (with identifiable centers) quality of care reports. Additionally, benchmarking can be performed anytime online using BARS, a web based application [3]. Screenshot of an executed benchmarking query is given in Figure 1. FQSD members participate in continuous medical education meetings with workshop character, which are organized twice a year in Austria and once yearly in Germany.

Improvements in process quality and intermediate outcomes achieved by Austrian FQSD members have been described elsewhere [4].

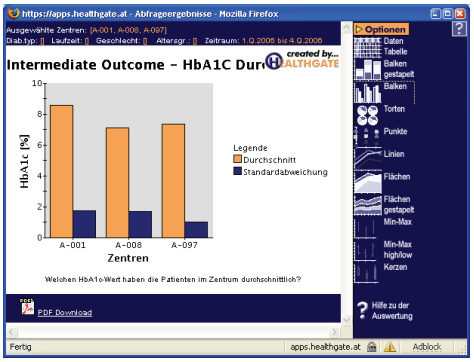

Figure 1 - Screenshot of executed query

For each center process quality measures (percentages of visits with recommended examinations or prescriptions) were calculated for the baseline and follow up period of 2 years before and after the deployment of the web application. During this time, all considered process measures were included in the reports, and for some of them, evidence has been reviewed in continuous medical education meetings.

If center personnel performed at least one additional online benchmark monthly during follow up period, this center was considered an online center. In order to adjust for the potential imbalance between online and offline groups of centers, analysis of covariance (ANCOVA) was used to assess the impact of additional online benchmarking. Centers that collected less than 10 yearly documentations during either baseline or follow up period were excluded from the analysis.

Results

147 and 17 centers have been classified as offline and online centers, respectively. Offline centers documented on average (mean ± SD) 137 ± 192 and 164 ± 288 visits during baseline and follow up period, respectively. Online centers documented 376 ± 400 and 604 ± 544 visits during baseline and follow up period, respectively, resulting in on average 179 (95% CI 65 – 292, p<0.001) more documented visits in the online group. Process quality results are shown in Table 1.

Table 1 - Process quality indicators. Data are means ± SD. Data are percentage of patients per center receiving recommended examination or medication

	Offline centers		**Online centers**		**p**
	Baseline	**Follow up**	**Baseline**	**Follow up**	
HbA1c recorded	89±19	91±16	94±5	95±5	0.761
RR recorded	95±6	96±6	97±3	95±5	0.195
Full lipid profile	32±41	74±28	31±39	78±18	0.497
Microalbumin recorded	55±34	54±38	65±22	60±25	0.652
Feet exam	64±31	63±28	76±21	70±22	0.896
Eye exam	58±25	54±24	58±20	52±24	0.652
RR> 140/90 treated	70±24	76±23	81±10	83±11	0.992
Statins prescribed**	49±30	53±29	51±18	52±17	0.810
Aspirin prescribed*	61±30	62±28	61±17	64±20	0.760

* Apply only to patients with myocardial infraction or stroke.

Discussion

In our study, online centers increased the number of documented patient visits, but did not improve process quality compared to offline centers. To our knowledge, this is the first study that evaluated the impact of additional online benchmarking on process quality measures.

In our study, only a low proportion (10%) of centers performed online benchmarking.

Alternatively, results of this study can be used to answer the question if more frequent feedback improves process quality. Results of the Cochrane review [2], in which no evidence of feedback frequency on process quality could be seen, is inline with our data.

There are several limitations of our study. Firstly, due to its non randomized design, results should be viewed with caution. Although we adjusted the results for the difference in the baseline performances, there are several other possible sources of bias we could not adjust for (dedication to quality improvement, resources available in centers …). Secondly, centers had relatively high baseline performance, which, according to the literature [2], leaves fewer opportunities for further quality improvement.

Reminders, which can be effective in improving process quality, especially if they provide timely information with actionable recommendations [5], were implemented after follow up period and their effect will be evaluated separately.

Conclusion

In our study, additional online benchmarking did not further improve process quality beyond improvements observed with the use of paper based benchmarking. Additional studies, preferably randomized controlled trials, are needed in order to objectively assess the impact of additional online benchmarking on process quality.

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Barriers to Interdisciplinary Use of Patient Problem Lists across an Integrated Health Care Delivery System

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Abstract

While the benefits of a dynamic patient problem list have been recognized for decades, evidence suggests that the practice of generating and maintaining problem lists is inconsistent, occurs in silos and is frequently not patient-centric. This poster includes a brief review of the literature on patient problem lists and then describes the process, tools and findings from an evaluation of interdisciplinary use of patient problem lists across levels of care in an integrated health care delivery system in the northeastern United States. Recommendations for building systems and processes that are supportive of enterprise wide use of patient problem lists are discussed.

Keywords:

problem-oriented medical record, problem list, patient-centered care, documentation

Introduction

The significance of the patient problem list as a key component of the medical record is well established. In 1968, Lawrence Weed described the value of the problem list with regard to its ability to enable the physician to systematically address patient problems. Weed viewed the problem list as the organizing feature of the medical record and in his seminal paper entitled, *Medical Records That Guide and Teach,* Weed (1968) described the problem list as the "dynamic 'table of contents' of the patient's chart, which can be updated at any time" (p. 597)[1]. Weed coined the phrase "problem oriented medical record" (POMR) to describe a patient record characterized by the presence of a complete and dynamic problem list that is informed by a structured, systematically collected database.

An important premise of the POMR is that the structure of the record (e.g. chronologically by problem) is more patient-centric than the traditional approach of structuring the medical record chronologically by discipline. The POMR facilitates integration of data entered by the interdisciplines and ubiquitous access to data, goals, orders, plans, and progress notes related to a particular problem. However, to achieve generalizable integration, a standardized taxonomy and approach to coding problems is needed. Significant barriers exist to capturing patient problem data in a structured, coded format. At present, a clinically useful, controlled medical terminology that adequately represents the range of problems encountered in clinical settings does not exist. Evaluation studies testing the adequacy of existing controlled vocabularies for representing clinician-generated problem statements found that that they are inadequate and require enhancement with additional terms to meet the needs of providers at the point of care.[1-3] An additional barrier to the use of an interdisciplinary patient problem list is the variability in approaches to design and function of the patient problem list that lead to lack of interoperability and preclude data reuse and sharing.

Data collection

An interview guide was developed from a review of the literature and the work of Campbell (1998) and Warren (1998) and was made available to participants prior to site visits. The interview guide standardized data collection across sessions and sites. Interviews were conducted using one-on-one and interdisciplinary focus group formats and centered on the following: 1) information and administrative attributes; 2) benefits and facilitators to existing problem list documentation processes; 3) barriers to enterprise-wide use of interdisciplinary patient problem lists. Participants were identified by hospital leadership due to their clinical leadership roles, expertise with local documentation systems and familiarity with use of patient problem lists.

Results

The degree to which include the features and achieve the benefits of a well-designed and well executed problem list (as defined by Campbell et. al (1998)) is reported in **Table 1**.[4] Vendor functionality is summarized on the left side of **Table 1** under the heading, "Vendor Functionality". The degree to which users perceive key attributes and benefits to be present in inpatient and outpatient settings are summarized by level of care and vendor product versus paper documentation systems on the right side of **Table 1**. Findings indicate that vendor products include many key problem list attributes. However, the degree to which users perceive the attributes and associated benefits to be present varies by site and by user. Of note is the variability of user perception of problem list attributes and benefits even when the vendor product in place is the same.

The primary barriers to use of a common patient problem list across disciplines and levels of care were identified in this evaluation and classified under the following categories: 1) Tools, 2) People and 3) Processes. In this context, tools are defined as the systems in place (e.g. electronic or paper documentation systems) designed to facilitate the use of an interdisciplinary patient problem list. The concept of people includes the attitudes and behaviors of users, patients and characteristics of the organizational culture that are facilitators or barriers to interdisciplinary use of a patient problem list. Processes include operations or events within a hospital or healthcare system that facilitate or prevent adoption of common patient problem list (e.g. organizational policy or implementation strategies).

Tool-related barriers include: 1) Lack of interoperability between systems. 2) The inability of outside vendors to employ web-based services. 3) Differences in structure and coding schemes that exist across vendor products limits the ability to execute a sharable list and assure that updates and changes to a patient problem list are reflected across the system.

People-related barriers include: 1) Attitudes or beliefs related to existing problem list functionality were inconsistent and in some cases inaccurate. 2) Cultural resistance to "patient-centric" problem lists rather than "discipline-centric" problem lists.

Process-related barriers include: 1) Institutional policies and implementation strategies and 2) dual electronic and paper documentation systems.

Conclusion

Barriers to use of a common patient problem list noted in this evaluation include the use of paper-based documentation systems, the execution and functionality of vendor products, and local documentation policy and practices. As organizations continue the transition from paper to electronic systems, it is important that careful consideration is given to EHR design so that systems include key information and administrative attributes of well designed problem lists and the problem list functionality is usable within the context of busy patient care workflows.

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Table 1 - Perceived problem list functionality and processes

	Vendor Functionality			Outpatient									Inpatient				
				PCP					Specialists			NPP	Interdisciplinary				
				V1									Paper		V2		V3
	V1	V2	V3	PCP1	PCP2	PCP3	PCP4	PCP5	SP1	SP2	SP3	NPP	Site1	Site2	Site3	Site4	Site5
Information Attributes																	
* Clinical focus/Interdisciplinary	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
* Codification	X		X	X	X	X	X	X	X	X	X						
* Resolution	X		X	X		X	X	X		X							
* Historicity	X	X	X			X	X	X			X				X	X	
* Viewability	X	X	X			X	X	X			X						
Administrative Attributes																	
* Workflow Integration	X		X		X	X	X	X		X							
* Administrative Cross-references	X		X							X							
* Clinical Utility	X		X	X	X		X	X			X						
Benefits/Payoffs of																	
* Orient clinician to patient?	X	X	X	X	X	X	X	X	X	X	X		X	X	X		
* Coordinate the processes of care?	X	X	X	X		X		X									
* Improve communication b/t providers?	X	X	X	X	X	X	X	X		X	X			X			
* Comply w/JCAHO/NCQA guidelines?	X	X	X			X	X	X	X			X	X	X	X	X	
* Promote research through case finding and audit?	X		X		X	X	X	X		X							
* Aid student/resident education?	X	X	X	X	X	X	X	X		X			X	X	X	X	
* Assist w/revenue management?	X		X					X									

PCP=Primary Care Provider; **SP**=Specialist; **NPP**=Non-Physician Provider; **V**=Vendor

Barriers to Interdisciplinary Use of Patient Problem Lists Across an Integrated Health Care Delivery System

Partners HealthCare Clinical Informatics Research & Development, Boston, USA

Patricia C. Dykes, Matvey B. Palchuk, Qi Li, Victoria Doroshenko, Howard Goldberg

Abstract

- While the benefits of a dynamic patient problem list have been recognized for decades, evidence suggests that the practice of generating and maintaining problem lists is inconsistent, occurs in silos and is frequently not patient-centric. This paper includes a brief review of the literature on patient problem lists and then describes the process, tools and findings from an evaluation of interdisciplinary use of patient problem lists across levels of care in an integrated health care delivery system in the northeastern United States. Recommendations for building systems and processes that are supportive of enterprise wide use of patient problem lists are discussed.

- **Keywords: Problem-Oriented Medical Record, Problem list, Patient-Centered Care, Documentation**

Project Goals

- The goal of the project was to describe “current state” with regard to interdisciplinary use of patient problem lists across Partners’ sites and levels of care and to evaluate the degree to which users perceive that key problem list attributes and benefits are present in existing vendor products.
- An additional goal was to identify barriers and facilitators to an enterprise-wide solution to a common electronic patient problem list.

Study Institutions

- Partners is an integrated health care delivery system located in Northeastern United States and includes academic medical centers, community and specialty hospitals and a network of providers and specialists across the healthcare continuum. Partners' has an enterprise patient problem list that has been a component of legacy ambulatory systems since 1990 (Kuperman et. al, 1995) and as part of the ambulatory Longitudinal Medical Record (LMR) since 2000 (Spurr et. al. 2001). Coded concepts in the Partners problem list dictionary were developed based on evaluation and synthesis of free text terms entered by physicians in the ambulatory setting.21 A paper-based patient record is employed on inpatient units in the Academic Medical Centers (AMCs) and vendor solutions at inpatient community and specialty sites.

Data Collection Methods

- An interview guide was developed from a review of the literature and the work of Campbell (1998) and Warren (1998) and was made available to participants prior to site visits. The interview guide standardized data collection across sessions and sites. Interviews were conducted using one-on-one and interdisciplinary focus group formats and centered on the following:
  1. Information and administrative attributes;
  2. Benefits and facilitators to existing problem list documentation processes;
  3. Barriers to enterprise-wide use of interdisciplinary patient problem lists.
- Participants were identified by hospital leadership due to their clinical leadership roles, expertise with local documentation systems and familiarity with use of patient problem lists.

Results

- Findings indicate that vendor products include many key problem list attributes. However, the degree to which users perceive the attributes and associated benefits to be present varies by site and by user. Of note is the variability of user perception of problem list attributes and benefits even when the vendor product in place is the same.
  - The degree to which problem list functionality and processes across Partners sites include the features and achieve the benefits of a well-designed and well executed problem list (as defined by Campbell et. al (1998)) is reported in **Table 1.**
  - Vendor functionality is summarized on the left side of **Table 1** under the heading, “Vendor Functionality”.
  - The degree to which users perceive key attributes and benefits to be present in inpatient and outpatient settings are summarized by level of care and vendor product versus paper documentation systems on the right side of **Table 1.**

Results

	Vendor Functionality			Outpatient									Inpatient				
				PCP					Specialists			NPP	Interdisciplinary				
				V1									Paper		V2		V3
	V1	V2	V3	PCP1	PCP2	PCP3	PCP4	PCP5	SP1	SP2	SP3	NPP	Site1	Site2	Site3	Site4	Site5
Information Attributes																	
* Clinical focus/Interdisciplinary	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
* Codification	X		X	X	X	X	X	X	X	X	X						
* Resolution	X		X	X		X	X	X		X							
* Historicity	X	X	X			X	X	X			X				X	X	
* Viewability	X	X	X			X	X	X			X						
Administrative Attributes																	
* Workflow Integration	X		X		X	X	X	X		X							
* Administrative Cross-references	X		X							X							
* Clinical Utility	X		X	X	X		X	X			X						
Benefits/Payoffs of																	
* Orient clinician to patient?	X	X	X	X	X	X	X	X	X	X	X		X	X	X		
* Coordinate the processes of care?	X	X	X	X		X		X									
* Improve communication b/t providers?	X	X	X	X	X	X	X	X		X	X			X			
* Comply w/JCAHO/NCQA guidelines?	X	X	X			X	X	X	X			X	X	X	X	X	
* Promote research through case finding and audit?	X		X		X	X	X	X		X							
* Aid student/resident education?	X	X	X	X	X	X	X	X		X			X	X	X	X	
* Assist w/revenue management?	X		X					X									

PCP=Primary Care Provider; **SP**=Specialist; **NPP**=Non-Physician Provider; **V**=Vendor

Table 1: Key problem list attributes by vendor, setting and provider

Results

- The primary barriers to use of a common patient problem list across disciplines and levels of care were identified in this evaluation and classified under the following categories: 1) tools, 2) people and 3) processes.
  1. **Tools:** The systems in place (e.g. electronic or paper documentation systems) designed to facilitate the use of an interdisciplinary patient problem list.
  - Primary Tool-related Barriers:
    1. Lack of interoperability between systems
    2. The inability of outside vendors to employ web-based services
    3. Differences in structure and coding schemes that exist across vendor products limits the ability to execute a sharable list and assure that updates and changes to a patient problem list are reflected across the system.

Results

2. **People:** Include the attitudes and behaviors of users, patients and characteristics of the organizational culture that are facilitators or barriers to interdisciplinary use of a patient problem list.

- **Primary People-related Barriers:**
  1. Attitudes or beliefs related to existing problem list functionality were inconsistent and in some cases inaccurate.
  2. Cultural resistance to “patient-centric” problem lists rather than “discipline-centric” problem lists.

Results

3. **Processes:** Include operations or events within a hospital or healthcare system that facilitate or prevent adoption of common patient problem list (e.g. organizational policy or implementation strategies).

- **Primary Process-related Barriers:**
  1. Institutional policies and implementation strategies
  2. Dual electronic and paper documentation systems

Discussion

- The technical capacity of electronic systems to support key attributes of patient problem list functionality exists in many vendor systems. However, this evaluation suggests that access to advanced functionality does not guarantee that key problem list attributes and associated benefits will be recognized by providers or that problem list functionality will be used enterprise-wide in ways that are patient-centric.

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Impact of a Clinical Decision Support System on Prescribing of Renally Cleared Drugs

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Abstract

The age-related decline in kidney (renal) function is poorly recognised by doctors prescribing renally cleared drugs in the elderly. This causes inadvertent overdosing of renally cleared drugs, increasing the incidence of adverse drug events. A clinical decision support system (GFR+) was developed for calculation of renal function and doses of key drugs adjusted for both weight and renal function. We examined the rate of appropriate prescribing for key renally cleared drugs before and after GFR+ implementation.

Improvements were seen in appropriate dosing of enoxaparin (from 68% to 86%, p=0.03), gentamicin (63% to 87%, p=0.01) and vancomycin (47% to 87%, p=0.07). More appropriate use of therapeutic drug monitoring for gentamicin (70% to 90%, p=0.0)3 and vancomycin (61% to 84%, p=0.17 was noted. With-holding renally cleared drugs during episodes of acute renal failure (43% to 64%, p=0.13) in creased, as did the frequency that frusemide was held (19% versus 31%, p<0.01). GFR+ improved prescribing habits of key renally cleared drugs in an elderly hospitalised population. This is expected to improve patient safety and outcomes in this susceptible group.

Keywords:

dosing, clinical decision support, drug safety, adverse drug reaction

Introduction

Adjusting doses of renally cleared drugs for renal function is an essential element of prescribing. Renal function declines slowly with age, but this is poorly recognised by doctors. The subsequent lack of dose adjustment leads to inadvertent overdosing in older patients, and an excess of adverse drug events, some of which are life-threatening[1]. The occurrence of an adverse drug event is associated with a two-fold increase in mortality rate, increased length of hospital stay of 1.91 days, and an extra US$2262 per patient[6]. Non-compliance for renal drug dosing within the hospital setting is common, with inappropriate prescribing in 19-67% of patients and this is often driven by over-reliance of serum creatinine as a marker of renal function, which is misleading in the elderly[2].

Renal function estimation, with a view to drug dosing, is not a reflex part of clinical practice for most clinicians. Lack of recognition of those drugs that are renally cleared may contribute to poor prescribing, along with the continuing reliance by some clinicians on serum creatinine as a quick guide to renal function in the elderly. Clinicians can easily be misled by normal-range serum creatinine measurements for elderly patients, which can mask significant renal decline. A serum creatinine of 100micromol/l is generally considered to be in the normal range, but results in vastly lower renal function estimations when applied to elderly patients. An 80 year old, 160cm, 45kg female with a serum creatinine of 100micromol/L has an estimated renal function of only 28ml/min, clearly necessitating adjustment of renally cleared drugs.

Methods

An integrated clinical decision support system (GFR+) was developed for the hospital inpatient setting (Figure 1). Functions included automatic renal function estimates, and development and incorporation of sophisticated dosing algorithms, including dose adjustment for renal function, weight and obesity. The module was linked through local databases to enable automatic input of required variables. Serum creatinine values were updated automatically as they became available. GFR+ was designed as a stand-alone module, outside of normal workflow, as electronic prescribing is not available at this hospital. Prescribers were under no obligation to utilize GFR+. Data were collected for 5 months pre- and post-intervention to assess the impact of GFR+ on appropriate prescribing of renally cleared drugs within the hospital setting. The focus was on several critical drugs with a low therapeutic index (gentamicin, enoxaparin and vancomycin), and whether appropriate drug management action was taken during episodes of acute renal failure. GFR+, along with key messages on prescribing issues surrounding renally cleared drugs was introduced using an academic detailing approach.

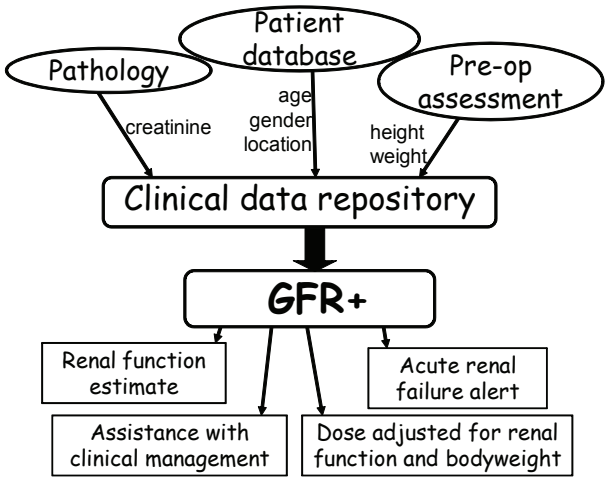


Figure 1

Results

Patient characteristics across the two groups were similar with the following exceptions: pre-intervention patients had better renal function, were less likely to be on frusemide as part of drug management, and more likely to receive gentamicin or vancomycin as part of their drug management during hospitalisation.

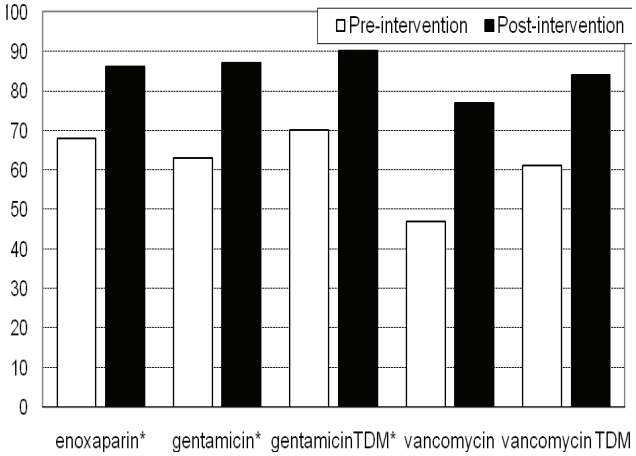
Table 1

	Pre-intervention	Post-intervention
N	509	492
No. of males	292	300
Age (y)	77.9 ± 11.2	78.6 ± 12.4
Weight (kg)	73.9 ± 17.8	72.7 ± 19.9
Length of stay (d)	7 (1-154)	7 (1-84)
Co-morbidities (median, range)	3 (0-12)	3 (0-9)
Renal function * (ml/min)	47.4 + 24.1	43.3 + 22.7
Acute renal failure	24	16
ACE Inhibitors	258	252
Allopurinol	50	54
Digoxin	98	80
Enoxaparin	44	58
Frusemide*	204	233
Gentamicin*	77	38
Lithium	1	1
Metformin	64	60
Vancomycin*	37	17

*p<0.05

Improvements occurred in targeted key drugs commenced during the hospital admission, as well as appropriate therapeutic drug monitoring for gentamicin and vancomycin (see Figure 2).

*Figure 2 - (*p<0.05)*



During the pre-intervention period 38% of renally cleared drugs were held in patients experiencing acute renal failure, improving to 62% after GFR+ (p=0.01).

Frusemide was held in 18.6% of patients at some time during an admission for the pre-intervention phase compared to 30.9% of patients after GFR+ (p=0.003). There was no impact on drug dosing in cases were the patient had previously been commenced outside the hospital on too high a dose (15% vs. 20%, p=0.49).

*p<0.05 for difference between groups

In the pre-intervention period where either an ACE I, allpurinol, digoxin or metformin were initiated during the course of the admission, the starting dose was too high on 11% of occasions, compared to 6% of occasions during the post-intervention phase (p=0.34).

Discussion

The implementation of GFR+ using an academic detailing approach significantly improved a number of aspects of the management of renally cleared drugs. Prescribing of key renally cleared drugs were successfully targeted. Two drugs of particular concern in our patient population were enoxaparin and gentamicin. These two drugs are used for potentially life-threatening conditions, have a low therapeutic index, require adjustment for impaired renal function, and commonly cause serious adverse drug events in the elderly. The dosing accuracy of both these drugs improved significantly. An unexpected benefit for gentamicin management was the improvement in therapeutic drug monitoring, driven by the presence of the monitoring recommendation given with the dose. Vancomycin prescribing also improved markedly (47% to 77%), as was the use of vancomycin therapeutic drug monitoring, but

the smaller patient numbers recruited failed to reach statistical significance (p=0.07 and p=0.17 respectively).

The combination of GFR+ and academic detailing resulted in a better understanding by prescribers of those drugs needing to be held when renal function decreased. This was reflected in an improvement from 38% to 62% for renally cleared drugs held during episodes of acute renal failure. There number of instances where patients on frusemide had this drug held or ceased at some point during an admission increased after the introduction of GFR+. A key message in the academic detailing process focused on frusemide use, and we feel this change reflected a better understanding by clinicians of the potential for frusemide to cause or exacerbate declining renal function.

GFR+ allowed use of sophisticated and better suited dosing algorithms that would not be possible outside this setting. This is expected to lead to decreased rates of adverse drug events for these drugs, especially in elderly patients.

There was a high impact on prescribing, despite GFR+ not being a part of the prescribers normal workflow. GFR+ was readily sustainable across the hospital. Formal user feedback was extremely positive.

Conclusion

GFR+ significantly improves prescribing and understanding of renally cleared drugs, in the hospital setting, which should translate into a decreased rate of adverse drug events.

References

[1] Corsenello A, Pedone C, Corica F et al. Concealed renal insufficiency and adverse drug reactions in elderly hospitalised patients. Arch Int Med 2005; 165: 790-5.

[2] Long CL, Raebel MA, Price DW and Magid DW. Compliance with dosing guidelines in patients with chronic kidney disease. *Ann Pharmacother* 2004;38:853-858.

[3] Vidal L, Shavit M, Fraser A, Paul M and Leibovici L. Systematic comparison of four sources of drug information regarding adjustment of dose for renal function. Brit Med J 2005;331:263-266.

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GFR+

Impact of clinical decision support on renally cleared drug dosing in elderly hospitalised patients.

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Dr. Chris Farmer[1]

Assoc. Prof. Bob Adams[2]

Mr. Scott Walsh[1]

Mr. Phil Cheney[3]

Mr. Steve Govis[3]

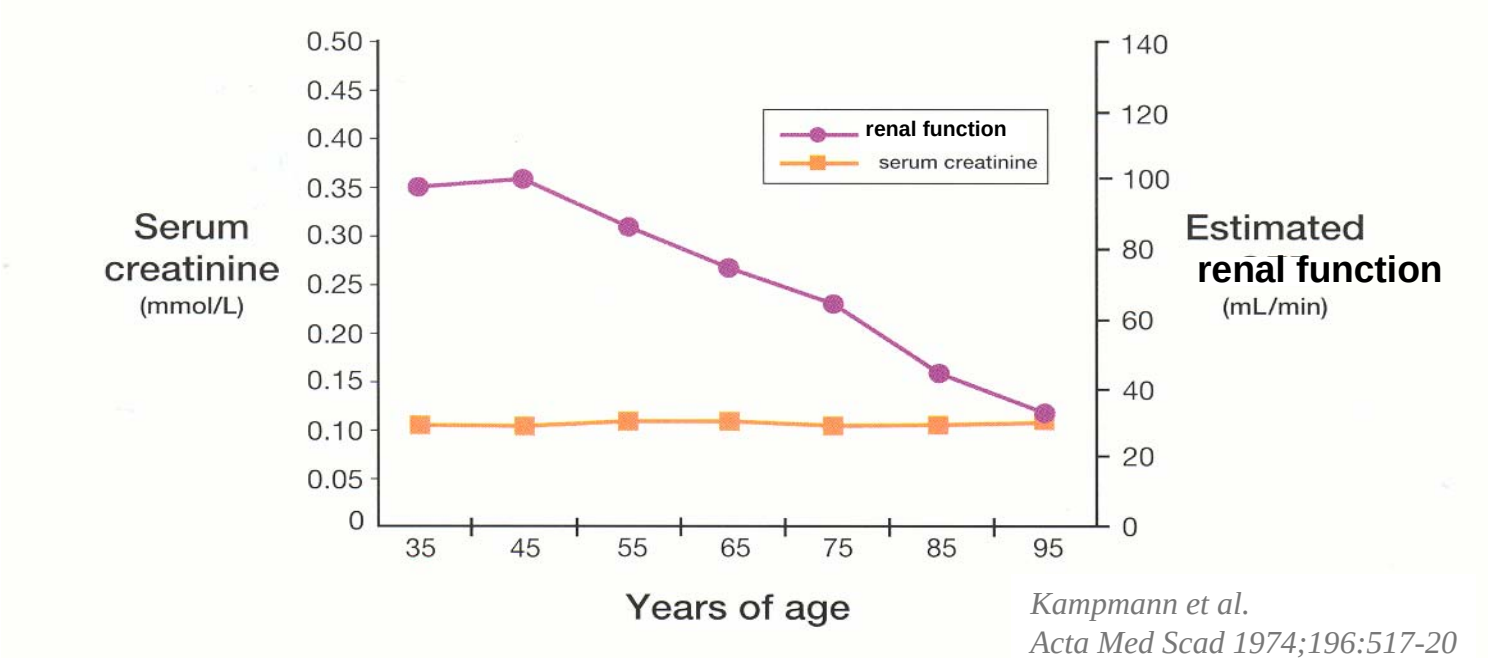
Mr. Tom Belcher[3]

Government of South Australia

1. Repatriation General Hospital
2. University of Adelaide
3. rL-Solutions

The Problem.

• lack of recognition of age-related decline in kidney (renal) function in hospital patients
• clinical culture revolves around using serum creatinine as a marker of renal function, which is very misleading in the elderly

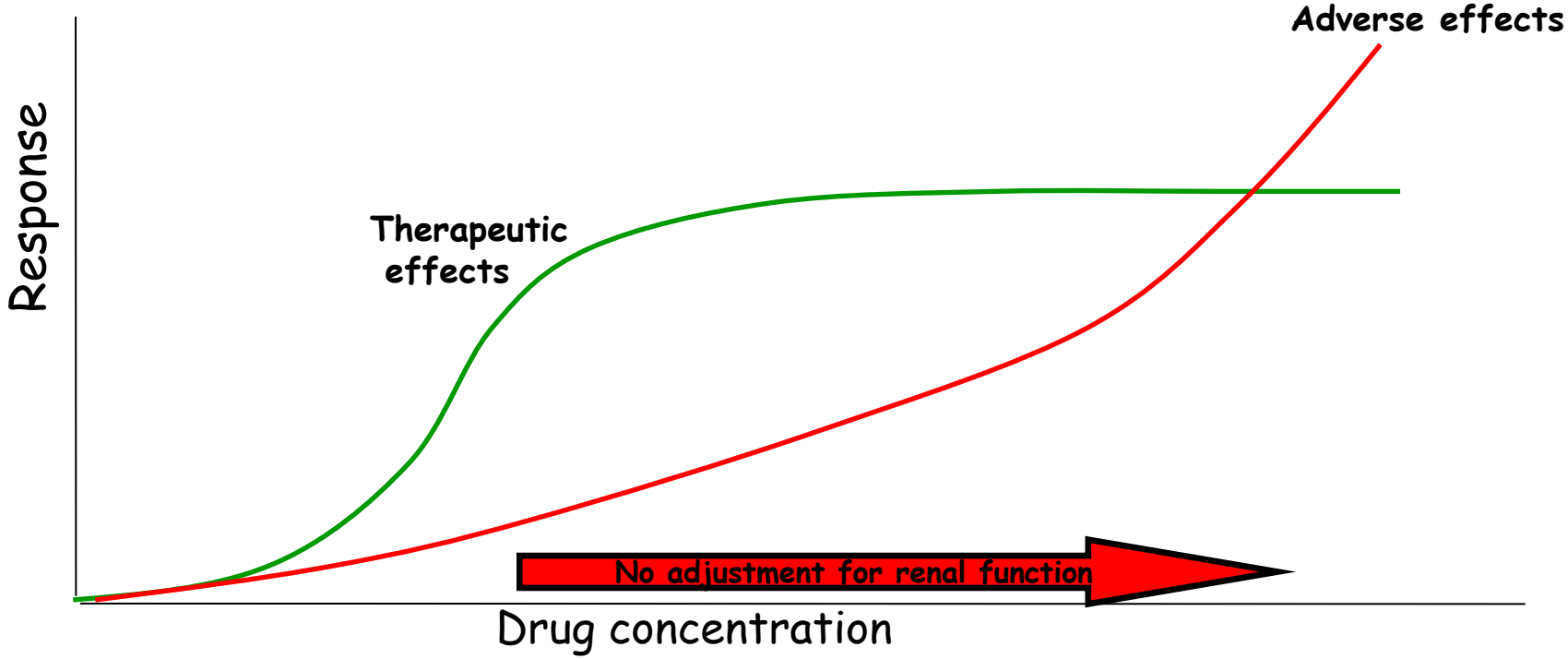


Kampmann et al.
Acta Med Scad 1974;196:517-20

• many key drugs excreted from the body via kidneys (renally cleared)
•the dose of these drugs needs to be decreased according to the decreasing renal function
•not being done in older patients with key drugs in particular (enoxaparin, gentamicin) - identified via death review audit process

The Problem.

•by not appropriately decreasing the dose when renal function is impaired, the patient inadvertently receives an overdose. The drug concentrations build up in the body, increasing the likelihood of adverse drug events.



•this causes a 2-fold increase in the rate of adverse drug events

Corsonello A et al. Arch Int Med 2005; 165: 790-5.

•adverse drug events are associated with a two-fold increase in mortality rate, increased length of hospital stay of 1.91 days, and an extra US$2262 per patient

Classen DC et al. JAMA 1997; 277: 301-6

Existing literature: Dosage adjustment in patients with renal impairment

Cantu et al. Am J Hosp Pharm 1992;49:2944-8.

- 169 inpatients with GFR<40 of which 60 patients were prescribed a renally cleared drug requiring dose adjustment
- 45% of renally cleared drugs too high
- on average 2.5 times higher than recommended dose
- prescribers notified of excessive dosing changed the dose 80% of the time

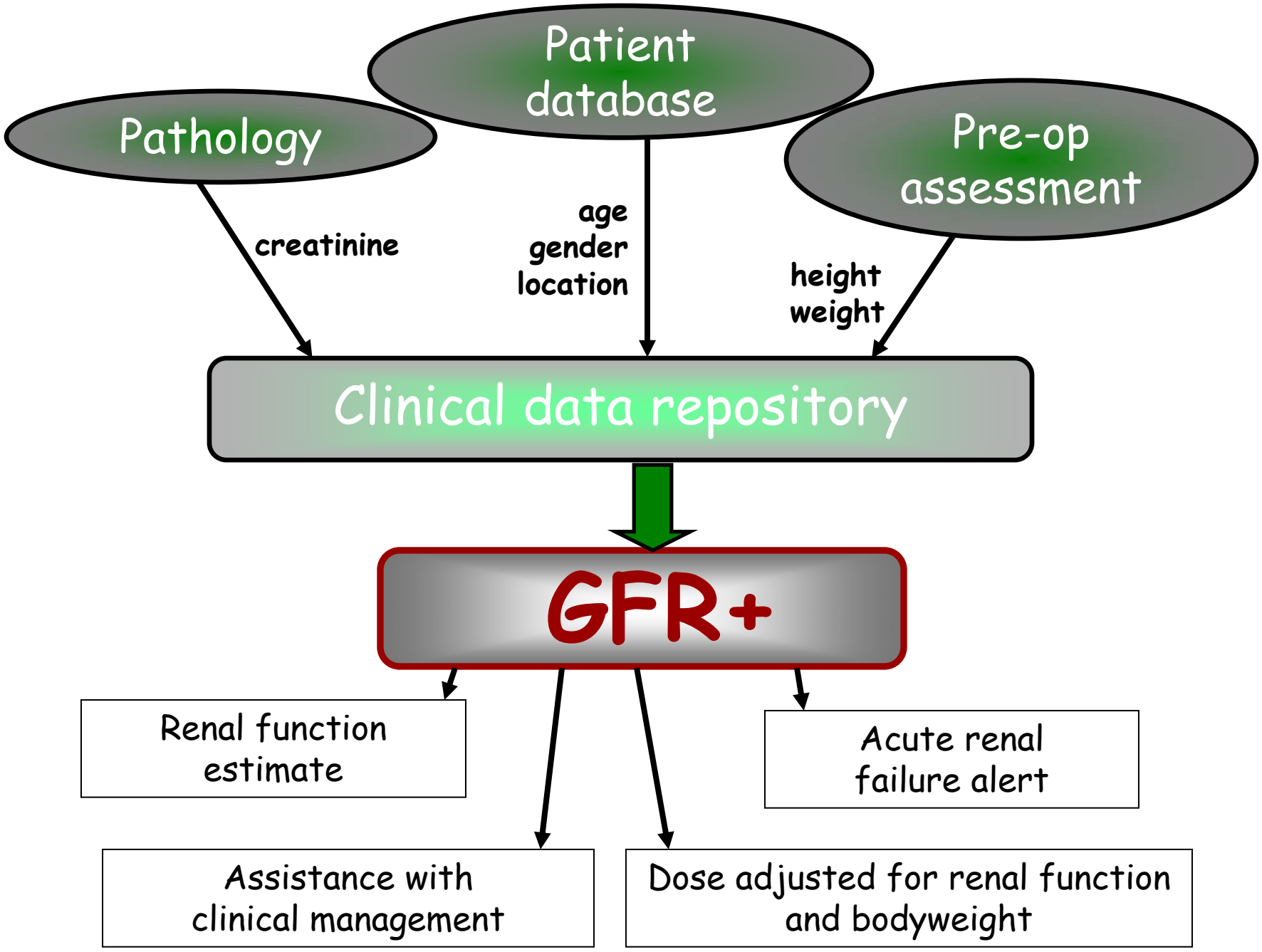
Formula required for estimation of patients renal function

- modified version of the Cockroft-Gault formula, using the lesser of ideal or actual weight, serum creatinine capped at a minimum of 60 mmol/l.

$$\textbf{Renal function (ml/min)} = \frac{(140 - \textbf{age}) \times \textbf{weight} \times k \ (\times 0.85 \text{ if female})}{\text{serum } \textbf{creatinine}}$$

Methodology

- clinical decision support module developed (GFR+). See next slide
- dosing guidelines developed with adjustment incorporated for renal function and body weight
- drugs included enoxaparin, gentamicin, metformin, ACE inhibitors, digoxin, vancomycin
- dosing and drug management data collected on 500 patients on renally cleared drugs before introduction of GFR+ to assess baseline
- GFR+ introduced to prescribers via academic detailing
- a further 500 patients were assessed and prescribing accuracy compared to baseline as well as drug management during episodes of acute renal failure


Patient database
Pathology
Pre-op assessment
creatinine
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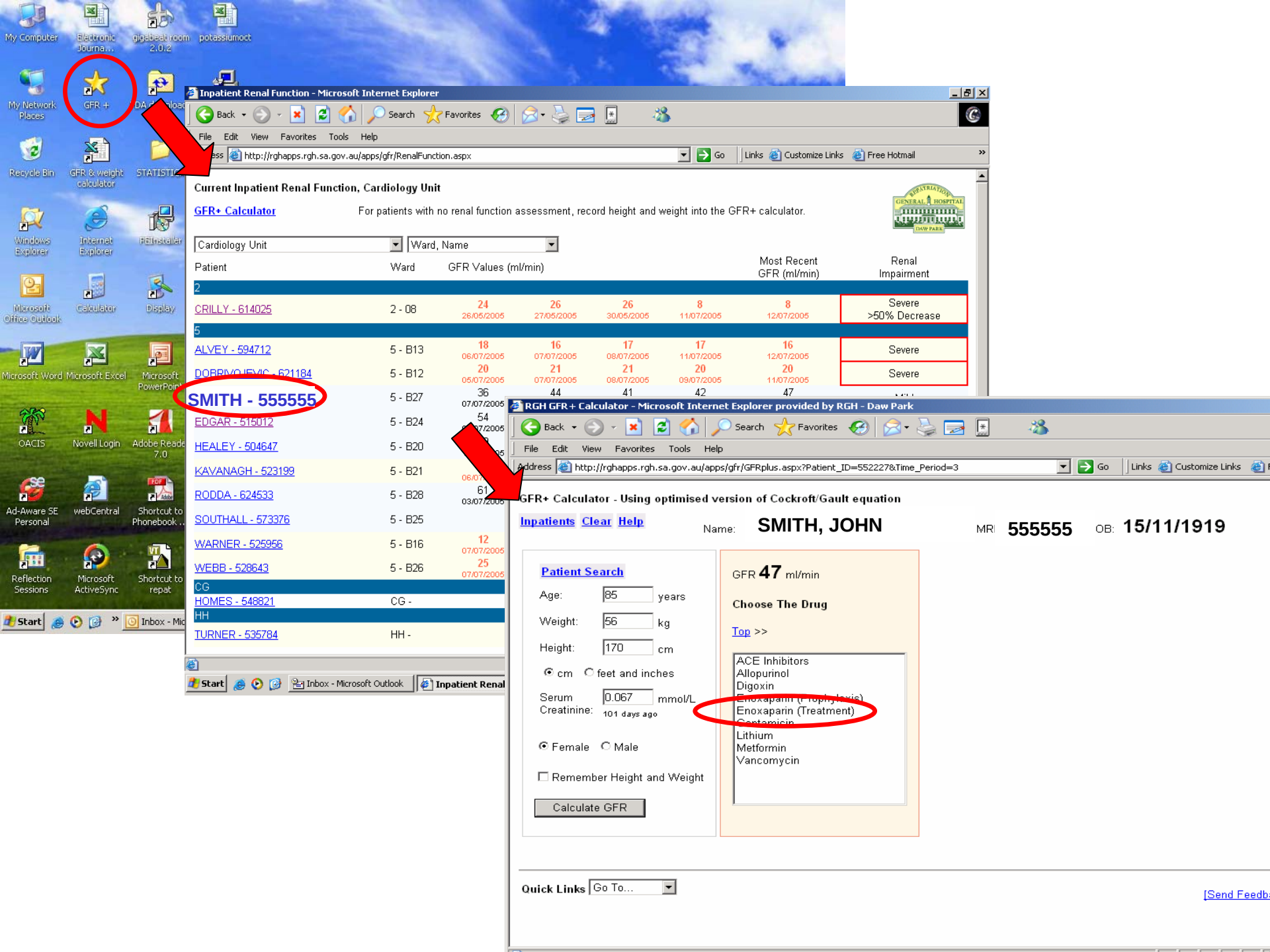
Clinical data repository
GFR+
Renal function estimate
Acute renal failure alert
Assistance with clinical management
Dose adjusted for renal function and bodyweight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Ad-Aware SE Personal
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Reflection Sessions
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Free Hotmail
Current Inpatient Renal Function, Cardiology Unit
GFR+ Calculator
For patients with no renal function assessment, record height and weight into the GFR+ calculator.
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Ward, Name
Patient
Ward
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Most Recent GFR (ml/min)
Renal Impairment
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26 27/05/2005
26 30/05/2005
8 11/07/2005
8 12/07/2005
Severe >50% Decrease
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5 - B13
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17 11/07/2005
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20 11/07/2005
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Go
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Customize Links
GFR+ Calculator - Using optimised version of Cockroft/Gault equation
Inpatients
Clear
Help
Name: SMITH, JOHN
MRN 555555
DOB: 15/11/1919
Patient Search
Age: 85 years
Weight: 56 kg
Height: 170 cm
cm
feet and inches
Serum Creatinine: 0.067 mmol/L
101 days ago
Female
Male
Remember Height and Weight
Calculate GFR
GFR 47 ml/min
Choose The Drug
Top >>
ACE Inhibitors
Allopurinol
Digoxin
Enoxaparin (Prophylaxis)
Enoxaparin (Treatment)
Gentamicin
Lithium
Metformin
Vancomycin
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RGH GFR+ Calculator - Microsoft Internet Explorer provided by RGH - Daw Park

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File Edit View Favorites Tools Help

Address http://rghapps.rgh.sa.gov.au/apps/gfr/GFRplus.aspx?Patient_ID=552227&Time_Period=3 Go Links Customize Links Free Hotmail

GFR+ Calculator - Using optimised version of Cockroft/Gault equation

Inpatients Clear Help

Name: **John Smith** MRN **555555** DOB: **15/11/1919**

Patient Search

Age: 85 years

Weight: 56 kg

Height: 170 cm

cm feet and inches

Serum Creatinine: 0.067 mmol/L
101 days ago

Female Male

Remember Height and Weight

Calculate GFR

GFR **47** ml/min

Choose The Drug

Top >>

- ACE Inhibitors
- Allopurinol
- Digoxin
- Enoxaparin (Prophylaxis)
- Enoxaparin (Treatment)
- Gentamicin
- Lithium
- Metformin
- Vancomycin

Enoxaparin (Treatment)

35mg s/c twice daily

Hide More Info Contact a Clinical Pharmacist

Enoxaparin Treatment Doses

Dosing Frequency

Dosing frequency is maintained at twice daily for all patients. Once daily dosing is generally discouraged in order to avoid peaks that may be associated with bleeding, although it may be a necessary option for patients receiving home based therapy being administered by RDNS nurses.

Doses are rounded up to the nearest 5mg in order to accomodate the commercially available pre-filled syringes (Clexane©). For doses lower than 60mg the 60 mg syringe will have to be used for all doses except 20mg and 40mg. The 20mg and 40mg pre-packed syringes do not have markings that allow their use for any other doses.

Commencing Warfarin

Continue enoxaparin treatment for at least 24 hours after the patients returns their first therapeutic INR.

Anti-Xa Monitoring

Internet

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RGH GFR+ Calculator - Microsoft Internet Explorer provided by RGH - Daw Park

Back | Search | Favorites

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Address http://rghapps.rgh.sa.gov.au/apps/gfr/GFRplus.aspx?Patient_ID=522846 | Go | Links | Customize Links | Free Hotmail

GFR+ Calculator - Using optimised version of Cockroft/Gault equation

Inpatients Clear Help

Name **Bill Jones** MRN: **555556** DOB: **25/10/1923**

Repatriation General Hospital, Daw Park

Patient Search

Age: 91 years

Weight: 90 kg

Height: 180 cm

cm feet and inches

Serum Creatinine: 221 µmol/L today

Female Male

Remember Height and Weight

Calculate GFR

GFR **20** ml/min

Choose The Drug

Top >>

ACE Inhibitors
Allopurinol
Digoxin
Enoxaparin (Prophylaxis)
Enoxaparin (Treatment)
Gentamicin
Lithium
Metformin
Vancomycin

Severe Renal Impairment

The estimated GFR is less than 30ml/min

The following drugs should only be used with caution, if at all:

- Acyclovir
- Allopurinol
- Gabapentin
- Lithium
- Metformin
- Morphine
- Spironolactone (pending potassium)
- Venlafaxine

Highlights drugs to be avoided if patient has severe renal impairment

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RGH GFR+ Calculator - Microsoft Internet Explorer provided by RGH - Daw Park

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Address http://rghapps.rgh.sa.gov.au/apps/gfr/GFRplus.aspx?Patient_ID=585543 Go Links Customize Links Free Hotmail

GFR+ Calculator - Using optimised version of Cockroft/Gault equation

Inpatients Clear Help

Name: **Bill Jones** MRN: **555556** DOB: **25/10/1923**

Patient Search

Age: 86 years

Weight: 55 kg

Height: 145 cm

cm feet and inches

Serum Creatinine: 0.083 mmol/L
4 days ago

Female Male

Remember Height and Weight

Calculate GFR

GFR **26** ml/min

Choose The Drug

Top >>

- ACE Inhibitors
- Allopurinol
- Digoxin
- Enoxaparin (Prophylaxis)
- Enoxaparin (Treatment)
- Gentamicin
- Lithium
- Metformin
- Vancomycin

Gentamicin

200mg STAT dose intravenously

Further doses ONLY after 24 hour trough level known

Extended interval dosing (one dose every 2 days or more) may be required for this patient.

Show More Info Contact a Clinical Pharmacist

Quick Links Go To...

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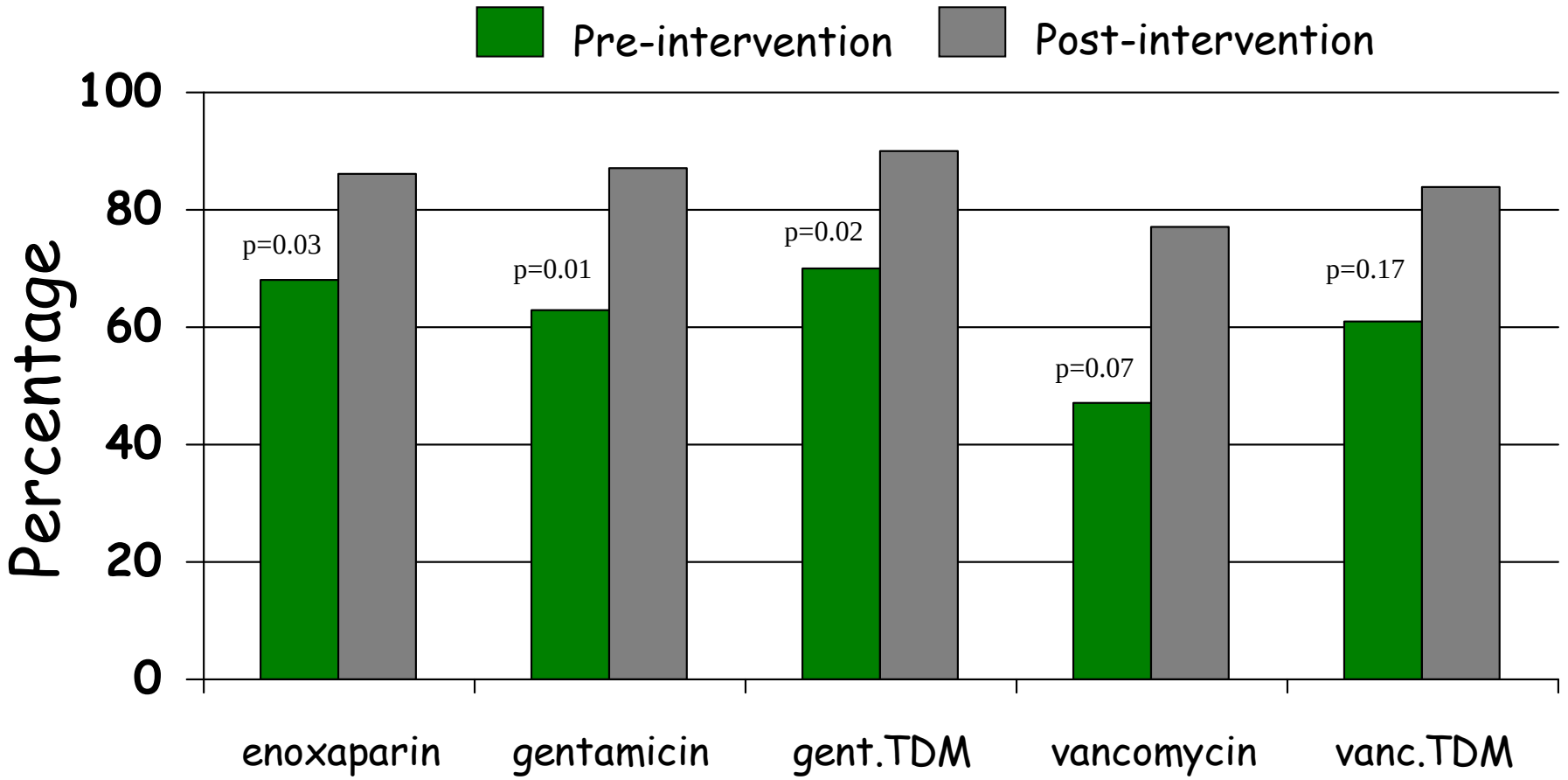
Improvement in prescribing of renally cleared drugs.



- frusemide was more likely to be held after the intervention (19% versus 31%, p<0.01).
- during episodes of acute renal failure, renally cleared drugs (ACE inhibitors, metformin, digoxin, frusemide) were held on 38% of instances in the pre-intervention period versus 62% post-intervention (p=0.01).

Discussion

- likely to lead to improved patient safety and outcomes
- extremely positive reception from medical staff
- apart from dose adjustment for renal clearance and weight, also possible to focus on different issues for different drugs:

✓ improving gentamicin dosing by extending the dosing interval during renal impairment rather than decreasing the dose

✓ encouraging appropriate drug monitoring

✓ encouraging maximisation of ACE inhibitor doses for heart failure

✓ building a general awareness of drug issues related to renal function

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How Could Consistent Management of Information according to Clinical Care Process on Injection Contribute to Patients' Safety?

Hidehiko Tsukuma[a], Takeshi Tanaka[a], Nakao Konishi[b], Kayo Sakata[c], Akie Kawamura[c], Norikazu Iwata[d], Minoru Ikeuchi[a], Kiyomu Ishikawa[a]

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[b] *Department of Pediatrics, Hiroshima University, Japan*
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[d] *Information Media Center, Hiroshima University, Hiroshima, Japan*

Abstract

It is evaluated how the consistent management of information of the clinical process on injection is useful to the improvement of patients' safety. As a result of the evaluation, when the information from the order entry to the execution could be consistently managed, it was found that the system was a sufficiently useful.

Keywords:

safety management, EHR, team practice,
adverse event report

Introduction

The necessary condition of patients' safety management in team practice is to be correctly shared the progress of process of order, acceptance of order, preparation, execution and recording on the clinical treatment among all members of a medical team.

For that purpose, the authors designed and developed the new EHR system which was able to support grasping and sharing the progress of clinical process among medical professions concerned, and check on correctness of combination of medical practice and patient with bar codes, even when the order was frequently changed [1][2]. The system has been operating at the inpatient ward of Hiroshima University hospital since December of 2004. We qualitatively evaluated the system by the questionnaire survey to the system users (medical professions) from the viewpoint of usefulness in team medical practice, and obtained the results that about 65 % of the respondent (88 % when limiting to the nursing staff) answered the consistent management of information was useful for team practice[2].

In this paper, in order to evaluate the effect of consistent management of medical information on the clinical process to patients' safety management quantitatively, injection business which is one of the most complex medical practices is studied.

Methods

We evaluated contribution of the injection system to patients' safety by the hand-written type adverse event reports which were submitted to the department of medical safety management of our hospital.

The procedure of analysis was as follows.

- First of all, we collected the adverse event reports submitted for half a year before and after the injection system introduction.
- Next, the collected reports were classified into four categories by the cause of the adverse event. Four categories are as follows:

  The first is an event that occurs due to description mistake of injection order by a doctor.

  The second is an event that occurs because those who prepare or execute the injection could not receive doctor's order and/or order change in appropriate timing. For instance, this category includes a case that a nurse did not recognize cancellation of the injection order by the doctor and executed it.

  The third case is that those who prepare the injection make a mistake in the kind and/or the dosage of medicine, etc.

  The fourth case is that the doer makes a mistake in confirmation of the target patient.
- Finally, the numbers of adverse events of each of the four categories are compared before and after the injection system introduction.

Results

The result is shown in Fig. 1. Fig. 1 shows that the numbers of reports of adverse events decrease for the 1st, 2nd, and 4th categories after introducing the system. On the other hand, it is understood that the third category doesn't decrease from fig. 1. In the first category, the checking system to the injection order is one of the reasons for decrease in the adverse event.

The effect of this system is especially expected for the event of the second category. Actually, the adverse event concerning the second category did not occur after having been introduced the system. The system should be able to prevent the adverse event of the 4th category in principle. However, two events happened because of violation of the rule, that is, the doer skipped the procedure of confirming the patient with the barcode reader near the bed side. On the other hand, from the result of the category 3, it is clear that the consistent management of the information on the process of injection doesn't contribute to the decrease of human mistakes too much.

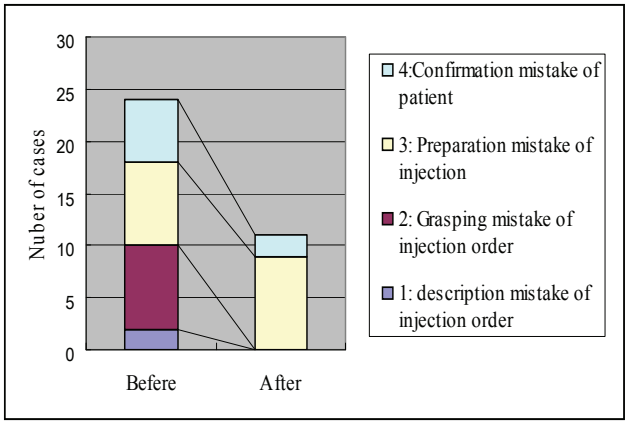

Figure 1 - Comparison of number according to the cause of the adverse event before and after the system introduction

Discussion

After analyzing adverse event reports in detail, we found the following features.

(A) There were few adverse events when the process of injection can be consistently managed by the system from an order entry to an execution. So it is possible to judge that the consistent management of information on medical treatment process contributes sufficiently to the patients' safety.

(B) The adverse event reports were classified into the following six types: (B-1) The doer obtained correct information, but didn't keep the working procedure, (B-2) The doer obtained correct information, but didn't carefully confirm it, and made a mistake when preparing, for instance, misunderstanding in the schedule time of injection, dosage of medicine, (B-3) The user mistook the usage of the system for understanding shortage,

For the problem (B-1) and (B-3), it is considered that a complex business procedure disturbs a decrease in risk factors. Therefore, it becomes more and more important to research a simple and intuitive business flow. For the problem (B-2), it might be a basic solution that the medical professions act carefully based on correct information that the system offers.

However, in one side, it is necessary to examine the improvement of the system. For instance, is it easy to understand the display and the size of the character? In this sense, we should pay attention to the fact that a lot of users pointed out that information displayed by computers didn't understand important points easily. Improvement of this viewpoint is one of the important problems for the safety management with a computer.

Conclusion

It became clear that the system consistently managed the process information from the order to execution was useful for the patient safety in team practice. However, it was suggested to have to improve the expression of the emphasis point etc. Moreover, it will be necessary to consider patients' safe in the emergency case that cannot input the order beforehand. These are next subjects.

Acknowledgements

This research was partly supported by Grant-in-Aid for Scientific Research (B) No. 18310107.

References

[1] K. Ishikawa et al. "A Clinical Management System for patient participatory Health Care Support", International Journal of Medical Informatics Vol. **73**, pp. 243 -249 (2004).

[2] H. Tsukuma et. al. "Construction and Evaluation of EHR which Supports Team Practice", Proceedings of Asia Pacific Association for Medical Informatics (APAMI) 2006 - Towards Global Interoperability for Electronic Health Records -, pp.160-164 (2006).

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tsukuma@hiroshima-u.ac.jp

How could Consistent Management of Information according to Clinical Care Process on Injection Contribute to Patients' Safety?

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Introduction

- The necessary condition of patients' safety management in team practice is to be correctly shared the progress of process of order, acceptance of order, preparation, execution and recording on the clinical treatment among all members of a medical team.
- For that purpose, the authors designed and developed the new EHR system which was able to support grasping and sharing the progress of clinical process among medical professions concerned, and check on correctness of combination of medical practice and patient with bar codes, even when the order was frequently changed [1][2].
- The system has been operating at the inpatient ward of Hiroshima University hospital since December of 2004. We qualitatively evaluated the system by the questionnaire survey to the system users (medical professions) from the viewpoint of usefulness in team medical practice, and obtained the results that about 65 % of the respondent (88 % when limiting to the nursing staff) answered the consistent management of information was useful for team practice[2].
- In this paper, in order to evaluate the effect of consistent management of medical information on the clinical process to patients' safety management quantitatively, injection business which is one of the most complex medical practices is studied.

Methods-1

- **We evaluated contribution of the injection system to patients' safety by the hand-written type adverse event reports which were submitted to the department of medical safety management of our hospital.**

Methods-2

- **The procedure of analysis was as follows.**
  - **First of all, we collected the adverse event reports submitted for half a year before and after the injection system introduction.**
  - **Next, the collected reports were classified into four categories by the cause of the adverse event. Four categories are as follows:**
    - **The first is an event that occurs due to description mistake of injection order by a doctor.**
    - **The second is an event that occurs because those who prepare or execute the injection could not receive doctor's order and/or order change in appropriate timing. For instance, this category includes a case that a nurse did not recognize cancellation of the injection order by the doctor and executed it.**
    - **The third case is that those who prepare the injection make a mistake in the kind and/or the dosage of medicine, etc.**
    - **The fourth case is that the doer makes a mistake in confirmation of the target patient.**
  - **Finally, the numbers of adverse events of each of the four categories are compared before and after the injection system introduction.**

Results-1

- The result is shown in Fig. 1. Fig. 1 shows that the numbers of reports of adverse events decrease for the 1st, 2nd, and 4th categories after introducing the system. On the other hand, it is understood that the third category doesn't decrease from fig. 1. In the first category, the checking system to the injection order is one of the reasons for decrease in the adverse event.

- The effect of this system is especially expected for the event of the second category. Actually, the adverse event concerning the second category did not occur after having been introduced the system.

Results-2

- **The system should be able to prevent the adverse event of the 4th category in principle. However, two events happened because of violation of the rule, that is, the doer skipped the procedure of confirming the patient with the barcode reader near the bed side.**

- **On the other hand, from the result of the category 3, it is clear that the consistent management of the information on the process of injection doesn't contribute to the decrease of human mistakes too much.**

Results-3

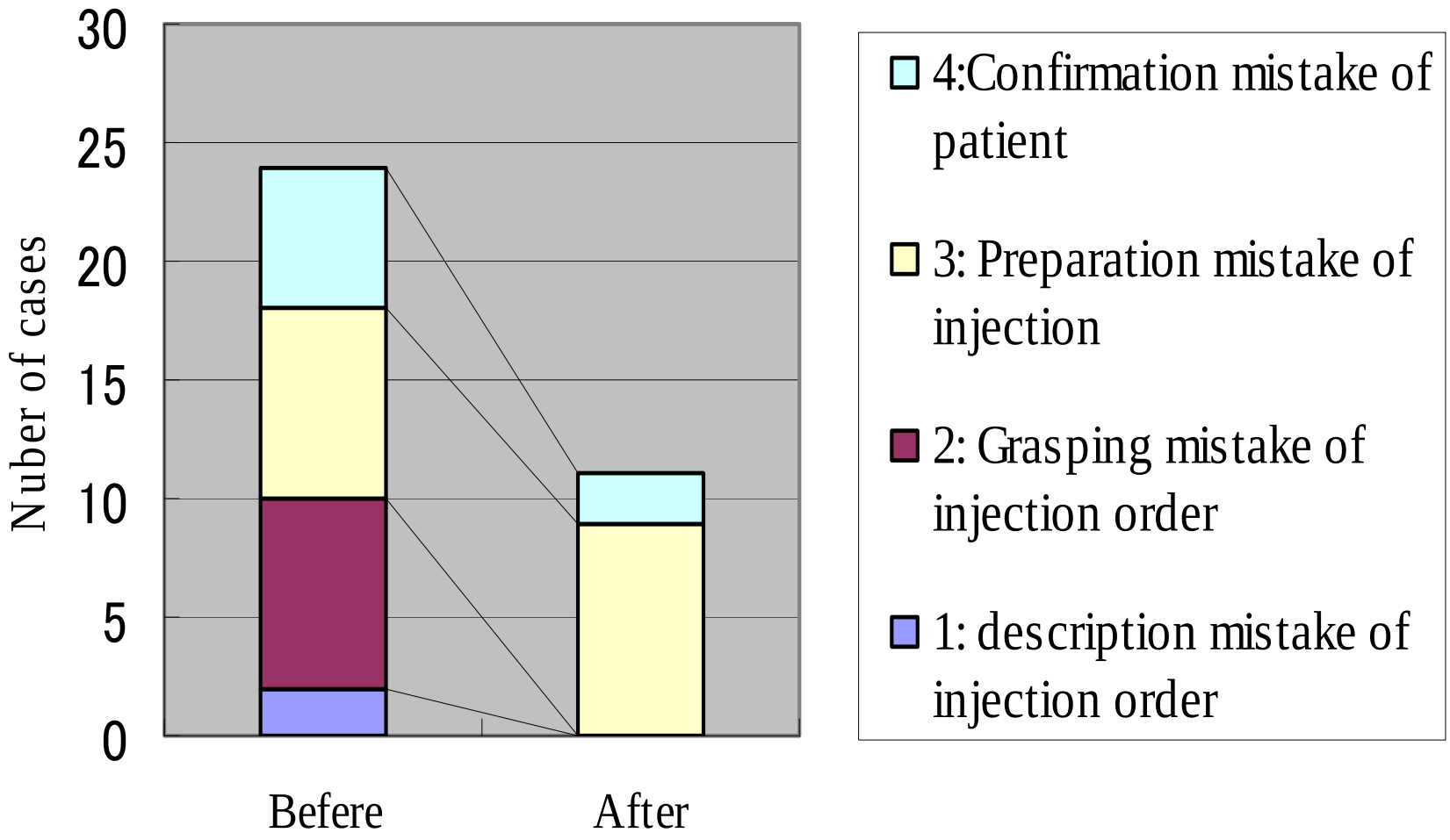

Fig. 1 Comparison of number according to the cause of the adverse event before and after the system introduction

Discussions-1

- **(A) There were few adverse events when the process of injection can be consistently managed by the system from an order entry to an execution. So it is possible to judge that the consistent management of information on medical treatment process contributes sufficiently to the patients' safety.**

Discussions-2

- **(B) The adverse event reports were classified into the following six types:**
  - **(B-1) The doer obtained correct information, but didn't keep the working procedure,**
  - **(B-2) The doer obtained correct information, but didn't carefully confirm it, and made a mistake when preparing, for instance, misunderstanding in the schedule time of injection, dosage of medicine,**
  - **(B-3) The user mistook the usage of the system for understanding shortage,**
- **For the problem (B-1) and (B-3), it is considered that a complex business procedure disturbs a decrease in risk factors. Therefore, it becomes more and more important to research a simple and intuitive business flow.**
- **For the problem (B-2), it might be a basic solution that the medical professions act carefully based on correct information that the system offers.**

Discussions-3

- It is necessary to examine the improvement of the system. For instance, is it easy to understand the display and the size of the character?
- In this sense, we should pay attention to the fact that a lot of users pointed out that information displayed by computers didn’t understand important points easily. Improvement of this viewpoint is one of the important problems for the safety management with a computer.

Conclusion

- **It became clear that the system consistently managed the process information from the order to execution was useful for the patient safety in team practice.**
- **However, it was suggested to have to improve the expression of the emphasis point etc.**
- **Moreover, it will be necessary to consider patients' safe in the emergency case that cannot input the order beforehand. These are next subjects.**

References and Contact Detail

- **References**
  - **[1] K. Ishikawa et al. “A Clinical Management System for patient participatory Health Care Support”, International Journal of Medical Informatics Vol. 73, pp. 243 -249 (2004).**
  - **[2] H. Tsukuma et. al. "Construction and Evaluation of EHR which Supports Team Practice", Proceedings of Asia Pacific Association for Medical Informatics (APAMI) 2006 - Towards Global Interoperability for Electronic Health Records -, pp.160-164 (2006).**
- **Acknowledgements**
  - **This research was partly supported by Grant-in-Aid for Scientific Research (B) No. 18310107.**
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Drug Dosage Adjustment Using Real-Time Renal Dosing System in Korea: Evaluation of the Early Stage of Application

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Abstract and objective

Medication error prevention using computerized physician order entry (CPOE) with clinical decision support system (CDSS) is known effective to reduce the incidence of adverse drug events (ADEs). In 2006, a renal dosing system was developed and implemented in Seoul National University Bundang Hospital (SNUBH) with a full electronic medical record (EMR) system. To assess the performance of the renal dosing system at the early stage and to analyze the system effects, alerts generated for one month were reviewed by clinical pharmacists retrospectively. Alerting rate was 5.4% and inappropriate alerts were 17.7%. Antihistamine and antimicrobials were mainly needed to adjust dosage. Users' acceptance and overriding rates were 32.4 % and 67.6% respectively. Despite of false-positive and overriding alerts, the renal dosing system adjusted considerable numbers of excess dosing in renally impaired patients and aroused physician's attention for safety.

Keywords:

Clinical Decision Support Systems (CDSS),
Renal Dosing System, Adverse Drug Events (ADEs),
alerts

Introduction

As the awareness of patient safety is increased, ADEs are considered as one of the most important problems to solve. CPOE with CDSS enables to reduce preventable ADEs by alerting at the time of prescribing. For the purpose of patient safety, we developed renal dosing knowledge base and implemented the renal dosing system in SNUBH. This study was designed to evaluate the first phase performance of the system and to identify physician's reaction patterns to alerts.

Methods

SNUBH is a 909-bed, secondary and academic hospital affiliated with Seoul National University of Medicine in Gyeonggi-do, Korea. Since the opening, it has adopted a full EMR system, BESTcare. After loading the renal dosing system in the prescribing environment, data of generated alerts during one month (September, 2006) was collected and reviewed retrospectively. Clinical pharmacists evaluated performance of the system by comparing prescribing dose with individual renal function and assessed physician's feedback patterns.

Results

The number of alerts generated during one month was 5,723 cases and 5.4% of total inpatients' prescriptions, and false-positive alert rate which didn't match criteria was 17.7%. Antihistamine (45.5%) and antimicrobial (17.0%) were main drug categories need to adjust dosage. Units occurred frequent alerts were Joint disease and Reconstruction Center and General Surgery; 18.8% and 14.2% respectively. Physicians' immediate and actual acceptance rates to alerts were 17.7% and 32.4%.

Conclusions

Alert rate of the renal dosing system (50%) was much higher than other types of medication-related alerts in terms of clinical decision support. False-positive alerts were mainly due to errors of study criteria and patient's information recorded in EMR. Considerable drug dosage adjusted within a few days after alerting, but many physicians still ignored alerts. It was accounted for insufficient applying of each medical unit's practice and medication used in procedure or operation. Despite of many limitations, the renal dosing system was meaningful in respect of trying preventable care in practice and beneficial effect of increasing physician's adoption of safer prescribing pattern. In conclusion, application of the renal dosing system adjusted inappropriate doses in many patients and affected physician's prescribing patterns. And further revision of the system and evaluation will be needed.

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Introduction

- Patient Safety
  - One of the most important challenges facing health care today
  - An increasingly recognized opportunity for stakeholders in improving quality of health care delivery
- Key solution of adverse events related to inappropriate prescribing: CPOE linked to CDSS
- Effect of CDSS for patients with renal insufficiency
  - NEPHROS study
    - Improvements in appropriateness of dosing(54→67%) and frequency (35→59%)
    - LOS 0.5 days shorter

Methods (1/3)

- Study sites
  - Seoul National University Bundang Hospital
    - 909-bed, secondary, teaching hospital
    - Geriatric patients oriented
  - Operating full electronic medical record system with medication-related decision support systems

- Implementation of renal dosing system
  - Development of renal dosing knowledge base
    - Pilot-test
    - Expert panel review
  - Put into operation of renal dosing system at August 24, 2006
    - Adult (age $\geq$ 12) inpatients only
    - 2 renal function categories: moderate & severe renal impairment (GFR $\leq$ 50 mL/min)

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Methods (2/3)

- Data collection
  - Study period: September 1~30, 2006
  - Study population: 4,159 inpatients of September
  - Electronically collected logs data whether generated alerts by the renal dosing system
- Evaluation
  - Patient's chart review by clinical pharmacists
  - Performance
    - Appropriateness of renal dosing alerts
  - Clinical impact
    - Acceptance rate of renal dosing alerts
    - Cause of ignorance

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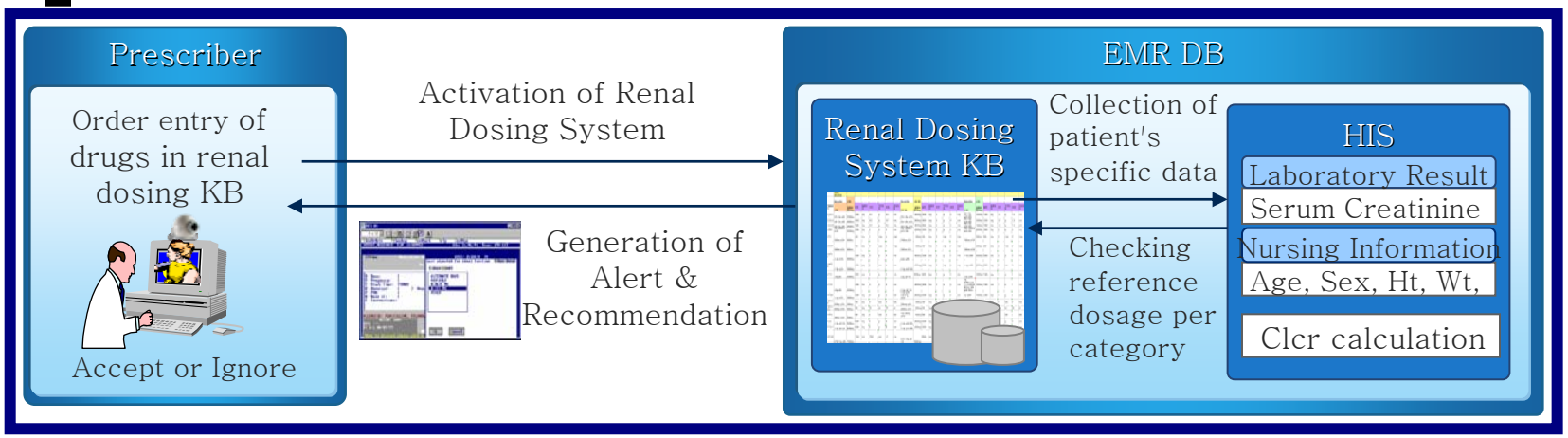
Methods – Study Flow (3/3)



Data Collection and Chart Review
Appropriateness of alert, Prescriber's Acceptance

Outcome Evaluation
Performance and Clinical Impact
of Renal Dosing System

Renal dosing system Evaluation and Revision

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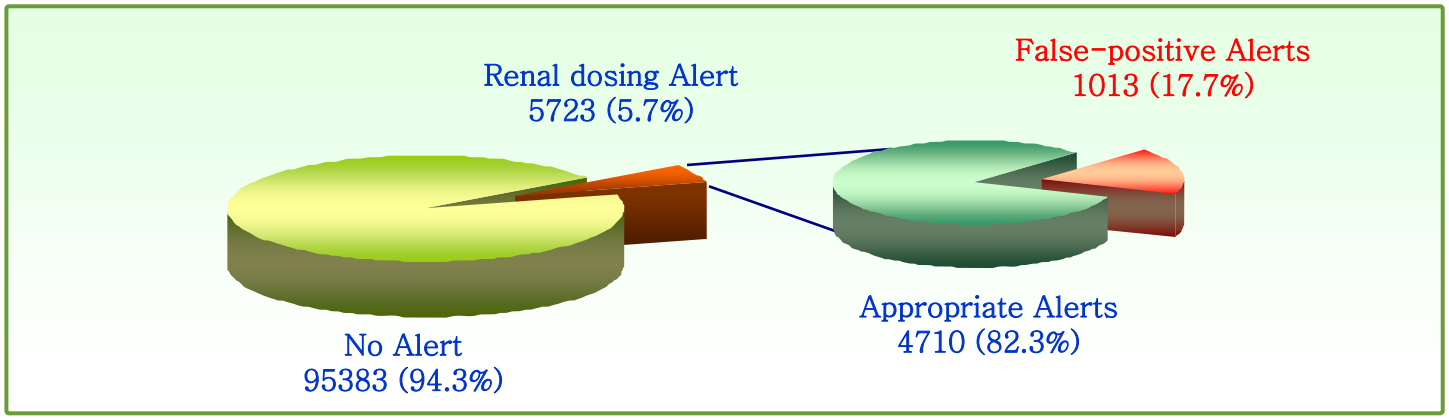
Results (1/3)

- Alert rate of renal dosing system - 5.7%
  - 5,723 alerts/101,106 inpatients' prescription for a 1-month

- Analysis of system performance
  - False-positive rate which didn't match criteria – 1,013 alerts
  - Error rate of renal dosing alerts – 17.7%

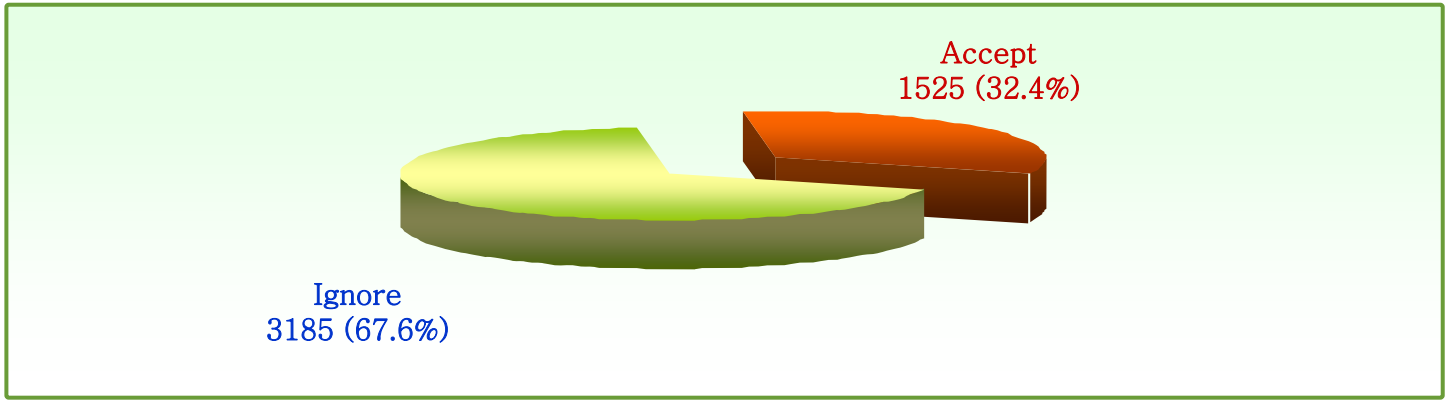
Renal dosing appropriateness alert rates



Results (2/3)

- Analysis of clinical effect
  - Chart review of 4,710 appropriate alerts/385 patients
  - Immediate accept rate (by computer logged data) – 17.7%
  - Ultimate accept rate (by chart review) – 32.4%
- Reason of ignore to alert
  - Therapeutic/temporal use, Don't know why
  - Just below borderline case & Set order

Accept rate of renal dosing alerts



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Results (3/3)

- Main drug categories need to adjust dosage
  - Antihistamine – 2, 124 case (45.5%)
  - Antimicrobials – 803 case (17.0%)
  - Hypoglycemic agents – 410 case (8.7%)

- Units occurred frequent alerts
  - Joint disease and Reconstruction Center – 18.8%
  - General Surgery – 14.2%
  - Urology – 12.3%

Discussion (1/2)

- Low alert rate of renal dosing system (5.7%)
  - Application of strict alerting rule: GFR ≤ 50 ml/min
  - Existence of several medication-related CDSS

- High error rate of alerts (17.7%)
  - Mainly due to error of GFR calculation based on confusion of selection patients' weight
  - Logic: If Actual body weight > Ideal body weight, then take ideal body weight

Discussion (2/2)

- Matters of low acceptance rate
  - Carry out re-test of patients' old renal function
  - Increment of consulting to specialist

  → Meaningful changes of physicians' prescribing behaviors and educational effect

- Issues of considerable ignorance rate of alerts
  - Insufficient applying of each medical unit's practice
  - Medication used in procedure or operation

- Main drug categories occurred alerts
  - Add specialized recommendation by specialist's consultation
  - Expectation of clinically valuable information for patient safety

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Conclusions

- Application of the renal dosing system
  - Adjusted inappropriate doses in many patients
  - Made a beneficial effect to physician's prescribing patterns

  → Meaningful tool with respect to try for preventable health care

- Future research issues
  - Revision of the system
  - Evaluation of economical effect

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Co-Construction of eHealth Services and Technology: Challenges and Solutions

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Abstract

Health care is a challenging context for ICT applications. There is no lack of studies reporting failed projects due to failure to merge professional, bureaucratic and technological missions, interests and focus. How could the experiences of these projects be structured and offered to others to support further health ICT projects? This paper describes a conceptualization of co-construction of a health service and information processing tools as a possible answer. It was created by structuring empirical findings of a case study with help of theoretical concepts. The conceptualization was further applied in two case studies as a framework to generate data for formative evaluation. The conceptualization helped in detecting the questions that the projects were failing to answer during the development. Co-construction requires multidiciplinary knowledge, and networking with experts already in the planning stage is beneficial in order to manage the complex parallel change process of services and ICT.

Keywords:

medical informatics applications, organizational innovation, technology assessment

Introduction

ICT is regarded as the key driver of economic growth in western as well as in transition economies. Due to increases in national spending on health care, the governments in welfare societies have increasingly turned to ICT in search of solutions for meeting the increasing demand without increasing the costs. Evidence supporting positive return on investments or the improved quality of the ICT enhanced health services is, however, shown to be still scarce (1, 2). Studies of eHealth projects report problems in merging technical and service orientations, interests and field-specific tools, finding the common language and tools for collaboration. A misalignment of interests, roles and communication of social and technical partners, poor management of the entity of sociotechnical change and a lack of usability and utility of the implemented technologies are also reported (3-5). The paper is based in a study that asks, how the experiences gained in these projects could be structured and offered for others to support future health ICT projects to develop systems in a more appropriate way? (6).

Methods

In an attempt to answer this question, empirical data was collected from an eHealth project. It was structured with help of three concepts that have been used in activity theoretical analyses of work as well as in the fields of ICT, CSCW and HCI studies (3, 7-10): a model of network of activity systems, the concept of developmental contradiction and a model of cycle of expansive learning (11-13). The model of network of activity systems was used for structuring the social and health care service activity in ex ante and ex post situation. The developmental contradictions were used to structure the needs and possible directions for development. The cycle of expansive learning was used to structure the process of solving the contradictions by generating and implementing a new eService concept in the eHealth project. (6).

This conceptualization was applied as a framework for structuring the results in Case Study I (for details, see 14). The data included statistics, annual reports, documents and interviews of the ex ante situation of the service, project plans and reports, meeting minutes, letters and other documents, and interviews of the stakeholders who had participated in the ICT project. Ethnographic participatory observation, interviews of the service providers and clients and documents of the ex post situation were collected. (6).

The empirical findings from Case I were reflected against theoretical concepts in an academic dissertation in order to create a preliminary, abstracted understanding of the findings. It was then applied in the second Case to study its potential in a context of formative and summative evaluation - providing information about an ongoing case and feeding the results back to the project managers for corrective action (see also 15). The data collected from the project and the service in transition was structured with helps of the conceptualization to study the project process quality. The analyses with conclusions were frequently fed back to the project for corrective action. The approach is likened to that of Constructive Technology Assessment (16). (cf.6).

In Case study III the conceptualization was applied to study, how the lessons learned in the previous cases could be used to support a project from early on. The conceptualization was used to generate questions for the project concerning the information that the project had collected

or planned to collect to extract and solve the developmental contradictions.

Results

Case study I: Elaborating the conceptualization

Case Study (14) structured the co-development of service and its tools in an eHealth project with theoretical concepts described above. The network of activity systems was used as a tool to structure data collection about the service prior to and after the intervention. The concept of contradiction and the model of expansive learning were used in structuring the change of the service. One cycle of expansive learning was not enough to depict the development of the service and ICT designed to support it. These remained as two separate foci of development with separate networks constructing them. Two parallel cycles of development - that of the service and that of the technology - were needed to depict the totality. How these two cycles interacted became the main focus of interest in Case Study I. The resulting conceptualization is presented in Figure 1.

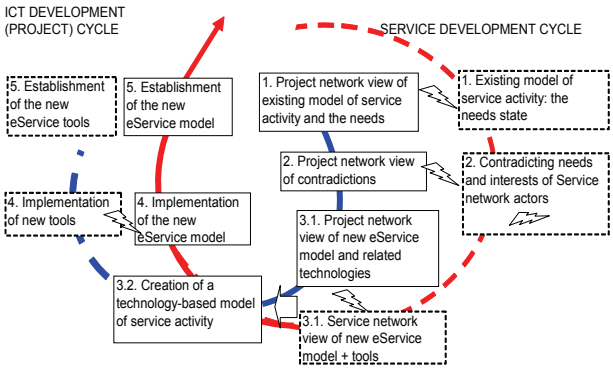

Figure 1 - Case I structured with help of the elaborated conceptual tools depicting the development cycle of the service activity (larger cycle), the development cycle of the ICT tools and the interaction of these two developments (6, 14)

The larger cycle in Figure 1 depicts the phases of service development. The smaller cycle depicts the phases of the ICT development. The cycles start with a conception of the service to be developed. This was different in the two networks. The ICT project view prevailed, leading to generation of an eHealth service concept that could not be implemented. The service concept was redesigned and implemented, but the ICT was not, leading to its abandonment after the pilot. The new eService model remained in use, supported by old technologies (telephone and fax).

Case studies II and II: The conceptualisation as a framework for formative evaluation

The conceptualization was used in consequent two case studies to assess its applicability in the context of formative project evaluation. In Case II, the ex ante and ex post service situation were delineated with help of the network model, the co-evolution of the eService and technology leading from ex ante to ex post situation with the elaborated expansive cycle model. Since the pilot was still ongoing, feedback could be provided to developers of the problems found in defining the developmental contradictions, as well as in the process of solving them. The project had, however, already developed the eService concept and its piloting was about to start when the study began. There was no time to redesign the system to solve the problems. There was a strong political will to get the piloting started quickly.

The implementation was not a great success. Of the four pilot areas, only three implemented the system, two stopped later, and the pilot use was minimal. Information of the ex post situation with unsolved developmental contradictions was collected and mediated to the project, to be used on a basis of preparing a new legislation. Some impact of the results can be seen in the consequent legislation that was issued to regulate the particular eService activity, and the related bill.

In Case Study III, the conceptualization was used to support the project which was in concept creation phase, to define the developmental contradictions and to solve them. The structured analysis of the project and the developmental contradictions, which the project was not addressing, were presented to the project actors. This led the project to go "back to basics", analysing the service activity, detecting bottlenecks and drafting of new eService processes where these would be solved. Information processes related to the service processes were delineated to produce the ICT requirements of different actors in different process phases. The project plans to spread the system to other health centres in the city as soon as the technology is redesigned according to the feedback.

Discussion and conclusions

As part of Case Study III, a workshop was arranged to collect feedback of the relevance of the conceptualization to the project participants. The initial results show that on a scale of 1-3 (1=no significance, 3=major significance), the city as well as the university regarded the support of "major significance" in 3 of 5 phases of development, and of "some significance" in the remaining two phases of development. The three most significant areas where the conceptualisation was regarded as important were: 1) structuring data collection from ex-ante and ex-post service situation 2) managing the co-development of the

service and technology 3) evaluation of the change in order to spread the system.

The results indicate that eHealth projects need better understanding of the multiple foci and objects of development. The two ongoing case studies (II and III) show some evidence of the usefulness of the conceptualisation for helping the future practitioners in the field to understand the challenges in ICT-enhanced service change, and find solutions to them. The network of activity systems proved as a useful concept to structure requirements from the ex ante service activity, and for planning the ex post service activity where the contradictions are solved. The model of expansive learnning with two parallel cycles can help manage the change and to evaluate the change process. The projects need to build a balanced network of actors who have adequate knowledge and the required skills for supporting the project in the required data collection and analysis as well as management of the entity. Further studies are needed for evaluating the impact of the conceptualization.

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Co-Construction of eHealth Services and Technology: Challenges and Solutions

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Introduction

Health care is a challenging context for ICT applications. There is no lack of studies reporting failures to merge professional, bureaucratic and technological missions, interests and focus. (1-2).

Evidence to support positive return on investments or improved quality of ICT enhanced health services is still scarce (3-4).

How could the experiences gained in various projects be structured and offered for others to support future health ICT projects to develop systems in a more appropriate way?

Methods

a) Methodology

Data from an in-depth case study on process and effects of an eHealth project were structured with theoretical concepts

The theoretical concepts were elaborated into a model of co-construction of service and technology

The model was implmented in two consequent case studies to assess its potential for formative (constructive) assessment of the eHealth projects

Evidence was collected on impacts of the model.

b) Data collected

Case study I

•Historical data (documents, interviews) on ex-ante service activity and on construction and implementation of the eService model. Empirical data (observation, interviews,documents, statistics) on the established (ex post) eService activity

Case study II

•Historical data (documents, interviews) on the early phases of the construction of the eService model. Empirical data (observation, interviews, documents, statistics) on ex-ante and ex post service activity. Empirical data (participatory observation, interviews, documents) on later phases of the eService model construction and implementation

Case study III

•Historical data (documents, interviews) on the early phases of the eService model construction. Empirical data (participatory observation, group sessions) on later process phases and implementation of the eService model

Results

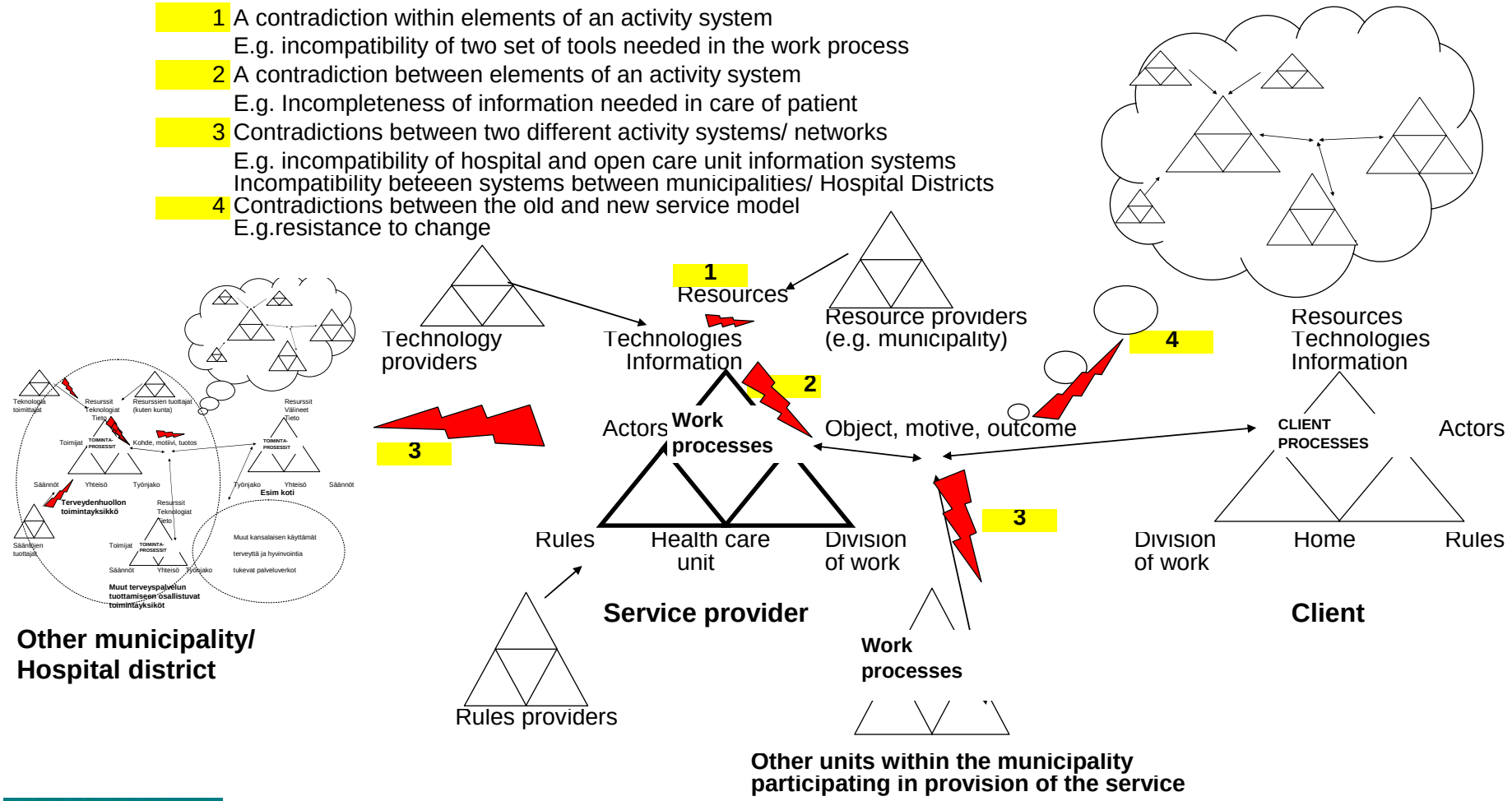
Case I: a retrospective study of construction, implementation and impacts of an innovation award-winning eService for Home Health Care (7; 1)

- Impacts of the eHealth project:
  - The new eHealth model helped to outsource part of the home health care service, did not save any money compared to the old, reduced availability and quality of the service
- The construction process:
  - No analysis of the ex ante work and information processes, their developmental contradictions to be solved or indicators of change.
  - The construction process concentrated on ICT, no simultaneous re-engineering of work processes in collaboration with service providers
- Conclusions of case study I:
  - There is a need to elaborate the existing conceptual tools. Conceptualization to structure the co-construction of eService and technology and related challenges was created:

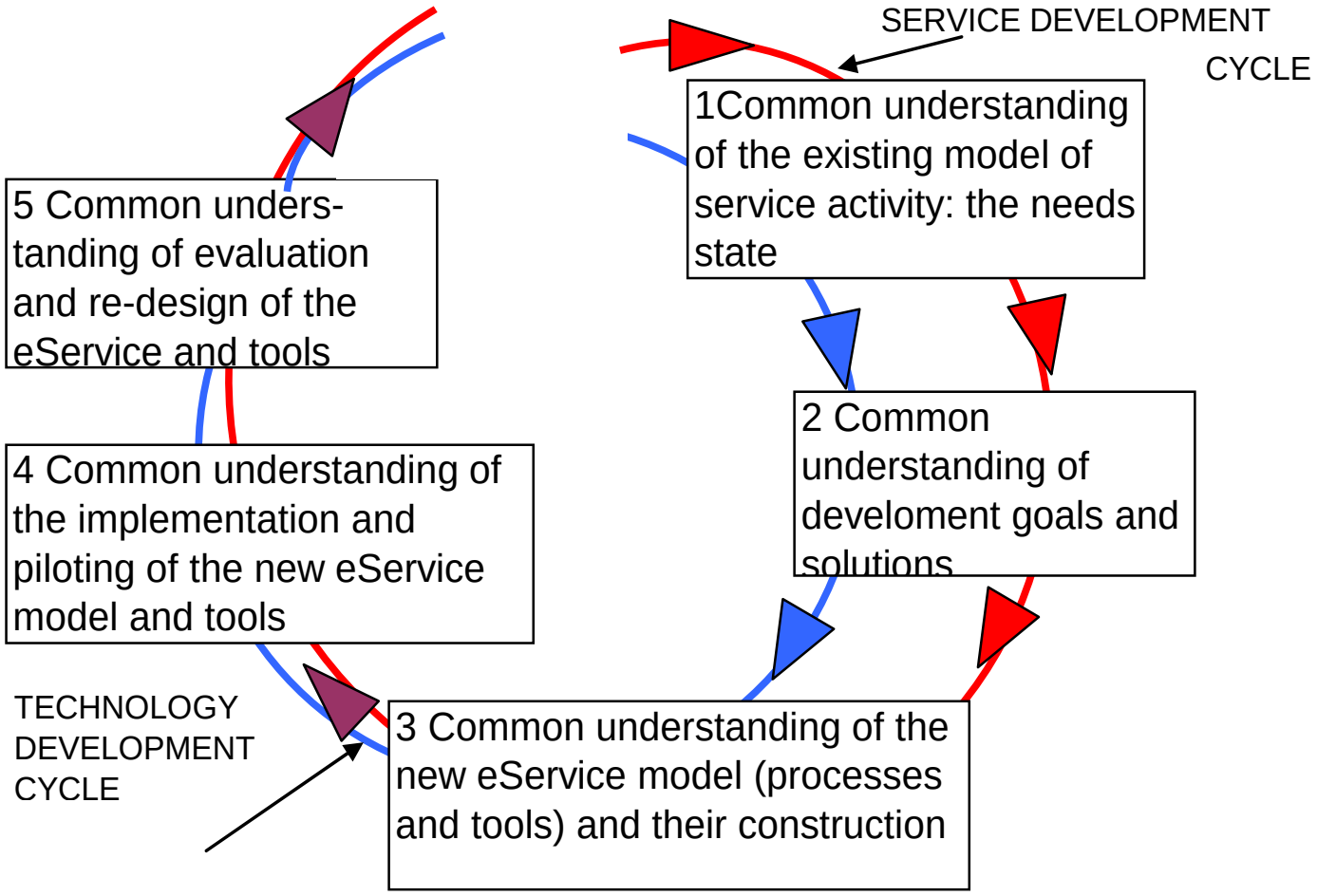
The created conceptualization to structure a service activity and its ICT-enhanced change

1) Network of activity systems and categories of problems triggering the change (7;1 cf. 5; 6)

1 A contradiction within elements of an activity system
E.g. incompatibility of two set of tools needed in the work process
2 A contradiction between elements of an activity system
E.g. Incompleteness of information needed in care of patient
3 Contradictions between two different activity systems/ networks
E.g. incompatibility of hospital and open care unit information systems
Incompatibility beteeen systems between municipalities/ Hospital Districts
4 Contradictions between the old and new service model
E.g.resistance to change



2) A cycle of expansive learning to co-construct the service and its tools (solving the developmental contradictions) (7; 1).



Case II: Implementation of the theoretical tools to structure formative and summative evaluation of the development and piloting of a national ePrescribing system (8;1)

- The construction process
  - The project was based on a comprehensive but superficial study of prescribing service and its problems in ex ante situation. No in-depth analysis of the local service network and developmental contradictions were done.
  - There was a common understanding of the overall development goals and solutions. The construction process, however, focused on ICT and regulations, the service processes were not re-engineered
- Implementation and piloting:
  - Three out of four piloting health care organizations implemented the system, two stopped due to technical, usability and utility problems; Less than 1000 ePrescriptions were written in 2 years
  - The system did not bring short term added value to the doctors, limited value to pharmasists, no short term value to the clients due to the problems
  - ePrescribing legislation was prepared on the basis of the experiences
- Conclusions of case study II:
  - Conceptualization was used to detect problems in the co-construction phases 1-3. Feedback came too late to have an impact on the project (implementation was about to start). The system functioning, utility and usability problems were classified as contradictions within and between the network activity systems. The data was used in preparation of the ePrescribing legislation.

Case III: Implementation of the theoretical tools to support construction of a citizens eHealth service

Intervention:

Two "mirrors" offered to the project:

A structured image of the development process as co-construction

A structured literature review of concrete tools to answer the problems

The construction process:

- The project was based on technology providers' idea, supported by municipal strategies
- Different studies of the ex ante work and information processes were conducted. The developmental contradictions to be solved or indicators of change were not extracted in the project planning phase
- Technology providers started to construct the ICT solutions, service providers the envisioned work processes. Little concrete collaboration between them
- "Return to the basics": service providers analysed the ex ante work and information processes, problems to be solved, indicators of change to steer the re-engineering of work processes and ICT development
- The implemented new eService model was well accepted, technologies still require re-engineering
- Diffusion of the system is planned with re-engineered technologies

Conclusions of case study III

- Problems pointed out in the co-construction phases 1-3 caused the service provider to analyse the old work and information processes, problems to be solved, to select indicators of change and to steer the re-engineering of work processes and ICT development. The technology provider did not re-engineer the technology that they had developed prior to the intervention
- The conceptual tools provided a tool for the project manager to structure the overall change and evaluation and information required in the process. The literature review offered some concrete tools for data collection.
- More detailed tools and support from different sciences (especially management, work and information sciences, economics, evaluation) would have been needed to direct informed data collection and analysis
- The project manager would also have required support for using the conceptual tools to structure the overall change and information required.

Discussion and conclusions

- The created conceptualization proved useful for classifying problems in the co-development and piloting of eHealth solutions. It also showed promise in classifying types of information that are required to answer the problems.
- eHealth projects would benefit from early adoption of a commonly agreed, adequately detailed and structured understanding of:
  - the multiple objects, interests and foci of development.
  - the context where the new tools, rules and practices will be implemented,
  - the development contradictions in the context, estimates of cost benefits of technology as a solution to them
  - the process and methods of co-construction.
- Management and execution of the co-construction requires a lot of cross-diciplinary information and methods. The projects need to build a balanced network of actors who have adequate knowledge and the required skills for supporting the project in the required data collection and analysis as well as management of the entity.
- More cross-diciplinary studies are required to elaborate the essential questions to ask and necessary information to be collected in different phases of different eHealth projects in order for the projects to succeed.

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What Kinds of Intangible are Important to Identify and Measure?

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Abstract

Information technology has the power to increase the quality of work creating accurate and update data, but gives the organization the capacity reduce cost of coordination, communications, and information processing.

In this poster we identify a number of intangible outputs that can be important to measure in medical informatics area. Three categories of outputs, namely technical, individual and organizational, are suggested to specially give attention to and to consider when discussing the intangible effects of the implementation and use of IS.

Keywords:

information systems, intangibles, healthcare

Introduction

Information technology, defined as computers as well as related digital communication technology, has the power to increase quality of work creating accurate and update data, but also to give organizations the possibility to reduce cost of coordination, communications, and information processing. (1)

The increased need and pressure for implementing information technology in all healthcare domains increased also the need to evaluate IT-applications. This is because evaluations can give decision makers knowledge about the benefits, effects and impacts of IT. Evaluation can also gives key information about which areas are specially influenced and about which kind of outputs, both tangibles and intangibles, are important to valuate and evaluate. According to Devaraj and Kohli (2002), intangible outputs play important role in organizational success. They also state that investing in IT make organizations profitable. (2) However, despite the importance of the intangibles, evaluation of them have not yet been justified or accounted. In this poster we identify categories their intangibles are important for organizational effectiveness and thus important to measure, account and justified, especially in the area of medical informatics.

Definition of intangible

Kaplan and Norton (2004) have described intangibles as "knowledge that exists in an organization to create differential advantage" or "the capability of the company's employees to satisfy customer needs". Some examples from their point of view are: workforce knowledge, leadership, high quality products and services, motivated and skilled employees, responsive and predictable internal processes, and customer satisfaction.(3) Intangibles assets according the new International Accounting Standard IAS 38 are defined as an identifiable non-monetary asset without physical substance held for use in the production or supply of goods or services, for rental to others, or for administrative purposes such as skills, information systems, and satisfied customers.(4)

Methods

A literature review of current studies on the area of evaluation of intangible outputs both at the industry and healthcare areas has been done. The review covers scientific publication like journals, books, Internet. Literature was reviewed using the terms and combinations of terms such as intangible evaluation, information system, and medical informatics from 1990 upward. Journals like Journal of American medical informatics association, the proceeding of AMIA and Medinfo conferences, Journal of Management Information system, and The Electronic Journal of Information Systems Evaluation was reviewed.

Result

Ruland et al (2003) in their study entitled "Usefulness and effects on costs and staff management of a nursing resource management information system" showed that a significant improvement in information management after four months of implementation of the new system. It was also observed that it became easier to analyze the relationship between patient activities, staffing, as well as the cost of care. The positive results were revealed regarding the ease of use and user satisfaction. (5) Vontetsianos et al (2005) indicated that with introducing the new system, the user (nurse, physician, and other staff) satisfaction has improved. (6)

Zhang et al (2004) showed that by introduction of computerized patient record, improved hospital administration (with 80% positive response) and better presentation of information (with 75% positive responses); the overall optimistic attitude were found to be evident.(7) Breslow et al (2004) showed that management or administration of

hospital/ward/department as well as information management has been improved as a result of introducing the new information system. (8) Jonathan et al (2005) showed that accuracy and readability as well as uniformity and availability of data have increased after the new system implementation. (9) Pizziferri et al (2005) as results of their evaluation indicated that, the physician believed that the input of the new system on communication, access, efficiency, workload, and quality of care indicated that the new system resulted in an improvement in many domains. (10) Robert et al (2005) affirmed that the new e-health improved efficiency and safety of delivering cares in their studies. (11)

Identifying three categories their intangibles are important for organizational effectiveness and example of intangibles

Category 1, examples of Technical intangibles	Category 2, examples of Individual intangibles	Category 3, examples of organizational intangibles
-Accuracy of data -Access and availability of data -Readability and uniformity of data	-IT proficiency for employee -Improving of decision-making -Clearer understanding of problem -Increasing of user satisfaction	-Improvement in communication (improved organizational teamwork) -Better organizational planning and control -Utilization of management time -Improved organizational learning

Discussion and conclusion

Managers or decision makers become more cautious about approving new investment, particularly investment in information system. It might be due to their less knowledge about the benefits arising by information system, especially the intangible one. They are often familiar with tangible output measurement like cost-benefit analysis that illustrates everything in numerical data, which are more defendable to executive board but it seems that considering intangible benefits is not common when decision maker going to justify.

The identification of categories of intangible outputs can make clearer the payoff mechanism and help decision makers and managers to know more about the impact of medical information system both at individuals and organization level.

It could be conclude that developing methods and models to evaluate intangible is a challenge that medical informatics will need to continue to improve and discus.

Acknowledgment

The author thanks Dr. Vivian Vimarlund for her great supporting for preparing and presenting this poster.

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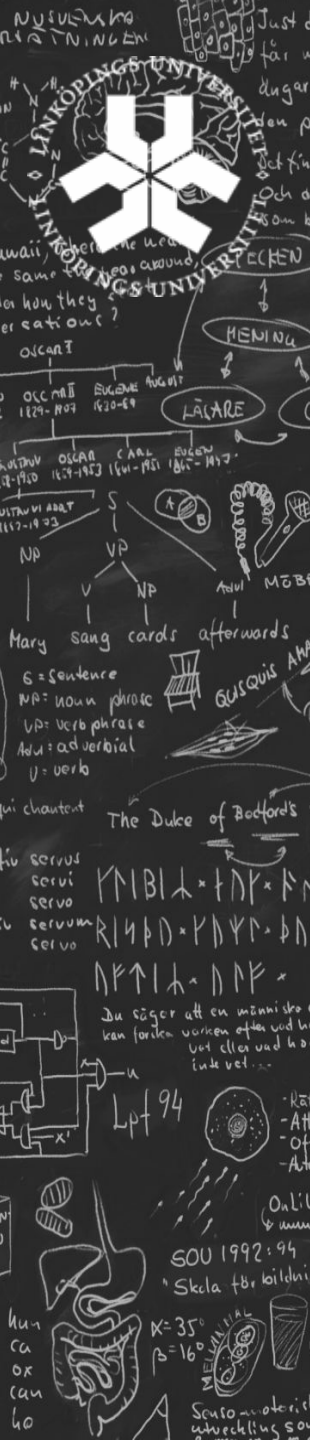

What kinds of intangible are important to identify and measure?

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Dept. of Computer and Information Science (IDA)
Linköpings universitet, Sweden

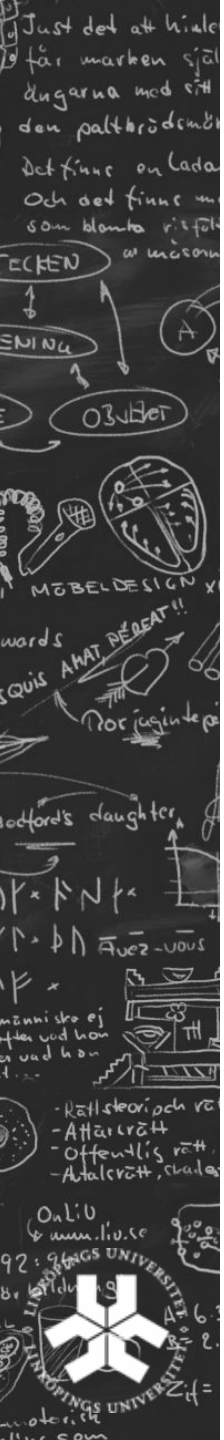
LiU expanding reality

Introduction

- Increased need and pressure for implementing information technology in all healthcare domains
- Increased need to evaluate IT-applications.
- Knowledge about the benefits, effects and impacts of IT
- Information about which areas are specially influenced and about which kind of outputs
- Both tangibles and intangibles, are important to valuate and evaluate.

Introduction (count..)

- Both tangibles and intangibles, are important to valuate and evaluate
- Intangible outputs play important role in organizational success
- Investing in IT make organizations profitable
- Despite the importance of the intangibles, evaluation of them have not yet been justified or accounted



Aim:

In this poster we identify categories their intangibles are important for organizational effectiveness and thus important to measure, account and justified, especially in the area of medical informatics.

Intangible:

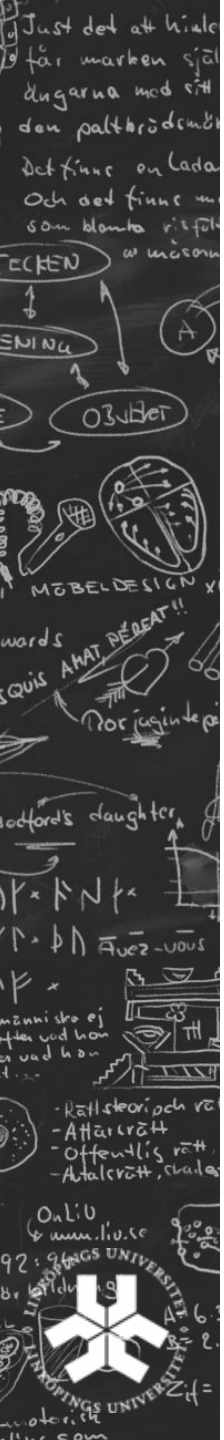
- Kaplan and Norton (2004) have described intangibles as “knowledge that exists in an organization to create differential advantage” or “the capability of the company’s employees to satisfy customer needs”.
  - ✓ Some examples from their point of view are: workforce knowledge, leadership, high quality products and services, motivated and skilled employees, responsive and predictable internal processes, and customer satisfaction.
- Intangibles assets according the new International Accounting Standard IAS 38 are defined as an identifiable non-monetary asset without physical substance held for use in the production or supply of goods or services, for rental to others, or for administrative purposes such as skills, information systems, and satisfied customers.

Methods:

- literature review of current studies on the area of evaluation of intangible outputs both at the industry and healthcare areas
- The review covers scientific publication like journals, books, Internet.
- Literature was reviewed using the terms and combinations of terms such as intangible evaluation, information system, and medical informatics from 1990 upward.
- Journals like Journal of American medical informatics association, the proceeding of AMIA and Medinfo conferences, Journal of Management Information system, and The Electronic Journal of Information Systems Evaluation was reviewed.

Result:

- **Identifying three categories their intangibles are important for organizational effectiveness and example of intangibles**
  - **Technical intangibles**
  - **Individual intangibles**
  - **Organizational intangibles**



Examples of “Technical Intangibles”

- **Accuracy of data**
- **Accessibility of data**
- **Availability of data**
- **Readability of data**
- **Uniformity of data**

Examples of Individual Intangibles

- ✓ **IT proficiency for employee**
- ✓ **Improving of decision-making**
- ✓ **Clearer understanding of problem**
- ✓ **Increasing of user satisfaction**

Examples of Organizational Intangibles

- ✓ **Improvement in communication**
- ✓ **Improved organizational teamwork**
- ✓ **Better organizational planning and control**
- ✓ **Utilization of management time**
- ✓ **Improved organizational learning**

Discussion & Conclusion

- The identification of categories of intangible outputs can make clearer the payoff mechanism and help decision makers and managers to know more about the impact of medical information system both at individuals and organization level.

- To develop methods and models to evaluate intangible is a challenge that medical informatics will need to continue to improve and discus.

Acknowledgment:

The author thanks Dr. Vivian Vimarlund for her great supporting for preparing and presenting this poster.

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Heuristic Evaluation of a Web-based Prototype for a Personal Digital Assistant-Decision Support System for the Management of Obesity

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Abstract

This study used heuristic evaluation to identify usability issues of a Web-based prototype for a personal digital assistant -based decision support system (PDA-DSS) for the management of obesity. Three usability experts evaluated the prototype using heuristics, scenarios, and an evaluation survey form. In a usability laboratory, evaluators were asked to think aloud and their verbalizations were audio and video recorded. The overall severity scores of each heuristic were between 0 (No usability problem) and 2 (Minor usability problem). Generally, the experts agreed that the navigation, terminologies, options, and abbreviations were clear and consistent.

Keywords:

decision support systems, clinical, heuristic evaluation, computers, handheld

Introduction

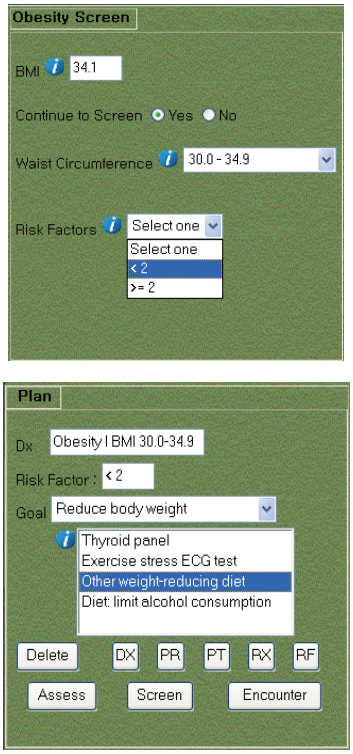
Handheld devices raise special interface design issues that do not occur with desktop applications, and this results in a formidable challenge for design and evaluation. In a systemic review of usability issues that involved the design and implementation of PDA-DSSs, user interface issues were classified as display, security, memory, Web browser, and communication issues [1]. Despite these obvious challenges, few studies have examined the special challenges of employing health care information systems on handheld devices, especially in health care settings. Therefore, studies are needed not only to assess user interface issues in the design and implementation of PDA-based information systems in a health care setting, but also to evaluate them through usability engineering methods. The purpose of this study was to identify usability problems in the Web-based prototype user interface for the PDA-DSS for the management of obesity through heuristic evaluation.

MODS-APN

The development and evaluation of a prototype PDA-DSS based on a clinical practice guideline (CPG) for the management of obesity is part of the Mobile Decision Support for Advanced Practice Nursing (MODS-APN) project. The goal of MODS-APN is to improve APN students' adherence to CPGs in three areas – obesity management, tobacco cessation, and depression screening. The DSS for the management of obesity is based on decision-rules and documentation templates, which remind APN students to document specific data for screening obesity and guide them to perform CPG recommendations. The system provides APN students with the appropriate obesity diagnosis based on the results of screening and a tailored plan of care based upon the patient's goal and the results of screening.

The development and evaluation of a Web-based user interface (Figure 1) of the PDA-DSS for the management of obesity was intended to get usability experts' quick feedback on the user interface (e.g., navigation, button labels, and drop down lists) before the full implementation on the PDA.

Figure 1 - Screen shots of the web-based prototype



Heuristic evaluation

Heuristic evaluation is a usability engineering method for finding usability problems in a user interface design and for structuring the critique of a system using a set of relatively simple and general heuristics [2]. Skillful experts can capture many system usability problems using heuristic evaluation, and this technique is effective, easy to learn, and relatively inexpensive [3].

Materials and methods

First, three experts who have experience related to the development of PDA-DSSs, heuristic evaluation, interface design or cognitive science and a doctorate in informatics or a related field were invited to participate via email. They were then given a general introduction to the heuristic evaluation protocol with five scenarios and a form for evaluating the application. The scenarios reflected all functions of the application and included the tasks to be tested. The evaluation survey form included seven principles of usability (Table 1) of relevance to the Web-based prototype user interface for the PDA-DSS for the management of obesity. These were derived from Nielsen's 10 heuristics and include sub-questions, yes or no questions to each sub-question addressing the adherence to heuristic principles, open-ended comments, and a severity rating (0-4) to rate the severity of usability problems for each heuristic.

The experts tested the Web-based prototype user interface independently with the scenarios for approximately 30-90 minutes in a usability laboratory. They were asked to verbalize what they were thinking, seeing, and trying to do while they were evaluating the application. During the evaluation, the experts were asked to identify the problems in the interface (e.g., navigation and labels of buttons or drop down lists), to rate the problems' severity using a severity rating scale, and to write additional comments on the heuristic evaluation survey form. The evaluation sessions were audio and video recorded.

The frequencies of adherence to usability principles were calculated according to the sub-questions of the seven usability principles. Total severity scores and mean severity scores were calculated for each heuristic principle. Evaluators' comments about usability problems were grouped and content-analyzed according to the usability principles.

Results

Experts responded that the usability principle was not violated in 14 of 19 sub-questions related to the seven usability principles. The overall severity scores of each heuristic ranged from 0 (No usability problem) for 2 of 7 heuristics to 2 (Minor usability problem) for 5 of 7 heuristics. Generally, the experts agreed that the navigation, terminologies, options, and abbreviations were clear and consistent, and that the system was easy to use.

Table 1 - Usability problems and mean severity scores

1. Match Between System and the Real World Location of button, Ambiguous instruction, Detailed information	0
2. User Control and Freedom Not to cancel, Radio button	.67
3. Consistency and Standards Less specified label/ instruction, Inconsistency in decimal points	.67
4. Help Users Recognize, Diagnose, and Recover from Errors Implicit warning message	.67
5. Recognition Rather Than Recall Long text in information, Necessary information display, Long lists in a pop-up list, More information	0
6. Aesthetic and Minimalist Design Too much text	.67
7. Error Prevention (mean severity score=.67) Small font, Unpreventable user's mistake in entering, Double negative statement	.67

Table 1 lists the sub-categories of the problems identified in the experts' narrative comments and the mean severity scores. The first and second experts mentioned seven problems each, and the third expert identified 11 problems. Most problems were related to detailed or less specific instructions or the information linked by Infobuttons, which provided users with information related to the screening of and planning for the treatment of obesity. Due to a lack of screen space, the information or instructions needed to be concise, and the display order of information was important. To resolve this issue, experts recommended specifying the labels and button names on some screens, as well as the titles of pop-up messages. User training was also an essential recommendation for improving usability problems.

Another problem that was identified for 'User Control and Freedom' was the irreversibility of the user interface once users decided whether or not to perform obesity screening. Not allowing users to reverse their responses can result in frustration, especially considering a PDA's interface constraints. The usability issues that were identified by the experts and potential design solutions were discussed with the project team members during the next step, the implementation of a PDA-DSS.

Conclusion

Heuristic evaluation using the scenarios was a useful method to find usability problems in the early phase prototyping a PDA-DSS. The findings of this study provided iterative feedback regarding the design and implementation of the PDA-DSS for the management of obesity. This approach had an important impact on making the system easier to use and more useful from the perspective of design and content in the proceeding iterations.

Acknowledgments

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[b] *Department of Biomedical Informatics, Columbia University, New York, NY*
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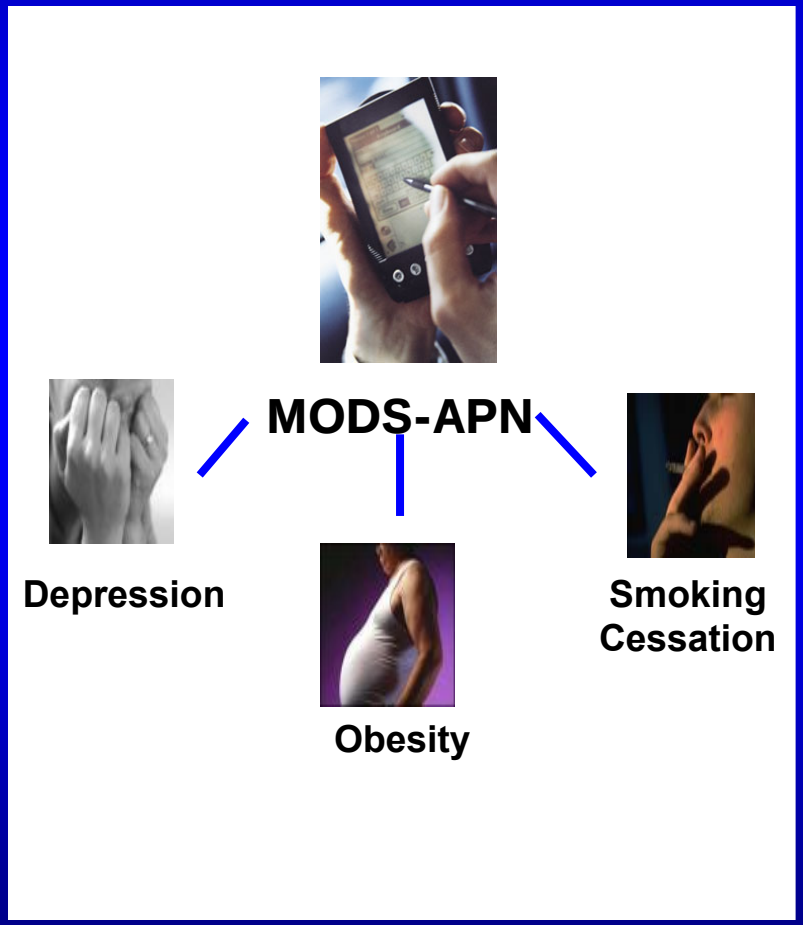
Introduction

- Handheld devices raise special interface design issues that do not occur with desktop applications
- This results in formidable challenges for design and evaluation
- Few studies have examined the special challenges of employing health care information systems on handheld devices in health care settings

Purpose of Study

The purpose of the study was to identify usability problems in the Web-based prototype user interface for the PDA-DSS for the management of obesity through heuristic evaluation

Mobile Decision Support for Advanced Practice Nursing (MODS-APN)



- Template-based approach to decision support for three guidelines on personal digital assistant (PDA)
- Randomized controlled trial is underway to compare APN students' adherence to guideline screening and treatment recommendations

Web-based Prototype of the PDA-DSS for the Management of Obesity

- The PDA-DSS for the management of obesity provides APN students with appropriate obesity diagnoses based on the results of screening and tailored plans.
- The Web-based prototype of the PDA-DSS was intended to get usability experts' quick feedback on the user interface

Materials and Methods

- Three experts in heuristic evaluation, interface design or cognitive science
- Usability laboratory at Columbia University School of Nursing
- Evaluation forms including 5 scenarios, 7 usability principles, sub-questions, a severity rating to rate the severity of usability problems, and open-ended comments
- Think aloud technique
- Audio and video recording
- Content analysis

Results: Overall Severity Score by Each Usability Factor

Usability Factors	Severity Score by Each Evaluator			Total Score	Mean Severity Score
	Expert 1	Expert 2	Expert 3		
Match Between System and the Real World	0	0	0	0	0
User Control and Freedom	0	0	2	2	0.67
Consistency and Standards	1	1	0	2	0.67
Help Users Recognize, Diagnose, and Recover From Errors	0	0	2	2	0.67
Recognition Rather Than Recall	0	0	0	0	0
Aesthetic and Minimalist Design	0	0	2	2	0.67
Error Prevention	0	0	2	2	0.67

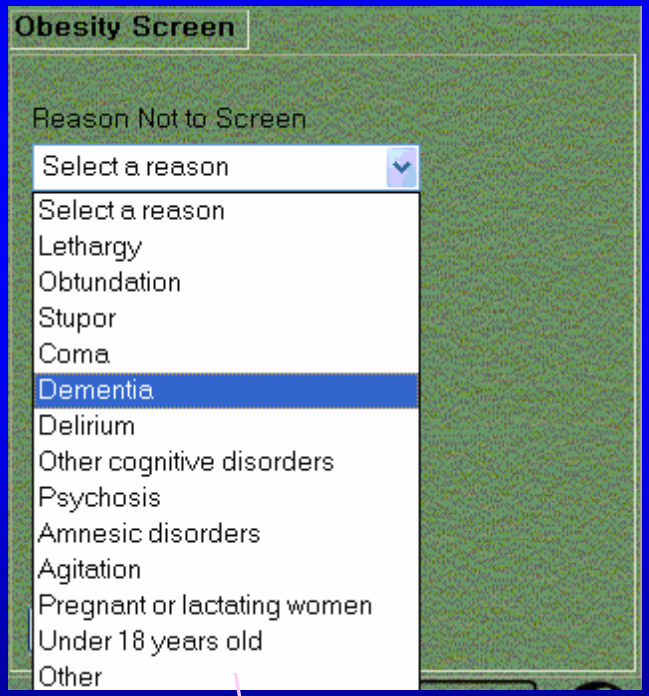
0=No usability problem, 1=Cosmetic Problem Only, 2= Minor Usability Problem, 3= Major Usability problem, 4= Usability Catastrophe

Results: Examples of Usability Problems

Radio button for navigation

Location of button

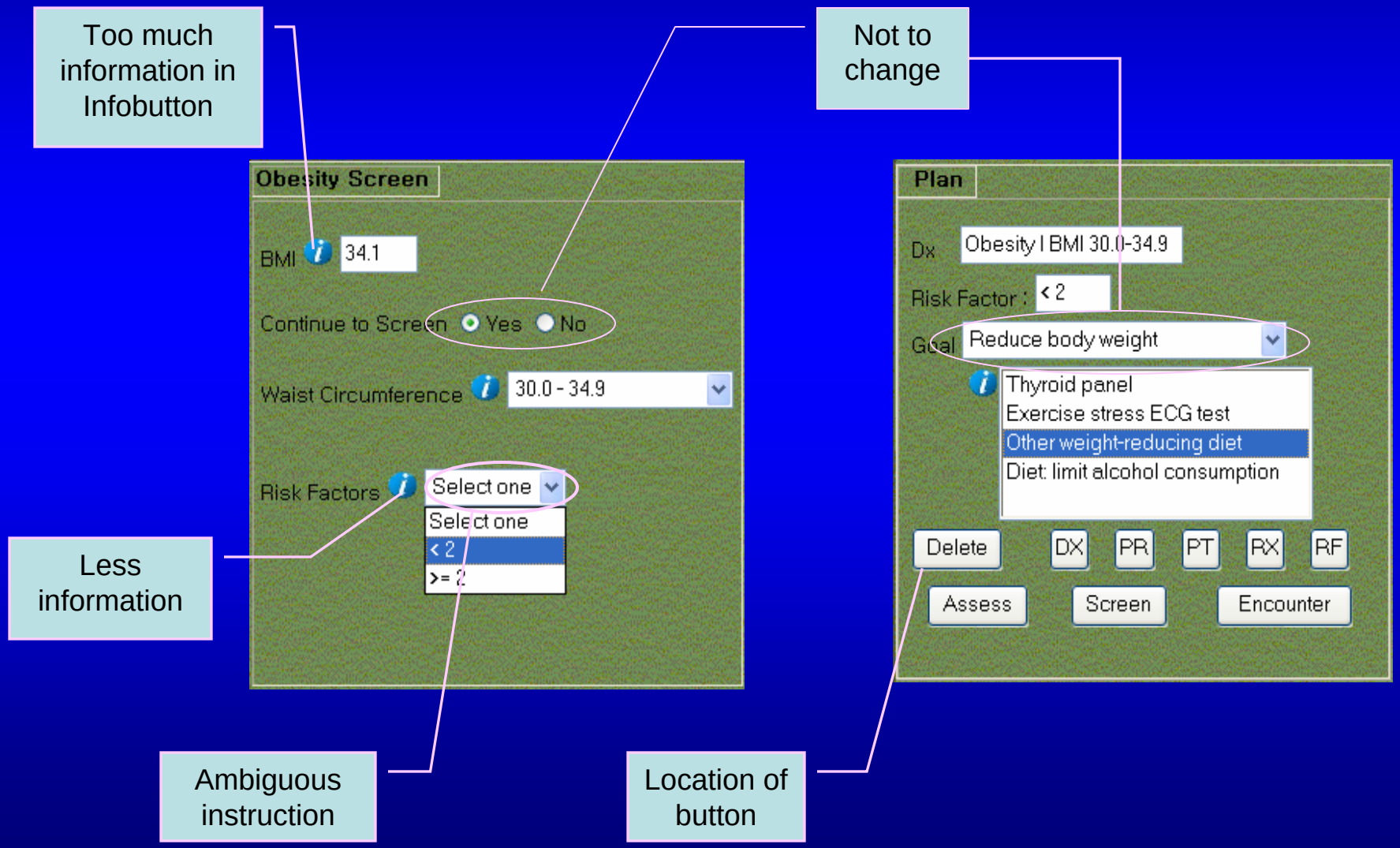
Less specified label



Small font

Long list

Results: Examples of Usability Problems (con't)



Results: Summary of Usability Problems

Usability Factors	Usability Problems
1. Match Between System and the Real World	▪ Location of button, ▪ Ambiguous instruction, ▪ Detailed information
2. User Control and Freedom	▪ Not to cancel, ▪ Radio button
3. Consistency and Standards	▪ Less specified label/ instruction, ▪ Inconsistency in decimal points
4. Help Users Recognize, Diagnose, and Recover from Errors	▪ Implicit warning message
5. Recognition Rather Than Recall	▪ Long text in information, ▪ Necessary information display, ▪ Long lists in a pop-up list, ▪ More information
6. Aesthetic and Minimalist Design	▪ Too much text
7. Error Prevention	▪ Small font, ▪ Unpreventable user's mistake in entering, ▪ Double negative statement

Conclusion

- Heuristic evaluation using the scenarios was a useful method to find usability problems in the early phase prototyping a PDA-DSS.
- The findings provided iterative feedback regarding the design and implementation of the PDA-DSS.

References

[1] Lee NJ, Starren J, Bakken S. A systematic review of user interface issues related to PDA-based decision support systems in health care. AMIA Annu Symp Proc. 2005:1021.

[2] Nielsen J. Heuristic Evaluation. 1994 [cited 2006 October]; Available from: http://www.useit.com/papers/heuristic/

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Infobuttons: A Study of Usability

Lily Gutnik[a], Sarah Collins[b], Leanne M. Currie[a,b], James J. Cimino[a], and Vimla L. Patel[a]

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[b]*School of Nursing, Columbia University, USA*

Abstract and objective

Studies of clinician's information needs while treating patients have shown that the resolution of these needs is often deferred or fails, which may lead to medical errors. The Infobutton Manager was developed to help improve the resolution of information needs by providing users with links to on-line health information resources. The aim of this study was to determine the usability of the Infobutton interface to resolve clinicians' information needs. We provided clinicians with typical case scenarios using a computerized order entry system (CPOE) and Infobuttons and asked them to verbalize their thought processes as they were using the CPOE. We video-recorded the computer screens as the users worked, conducted brief exit interviews, and analyzed these data. Results indicated that the participants found the resources provided by Infobutton helpful and easy to use.

Keywords:

usability testing, clinical information needs, information retrieval decision support

Introduction

Though technology for clinical care is created to facilitate the clinician's workload and enhance patient care, tools that are inadequately designed can actually have adverse effects [1]. Inadequate design can result from a disconnect between the design process and the needs of the end-users [2]. Infobutton is a tool designed to provide clinicians with access to on-line health information resources to quickly resolve their information needs [3]. This study explored the usability of a new user Infobutton interface which was designed to be easier to read, more concise, and have more consistent navigation.

Methods

We conducted the present laboratory study to seek in-depth feedback from clinicians about the design and usability of Infobuttons within a CPOE system. Each participant was given three typical scenarios to be interpreted using the CPOE system and Infobutton. The computer screen was video recorded using Morae™ software. Participants were asked to "think aloud," that is to verbalize their thoughts. At the end of the session, the researcher conducted a brief exit interview. A previously established coding framework was applied to the data to characterize information needs.

Results

Two nurses, one physician, and one physician's assistant took part in the study, yielding a total of 79 information needs. Twenty-three of these needs (29%) were related to drug information, 28 (35%) concerned institutional procedures or policies, and the remainder were related to patient care and the treatment plan. Forty-eight information needs (60%) were successfully resolved using Infobuttons, 15 were deferred, and 14 needs failed to be resolved. Fifty-one needs (65%) were from an external source (e.g., Micromedex) and 26 (33%) were from an internal source (e.g., the local intranet). Exit interviews revealed an overall satisfaction with the resources provided by and the usability of Infobuttons. Excess information making navigation difficult was one of the problems identified.

Conclusion

Although clinicians show a high occurrence of information needs as they treat their patients, many of these needs can be met with Infobuttons All participants agreed that the information resources provided by Infobutton were valuable and easy to understand. This study imparted us with insight on the questions clinicians need to have answered for effective decision-making, and accentuated the need to be mindful of information overload.

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Disclosure of Health Care Infrastructure

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Abstract

The paper develops a language for addressing transformations of communication and workflow in health care from implementing IT. Introducing categories for identifying distorted communication; different levels of IT-interactions are discerned into a framework for identifying IT initiated problems in health care. The categories evolved from synthesizing three studies of IT-implementation in healthcare arrangements, i.e. on IT-implementation for supporting communication across different health care institutions, across wards in a University Hospital and for internal communication at a medical ward and major empirical usability studies in health care. The studies are based on qualitative interviews and observation. The analysis of the studies is inspired from theoretical work on IT-infrastructure. The conceptual framework of identifying distorted communication and collaboration mediated by IT is discussed and additional strengthened in a metaanalysize with recent research on unintended adverse consequences from implementing CPOE, computer order entry systems in health care practices.

Keywords:

HCI, socio-technical, infrastructure, communication, IT

Introduction

Along the line of many other western countries the Danish society is facing new challenges in organizing Health Care. An aging population, rising demands and possibilities of treatment and care, lack of clinical staff among other issues are pressing new national politics onto health care practices, management and organization. Information technology is given a central role as change agent of health care infrastructure towards visions of more quality, safety and continuity in and across healthcare settings [1, 2]. This paper questions the nature of infrastructure as some'thing' that can be deliberately planned for by authorities and vendors. IT-systems in health care have often enough failed to fulfill the desired hopes designed for, leaving the health care organizations with systems that nobody use and at great financial expenses. Building project organizations within the health care institutions to support an ongoing process of implementation and customization of systems to living clinical practices have become an answer to the unpredictable nature of IT-systems on health care infrastructure. The project organization not only have to train the vast amount of users in clinical settings in the functionalities of the specific system, but also to offer continuous support on both system demands and user demands, both running or working 24 hours a day, seven days a week, 365 days a year. The 'working relation' [3] of users and system depends highly on the degree of stability, of usability and of utility of the concrete artifact in the specific care domain and practice. This less predictable evolvement of infrastructure from IT-implementation, also termed risk management [4] put emphasis on screening, evaluation and learning from unintended consequences of implementing IT system into health care. The project organization is thereby also facing additional implementation challenges of becoming aware of new kinds of possible 'errors' arising from putting IT-system into clinical use. The categories and framework presented in the following, hope to facilitate the identification, articulation and negotiation of undesirable changes of health care infrastructures.

Materials and methods

Implementation of ICT in health care have shown to have unintended consequences for the organization of health care work [5]. Some of the communicational inadequacies can not be reduced to neither technical nor usability problems but rather utility inconsistencies in the social and technical relations of system and user. Therefore such socio-technical problems following IT-implementation are characterized in framing the relation between the main actors in the health care system differently. These differences make infrastructural questions visible and prepare the ground for negotiation and redesign.

Three qualitative studies of IT-implementation in Health Care have been conducted. The studies are of IT-implementations 1. across different health care institutions, 2. across wards in a University Hospital and 3. for internal communication at a medical ward.

The first study is about implementation of electronic exchange of information between the municipality and the hospital [6, 7]. The aim was to gain a more correct exchange of information and also a faster and more holis-

tic treatment of the citizen involved by switching from communicating through telephone and letters to electronic information exchange. A well known standard, EDI messages by ways of Vans technology, was chosen for exchange of information, but a more complicated and demanding infrastructure evolved. Some of the problems were due to complicated interaction style by an old patient administrative system (PAS) at the hospital and to computer inexperience among the staff. It was a highly time demanding task so send and receive messages and doubtfulness arose concerning the rules for exchange of information and to some extend questioned the rationale of using the system. The agreements that should solve the problems got rather complicated in order to cover all situations. This implied that the staff had to double communicate, i.e. more work instead of less work, to secure the communication. Adding to this, and coming from societal context, there were the whole issue of patient consent, which questioned the legality of the basic intensions and goals behind the project.

The second study is about new tasks of the project organization in a university hospital implementing electronic order-entry-system, CPOE. The aims of the system are among other to improve patient safety and continuity of patient treatment and care. In relation to a new health law clinicians have been reporting on unintended consequences in clinical work. Within a 6-month period 97 unintended consequences from using the CPOE-system in the University Hospital have been reported to the County, the Hospitals owners. These are in an Audit Report from the County [8] categorized as 45 unintended consequences of technical nature, due to an instable system and inadequate user interface and 52 unintended consequences of organizational nature, expressed as a lack of correspondence between electronically documentation of medication and other registration of data. The responsible implementer of the project organization experienced though that the so called 'technical errors' and 'organizational errors' were mutual dependent. They even feed each other in practice and affected the infrastructure of health care as well.

The third study [9, 10] points to central situation of enacting medication with CPOE at two internal medical wards at a middle-sized Danish hospital. The program of action for medication consists of minimum seven core acts or 'subprograms of action': 1) the indication of treatment, initiated by the patient's problem/diagnose, 2) the 'prescription' (recommendation of treatment and patient's consent of choice), 3)'requisition', i.e. 'registration', i.e. order in CPOE-system, 4) 'dosage', i.e. making drug ready for consumption, 5) 'administration' (patient is given the drug), 6) 'assessment' of drug effect on the patient, and 7) 'considerations on how to proceed', i.e. whether to continue or withdraw the drug. This process takes place within a different temporal rhythm, and located at different places, for example at the patient's bedside, in the hallway, in different offices and the drug storage. Global access from other wards or institutions is possible. The CPOE interacted with four of the seven subprograms in the medication process, 2) the prescription, 3) the requisition (order entry), 4) dosage and 7) withdrawal or continuity of treatment. The study identifies transformation of ordination with the CPOE, of the registration of clinical collaboration and possibly transformation of patient trajectories with CPOE. Core relations between patients and clinicians are touched upon by these transformations of the local medication practice.

The above mentioned studies were analyzed according to the usability of the system when 'entering and receiving messages' [5:106], i.e. in the direct interaction between user and system. And in relation to the 'communication and coordination Process' [5:107], i.e. the mediated collaboration with the system between users at different locations. Finally infrastructural changes are cybernectically understood as 'trans-contextual syndromes' or 'double bind' [11] in the case of paradoxes between the organizational purpose of the system and the utility in use [3]. Systemic experiences of double binds point to 'socio-technical problems' that open up for 'politics of design' [12] and a 'Parliament of Things' [13] in the responsible organization.

Results

The findings of the studies can be summed up at different analytical levels of interacting with the IT. At one level there were interruptions in the direct interaction between user and system, entering or receiving data. At another level or shift in the meaning of interaction there were discontinuity in the mediated interaction and collaboration of the users with the system. Transformations of infrastructures were disclosed as socio-technical problems (double binds or paradoxes) as the organizational structure enacted with the IT dis-cohered with the intentions of implementing the system. The findings of the studies can be summed up accordingly.

IT communication across institutions: municipality and hospital

The first study showed the complexity of the problems related to achieve the aims of implementation of a new infrastructure with the EDI standard. Doubtfulness and double communication was some of the unintended consequences and the findings of the study can be summed up as follows:

1. Level of interaction with the EDI standard: the communication between municipality and hospital where interrupted as their existing PAS was difficult and time consuming to use

2. Level of IT-mediated interaction among users: the users needed to establish new procedures for sending and receiving messages to each other, dividing them into urgent/complicated messages and un-urgent messages where only the latter could be sent electronically, and additionally to set rules for who was responsible for reading and acting upon the electronic information.
3. Infrastructural level: In contrast to the expected vision of optimizing communication the information exchange expanded, double communication including IT and telephone were necessary to secure quality of collaboration. The exchange of electronic patient data also collided with the law on data security, where by a whole new infrastructural problem arose at national level.

IT communication across wards in university hospital

The second study showed that IT-implementation gives new communication problems in the health care organization, and thus that intentions of more patient safety and less continuity problems are not automatically a result of a CPOE system, but a new challenge to health care and project organizations that cannot be reduced to neither technical nor organizational errors. The two studies can be summed up as problems at the following levels of interacting with IT.

'Technical error' of patient safety

1. Level of interaction: the technical error in the CPOE-system of showing wrong patient identification numbers, CPR interrupted the patient safety through out the organization, leaving the responsible management with the communication problem: *But how do you communicate to 3000 end-users?*
2. Level of mediated interaction: warning the end-users by a telephone-chain informing all wards failed, as sudden emergency patients toke the attention of the clinicians at the medical ward. The clinical collaboration with the CPOE became more risky for patients as well as for users as the last ward in the telephone chain never received the warning.
3. Infrastructural level points to the possible arousal of new medication errors and to socio-technical problems in taking responsibility for individual patients' safety as a clinical user, and as responsible manager of the reliability of the system to all patients and users.

'Organizational error' of patient continuity across wards

1. Level of interacting: the ward of intensive care lack information in the CPOE on patient transferred from the ward of surgery.
2. Level of IT-mediated interaction between the wards: as the surgeons do not need the CPOE for their work discontinuity appeared in the collaboration between the wards with the replacement of paper with the CPOE.
3. At the infrastructural level the problem of re-creating patient continuity between the wards with CPOE became a new socio-technical problem, also pushing the question: *Who is responsible for things to flow?*

Communication on medication across clinicians using a CPOE System at two medical wards

The study points to that more 'global access' to patients' medication data with CPOE-system might locally give more difficult access. New, physical and social distance of prescribing and coordinating medication work with the CPOE arose, alongside with new tasks of and divisions of work.

Transformation of ordination with CPOE

1. Level of interaction: the physical distance between the patient's bed, the CPOE and other artifacts interrupts the physician's prescription and requisition of drugs in the CPOE on doctors rounds
2. Level of IT-mediated interaction: the physician would reduce the walking by memorize tree and four patients at a time and order their prescriptions in the CPOE after dictating to the patient record in the hallway.
3. Level of infrastructure: socio-technical double binds arose as the doctor-patient relation transformed into collective e-patient, when entering 'mass-orders' several patients at a time. Cognitive pressure is put on the individual doctor in order not to mix up the patients, the patients' prescriptions and orders up with each other. Mistakes are likely to be difficult to trace in the CPOE as they happen before the orders are prescribed.

Transformation of user rights and clinical teamwork

1. Level of interaction: the users are interrupted in their workflow by an inflexible system for entering and retrieving information.
2. Level of IT-mediated interaction: discontinuity between the rationality of medication work inscribed in the software, the numbers and location of PC made the clinicians work-around their personal user-rights in order to coordinate teamwork and continue workflow.
3. Level of infrastructure: tensions are created with the CPOE between the formal right and duties of nurses and physicians, inscribed in their different user-rights with their actual collaboration. As an outcome a collective e-clinician came into being for team working under seemingly, strictly individualized user-rights.

Possible transformation of patient trajectories with CPOE

1. Level of interaction: discharging patients with CPOE interrupt the clinicians practice, as withdrawn

medication unlike the limited time-span and contextual use of the prior paper medication scheme - has to be actively withdrawn in the electronic system.

2. Level of IT-mediated interaction with future users: a discontinuity in patient's medical treatment might happen when the patient reenters the health care system, unless the users envision future users and also withdrawn orders in the system
3. Level of infrastructure: transformation of patient continuity across different health care sites with the risk of wrong medication.

The analytical findings of the three studies of disclosure of infrastructures by IT-implementation can be summed up as *situations and moments of interruption, discontinuity and sociotechnical tensions in the users' communication with the system.* These spatial and temporal points of departure for infrastructural changes can be framed in the following matrix:

Table 1 - Infrastructural relations in HCI

Categories of HCI relations	Interruption	Discontinuity	Socio-technical tensions
Direct interaction			
IT-mediated interaction			
Infrastructures			

The framework can afford the identification and articulation of IT-implementation problems in relation to usability and utility of the system - as experienced by the individual user interacting directly with the system entering or retrieving data, from experiencing the social collaboration in mediating clinical task with IT, and how these work relations are cultivated by the IT-system and identities are folded and molded into the organizational infrastructure:

Examples of (easier recognizable) computer experiences from our studies can highlight the blanks of the matrix in following way:

Table 2 - Problems in healthcare infrastructures

Categories of HCI relations	Interruption	Discontinuity	Socio-technical problems
Level 1 Direct interaction of user and interface	"Receiving and entering data" <=> User-rights, accessibility, training	Performance loss <=> 'deskilling'	'cognitive overload' <=> Stress
Level 2 IT-mediated interaction/ collaboration	Stability of system, software design, GUI <=> 'Entfremdung'	Coordination problems <=> Work-around, Arbitrary or double communication	Conflicts, indifference, delegation of work 'Unsafe', risky

Discussion

The presented studies of infrastructural chances in and cross different health care institutions underline that the intended effects and visions of implementing IT into their infrastructures are not easily realized. Instead the complexity of implementing IT into existing health care practices draw attention to the established relations of coordinating and mediating work, including other techniques, and the material surroundings of always enacting health care locally.

The categories of HCI relations and framework developed in this paper to identify interruptions, discontinuities and socio-technical problems in the health care infrastructure from implementing IT are not valid by the frequency and similarity of the problems identified. This paper does not build on large, quantitative data collections, across many hospital and many informants. In stead in depth analysis of local experiences and settings have prevailed. The results and research purpose of the studies are therefore not to generalize infrastructural changes from IT-implementations, but to develop a language for informaticians and project organizations to address future infrastructural changes as situations and moments that are sensitive to adjustments and renegotiation of the IT-system (artifact) and the work practices in question. In order to falsify, and possibly strength the synthesis of the studies, the categories of human-computer relations (table 1) can be tested by other studies.

Cambell, Sittig, Ash, Guappone and Dykstra [14] identify nine types of unintended consequences related to CPOE. The types are the outcome of a major qualitative study over 9 month, 390 hours of observation, 43 hours of interview, transcripts and field notes of approximate 1900 pages at five US-hospitals using either homegrown and vender built COPE-systems. The nine major categories are in order of decreasing frequency: 1) more/new work for clinicians; 2) unfavorable workflow issues; 3) never ending system demands; 4) problems related to paper persistence; 5) untoward changes in communication patterns and practices; 6) negative emotions; 7) generation of new kinds of errors; 8) unexpected changes of power structure; and 9) overdependence on the technology. A metaanalysis of the nine types of unintended consequences with the categories of HCI relations reflects the following

relations between the types and the human-computer interactions:

Table 3 - Types of UC from Health care infrastructures with CPOE, ranged by frequency

Categories of HCI - relations	Interruption in usability	Discontinuity in utility	Socio-technical tensions/problems
Direct interaction of user and interface	'Negative emotions' (6)	'Problems related to paper persistence' (4)	'More/new work for clinicians' (1)
IT-mediated interaction/ collaboration	'Never ending system demands' (3)	'Unfavourable workflow issues' (2)	Untoward changes in communication patterns and practices (5)
Infrastructures	'Overdependency of the technology' (9)	'Generation of new kinds of errors' (7)	'Unexpected changes in power structure' (8)

The outcome of this metaanalysis of the types and of the test of the categories on the more generalizable studies of CPOE is twofold. The categories of HCI relations can be said to *anchorage* the nine types of UC from a more generalized, decontextualized knowledge on IT-implementation to the framework's more concrete, spatial and temporal relations of enacting health care within socio-technical infrastructures. The nine types of UC *verify* the categories of HCI relations as far as the relations in the framework for identifying transformation in working relations between users and computers are confirmed.

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Using Participatory Action Research to Evaluate and Improve Change: Pilot Implementation of an Electronic Health Record in Rural Tanzania

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Abstract

The purpose of this study is to use a Participatory Action Research (PAR) approach to facilitate the implementation of a new electronic Health Information System (HIS) in rural Tanzania. Health care funding to Africa has increased the electronic tracking of patients. There is a gap, however in HIS implementation and evaluation research in Sub-Saharan Africa. The implementation process can be considered a mutual transformation between the organization and the technology, best served by iterative feedback from users. Hence, we will use a PAR approach to build local capacity to evaluate the impact of the new HIS within a local context. Stakeholders will be empowered to participate in the identification, collection, and analysis of issues related to the implementation and to build and evaluate shared plans for change. This will be an iterative process. This collaborative study will contribute to knowledge of the PAR approach in health informatics and will fill a gap in the knowledge of HIS implementation and evaluation research in Sub-Saharan Africa.

Keywords:

Sub-Saharan Africa, technology, healthcare, evaluation, action research

Introduction

Health Information Systems (HIS) have increasingly become part of healthcare management and delivery in low- and high-income countries. The implementation of HIS involves the set-up and adoption of electronic systems in varied care settings. The implementation process can be considered a mutual transformation of the organization and the technology in tandem, best served by utilization of users' perspectives being fed back into a constantly evolving system. Evaluation of the HIS is considered imperative to provide information that could enable ongoing adjustments to be made to the implementation process [1]. There is a gap, however, in HIS implementation and evaluation research in Sub-Saharan Africa [2].

Theoretical approach

In designing this study we recognized that summative assessment does not build capacity within the research environment. As most theoretical frameworks are summative and based on Western (or high-income) countries [2] they are usually not transferable to low-income countries. Likewise, adapting evaluation studies from high-income countries can be problematic. Integrating HIS into clinical environments has context specific conditions and limitations in low-income countries particularly in rural areas [3]. It is therefore important to take the local context and culture into consideration.

PAR is a way of "knowing" about a phenomena that is driven by stakeholders "living" the phenomena. Our approach will thus be both formative and summative in nature which will enable us to continuously refine and adapt as we explore emerging trends and use iterative data collection and analysis to guide future steps. PAR involves three basic actions: data collection ("look"), data analysis and theorization ("think"), and planning, implementation, and evaluation ("act"). These actions are guided by a facilitator [4]. PAR builds capacity by empowering local stakeholders to participate in the identification, collection, and analysis of issues directly related to the implementation process. This can help drive the sustainability of the study and identify cost-effective solutions to iterative quality improvement [5].

The research question is: "How can Participatory Action Research be used to facilitate the implementation of a new electronic Health Information System within a rural Tanzanian clinical environment?

Research methodology

Research Locus

Field research began in April 2007 and will occur over a 12 – 18 month period at Haydom Lutheran Hospital (HLH), Mbulu, Manyara, Tanzania. HLH is located approximately 300km southwest of Arusha in the Mbulu District, and borders 4 other districts which it also serves, a population of approximately 580,000. HLH has roughly 12,000 inpatients and 60,000 outpatients each year. The hospital currently works over capacity with an average of 370 inpatients/day assigned to 350 beds. HLH is a pilot site for the implementation of the Care2X HIS, an open-source software application introduced to collect and store administrative and clinical data.

Participatory action research

We will engage local stakeholders to work through the iterative Participatory Action Research approach to evaluate the implementation of the Care2X system, and build and implement shared plans for change. It is anticipated that one full cycle of the action research stages (look, think, act) will take approximately 8 weeks. There will be 6 cycles over the course of a year. Stakeholders are identified as those who are or will be using and/or making decisions about the new electronic Health Information System and include employees and administrators.

Data collection will consist of interviews, meetings, observation and document review, and will occur on site at HLH in Haydom and ELCT Health in Arusha. Data analysis is also an iterative process in which findings are summarized into reports for participant review and feedback. The research results will be widely disseminated in a manner that is accessible to local stakeholders, as well as national and international audiences.

Results

Progress to date

Grimm visited Haydom Lutheran Hospital and ELCT Health in January 2006, at which time the research project was identified. Ethical approval, and ethical and research clearance have been obtained from the University of Alberta, the National Institute of Medical Research Tanzania, and the Tanzania Commission for Science and Technology respectively. Grimm moved to Haydom, Tanzania in March 2007 in order to conduct the field research.

Discussion

Unlike hypothesis-driven orthodox research, or researcher-driven social science research, PAR is stakeholder-driven and drives social change. Local stakeholders will provide essential and ongoing input to the iterative evaluation and improvement of the Care2X HIS implementation. The use of a PAR approach will build capacity at HLH and the Evangelical Lutheran Church of Tanzania Health to identify issues related to the implementation of the Care2X system, and to build and evaluate shared plans for change. The PAR approach is scalable and can be used by our study partners to build capacity for HIS implementation initiatives at other sites. This, in turn, contributes to the sustainability of the initiative.

Conclusions

This collaborative study has the potential for the advancement of excellent research by filling a gap in the knowledge about HIS implementation and evaluation in Sub-Saharan Africa. This research contributes to knowledge of the PAR approach in health informatics and of HIS implementation in a low-income country. It also provides insights into the modification and use of the Care2X system for administrative and clinical management in Sub-Saharan Africa. Our research is exceptionally timely as the need for knowledge about evaluating the impact of HIS is increasing exponentially as electronic HIS implementation rates increase internationally. The case study within a resource-poor country will be used to inform HIS studies in resource-rich countries, specifically rural and remote health care environments.

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Using Participatory Action Research to Evaluate and Improve Change: Pilot Implementation of an Electronic Health Record in Rural Tanzania

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INTRODUCTION

- Electronic Health Information Systems increasingly part of health care management & delivery
- Funding has increased electronic tracking of patients, drug inventory and order planning
- Change management issues at organizational & individual levels
- Gap in Health Information System evaluation research for Sub-Saharan Africa and internationally
- High-income countries can learn from Health Information System implementations

EVALUATION OF HEALTH INFORMATION SYSTEMS - SOCIAL RESEARCH

- Health Information Systems are part of a larger system
- Social, contextual, and technological influences
- Multiple methods (quantitative and qualitative)
- Formative and summative
- Most theoretical frameworks are based on high-income countries
- Adapting evaluation studies can be problematic

PARTICIPATORY ACTION RESEARCH

- An approach not a method
- Hypothesis-generating
- Build capacity to evaluate implementation within local context
- Mixed methods case study
- Social interactionism, socio-technical paradigms
- Iterative Quality Improvement
- Drives social change

CONTEXT

- The Opportunity
  - ELCT Health of Tanzania implementing Care2X Health Information System
  - Haydom Lutheran Hospital pilot site (commenced January 2007)
- Research question
  - How can Participatory Action Research be used to facilitate the implementation of a new electronic Health Information System within a rural Tanzanian clinical environment?

PURPOSE AND OBJECTIVES

- Purpose
  - To facilitate the implementation of a new Health Information System in rural Tanzania using a Participatory Action Research approach.

- Objectives
  - Identify opportunities to improve
  - Create, implement and evaluate shared plans
  - Build local capacity
  - Provide local information
  - Disseminate results broadly

METHODOLOGY

- Research Locus
  - Haydom Lutheran Hospital, Mbulu, Manyara, Tanzania
  - 12-18 months field research
- Stakeholder Recruitment
  - Administrators, employees, contractors

path paving the way
AHFMR Alberta Heritage Foundation for Medical Research
University of Alberta
Capital Health Edmonton Area
IDRC CRDI
iCARE about health Integrated Centre for Care Advancement through Research

METHODOLOGY

- Participatory Action Research
  - Stakeholder-driven
  - Researcher as facilitator
  - Formative, summative, iterative
  - Drives social change
- “Look”, “Think”, ”Act”
  - Identify issues of importance and build shared plans for change
  - Interviews, focus groups, meetings, observations, literature and document review
  - 8 week cycles (6 cycles in one year)

METHODOLOGY

- Construct validity
  - Multiple perspectives and sources of evidence
  - Member-checking
  - Journaling
  - Action research is modifiable
- External validity
  - Incorporation of general theory
  - Explore rival explanations
- Reliability
  - Protocol will be systematically documented

SIGNIFICANCE

- Contributes to knowledge of the Participatory Action Research approach in health informatics
- Insights into the modification and use of the Care2X system in Sub-Saharan Africa
- Fill a gap in knowledge about Health Information System evaluation research in Sub-Saharan Africa and internationally
- Case study will be used to inform Health Information System evaluation research in resource-rich countries, specifically rural and remote health care environments

TO DATE…

- January 2006 site visit to ELCT Health and Haydom Lutheran Hospital
- Ethical approval from University of Alberta

- Research and ethical clearance from the Tanzania Commission for Science and Technology and the Tanzania National Institute for Medical Research
- Field research commenced April 2007

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Research Team

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- Dr. Richard Scott, University of Calgary
- Dr. Thorkild Tylleskär, University of Bergen
- Dr. Alan Gillies, University of Central Lancashire

Tanzania Collaborators

- Dr. Mauri Niemi, ELCT Health
- Dr. Øystein Olsen, Haydom Lutheran Hospital
- Ms. Neema Mgana, African Regional Youth Initiative
- Mr. Oscar Mukasa, Ifakara Health Research and Development Centre

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Evaluation Framework for the Electronic Transmission and Processing of Prescriptions Project in the Iranian Social Security Organization

Ramin Moghaddam

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Abstract

Fifty to seventy percent of information system projects fail. [1] Most of the failures are not the victims of flawed technology, but rather organizational and people related issues. According to a long term plan, Iranian Social Security Organization(ISSO) is going to enable the sharing of health related information in a secure environment by means of reliable data in the right time to improve health of insured people throughout the country. Electronic Transmission & Processing of Prescriptions (ETPP) project in this organization deals with the prescribed medicaments related information from around 7000 pharmacies throughout the country that ISSO contracted with them in order to deliver seamless services to 30 million insured people .It was crucial to define an evaluation framewrok for this nationwide project in order to apply formative and summative evaluation . [1][2][3] This framework facilitates scientific and practical multidimentional judgment about success or faliure of this project. [2][3]

Keywords:

evaluation framework, electronic transmission, processing prescriptions, ETPP, success, failure

Introduction

Introducing an innovation into a big organization such as ISSO evokes changes . In some cases these changes will be minor ones that hardly affect the organization and the people working in it. [3] In other cases, those having to use the innovation might experienece major changes. ISSO is responsible for delivering direct & indirect medical services to thirty million insured people through the ISSO's health care network in the country . In the ISSO healthcare network , there are more than 350 owned medical centers in addition to 40000(including 7000 pharmacies) contracted healthcare institutions. ETPP project has been designed in order to enable sharing of valuable prescription information using a secure electronic environment to improve health and safety of insured people based on scientific approach alongside the facilitation of tracking the financial loads & risks. This electronic environment brings facilities for different stakeholders in the ISSO by means of reducing chances of abuse and redundant inspections, simplification of outpatient procedures, increasing the accuracy of medical expenses report information, holding the reimbursement information, medical records, etc. However, only a thorough evaluation study can show whether or not a specific system was successful in a specific setting. [3] With having this insight, a wide range of attributes shall be measured in evaluation of the ETPP project. These attributes vary from purely technical factors to outcome measures such as quality of services and from end user evaluation to extent of diffusion into the organization. It is likely that no single criterion can account for success or failure of the project. [2][3]

Methods

After a robust literature review, the ETPP evaluation framework has been developed mainly based on Delone and McLean multidimensional success model. [3][4] Delone and McLean proposed to subdivide success measures of management information systems into six distinct categories: 1) system quality, 2) information quality, 3) usage, 4) user satisfaction, 5) individual impact, and 6) organizational impact. Within each category several attributes could contribute to success. [3] Delone and McLean concluded that success was a multidimensional construct that should be measured as such. [4] In addition, they argued that the focus of an evaluation depended on factors such as objectives of the study and the organizational context. [4] The comprehensive evaluation information could be emerged from each entity by different qualitative and quantitative data collection methods such as questionnaire, chart review, interview, time sampling, work sampling, focus group and observations. [3]

Results

The system development, system quality, implementation, information quality, system usage, user perspective, individual impact and organizational impact are entities of ETPP evaluation framework. The attributes of each entity have been customized. The system development entity has several attributes as: system design, system architecture, development methodology, data modeling and normalization, extent of user group involvement. The system quality entity has several attributes as: ease of use, response time, timesavings, creating extra works, perceived ease of use, usability, up-time, ease of learning, complicated built in business rules, reliability, security, help, data accuracy.

The implementation entity has several attributes as: user group ownership, training efficacy, time delay for maintenance. The information quality entity has several attributes as: completeness, accuracy of data, legibility, timeliness, perceived usefulness, availability, comprehensiveness, consistency, reliability and format. The system usage entity has several attributes as: frequency of use, number of entries, duration of use, location of data, frequency of use of specific functions, frequency of report generation. The user perspective entity has several attributes as: user satisfaction, user attitude, user friendliness, expectations, competence. The individual impact entity has several attributes as: direct benefits, changed documentation habits, information use, efficiency and effectiveness of work, job satisfaction. The organizational impact entity has several attributes as : communication and collaboration, social accountability, time savings, cost, reduction of staff, number of procedures reduced . [3]

Discussion

The framework can be circulated between different parties and is a perfect evaluation tool from different perspectives when a large scale information system as ETPP is designed, developed and implemented. A good evaluation should include multiple, carefully selected periods of data collection and should include all stakeholders' points of view. [3] Kaplan suggested the following methodological guidelines for evaluations: 1) focus on a variety of concerns, 2) choose a longitudinal study design, 3) use multiple methods, 4) choose a study design that can be adapted to the study findings whenever necessary, and 5) be both formative and summative. [3][5]

Conclusion

Among healthcare professionals, new innovations are predominantly judged by their direct value for patient care. Information systems with a practical utility for patient care or diagnostic procedures are relatively easily accepted, sometimes even without any scientific evidence of their value. [3] However, systems like ETPP that support the process of healthcare without being directly relevant to patient care are less easily accepted. [3] To address a blending approach to formative and summative information systems evaluation, it should start before system development and should have no fixed end. [3] This is the nature of evaluation which is a dynamic process in information systems life cycle.

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[3] M.J.Van Der Meijden, H.J.Tange, J.Troost, A.Hasman. Determeinants of success of inpatient clinical information systems: a literature review. IMIA Yearbook of Medical Informatics 2005; 354-362

[4] DeLone WH, McLean ER. Information systems success. The quest for the dependent variable. Inf Sys Res 1992;3:60-95

[5] Kaplan B. Addressing organizational issues to the evaluation of medical systems. JAMIA 1997; 4: 94-101

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Evaluation framework for the Electronic Transmission and Processing of Prescriptions (ETPP) project in the Iranian Social Security Organization (ISSO)

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Iranian Social Security Organization (ISSO)

- ISSO is responsible for delivering direct & indirect medical services to thirty million insured people through the ISSO's health care network in the country . In the ISSO healthcare network , there are more than 350 owned medical centers in addition to 40000(including 7000 pharmacies) contracted healthcare institutions

Electronic Transmission and Processing of Prescriptions (ETPP)

- **ETPP** project has been designed in order to enable sharing of valuable prescription information using a secure electronic environment to improve health and safety of insured people based on scientific approach alongside the facilitation of tracking the financial loads & risks

- This electronic environment brings facilities for different stakeholders in the ISSO by means of reducing chances of abuse and redundant inspections, simplification of outpatient procedures, increasing the accuracy of medical expenses report information ,holding the reimbursement information , medical records , etc.

Evaluation of the ETPP project

- Only a thorough evaluation study can show whether or not a specific system was successful in a specific setting
- A wide range of attributes shall be measured
- These attributes vary from purely technical factors to outcome measures such as quality of services and from end user evaluation to extent of diffusion into the organization
- It is likely that no single criterion can account for success or failure of the project

ETPP evaluation framework

- Has been developed mainly based on Delone and McLean multidimensional success model
- Delone and McLean proposed to subdivide success measures of management information systems into six distinct categories : 1) system quality , 2) information quality , 3) usage , 4) user satisfaction , 5) individual impact , and 6) organizational impact

ETPP evaluation framework entities

- The system development , system quality , implementation , information quality , system usage , user perspective , individual impact and organizational impact are entities of ETPP evaluation framework
- The comprehensive **evaluation information** could be emerged from each entity by different **qualitative** and **quantitative** data collection methods such as questionnaire , chart review , interview , time sampling , work sampling , focus group and observations

ETPP evaluation framework entities

- The system development entity has several attributes as : system design , system architecture , development methodology , data modeling and normalization , extent of user group involvement

- The system quality entity has several attributes as : ease of use , response time , time savings , creating extra works , perceived ease of use , usability , up-time , ease of learning , complicated built in business rules , reliability , security , help , data accuracy

- The implementation entity has several attributes as : user group ownership , training efficacy , time delay for maintenance

- The information quality entity has several attributes as : completeness , accuracy of data , legibility , timeliness , perceived usefulness , availability , comprehensiveness , consistency , reliability and format .

ETPP evaluation framework entities

- The system usage entity has several attributes as : frequency of use , number of entries , duration of use , location of data , frequency of use of specific functions , frequency of report generation
- The user perspective entity has several attributes as : user satisfaction , user attitude , user friendliness , expectations , competence .
- The individual impact entity has several attributes as : direct benefits , changed documentation habits , information use , efficiency and effectiveness of work , job satisfaction .
- The organizational impact entity has several attributes as : communication and collaboration , social accountability , time savings , cost , reduction of staff , number of procedures reduced

ETPP evaluation framework

- The framework can be circulated between different parties and is a perfect evaluation tool from different perspectives when a large scale information system as **ETPP** is designed , developed and implemented

- Kaplan suggested the following methodological guidelines for evaluations : 1) focus on a variety of concerns , 2) choose a longitudinal study design , 3) use multiple methods , 4) choose a study design that can be adapted to the study findings whenever necessary , and 5) be both formative and summative

ETPP evaluation framework

- Information systems with a practical utility for patient care or diagnostic procedures are relatively easily accepted , sometimes even without any scientific evidence of their value

- Systems like ETPP that support the process of healthcare without being directly relevant to patient care are less easily accepted

ETPP evaluation framework

- To address a blending approach to formative and summative information systems evaluation , it should start before system development and should have no fixed end

- This is the nature of evaluation which is a dynamic process in information systems life cycle.

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Medical Informed Consent in the Digital Age: Usability of a Computerized Informed Consent Application among Cardiology and Ophthalmology Patients and Clinician Users

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Abstract

The study evaluated the usability of a computerized informed consent software product, iMedConsent by analyzing the trend in satisfaction ratings using Likert scale to survey questions. Cardiology and Ophthalmology patients and clinician users in a Veterans Affairs Hospital in southwestern United States were provided questionnaires to describe levels of satisfaction upon using the software. Data analysis of satisfaction ratings demonstrated that, iMedConsent is highly usable to patients and clinicians alike. However, patients with less computer knowledge and experience may be less satisfied with using the computer to learn about an upcoming procedure. These differences merit further consideration in the future widespread implementation of computerized consent software.

Keywords:

informed consent, ethics, medical malpractice, Veterans Affair

Introduction

In the US, lack of proper informed consent is listed as a factor in 40%-60% of all malpractice cases. Indeed, failure to obtain proper consent itself ranks among the top ten reasons for malpractice claims [1]. State medical boards investigate patients' allegations of violations involving informed consent. Physicians found to be in violation can face fines, suspensions, or revocation of their professional licenses.

The current standard of obtaining informed consent is a paper-based form. Nonetheless, different studies echoed the need to improve the paper based consent process [2]. In 2003, the Department of Veterans Affairs system adopted computerized informed consent software, iMedConsent based on Department of Veterans Affairs and Joint Commission on Accreditation of Healthcare Organizations standards [3]. It is being positioned for full implementation after undergoing successful pilot studies.

Materials and methods

A questionnaire form was made available to patients who consented to a procedure using iMedConsent in the Cardiology and Ophthalmology Outpatient clinics from May 20, 2005 to Dec 30, 2005 and clinicians who actively use iMedConsent. The level of satisfaction was rated on a Likert scale: 5 – very satisfied, 4 – somewhat satisfied, 3 – neither dissatisfied nor satisfied, 2 – somewhat dissatisfied, 1- very dissatisfied. Each participant was asked to state perceived level of computer knowledge: none (N), beginner (B), average (Av), above average (AA) and advanced (Ad). A space was provided for comments not covered by survey questions.

Frequency distribution was used to identify statistical trends on patients' and clinicians' data. SPSS's nonparametric Kruskall-Wallis test was used to establish statistically significant similarity ($p=0.01$) of satisfaction ratings among different patient groups. To improve statistical power, patients were divided into two major groups. Unskilled computer users (UCUs), consisted of N and B groups and skilled computer users (SCUs), consisted of Av, AA and Ad groups.

Results

Clinicians' comments encompassed software implementation concerns (downtime, does not always load up), design issues (inability to edit, the need for physician's availability, procedures selection) and knowledge problems (related to finding the right procedure).

Table 1 - Percentage of patients (N = 152) who were somewhat satisfied and very satisfied

Survey question	N	B	Av	AA	Ad
Understanding of the procedure	90	92	100	100	100
Understanding of a) risks	83	92	100	100	100
b) benefits	86	92	100	100	100
c) alternatives	75	92	95	100	100
Addressing patient concerns	86	97	98	100	94
Ease on signing	83	91	100	96	100
Computer as learning medium	67	81	95	96	100
Computer- based versus paper-based consent	74	81	98	100	100
Overall satisfaction	86	97	100	100	100

Table 2 - Percentage of clinician users (N =8) who were somewhat satisfied and very satisfied

Amount of time/training needed/spent learning iMedConsent	75
Amount of time needed to complete an informed consent document	75
The information presented to the patient	
a. Indications of a procedure	63
b. Risks/Benefits of a procedure	75
c. Alternatives of a procedure	63
Do you feel that the patient concerns about the procedure have been addressed?	50
Computer as medium for discussion and documentation of an informed consent	63
Anatomical images and diagrams, patient educationmaterialsanddruginformation.	37
Overall satisfaction with the process	63

Discussion

Using a p value of 0.01, there were no statistically significant differences in the satisfaction ratings among different patient subgroups (p range: .03-.166) on overall satisfaction with the process, overall understanding of procedure, understanding of risks, benefits and alternatives involved (Table 1). However, use of iMedConsent as a learning medium and comparison of paper-based versus computer based consent process were met with mixed responses. There were statistically significant differences noted on the low ratings among N and B users (p = .001, .006 respectively) which was demonstrated also by comparison of the UCUs and SCUs (p = .000 and .002).

Five out of eight clinician users expressed satisfaction with using the software. However, only 4 out of 8 clinician users surveyed felt that patient concerns were addressed and only 3 out of 8 were satisfied with the educational support features (Table 2).

Conclusion

Overall, iMedConsent software is a highly usable digital tool for obtaining a patient's informed consent in the outpatient Ophthalmology and Cardiology clinics for patients of all levels of computer knowledge and among early clinician users. However, iMedConsent as an educational tool, showed significant differences in the satisfaction ratings of patients with varying levels of computer skills. This was mirrored in the clinician arm of the study. This finding needs consideration in the future widespread implementation of the software.

Acknowledgement

Paul Gorman MD, Glenn Anderson Pharm D, Nora Arguello, Bruce Boland CAC, Michelle Carlson NP, Andrea Ilg, Jackie Hall JD, Richard Herrod RT, Margaret Jenkins RN CS, Dawn Johnson, Diane Koerting, Jane Stewart, Virginia Sicola RN CS PhD, Kathy Thomas, Jasmine Uy, Amy Y. Wang MD.

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Medical Informed Consent in the Digital Age: Usability of a Computerized Informed Consent Application Among Cardiology and Ophthalmology Patients and Clinician Users

Julito Uy, MD

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Objective

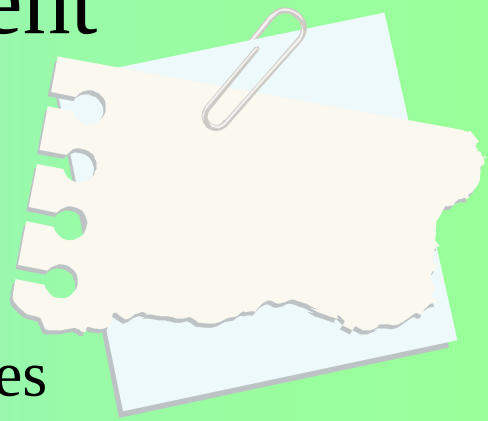
- To evaluate the usability of a computerized informed consent software product, iMedConsent, by analyzing trend in satisfaction ratings to survey questions among Cardiology and Ophthalmology patients and clinician users in a Veterans Affairs Hospital in southwestern United States .

- Specifically, this study attempts to demonstrate that positive rating is observed in all levels of computer knowledge.

Background

- In the US, lack of proper informed consent is listed as a factor in 40%-60% of all malpractice cases.
- Failure to obtain proper consent itself ranks among the top ten reasons for malpractice claims with median award of $500,000 from 1994-2003 [1].
- State medical boards investigate patients' allegations of violations involving informed consent. Physicians found to be in violation can face fines, suspensions, or revocations of their professional licenses.

The Paper-based Informed Consent

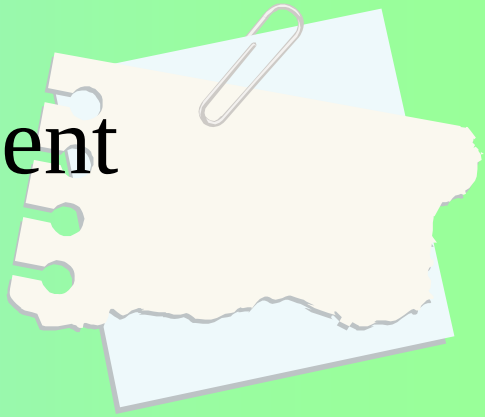


- The Veteran's Health Administration (VHA) National Center for Ethics in Health Care reported that the paper based consent process does not completely comply with the VA policy on informed consent.[2]

Content analysis of 540 paper-based informed consent forms for procedures from members of the American Hospital Association showed [3]:

- **26%** of the forms studied had complete documentation of all four essential elements of a valid informed consent,
- **35%** had only three, **23%** had only two and **14%** had only one.
- Only **14%** of the forms were useful in helping patients in their decision-making.

The Paper-Based Informed Consent



- Only **10.2%** of encounters with surgeons and **7.7%** of encounters with primary care physicians out of 1,057 encounters studied showed inclusion of all elements of informed consent [4].

- Significant majority (**59.5%**) of patients had difficulty understanding the standard informed consent documents in a study on health literacy among public hospital patients [5].

Materials and Methods

- iMedConsent simplifies and standardizes the process of obtaining informed consent by using templates constructed based on US Department of Veteran Affairs and Joint Commission on Accreditation of Healthcare Organizations standards [6].

- Presents a comprehensive discussion of nature of procedure, risks, benefits, and alternatives in a time-efficient way.
- Contains illustrations depicting anatomical structures with patient education materials in 4th grade readability levels.
- Contains a drug information library.
- Comes with a signature capture device ePad.
- Creates a legal document that is legible, retrievable, verifiable and complete, a defense against medical liability claims arising from failure to inform.

- The software versions used were v3.81 patch 347 and 3.81 389b.

Materials and Methods

- Questionnaires provided to Ophthalmology and Cardiology patients and clinician users who use iMedConsent software.

- Level of satisfaction was rated on a Likert scale:

5 – very satisfied,

4 – somewhat satisfied,

3 – neither dissatisfied nor satisfied,

2 – somewhat dissatisfied,

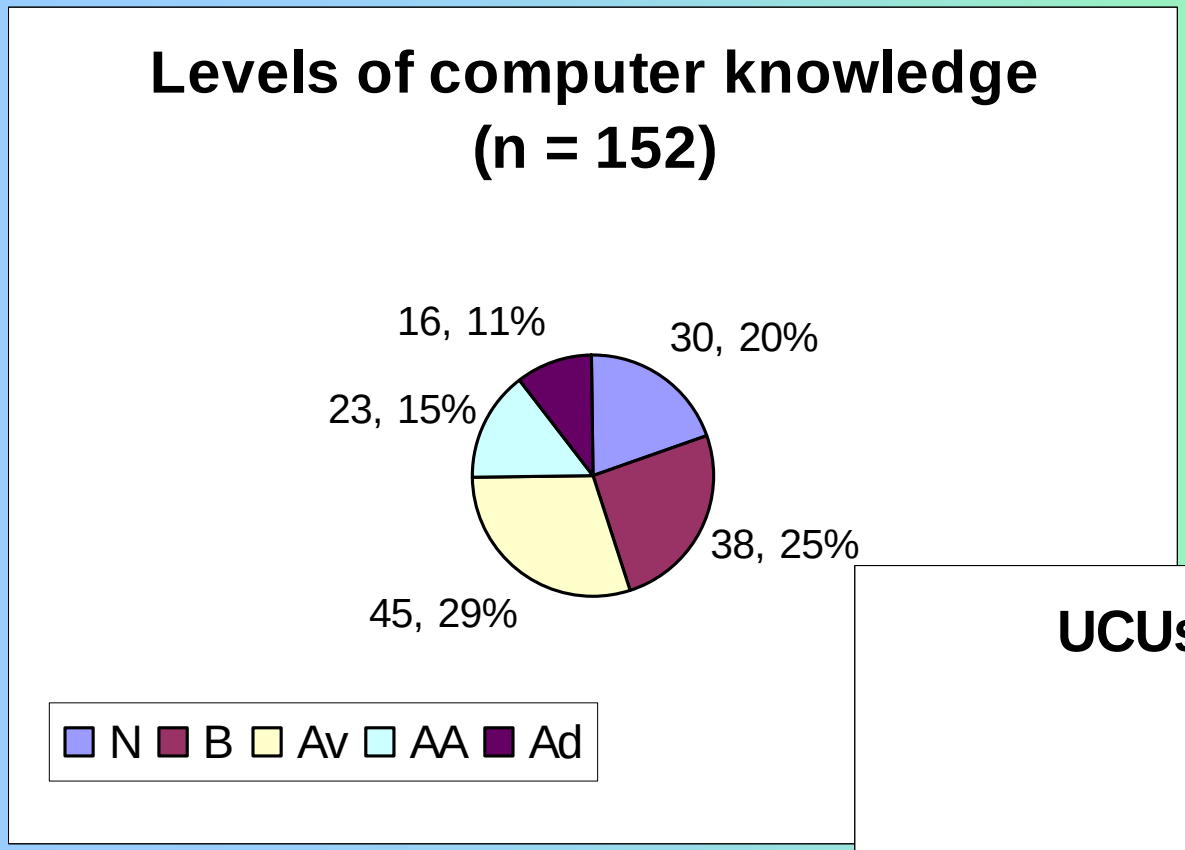
1- very dissatisfied.

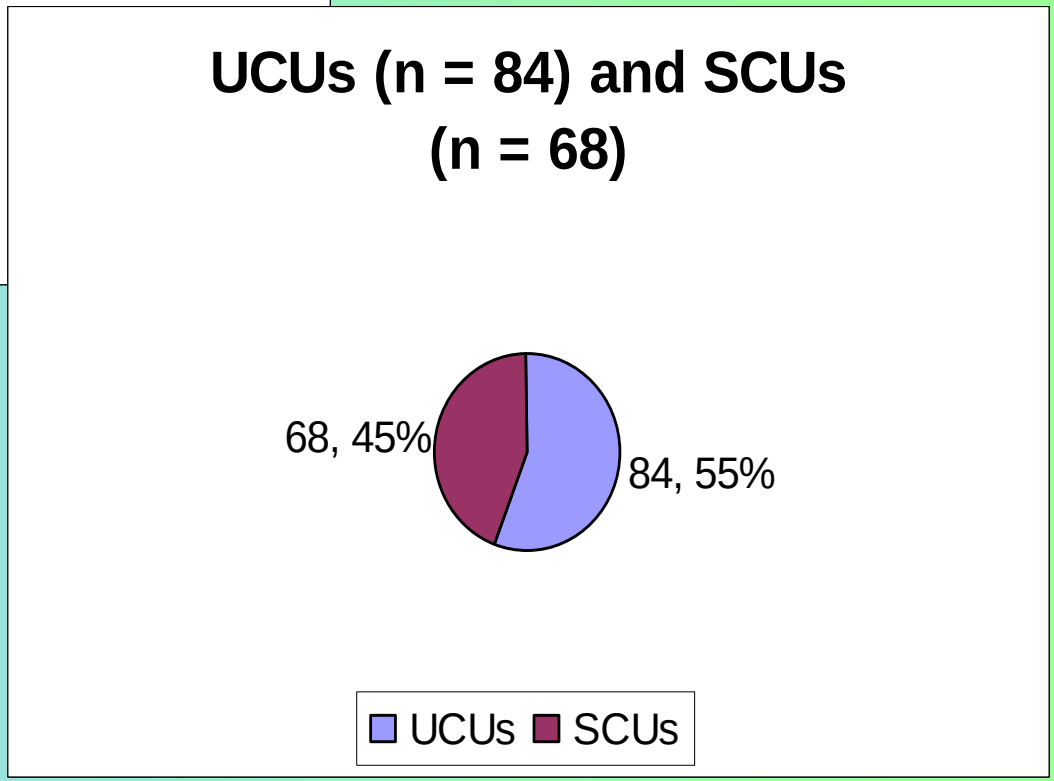
- Levels of computer knowledge were: none (N), beginner (B) , average (Av), above average (AA) and advanced (Ad).

- To improve statistical power, N and B users were grouped as “Unskilled Computer Users” or UCUs and Av, AA and Ad were grouped as “Skilled Computer Users” or SCUs.

- Comments and recommendations

Results


Levels of computer knowledge
(n = 152)
16, 11%
30, 20%
23, 15%
38, 25%
45, 29%
N
B
Av
AA
Ad


UCUs (n = 84) and SCUs
(n = 68)
68, 45%
84, 55%
UCUs
SCUs

Percentage of patients who were somewhat satisfied and very satisfied.

Using $p < 0.01$, No statistically significant differences among patient subgroups (p range: .030-.166) on

- understanding of procedure,
- understanding of risks, benefits and alternatives involved,
- overall satisfaction with process

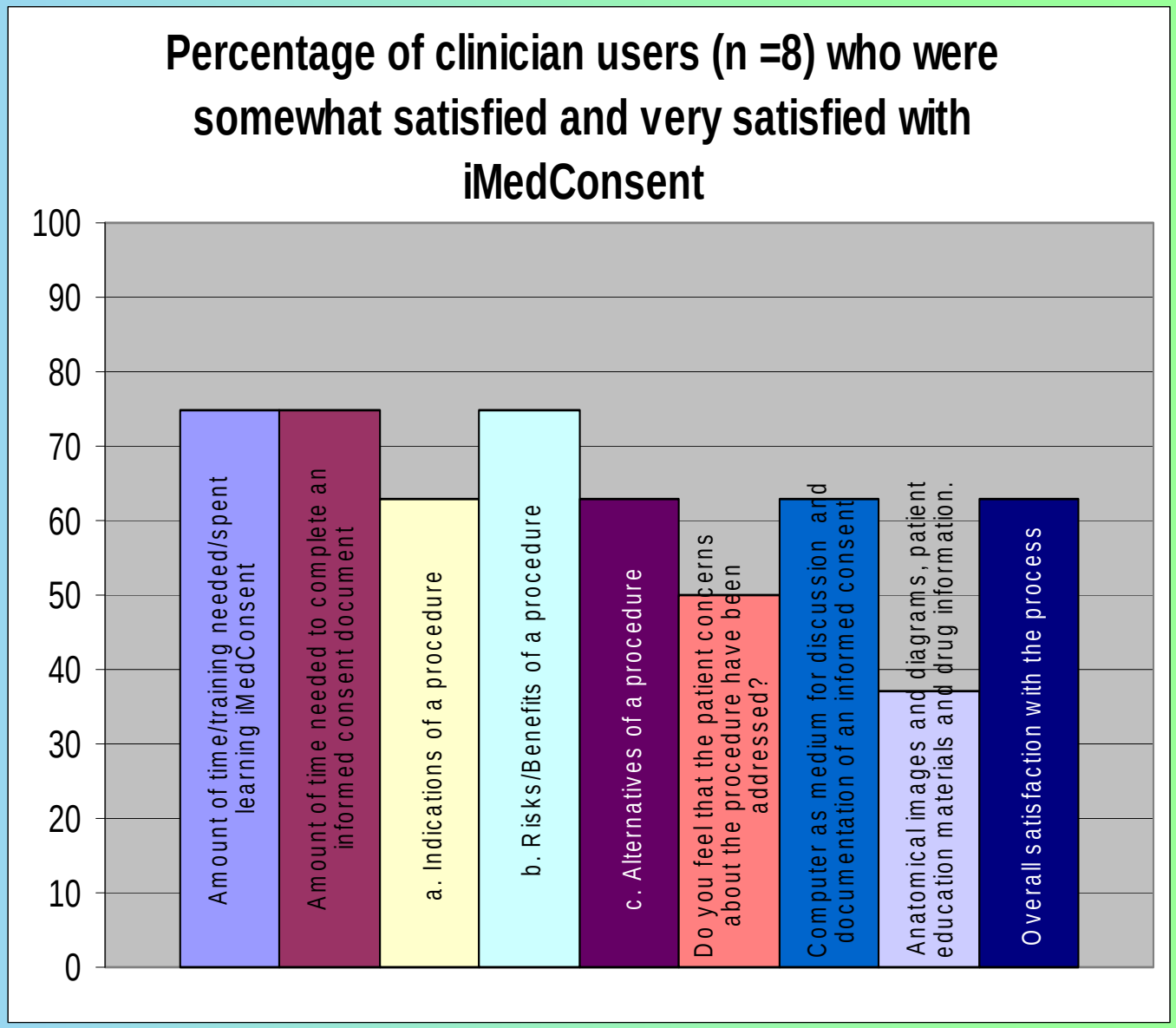
Statistically significant differences observed among patient subgroups on:

- Computer as a medium for learning ($p = .001$)
- Comparison of paper-based versus computer-based consent process ($p = .006$)
- Statistically significant differences were also demonstrated by comparison of UCUs and SCUs ($p = .000$ and $.002$).

Survey questions	N	B	Av	AA	Ad
Understanding of procedure	90	92	100	100	100
Understanding of a) risks	83	92	100	100	100
b) benefits	86	92	100	100	100
c) alternatives	75	92	95	100	100
Addressing patient concerns	86	97	98	100	94
Ease on signing	83	91	100	96	100
Computer for learning	67	81	95	96	100
Computer based versus paper based consent	74	81	98	100	100
Overall satisfaction	86	97	100	100	100

- Majority expressed overall satisfaction with using iMedConsent.
- 4/8 of clinician users surveyed felt that patient concerns were addressed.
- 3/8 were satisfied with the educational support features.
- Comments:

a. software implementation concerns
b. design issues
c. knowledge problems



The number of returned questionnaires is small from the clinician users arm to attain statistical significance.

Conclusion

- Overall, iMedConsent software is a highly usable digital tool for obtaining a patient's informed consent in outpatient Ophthalmology and Cardiology clinics for patients of all levels of computer knowledge and among clinician users.

- However, as an educational tool, there are significant differences in satisfaction ratings of patients with different computer skills.

- This finding needs consideration in future widespread adoption of iMedConsent software.

Acknowledgement: Dr. Paul Gorman, Capstone project advisor, Oregon Health Science University, Glenn Anderson Pharm D, Nora Arguello, Bruce Boland CRC, Michelle Carlson NP, Jackie Hall JD, Richard Herrod RT, Margaret Jenkins RN CS, Dawn Johnson, Andrea Ilg, Diane Koerting RN, Jerry Little MSN, Barbara Moore, Jane Stewart (IRB), Virginia Sicola RN CS PhD, Kathy Thomas RN (IRB), Jann Uy, Amy Y. Wang MD.

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Assessing Clinical Processes – Lessons Learned

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Abstract

Introduction: This paper deals with the systematic assessment of clinical processes. In this context, an own assessment approach is introduced. It was developed during a two year lasting cooperative project. Aim: The aim of this paper is to share the experiences that were made with the selected approach. Method: Processes are assessed with the help of "views" and "rule-sets": Within a view selected elements of a clinical process are combined in a matrix. The analysis determines which details are needed. Specific flaws are then detected by applying rule-sets on these views. Results: The strengths and limitations which were observed during the evaluation of the approach are summarised in a structured way. Conclusion: The experiences in this paper contribute to future developments in process assessment. The approach itself could support the process oriented information management in hospitals.

Keywords:

process assessment (health care), process measure, public health informatics, information system

Introduction

Clinical processes can be seen as complex interactions between several hospital departments. Each department has its own objectives that lead to specialised workflows, role definitions and proprietary tools. This cooperative environment with its high demand on communication (e.g., [1]) is often seen as a main reason for the weaknesses clinical processes show, e.g. regarding their efficiency [2-4]. Similar problems are already known outside of the health care domain. Thus it seems feasible to adopt concepts like the well established Business Process Reengineering (BPR). One of its main principles says that companies can only improve their efficiency by focusing on their main processes [5]. The successful application of the BPR in turn depends on adequate process descriptions [6] which are analysed for possible weaknesses, in order to derive improvements (according to Deming's Plan-Do-Check-Act cycle, [7]). In fact, there are established tools which are meant to model and assess processes regardless of their professional context (e.g. the ARIS toolset [8]). Hence, their application on clinical processes basically seems possible. Based on the understanding of authors like Harrington who named in [9] measurements as the keys to improvement, BPR tools often equate assessment with measuring discrete process attributes (e.g. temporal or monetary details). But measurements themselves have no value without a context in which their results are judged [10]. This context is explicit process knowledge that guides measurements and helps to interpret results. In case of clinical processes this kind of context is missing. Thus, the degree in which the versatile capabilities of the BPR tools contribute to a feasible process assessment strongly depends on the subjective viewpoint of the person who uses these functions. A possible conclusion is therefore, that a systematic assessment of clinical processes is still missing [11].

The MedFlow project

Motivated by these drawbacks, the MedFlow project was initiated together with partners from the Leopold-Franzens-University of Innsbruck and the health care IT company ITH (Information Technology for Healthcare). The project lasted from 2004 until 2006 and aimed to develop a practical method and appropriate tools that support the systematic assessment of clinical processes. In this context, processes were regarded as interrelated actions that were augmented by descriptions of involved tools, roles and information objects. The resulting method takes this into account by declaring a core model that integrates sub-models for each of these four process aspects. The developed concept for assessing clinical processes bases on the application of so called "views" and "rule-sets": Within a view selected elements of at least two sub-models are combined in a matrix. Here, the kind of analysis determines which sub-models are combined. Specific flaws are then detected by applying rule-sets on these views. Each rule-set represents a pattern which is searched for in the view-matrix. The combination of a view with a corresponding rule-set is referred to as a "quality check".

The idea of the quality checks is further explained with an example in the following method section. However, the focus of the paper lies on summarising the strengths and limitations of the newly developed approach (i.e., applying rule-sets on views). These were gathered by applying the method on the process of ordering radiological examinations.

Aim of this paper

This paper is meant to share the experiences that were made with an assessment approach which uses rule-sets on appropriate extractions of process models.

Materials and methods

Preconditions for process assessment

Dealing with proper process assessment, the following open issues or rather conditions were identified:

- Important quality criteria for the regarded process must be determined in advance. On the basis of these criteria the relevant process details are identified.
  1. The model must adequately describe all details of the examined process which have been identified as relevant in 1.
  2. The model details must be organized in a way that they are accessible for the assessment.
  3. In order to avoid that criteria are skipped during the assessment, all criteria must be collected and arranged in a structured way.
  4. There must be a practical way to test the process for each criterion.

In the MedFlow project, the first condition was met by using methods like system analysis and literature research (e.g. [12, 13]). In this way quality criteria like "Number of distinct input information objects" or "Existence of media breaks" were gathered for the example process of ordering radiological examinations. Necessary process details are determined by deriving weak points from each criterion.

In order to meet the second and third precondition, a new core model which uses an own meta-model was developed: This core-model consists of four sub-models (process model, information model, tool model, organisational model) with each concentrating on distinct aspects of a process (i.e., control flow, data flow, tool usage, organisational information) – they are realised for instance on top of UML Activity Diagrams [14] and the Three Layer Graph-Based Meta-Model (3LGM², [15]). Additionally, own elements were introduced. Details can be found in [16].

The fourth condition was fulfilled by sorting the found criteria into a catalogue. In accordance to the basic quality aspects that are provided in [13] the catalogue was structured as follows:

- Quality of structures: This aspect can be further divided into the quality of documentation, logical and physical tools and finally the quality of integration between those tools.
- Quality of the processes
- Quality of the outcome (i.e., the degree the process contributes to achieve the hospital's strategic goals)

Thus, the above mentioned criteria "Existence of media breaks" can be found in the catalogue under the aspect "Quality of documentation" (which is part of "Quality of structures").

The fifth precondition was considered by developing a generally applicable assessment concept: In this concept the assessment is regarded as a series of questions. Each question scrutinises the existence of one process weak point. Because every weak point pertains to only one certain quality criterion, each question is answered on the basis of a specific subset of the details within a process model. This subset can either just list the elements of one sub-model or combine the elements of two sub-models. Because of this selective view on the process model the subsets are also called "views". In order to test a process model for a weak point, a specific pattern is searched within the appropriate view. Every pattern is expressed as a "rule-set". The combination of view and rule-set is also stored in the structured catalogue. Table 1 illustrates the structure of the catalogue entries using the example of media breaks.

Table 1 – Excerpt from the criteria catalogue

Quality Criteria	Quality Check		Possible weak point
	View	Rule-set	
Existence of Media breaks	Information-Model x Media Info	All information objects which are stored electronically and paper-based	Media cracks potentially cause inconsistencies in information objects.

Example for the detection of weak points

This section provides a small example on how the assessment method is used to detect media breaks. According to the appropriate catalogue entry (shown in Table 1), this criterion is assessed on basis of a view that combines the logical sub-model with the info.

An extraction of such a view is shown in Table 2: The lines of the matrix contain the information objects (e.g., a CT image, report) which are created, read, written or copied in the process. The columns contain the possible media states in which information objects can reside (e.g., in Table 2 "persistent (digital)" means that the information object is stored permanently on a server or a PC where it is available for distributed access). An information object can reside in only one media state at a time. If copies exist these copies should be stored at least on the same media type (i.e., paper-based or digitally). A common weak point in this context is that an information object is stored on different media types which is also called media break.

Media breaks are detected by selecting all lines (i.e., information objects) of the view which have multiple cross points. A cross point means that an information object is represented at least once in this state. Thus, multiple cross points in one line with different media type indicate media breaks. This is the case for the information object "Order form" in Table 2.

Table 2 – Excerpt of the view for detecting media breaks (see highlighting)

Media Information / Inform. object	…	persistent (digital)	persistent (paper-based)	…
CT image		X		
Order form		X	X	
Report	…	…	…	

Results

This section first shortly summarises the major achievements of the MedFlow-project in terms of its aim. After that, the second part explains the experiences regarding strengths and especially limitations of this approach.

Results of the MedFlow project

The aim of the MedFlow project was the development of a method that supports the systematic assessment of clinical processes. As explained in the methods section, the approach assesses process models by applying specific rule-sets on appropriately selected details. Considering this, the significant results can be resumed as follows:

- The development of the core model with its integrative meta-model: It allows to model processes with those details which were identified as relevant for process assessment. The organisation of the details into the specialised sub-models allows the access to those details for the assessment.
- The compilation of the structured catalogue: It contains essential quality criteria – not only with respect to processes but also the documentation and the involved tools. A first version of the catalogue comprised 38 useful quality criteria (see Table 3). However, it was not possible to develop checks for all criteria. The limitations, their reasons and the further efforts are explained in more detail in the succeeding section
- The implementation of a prototypic software: Making use of the newly developed meta-model this software is able to assess process models which were described in the MedFlow-notation. It has interfaces for established modeling suites like Microsoft's Visio. Elements are stored in a repository which can be queried for assessing the process model. The output is provided in a web front-end. The result of a check is presented in a view which is similar to that shown in Table 2.

Table 3 - The quality aspects and the related criteria

Quality Aspect	Sub-aspect	Quality criteria
Quality of structures	Quality of documentation	Correctness, integrity, reliability, completeness, accuracy, relevance, authenticity, availability, confidentiality & security, backup
	Quality of logical tools	Functionality, reliability, usability, efficiency, maintainability, portability
	Quality of physical tools	Adequacy, availability / accessibility, versatility, efficiency, adaptability, stability & reliability, security, harmlessness, usability, degree of standardisation
	Quality of integration	Adaptability & extensibility, controlled redundancy of data
Quality of processes	-	Efficient information logistic, adequate number of tools, information acquisition & usage, controlled data transmission, patient-centered information management
Outcome quality	-	Efficient communication, availability of all relevant patient data, comprehensive (electr.) patient record, increased usage of mobile information processing tools, optimised user interfaces, patient access on the own record, availability of medical data for research

Strengths and limitations of the developed approach

As already explained in the previous sections, the MedFlow project introduced an own approach for assessing clinical processes (i.e., "views" and "rule-sets"). In order to evaluate this approach a typical and sufficient complex clinical process was selected – the ordering of radiological examinations, and the communication of the related findings. Those processes were described based on a system analysis performed at the University Hospitals of Innsbruck, Austria. Here, the following strengths and limitations could be experienced:

Regarding the strengths:

- The concept of view/rule-set is flexible in configuration and generally applicable. New quality checks can be defined very quickly on the basis of details available in the core model.

- Assessment results just include those details which are essential for the certain quality check and the underlying question. Thus, the results can be anticipated more easily.
- Because of its structured and methodical way this approach guarantees that none of the registered process aspects (which are identified as relevant) are skipped.
- Including also descriptions about which information is needed to answer the checks and how to use them properly, the catalogue is applicable on all kinds of BPR tools.
- The resulting catalogue itself could be used as a collection of requirements which helps to improve BPR tools or as a guideline for the development of new assessment software.

Regarding the limitations:

The limitations must be separated into two groups: The first group contains general limitations which are common to all model-based process assessment methods. The second is made up of limitations specific to the new approach.

General limitations:

- The feasibility of the assessment is directly dependant on the quality of the process model. Aspects of this quality are for instance the correctness, consistency and completeness of the model. In order to avoid poor model quality, additionally acquisition guidelines must be defined in advance and used during the modelling stage.
- Even if the assessment is applied on adequate process models, it showed that the found results can be just regarded as hints on possible weak points. Found weaknesses like redundant information objects can be already known and even intended.

Specific limitations:

According to their reasons, the limitations in this group can be further divided into the following sub-groups:

- Limitations due to the implementation-specific meta-model: The meta-model describes the relationships between the elements of one sub-model and also between the elements of different sub-models. It defines details like directions of associations and cardinalities. However, the meta-model must be translated into a machine-useable form before it can be used to build a model repository which can be queried for assessing its details.
- It showed that the implementation puts strict restrictions on the associations within the meta-model. In consequence, not all necessary views could be generated by the latter prototype. Although improvements were applied relatively easy on the theoretic meta-model, several views could not be generated because the required associations could not be implemented.

Limitations due to the expressiveness of views:

- In contrast to the previous one, this limitation is not caused by missing elements or associations. It rather means that some quality checks require process details that cannot be represented in form of a view (i.e., combining independent details in a matrix). An example for this limitation is for instance the criterion “adaptability & extensibility” which belongs to the aspect “quality of integrations”.
- Limitations due to the validity or rather adaptability of the used criteria: This is one of the most essential limitations to probably any assessment method. In case of the MedFlow approach especially those criteria that deal with the quality of documentation point to this kind of limitation (e.g., “accuracy” or “reliability”). Their checks mostly require the utilisation of the content of model elements. An implementation of methods for assessing these checks is hardly possible.
- On the other hand, the contribution of these checks to a meaningful assessment of the process quality is vague. It must be further examined in more detail for each of the affected criteria.

The approach is suitable for assessing aspects dealing with the quality of processes. Further, the media type information and the defined storage states within the information model support the basic assessment of the information object life cycle. In contrast, the approach lacks in the assessment of content-related or organisational issues. These include criteria like efficient staff employment, efficient communication or accuracy of information objects.

Discussion and conclusion

This paper deals with a newly developed method which is meant to supports the structured assessment of clinical processes. However, the main focus lies on the strengths and limitations of this approach: An own core model is used to integrate four sub-models with each concentrating on distinct aspects of a process (i.e., control flow, data flow, tool usage, organisational information). In order to assess the quality of a process, selected elements of at least two sub-models are combined in a matrix. Weak points are then detected by applying specific rule-sets on these views. Each rule-set represents a pattern of critical cross-points which are searched for in the appropriate view-matrix. A main component of this assessment approach is the structured catalogue. It contains essential quality criteria, according weak points and appropriate quality checks (see Table 3 in result section for a list of quality aspects and criteria).

The experiences presented in this paper result from the evaluation of the new method. In this evaluation the method was applied on the sufficient complex process of ordering radiological examinations (as observed in the University Hospitals of Innsbruck, Austria).

The limitations of the approach can be separated into general and approach-specific: The general limitations are common to all model-based assessment approaches. The feasibility of this kind of assessment directly depends on the quality of the process model. Thus, poor model quality aggravates the detection of possible weak points.

Limitations specific to the selected approach can be summarised as follows: The underlying architecture of the new assessment method (i.e., the core-model) is based on an integrative meta-model. The implementation of this meta-model has put restrictions on the possible associations. Therefore, not all quality checks could be implemented. Further, some quality checks required process details which cannot be represented in form of a view. In turn, other quality criteria within the structured catalogue required the examination of the content of process elements (e.g., content of information objects). Their implementation – as far as possible – would mean big efforts. However, the degree of contribution of these checks is still to determine.

The strengths of the presented approach can be summarised as follows: It is flexible in usage - new quality checks can be defined easily on the basis of available process details. It provides a structured way to assess clinical processes - all relevant quality checks are registered in the structured catalogue. Thus, none of the checks are skipped during assessment. Overlooking and understanding the results is facilitated - the assessment results just contain those details that are relevant for the specific quality check. Because the structured catalogue also defines which details are needed to check the existence of weak points it can be also used as a guideline for the process assessment with other BPR tools. Moreover, it can be seen as a set of requirements for the development of new BPR tools.

It turned out that the presented approach is best used to assess clinical processes regarding their control flow (i.e., the sequence of involved activities - including control elements like associations, conjunctions and disjunctions) and information handling. The latter represents criteria like “efficient information processing”, “appropriate amount of tools”, “controlled data transmission within processes” or “availability of information objects”. The information-handling deals with the acquisition of new information objects (e.g., final report or ordering of examination), their manipulation and storage. The correct handling of information objects directly influences the quality of communication between involved actors or hospital departments. This in turn is essential for good treatment processes.

The presented approach could help to improve the documentation and communication within clinical processes. This also includes the involved infrastructure in terms of logical tools (e.g., software applications) and physical tools (e.g., server). Therefore, further developments should concentrate on these aspects. After this, the resulting method could be used to derive performance indicators, e.g. by analysing the result-sets for critical patterns. Tools which will be implemented on the basis of this approach could be used in scope of the strategic and tactical information management.

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Applications of Data Mining in Healthcare

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Abstract

In this paper we discuss the use of data mining in many areas of Healthcare such as the treatment effectiveness, healthcare management, customer relationship management and the fraud and abuse detection.

Keywords:

data mining, healthcare informatics

Introduction

Healthcare is one of the world fastest growing industries and profession [7]. One of the main objectives of a healthcare organisation is its ability to obtain, store, analyse and be able to utilise data across the whole organisation effectively. The growth of databases in healthcare practices and researches are evident in the large number of claims databases, registries, electronic medical record databases, disease surveillance systems, and ad hoc research database systems. Pattern-identification tasks such as detecting associations between certain risk factors and outcomes, ascertaining trends in healthcare utilisation, or discovering new models of disease in certain population rapidly becoming striking. As Healthcares emphasise on high level decision making from the collected current and historical data for identifying useful trends and creating summaries of the data, query languages written for databases alone are not able to handle that. In order to effectively use the available data, advanced data analysis techniques such as data mining are required. Data mining (DM), also known as knowledge discovery in databases, has been successfully deployed to find trends and patterns of interest in many domains [8]. This paper explores applications of data mining to Healthcare in areas such as the evaluation of treatment effectiveness, management of healthcare, customer relationship management and the detection of fraud and abuse.

Data mining in clinical care and customer services areas

Data mining is increasingly being used to determine the diagnosis and the most suitable treatments that should be prescribed. It assists (1) to study what factors may interfere with a drug, for example high-fiber foods can interfere with the absorption of certain antidepressants and heart medicines [3], (2) to examine between allergies and a disease to find most effective treatment [10], (3) to correlate the presence of one set of symptoms with another set of symptoms in a diagnosis by analyzing the outcome [12], (4) to find common symptoms to aid diagnosis of an outbreak so that prevention can occur before the outbreaks, and (5) to identify chronic diseases such as who are the high risk patients and how to reduce their number of hospital stay and claims [5]. Data mining techniques can establish the behaviour patterns relevant to a disease. This helps administrators to determine the optimal lengths of hospital stay for specific diseases and to establish best practices for treating diseases [6].

Predictive modeling is immensely useful in predicting the cause of a disease and determining effective treatments based on many known inputs. For example to analyze what symptoms are responsible for thrombosis attacks (blood clots in the heart), a data mining algorithm examines the conditions pre and post the attacks of many patients. Information like: changes in lab results over time, patient demographics, thrombosis diagnosis symptoms leading to thrombosis and other collagen diseases; are extracted from clinical databases. The extracted patterns such as “high APPT levels are 80% responsible for thrombosis” help in interpretation of the patient profile. The accuracy for these kinds of predictions is reported as being above eighty percent [2].

Health Geomatics helps decision makers and service planners to understand the relationship between location and healthcare services [1]. Data mining can be used to evaluate the geography of diseases and healthcare resource utilization. The geography of diseases covers exploration, modeling spatiotemporal incidences of diseases and generating hypotheses of new disease. It helps to identify diseases that occur in a particular area. Health care institutions can then use this information to implement preventative schemes to reduce an outbreak. The information provided to health care officials is more powerful than any spreadsheet database table because it helps to discover new knowledge. Additionally, various information can be integrated to aid health related analysis, this includes: population (census and socioeconomic data), environmental and ecological data, topography, hydrology and climate data, health infrastructure (data on mortality, morbidity, disease distribution and health care facilities) and data needed to perform different types of health related analysis.

Data mining is also been used in modelling and analysis of complex data sets such as genome to understand the human genetic structure [4]. The pattern recognition of a cancer cell based on the genes with the use of predictive data mining technique helps physicians to build more precise treatments. Data mining programs can analyse data at a rate and level of complexity that is impossible to do with other methods. For health care professionals, disease progression is an example where sequence based data mining algorithms may be used. Attributes such as how the viruses or cancer cells spread, the different stages, symptoms etc are taken into consideration while analyzing the path of progression. The sequential patterns helped to determine which organ the disease is likely to spread to or confined to an organ according to the endpoint in the sequence generated.

To improve the clinical and management decision support, the health care industry is increasingly using data mining to determine health policies and priority areas, to coordinate care trials and in improving customer relationship management. Many hospitals have been applying DM techniques to the patients' survey collected. The results give hospitals the knowledge on patient requirements so that they can tailor services to suit patients' needs [9]. Predictive DM is also being used to match the clients' need with a suitably qualified staff member in a home-based health care environment by a health care agency where the coordinator had to match manually otherwise after receiving the request [11].

Application of DM techniques has also been used in financial areas of the healthcare organisation such as fraud detection and monitoring of cost and resources. Association rules are used for analysing the relationships among people, departments and organizations in health informatics A Health insurance organization can benefit from applying association rules to analyze their patient claims, in particular with the steady rise in health-care costs and the growing urgency to control these costs. For example, association rules can be used to detect patterns in ordering pathology services and the claims made by the patients. For example if a patient claims "test-B with test-C, there will be a 92.8% chance that a test-A would also be claimed". The Insurance company can use association rules to prevent fraud and inappropriate practices of requesting or providing services which are unreasonable, unnecessary or excessive (e.g., indiscriminate ordering of blood tests).

Conclusion and future trends

Over the past decade, data mining has been increasingly utilised by many major health institutes. Healthcare organisations have come to realisation that data, stored in the form of databases, are not being used to their maximum capability. Data mining methods are required for decision-making thus assuring quality healthcare. Data mining helps healthcare insurers to detect fraud and abuse; healthcare organisations in customer relationship management decisions; physicians to identify effective treatments and best practices; and patients to receive better and more affordable healthcare services.

The future of data mining in the field of healthcare is still an emerging process. Many aspects of data mining need to be introduced. One cannot depend entirely on a data mining output because its incorrect interpretation of the data can be a matter of life and death. The post-processing in which the outcomes are evaluated should be in depth. Alternative measures such as sensitivity, specificity, post-test probability and misclassification cost should also be considered when evaluating the quality of data mining outcome in a medical domain.

Dealing with more comprehensive data such as ultrasound images, temporal data and mixed data types, is a key direction for the future. In particular, when we have large datasets that contain rare events (temporal sequences), it is due to the risk factors that a straightforward application of data mining might not be able to identify frequent patterns of discovery such as low occurrence rate of adverse drug reactions or biomedical fluid flows during respiration.

Incorporating any associated knowledge from multiple locations significantly increases the efficiency of the mining process and the quality of the knowledge discovered. In particular, there is a wealth of information exists on Internet for medical domain. The mining process should take advantage of existing information in real time while making decision. A standard format for communication also needs to be devised such as XML. Research has shown that the better and improved results are achieved when combined the results of many DM algorithms and operations. Currently, each algorithm produces output in its own format. The integration takes extra processing. When the inputs to and outputs from a model uses the same expression language such as XML, the integration process will be easier.

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Applications of Data Mining in Healthcare

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Introduction

- Healthcare is one of the world fastest growing industries and profession [7].
- One of the main objectives of a healthcare organisation is its ability to obtain, store, analyse and be able to utilise data across the whole organisation effectively.
- The growth of databases in healthcare practices and researches are evident lately.
- Pattern-identification tasks such as detecting associations between certain risk factors and outcomes, ascertaining trends in healthcare utilisation, or discovering new models of disease in certain population rapidly becoming striking.
- Healthcares emphasise on high level decision making from the collected current and historical data for identifying useful trends and creating summaries of the data, query languages written for databases alone are not able to handle that.

Introduction

- In order to effectively use the available data, advanced data analysis techniques such as data mining are required.
- Data mining (DM), also known as knowledge discovery in databases, has been successfully deployed to find trends and patterns of interest in many domains.
- This paper explores applications of data mining to Healthcare in areas such as the evaluation of treatment effectiveness, management of healthcare, customer relationship management and the detection of fraud and abuse.

Data mining in clinical care

- Data mining is increasingly being used to determine the diagnosis and the most suitable treatments that should be prescribed.
- It assists
- (1) to study what factors may interfere with a drug, for example high-fiber foods can interfere with the absorption of certain antidepressants and heart medicines,
- (2) to examine between allergies and a disease to find most effective treatment,
- (3) to correlate the presence of one set of symptoms with another set of symptoms in a diagnosis by analyzing the outcome,

Data mining in clinical care

- (4) to find common symptoms to aid diagnosis of an outbreak so that prevention can occur before the outbreaks
- (5) to identify chronic diseases such as who are the high risk patients and how to reduce their number of hospital stay and claims.
- (6) to establish the behavior patterns relevant to a disease. This helps administrators to determine the optimal lengths of hospital stay for specific diseases and to establish best practices for treating diseases.

Data mining in customer services areas

- To improve the clinical and management decision support, the health care industry is increasingly using data mining to determine health policies and priority areas, to coordinate care trials and in improving customer relationship management.
- Many hospitals have been applying DM techniques to the patients' survey collected. The results give hospitals the knowledge on patient requirements so that they can tailor services to suit patients' needs.
- Predictive DM is also being used to match the clients' need with a suitably qualified staff member in a home-based health care environment by a health care agency where the coordinator had to match manually otherwise after receiving the request.

Data mining in customer services areas

Billing claims and fraud detection

- Application of DM techniques has also been used in financial areas of the healthcare organisation such as fraud detection and monitoring of cost and resources.
- Association rules are used for analysing the relationships among people, departments and organizations in health informatics.
- A Health insurance organization can benefit from applying association rules to analyze their patient claims, in particular with the steady rise in health-care costs and the growing urgency to control these costs.

Data mining in customer services areas

Billing claims and fraud detection

- Association rules can be used to detect patterns in ordering pathology services and the claims made by the patients.
- For example if a patient claims “test-B with test-C, there will be a 92.8% chance that a test-A would also be claimed”.
- The Insurance company can use association rules to prevent fraud and inappropriate practices of requesting or providing services which are unreasonable, unnecessary or excessive (e.g., indiscriminate ordering of blood tests).

Summary

- Over the past decade, data mining has been increasingly utilised by many major health institutes.
- Healthcare organisations have come to realisation that data, stored in the form of databases, are not being used to their maximum capability.
- Data mining methods are required for decision-making thus assuring quality healthcare.
- Data mining helps
  - healthcare insurers to detect fraud and abuse;
  - healthcare organisations in customer relationship management decisions;
  - physicians to identify effective treatments and best practices;
  - and patients to receive better and more affordable healthcare services.

Reality

- The future of data mining in the field of healthcare is still an emerging process.
- One cannot depend entirely on a data mining output because its incorrect interpretation of the data can be a matter of life and death.
- The post-processing in which the outcomes are evaluated should be in depth.
- Alternative measures such as sensitivity, specificity, post-test probability and misclassification cost should also be considered when evaluating the quality of data mining outcome in a medical domain.

Future

- Dealing with more comprehensive data such as ultrasound images, temporal data and mixed data types, is a key direction for the future.
- In particular, when we have large datasets that contain rare events (temporal sequences), it is due to the risk factors that a straightforward application of data mining might not be able to identify frequent patterns of discovery such as low occurrence rate of adverse drug reactions or biomedical fluid flows during respiration.
- Incorporating any associated knowledge from multiple locations significantly increases the efficiency of the mining process and the quality of the knowledge discovered.
- In particular, there is a wealth of information exists on Internet for medical domain. The mining process should take advantage of existing information in real time while making decision.
- A standard format for communication also needs to be devised such as XML. Research has shown that the better and improved results are achieved when combined the results of many DM algorithms and operations. Currently, each algorithm produces output in its own format. The integration takes extra processing. When the inputs to and outputs from a model uses the same expression language such as XML, the integration process will be easier.

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Efficiency and Safety of New Radiofrequency Identification System in Japanese Hospital

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Abstract and objective

Radiofrequency identification (RFID) uses radio-frequency tags attached to people or objects to provide identification, tracking, and security under the general heading of automatic identification. New RFID system (UHF band, 953 MHz) has been available since April, 2005 in Japan. We tested efficiency and safety of new RFID system in our hospital. Electric fields produced by new RFID had no significant effects on cardiac pacemakers, implantable cardioverter defibrillators (ICD), and other medical devices(ex. Electrocardiogram recorder, cardiac monitor, intra-aortic balloon pumping, infusion pump, and respirator) in our hospital. New radiofrequency tags seemed to provide extensive patient identification and to track capital equipments within our hospitals. Healthcare systems today are increasingly complex and interrelated processes, while new RFID technologies will provide opportunities for enhanced patient care and safety in Japanese hospital.

Keywords:

cardiac pacemaker, implantable cardioverter defibrillators, healthcare, patient safety

Introduction

Radiofrequency identification (RFID) has recently begun to receive increased interest in supply chain, in order to increase the efficiency and visibility of material and information flows. RFID may address to improve safety and increase in productivity. New RFID system (UHF band, 953 MHz) has been available since April, 2005 in Japan. However, there has been no attempt to determine whether electric fields produced by new RFID can influence cardiac pacemakers, implantable cardioverter defibrillators (ICD), and other medical devices in our hospital. We further examined to track new IC tags attached to people and medical equipments in hospitals.

Our data may provide the potential benefits, the area of applications, and the corresponding strategies of RFID in hospital environments.

Methods

We examined effects of RFID system on 7cardiac pacemakers and 5 ICDs in 0.18 % salt solution, similar electric condition to human body. The experimental conditions for interference induced by RFID were between a homogeneous electric field perpendicular to the area formed by the antenna and radio-frequency tags.

We next tested whether Electrocardiogram (ECG) recorder, ECG monitor, intra-aortic balloon pumping (IABP), infusion pump, and respirator in our hospital could work normally under new RFID system.

Furthermore, we evaluated to track new IC tags attached to people and medical equipments in our hospital.

Results

Electric fields produced by RFID had no significant effects on cardiac pacemakers. The RFID systems did not interfere with ICDs.

ECG recorder, ECG monitor, IABP, infusion pump, and respirator were worked normally under operation of RFID systems.

Radiofrequency tags attached to people and capital equipments within our hospitals provide more extensive identification than traditional bar coding can. New RFID tags increased read accuracy, even with the tag placed on metallic objects. However, the read range seemed to be reduced from an average of 2.5m.

Conclusion

RFID may be ultimately used for many of the functions currently carried out using bar coding if the cost of RFID comes down. Healthcare systems today are increasingly complex. RFID is a technology that will have a profound impact on effective and safe patient care in Japanese hospitals in near future.

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A Comprehensive Health Information System to Support Health Promotion and Disease Prevention in Japan

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Abstract

The Japanese Ministry of Health, Labour, and Welfare intends to reform the health promotion and disease prevention system in 2008. We are developing a comprehensive health information system that will support health examination, health education, and outcome assessment in compliance with the newly-proposed national guidelines. The system adopts a state-of-the art secure communication protocol - TCP2, which will enable information sharing based on personal identification and hardware- and software-independent security.

Keywords:

health information system, internet, health examination, health education, outcome assessment, Japan

Introduction

In order to promote the prevention of cardiovascular diseases, the Japanese Ministry of Health, Labour, and Welfare intends to reform the health promotion and disease prevention system in 2008. Under the new system, medical insurance organizations will be responsible for providing annual health examination and health education for every insured person aged 40 years and implementing outcome assessment. They fervently hope for a comprehensive health information system because they will have to deal with health information that is collected from various sources (Figure 1).

In 2006, we established a university-industry collaboration project with the aim of developing a comprehensive health information system to support health promotion and disease prevention in Japan (J-CHIS).

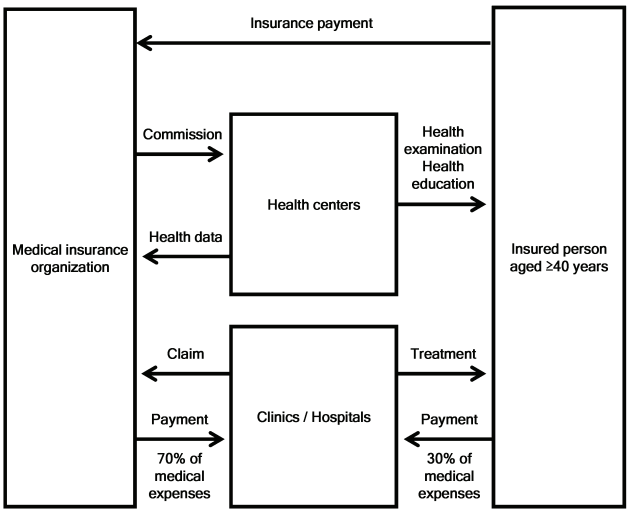

Figure 1 - Overview of the public health system in Japan

Methods

The J-CHIS is designed to support health examination, health education, and outcome assessment in compliance with the newly-proposed national guidelines (available for download at http://www.mhlw.go.jp/bunya/kenkou/seikatsu/index.html).

Results and discussion

The J-CHIS consists of three components - health data, health education resources, and medical insurance data (Figure 2). Health data shown in Table 1 are collected from health centers where the insured people receive health examination and health education. Notice that each medical insurance organization will commission more than one health center to provide health examination and health education for the insured people, and health examination and health education for each insured person will possibly be conducted at different health centers. Health education resources include information about health promotion and

disease prevention and instruction materials that are useful for health education at health centers or at home. Medical insurance data are collected from clinics and hospitals where insured people receive medical treatment, as part of the procedures for payment of medical expenses.

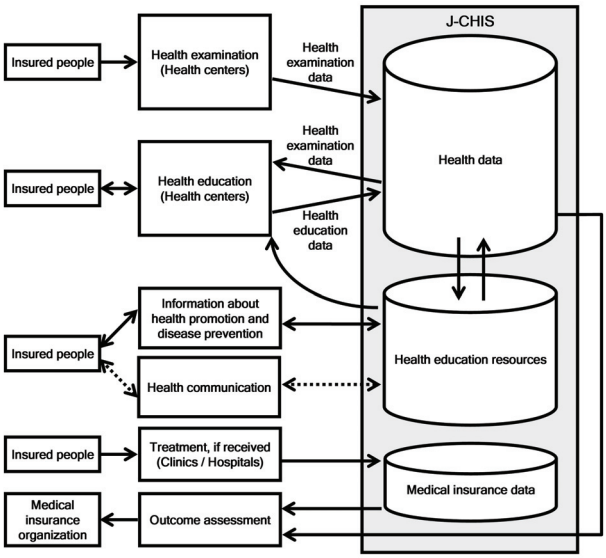

Figure 2 - Overview of the J-CHIS

Table 1 - Health data

Health examination
Height, Weight, BMI, Waist circumference, Blood pressure, Blood glucose, HbA1c, LDL, HDL, Triglyceride, AST, ALT, GT, Urinalysis, Smoking habit, Medication
Health education
Participation in health education sessions, Goal setting

The users will access each component through the Internet. Communication on the Internet is timely and easily accessible, but data on the Internet is vulnerable. The J-CHIS requires vigorous security measures to preserve strict privacy. Moreover, the components of health data and health education resources will be accessed by various people from various places using various computer hardware; insured people will check their own health data and seek information about health promotion and disease prevention; health center staff will input and check their clients' health data and use instruction materials for health education at health centers. It is difficult to prepare specific software that is usable under such wide variety of circumstances. In order to deal with these problems, the J-CHIS adopts a state-of-the-art secure communication protocol - TCP2 (developed by T.T.T. kabushikikaisya, Tokyo, Japan; available for download at http://www.tttnet.ne.jp/tcp2.html). TCP2 performs encryption, certification, key switch, and firewall on the fourth (transport) layer of the Open System Interconnection (OSI) reference model (Figure 3). The use of TCP2 makes it possible 1) to identify the person who accesses the system, 2) to establish secure communication independent of hardware and software, and 3) to build strict privacy and security measures into the system. Information sharing based on personal identification and hardware- and software-independent security will be realized in the J-CHIS.

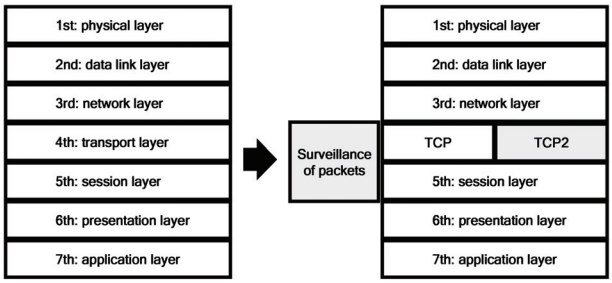

Figure 3 - TCP2

Conclusion

The J-CHIS will support health examination, health education, and outcome assessment in compliance with the newly-proposed national guidelines. It will contribute to promoting the Japanese health promotion and disease prevention system by information sharing based on personal identification and hardware- and software-independent security.

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A Comprehensive Health Information System to Support Health Promotion and Disease Prevention in Japan

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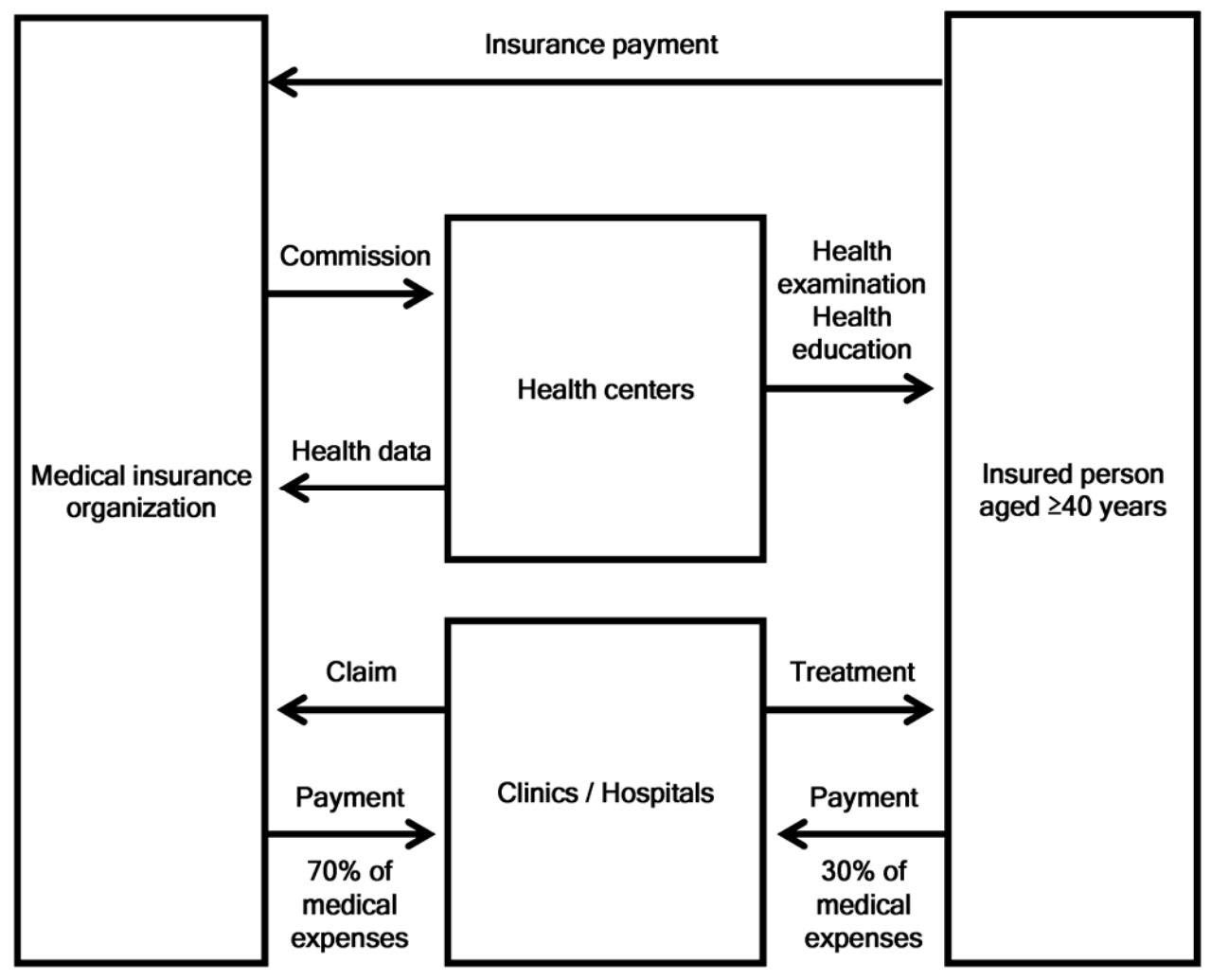
Background

- The Japanese Ministry of Health, Labour, and Welfare intends to reform the health promotion and disease prevention system in 2008.
- After the introduction of the system, medical insurance organizations will be responsible for providing annual health examination and health education for every insured person aged ≥40 yrs and implementing outcome assessment.
- And they will have to deal with health information that is collected from various sources (Figure 1).

Figure 1 – Public health system in Japan



Objective

- In 2006, we established a university-industry collaboration project with the aim of developing a comprehensive health information system to support health promotion and disease prevention in Japan (J-CHIS).

Methods

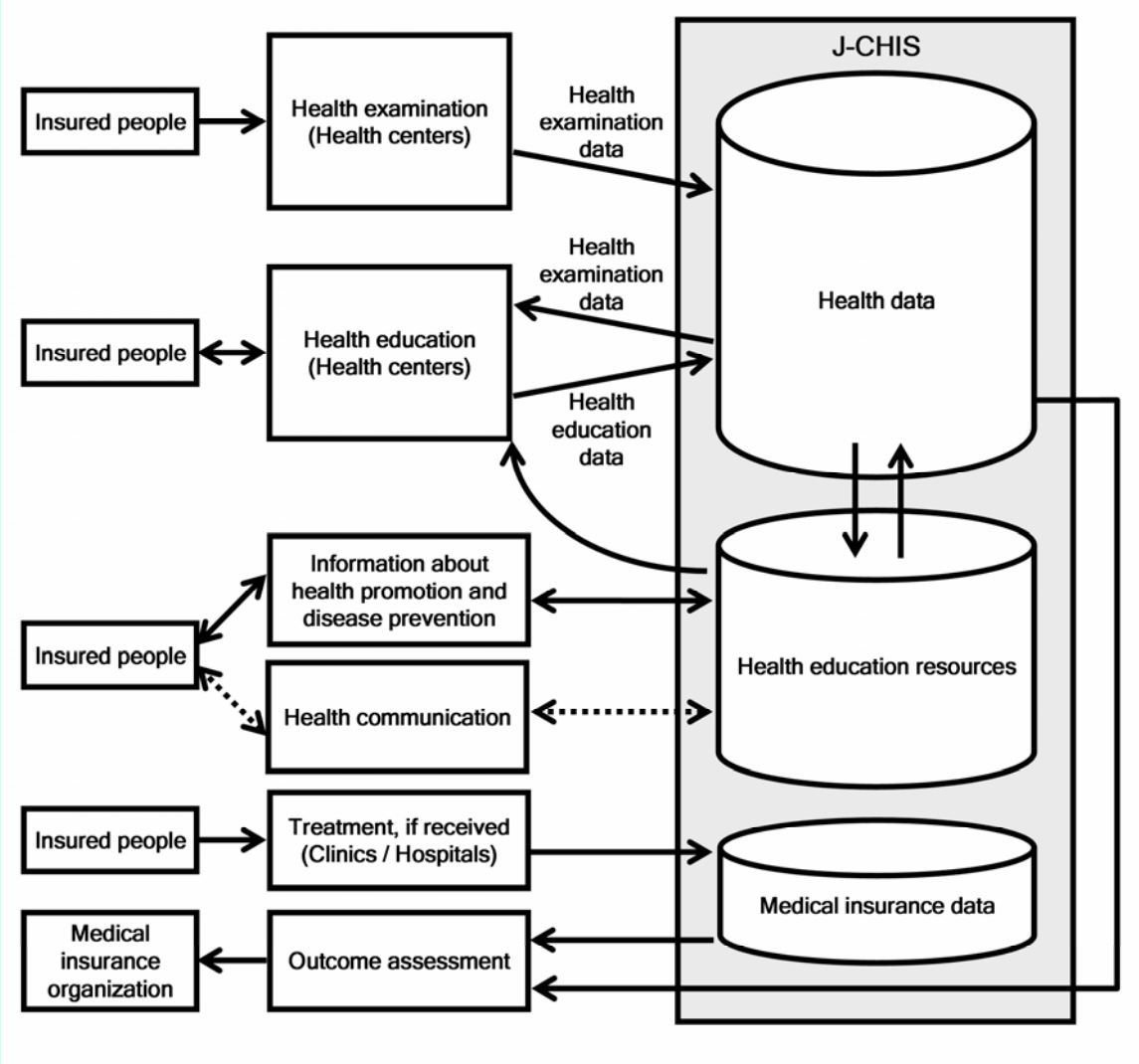
- The J-CHIS is designed to support
  - health examination
  - health education
  - outcome assessment

  in compliance with the newly-proposed national guidelines (available at http://www.mhlw.go.jp/bunya/kenkou/seikatsu/index.html).

Overview of the J-CHIS

- The J-CHIS consists of 3 components (Figure 2):
  - “Health data” are collected from health centers where the insured people receive health examination and health education.
  - “Health education resources” include information about health promotion and disease prevention and instruction materials.
  - “Medical insurance data” are collected from clinics and hospitals where insured people receive medical treatment.

Figure 2 - The J-CHIS



Problems to be solved

- The users will access each component through the Internet.
  - Communication on the Internet is timely and easily accessible, but data on the Internet is vulnerable.
- The components of health data and health education resources will be accessed by various people from various places using various computer hardware.
  - It is difficult to prepare specific software that is usable under such wide variety of circumstances.

Breakthrough

- The J-CHIS adopts a state-of-the-art secure communication protocol - TCP2 (developed by T.T.T. kabushikikaisya, Tokyo, Japan; available at http://www.tttnet.ne.jp/tcp2.html).
- TCP2 performs encryption, certification, key switch, and firewall on the 4th (transport) layer of the Open System Interconnection (OSI) reference model.

Effectiveness of TCP2

1) to identify the person who accesses the system
2) to establish secure communication independent of hardware and software
3) to build strict privacy and security measures into the system

Information sharing based on personal identification and hardware- and software-independent security will be realized in the J-CHIS.

Conclusion

- The J-CHIS will support health examination, health education, and outcome assessment in compliance with the newly-proposed national guidelines.
- And it will contribute to promoting the Japanese health promotion and disease prevention system by information sharing based on personal identification and hardware- and software-independent security.

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A Web-based Data Visualization System to Present Infectious Disease Surveillance Data

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Abstract

Based on the Japanese infectious disease surveillance scheme, weekly or monthly reports on infectious diseases are collected from all over the country. We have developed a Web-based data visualization system to make the infectious disease surveillance data more comprehensible for medical personnel. The main feature of the system is that it automatically generates Flash animation by using the collected numerical data which visualizes the time series and spatial shift of the case incidents of disease simultaneously on the home page. This system can provide support for medical personnel to grasp the trend of infectious diseases morbidity and to warn them of any impending outbreak of the diseases.

Keywords:

web-based system, infectious diseases, flash animation

Introduction

The Japanese infectious disease surveillance scheme has been established to detect infectious disease outbreak in early stage, to identify the causative viral strains and to rapidly assess related morbidity and mortality. Based on this schemes, information gathered weekly or monthly on infectious diseases are collected from assigned hospitals or clinics and distributed by print or by home page through the Internet. Because the information reported on the home page is usually numerical data or simple graphic chart, it is difficult for medical personnel to grasp the trend of infectious disease morbidity all over the country. To make a scheme function well, it must provide a good representation of the results of the surveillance [1]. We thought that an animated representation of the data would be a useful way to visualize the time series and spatial shifts of the case incidents of disease simultaneously. However, it is time consuming task to generate animation based on the numerical data gathered weekly or monthly. So, we have developed a web-based data visualization system which can automatically generate Flash animations or graphic images and can visualize time series and spatial shifts of case incidents of disease simultaneously according to the numerical data collected on the home page.

Methods

The operating system used is a Windows2000 Server with Apache 2.0 and MySQL 4.1 as the Web server software and the database management system, respectively. PHP4 was used as a server-side script language and Flash Action Script (FAS) was also used to create animation. The hardware in use for the server is an IBM PC compatible computer with Pentium 4 processor, 512MB of RAM, 80 GB hard discs and 100 base-T network interfaces. Figure 1 shows a block diagram of the server computer setup.

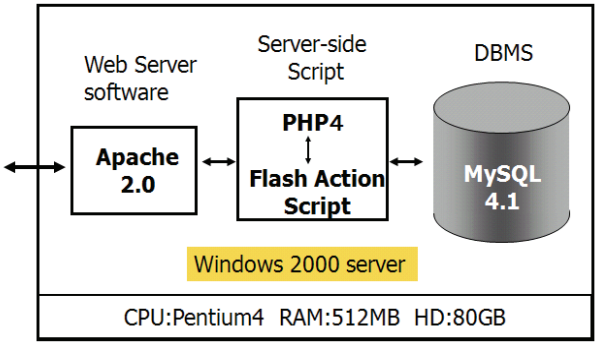

Figure 1 - A block diagram of the server computer setup

The procedure for presenting the animation or graphic image is as follows:

1) the PHP4 server-side script interprets the query keys' input in the request form and retrieves suitable data from the database;
2) the server-side script then passes the data to FAS and FAS automatically generates Flash animation according to the data passed;
3) besides the animation, the PHP4 server-side script automatically generates graphic image file, such as PNG format file, using the data retrieved;
4) Apache sends the Flash animation or image file to the client computer;
5) and the clients' browser displays the animation or image.

A pilot version of this system is usable as a hyperlink at http:// infectsrv2.med.tottori-u.ac.jp/infectious/itis3.html.

Results

At this time, the information stored in the database system is 1) data related to 47 prefectures in Japan and 2) 21 administrative medical districts on the island of Hokkaido, the largest prefecture in Japan located off the northernmost tip of the main island. In case 1), epidemic parotitis data from January 1990 to October 2006 was collected and reflects about 80,000 cases. Case 2) represents epidemic parotitis and measles data collected from January 1990 to February 2007 and reflects about 18,000 cases. This system can present the following three kinds of animation or graphic image:

1) Flash animation simultaneously showing geographical and progressive changes in morbidity throughout the country (Fig. 2): as soon as the start button is clicked, the animation starts and each prefecture is classified into five color coded levels, showing the intensity of the epidemic, which change accordingly as the time progress;
2) A three dimensional bar chart showing annual weekly series rates of occurrence in each prefecture (Fig. 3): The x-axis and y-axis reveal annual weekly periods (1 year is shown as 52 weeks) and rates of occurrence in each prefecture, respectively;
3) A map chart showing the morbidity of any arbitrary 4 consecutive weeks in Hokkaido (Fig. 4): the map shows the intensity of the epidemic of each 21 administrative medical districts by color coding.

Discussion

To make the surveillance scheme function well, it is important to provide a good representation of the data collected in compliance with users' requests. It has also been mentioned that two kinds of output are useful for monitoring the morbidity of epidemic disease: time series of incidents of cases and spatial spread of infectious disease incidents [2]. Our system can visualize time series and spatial shifts of the case incidents of disease simultaneously as images or animations on the home page. Because the animation generated is in Flash movie format, almost any browser can show it. The system can provide support for medical personnel to quickly grasp the trend of infectious diseases morbidity and to warn the general population of any impending outbreak of diseases. We believe this makes infectious disease surveillance data more easily comprehensible for medical personnel.

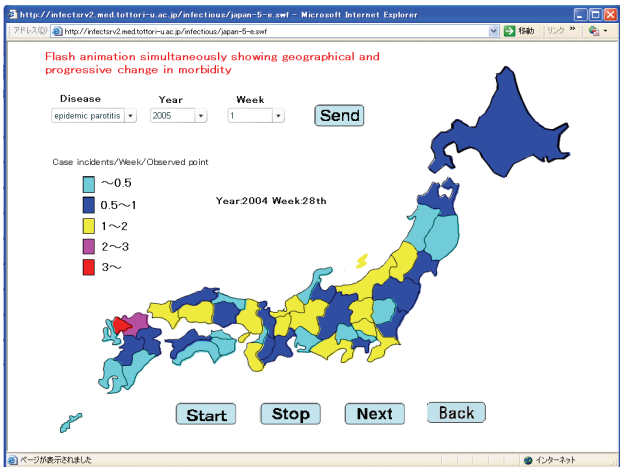

Figure 2 - Flash animation simultaneously showing geographical and progressive changes in morbidity

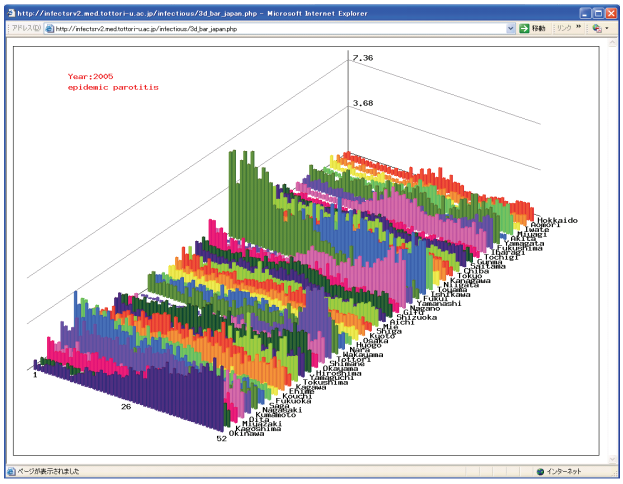

Figure 3 - A three dimensional bar chart showing annual weekly series rates of occurrence in each prefecture

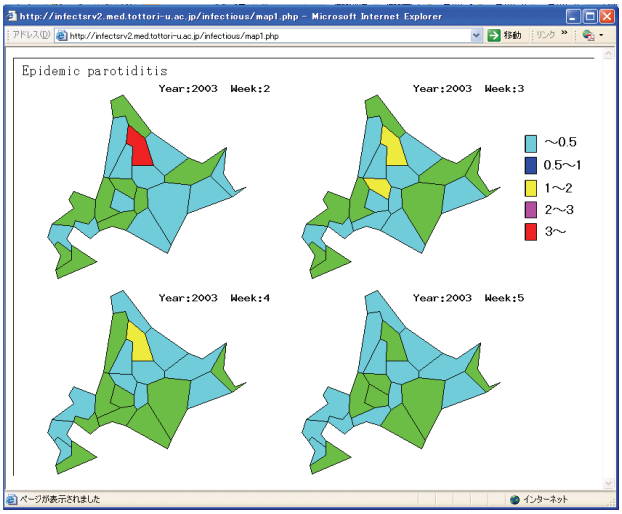

Figure 4 - A map chart showing the morbidity of any arbitrary 4 consecutive weeks in Hokkaido

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Applying Clinical Ontology for Biomedical Information Retrieval

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Abstract

Information retrieval (IR) is a technology to help people find information, however it is hard to formulate information need into just a few words. In order to solve this problem, we adopted knowledge ontology in the IR process to design a query expansion. We implemented three IR models, Vector Space Model (VSM), Hidden Markov Model (HMM), and Topical Mixture Model (TMM) and evaluated these models with and without ontology-based query expansion. In conclusion, TMM has the best performance and people who are not familiar with specific domain knowledge, the ontology-based query expansion can help them generate queries and obtain relevant information.

Keywords:

ontology, information retrieval, Vector Space Model, Hidden Markov Model, Topical Mixture Model

Introduction

Due to the advancement of computer technologies, tremendous volumes of biomedical data have been digitized. In order to retrieve useful information from these data, the development of intelligent information retrieval (IR) methods becomes more important. In most IR systems, term matching is a common approach; however no searching result can be obtained if query terms are not found in the system lexicon. For biomedical professionals, they know what keywords can be used to find correct information; for people who don't have enough knowledge, it is difficult to obtain accurate information by using inappropriate keywords. Thus, we developed an ontology-based query expansion adopted in three IR models, Vector Space Model (VSM), Hidden Markov Model (HMM), and Topical Mixture Model (TMM) and evaluated the performance of these IR models with and without ontology-based query expansion.

Methods

Information Retrieval Model

Vector Space Model

Each document, D_i, is represented by a feature vector, $\overrightarrow{D_i}$; each component, $g(t)$, in the vector is associated with the statistics of a specific index term, t,

$$g(t) = \left(1 + \ln\left(c(t)\right)\right)\ln\left(N / N_t\right) \tag{1}$$

where $c(t)$ denotes the occurrence count of term t within document D_i, and the logarithmic operation is used to compress its distribution. The term weighting scheme, $1+ln(c(t))$, is a variation of conventional schemes. N_t is the total number of documents in the collection in which the specific indexing term t appears, and N is the total number of documents in the collection. A query, Q, is also represented by a vector, $\vec{Q}$, in which every component is a word in the query. The cosine measure is used to estimate the relevance between query Q and document D:

$$R(Q,D) = \cos(\vec{Q},\vec{D}) = \left(\vec{Q} \bullet \vec{D}\right) \Big/ \left(\left\|\vec{Q}\right\| \cdot \left\|\vec{D}\right\|\right) \tag{2}$$

HMM/N-gram Model

In our implementation of the HMM/N-gram model, each document is composed of a mixture of N-gram distributions, which can be represented as a special case of HMM. The N-gram distributions are estimated on the basis of frequency of words or word pairs occurring in documents and are smoothed using linear interpolation with background unigram or bigram language models estimated from a large outside text corpus. In this study, we only implemented HMM/Unigram model. For example, given a query Q and a document D, the relevance measure for the HMM/Unigram model can be expressed as:

$$P\left(Q|D\right) = \prod_{n=1}^{N}\left[m_1 P\left(q_n|D\right) + m_2 P\left(q_n|Corpus\right)\right] \tag{3}$$

where $P(q_n|D)$ is the unigram probability of a index term q_n within the document D and $P(q_n|Corpus)$ is the probability of an index term q_n within the large corpus. Weighting parameters, m_1 and m_2 are summed to one and tied among the entire document collection. They are opti-

mized using the expectation-maximization (EM) algorithm.

Topical Mixture Model

Each document D_i is interpreted as a mixture model and a set of k latent topical distributions characterized with unigram language modeling are used to predict the input query words and each of the latent topics is associated with a document-specific weighting parameter.

$$P(Q|D_i) \approx \prod_{n=1}^{N} \sum_{k=1}^{K} P(q_n|T_k) P(T_k|D_i) \quad (4)$$

where $P(q_n|T_k)$ is the probability of the query word q_n occurring in a specific latent topic T_k, and $P(T_k|D_i)$ is the posterior probability of the topic T_k conditioned on the document D_i, with the constraint $\sum_{k=1}^{K} P(T_k|D_i) = 1$. The key idea of TMM is that the relevance measure of a query word q_n and a document D_i is not calculated directly based on the frequency of q_n occurring in D_i, but instead based on the frequency of q_n in the latent topic T_k as well as the likelihood that D_i generates the respective topic T_k.

Query expansion based on the ontological structure

The SARS ontology, which was developed by referring to biomedical literatures, medical textbooks, and MeSH was used to designed an ontology-based query expansion: First, synonyms of query words are extracted from a synonym database as additional query words. Then if a query word is matched in the ontological term, its precedent parent node terms, its sibling node terms, and its descendant child node terms are also extracted as additional query words. In addition, the synonym extraction procedure is carried out again to find synonyms of the extracted ontological terms. Finally, the original query is expanded to a vector that includes SARS related words and corresponding weightings.

$$\{(q_1, W_1), (q_2, W_2), ..., (q_k, W_k), ...(q_n, W_n)\} \quad (8)$$

Results

We defined two retrieval modes, ontology-based mode and keyword-based mode for evaluation of IR model with and without ontology-based query expansion. The values of precision for the three IR models are shown in Table 1. In both retrieval modes, TMM has the best performance than the other IR models. In general, the values of precision of ontology-based mode are always lower than the keyword-based mode.

Table 1 - Values of precision of three IR models

IR Model	VSM	HMM	TMM
Keyword-based	0.5047	0.4896	0.7346
Ontology-based	0.4798	0.3631	0.6544

The interpolated recall-precision curves of three IR models in the ontology-based mode are shown in Figure 1. Except for recall level 0, the precisions of TMM are much higher than those of VSM and HMM. The patterns of the recall-precision curves of these models are different: TMM curve is concave downward and VSM and HMM curves are concave upward. This means the acceleration of decrease in precision with increase in recall of TMM is negative and those of the other two models are positive. Usually, the models are operated in the range of low recall values; therefore, TMM is the best model we should choose for the reason that it's curve slope in that range is the lowest among the three models.

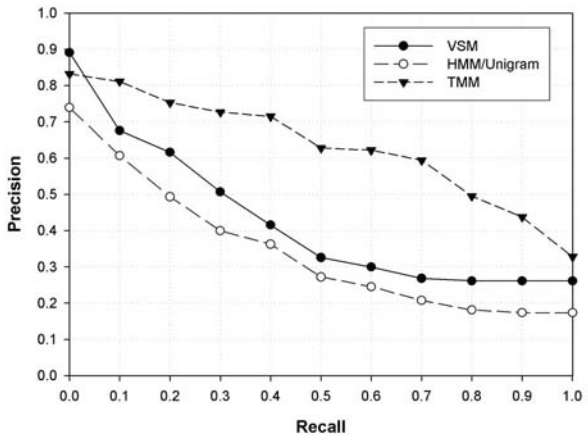

Figure 1 – Interpolated recall-precision curves of VSM, HMM/Unigram model, and TMM with ontology-based mode

Discussion

The value of precision of TMM in both keyword-based and ontology-based retrieval mode is much higher than other IR models. In Figure 1, the interpolated recall-precision curve of TMM is more stable than others. Thus the performance of the ontology-based query expansion is the best when it is applied to TMM. Relevant information is required to train TMM, however it is usually unavailable at beginning of building an IR system. An alternative way is that using VSM or HMM to develop the IR system and logging user's queries and reviewed documents. Then we can establish relevant information according to searching logs for training and updating model parameters. In addition, people usually review only top 10 or 20 records from searching results. For VSM and HMM, precision at recall level 0 is greater than 0.7 in the ontology-based mode. Therefore the performances of VSM and HMM are good enough when people only review preceding retrieval results.

Conclusion

We used ontological structure to design query expansion and applied it to three IR models. The evaluation results showed that the performance of TMM is better than other two IR models in both keyword-based and ontology-based retrieval mode. In practical use, we conclude that for users who are familiar with specific knowledge, using keyword-based method to obtain more precise information; otherwise, using ontology-based query expansion to generate queries and find relevant information.

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IT Strategies for Sustainable Healthcare Systems: Case Studies

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Abstract

In this paper the challenge of sustainable healthcare has been addressed by examples of intelligent cost-effective IT solutions multiplying human capabilities in three different directions. Intelligent monitoring improves the frequency and depth of patient surveillance without any hotelling expenses. The NEUROWEB project is promising an accelerated knowledge acquisition at the frontline of neurology and genomics, hopefully leading to personalized and optimal treatments. Brvain bioelectrical imaging provides a novel low-cost, high spatio-temporal resolution technology of brain studies which directly address the physical phenomena behind the neural activity. Case studies outlined emphasize specific features essentially contributing to sustainability.

Keywords:

brain mapping, patient-monitoring, telemedicine, information distribution, genomics

Introduction

It is generally agreed that the steadily growing expenses of healthcare cannot be stopped without intelligent solutions saving manpower in routine procedures of care or without well organized knowledge centers efficiently disseminating validated information between specialists, or without equipments with improved diagnostic capabilities. A further aspect of the design of sustainable systems is the involvement of new technologies like mobile phones, internet, etc. The case studies shown below provide examples with obvious benefits in this direction.

Materials and methods

In sustainable healthcare systems patients and medical doctors should benefit for a long run from the application of Information Technology. Improved diagnostic procedures, easy and continuously updated knowledge management,, solutions for home care are just some examples. In the followings, we briefly discuss three example projects applying state-of-art IT.

General frame of a cardiovascular tele-monitoring system

Telemedicine provides a cost-effective and comfortable means of medical care [1, 2]. There are several Tele-Monitoring Systems (TMS) that can receive ECG and other signals via various telecommunication connections. In the usual setup, a portable device records and stores the measured electrical signals which are transmitted via modem-based digital links [3], fax [4], or phone [5] to a workstation. After signal processing, the results can be displayed, or printed for human evaluation.

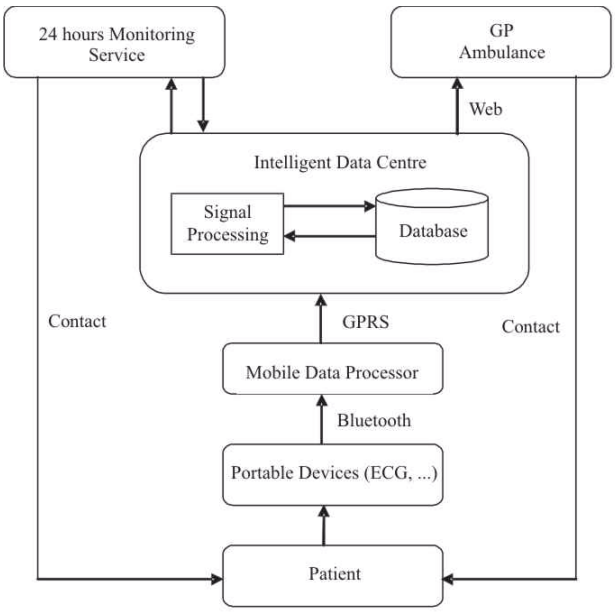

Figure 1 - The TMS architecture

The architecture of our TMS is shown in Fig 1. The monitoring procedure starts at the Monitoring Service by recording a sample of 12-lead ECG measurements. Our methods use these ECGs as baseline measurements. Later on, a portable 3-lead ECG (I, II, V2) device is used to monitor the patients in their home and to transmit the ECG results via Bluetooth to a mobile phone, which forwards them to a data centre. The ECG sampling rate of the device (300Hz, 600Hz) and duration (30 sec., 60 sec.) can be changed remotely from the Monitoring Centre at any time. The portable ECG recorder is shown in Fig 2. If needed (e.g. in the case of electrode reversal), an automatically generated warning SMS and/or e-mail is sent to the patient. Then an AI expert system evaluates the results, and if needed an alarm signal and the related actual and the previously collected trend data are sent to the 24-hour

Monitoring Service. An alarm signal is an indicator of a significant change in a clinical parameter (or parameter vector). The final medical diagnosis is to be drawn by the cardiologist at the Monitoring Centre. To avoid frequent false alarms, special attention was paid to the personalized analysis of significant and malignant changes in the monitored parameters.

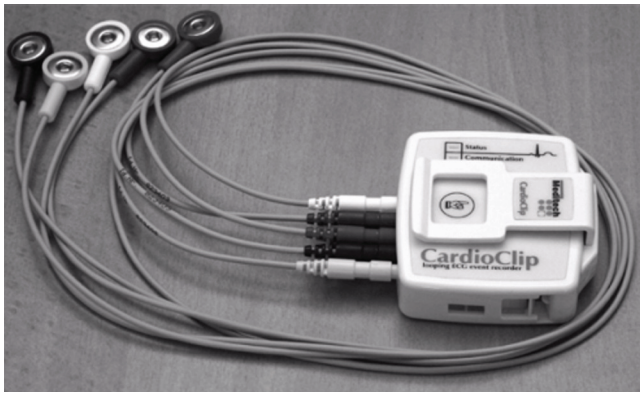

Figure 2 - The mobile ECG device

Intelligent solutions

We added three intelligent features to enhance the TMS, electrode reversal detection, personalized evaluation and lead reconstruction (not detailed in the paper).

Electrode reversal detection. The 3 signal electrodes and the fourth ground electrode can be placed in distinct 24 configurations, out of which only one is correct. This error is often made by inexperienced users. The correlation between reversed and normal (correctly placed) signal morphology is examined in all the 24 cases. We use linear discriminant analysis to decide whether the electrodes were reversed or not. If there is an incoming home measurement in the Intelligent Data Center, the algorithm systematically generates the 18-element vector based on the incoming recent measurement and the baseline measurement stored in the database. In case of interchange the patient will be notified with a warning SMS or/and email to check the placement of the electrodes.

To test the method, we used a training sample of 598 ECG records (60 sec., 1KHz, 3-lead) in each group. The testing sample included 65 ECGs in each reversal group (60 sec., 600Hz, 3- lead) and a single baseline measurement (60 sec., 600Hz, 12-lead) for each subject. The linear discriminant analysis revealed that out of the 65 properly placed ECGs 64 were correctly classified, which means 98.4% sensitivity. In 14 reversed groups the sensitivity was at least 90%, in 4 group the sensitivity was between 80% and 90% and in 3 groups the sensitivity was lower than 80% (51% worst case). Out of the 1495 interchanged ECGs 1316 were classified correctly, which means 88% specificity.

Personalized evaluation. A new learning type interpretation algorithm was developed to make the evaluation system personalized. The method calculates the personalized decision thresholds for several P, Q, R, S, T wave-parameters of the patient. If any of the ECG parameters of the incoming measurements exceeds the decision threshold, then a significant change in that ECG parameter is assumed to be present. At first threshold calculation is based on published standard deviations representative on the whole population. Based on home/monitored signals the thresholds are gradually adapted to the patient monitored.. After 100 home measurements the threshold is calculated exclusively from the patients' own measurements. This algorithm automatically considers both long term ECG variability and small, habitual electrode misplacement errors

The Tele-Monitoring System is currently being implemented as an application for monitoring persons under extreme working conditions. The implementation supports further monitored signals like temperature, blood oxygen level and acceleration.

Advanced knowledge dissemination: The NEUROWEB project

NEUROWEB is a startup European research project in the Sixth Framework Program of the European Community, aiming to integrate and share knowledge and information in neurology and neurosciences. The project is led by the National Neurological Institute "Carlo Besta" of Milano, Italy. The consortium has four IT companies, five academic institutions, one governmental body and four neurological/stroke clinics in Italy, Hungary, Netherlands and Greece. The project runs from mid-2006 to 2008 and the expected outcome is an internet-based software framework that allows:

- the integration into a single virtual database the clinical and genetic databases of the 4 participating clinical centres, which are different in structure, language, territorial area and pathologies of interest;
- to query also the databanks present on the web containing human polymorphism profiles in normal and pathological populations.

For the professional user, the system provides the following main functions:

- Clinical diagnosis validation based on Clinical Protocol Paths. This means that the system will search for cases with a similar anamnesis and medical data using a pre-defined set of clinical protocols. Similarity analysis will be based on standard data mining tools and on a reference ontology that connects the various databases. of the clinical partners (ontology driven reasoning). See Clinical Engine and Semantic Engine in Fig. XX..

- Genomic Polymorphic Analysis. It will be possible to inspect a patient's genomic status against the state-of-art in Genomic Research to contrast genomic and clinical data. (Genomic Engine in Fig. XX) The genomic engine will mine public genomic databases in order to extract (and continuously update) a collection of polymorphisms related to the pathologies of interest; then it will cross-check these polymorphisms against the available genomic information concerning specific patients.

Special system components will automatically search available public databases and other resources and offer new scientific results that bear importance for a given case.

We plan to support "learn by search and example": an IT architecture which will remember users experience and offer the capability to verify existing Patient Records (Clinical and/or Genomic data) by new experimental Clinical Protocol Paths.

The architecture of the planned system with the Semantic, Clinical and Genomic Engines is shown in Fig. 3.

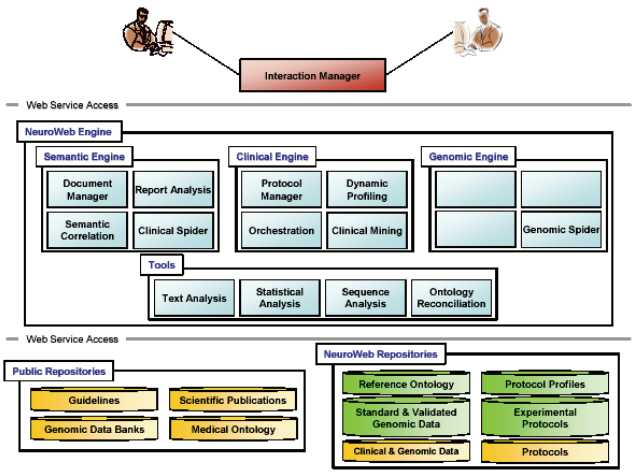

Figure 3 - The NEUROWEB architecture

The protocol manager will enable users to define, modify, store, retrieve according to criteria defined by clinicians and execute clinical protocols. Moreover, it will support the definition of new experimental protocols that can be defined and statistically validated by the NEUROWEB system. Protocol execution will rely on a protocol enacter that orchestrates and invokes remote web services, and a clinical miner that supplies the functionalities to extract data from the clinic databases involved in the project.

The Semantic Navigator, joined to a Text Miner, will support intelligent searches on distributed databases of clinical cases, with direct reference to the information stored in the Patient Records, through a unified interface shielding the user from the details of organization specific implementation. The Clinical Miner will learn the issued meta-queries and also rank them.

The whole system will also include:

- A tele-consulting system based on discussion forums. Each thread in discussion forms should be linked to a case, a query (several cases) or to a protocol. Users should be able to retrieve past discussion on the basis of queries, cases, and protocols.
- A front-end for the MEDLINE database, enabling to associate clinical papers to queries. Users should be able to navigate from cases and workflows to relevant literature, and vice versa. Associations should be established in a manual manner by clinicians.

The first results of the project are expected by mid-2007.

Elaborating new modalities: The BEM project

The BEM project's (Brain Electro-Mapping) aim is to create a system that with the modeling involved takes the challenge of creating a high-resolution mapping method that is able to show the possible changes in brain function after a stoke incident at the level of bioelectric equivalent sources. The investigation of brain plasticity requires the highest possible resolution available. The main goal is to create a cost-effective alternative to current solutions (fMRI, PET) that is comparable to those in spatial resolution, while significantly better in temporal resolution, allowing a rather accurate characterization of within brain communications. This project if financed by the Government of Hungary, runs from mid-2004 to mid-2007.

A high percentage of the stroke affected patients (over 70%) tend to recover from their state through a healing, functional regeneration process (this property of the brain is called plasticity). To understand this process and extend our current knowledge we develop a brain source mapping and imaging modality which could intensely help doctors at supporting and accelerating the process by therapy, and could validate drug effects promising this speed-up. The system presented herein solves the inverse EEG problem taking EEG measurements to calculate bio-electric activity at cortical level. The problem is solved using the mathematical description of bio-physical processes. Figure 4 presents the tasks of such a system, the process of EEG-based brain mapping.

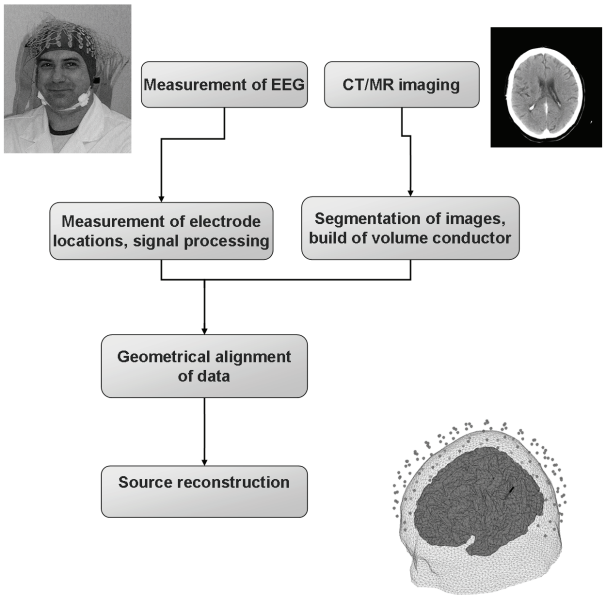

Figure 4 - The BEM architecture

Surface Laplacian maps One of the other methods the project is to utilize is the surface Laplacian maps. This method calculates cortical radial currents based on the EEG (scalp recorded potential-distribution). This method has high importance and tradition in medical analysis of brain activity, therefore this was the first stage of our modeling. Figure 5 presents images created by the linear Laplacian operator.

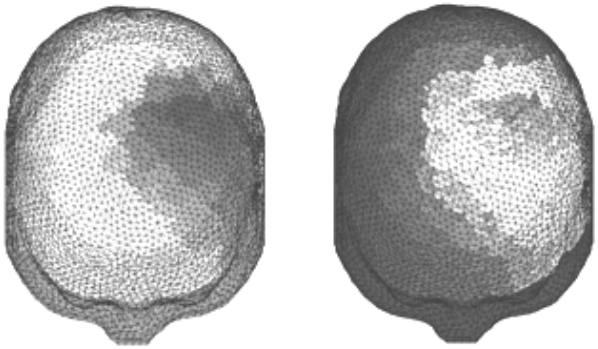

Figure 5 - Potential (left) and Surface Laplacian (right) maps in a finger tapping experiment

Analysis of error As currently there exist no study that investigates plasticity in these matters, it is only presumed that it requires the millimeter-precise recovery of neural brain activity. Similar studies involving the estimation of brain activation casuality underline this thesis [7, 8, 9, 10, 11]. The effectiveness of such a system is dependent of the resolution it is able to reach, therefore it is important to investigate the factors that affect it. In this analysis the following factors are considered:

- parameters describing the geometry of the volume conductor (the model representing the head and the brain)
- conductivity parameters of the volume conductor
- noise arising at EEG measurements
- possible errors entering the system at electrode positioning.

According to results of analysis a source localization error of under 2mm for near cortical sources would need an EEG measurement SNR of 20dB or higher and uncertainties of at most 1mm rms in electrode placement. Tests revealed, that localization error reacts sensitively to changes in conductor geometry parameters, but allows for an under 1mm localization error with errors of 5% in conductivity parameters.

Results

The paper briefly described three projects currently being implemented at the University of Pannonia, Veszprem, Hungary. Results achieved so far were discussed above, new results are expected particularly from the startup projects. We believe that the application of such IT based intelligent solutions is the only way of making our healthcare systems in the long run sustainable.

Acknowledgments

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The iAccess Handbook: A Methodology for Access Control Integration

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Abstract

Health care information about a patient is usually scattered among several clinical systems - potentially more than a hundred separate systems just within one hospital. System integration and interoperability is difficult to achieve, and various strategies for integration exist. However, one topic that has not received much attention is how to integrate system specific security mechanisms such as access control. This paper presents the iAccess handbook, which is a tool to aid this process. It consists of a repository of reference information and a set of methods for collecting information and presenting results, and concerns the legal, organizational and technological aspects of integrated access control for health information systems. The methods have been applied on two separate integration efforts in Norway.

Keywords:

access to information, information protection, computer security, medical records

Introduction

In this paper we present the iAccess (*Integrated Access Control for Health Care Information Systems*) handbook which is a tool to be used during planning, designing and describing access control for integrated health care solutions. The handbook consists of a repository of reference information and a set of methods for collecting information and presenting results.

The methods have been applied on two separate integration efforts in Norway.

Methods and results

The iAccess handbook

The purpose of the iAccess handbook is to serve as a collection of information and methods that are useful and appropriate when integrating the access control of heterogeneous health care information systems. The handbook itself is web-based, and both readable and editable for registered users, such as people from health care organizations, researchers and students (doctoral fellows primarily). The handbook has been created using the free MediaWiki software package[1], which allows easy publication and development of content in a collaborative setting. The following sections will briefly explain the main contents from each of the three parts of the handbook.

Handbook part 1: Reference information

For the reference part of the iAccess handbook, we have borrowed the concept of viewpoints from the software architecture field - specifically from *IEEE 1471-2000 Recommended Practice for Architectural Description of Software-Intensive Systems* [1]. We have defined three viewpoints; *legal, organizational and technical*. These viewpoints were selected in recognition of the fact that access control is not merely a technical issue. Organizational measures are important in enforcing access control and ensuring patient privacy. The legislation defines *if*, *how* and *when* sharing of sensitive health information can take place.

Handbook part 2: Survey methods

This part of the handbook defines a set of survey methods, and we will here briefly present the main ones and discuss our experiences with them.

Study of documentation

From studying documentation you can learn a lot about an organization and/or a system that will be useful when working with access control integration, and also for planning workshops and interviews (see the following sections). There are certain kinds of documentation with relevance for access control, which should be present in a health care organization, and we recommend focusing on the following: organizational information security policies, organizational structure - including roles and responsibilities for information security, organization-level access control policy, strategies - for instance integration strategy, high-level system documentation, description of implementation and use of access control mechanisms, requirements with respect to identification, authentication and authorization, risk analysis based on system security and patient safety.

Different organizations have different types of documentation. The results from a documentation study greatly depend on the organizations studied. It can be just as interesting to see what kind of documentation exists, as to study

1 MediaWiki is a free software wiki package originally written for Wikipedia, see http://www.mediawiki.org.

the actual content. If the anticipated documentation does not exist, asking for it still serves a purpose by making the organization aware of what information could be expected to be present.

Process workshops

Our process workshop is based on the methodology defined by Dingsøyr et al in [2]. The purpose of the process workshop is to get input from a heterogeneous group of people that are involved in a given process. In other words: While documentation can provide information about how something is supposed to be done - the process workshop conveys information about how it is actually done.

During a process workshop, the participants are presented a scenario, and then each one writes down keywords related to activities, participating roles, documentation and tools that are used to solve the scenario. This is done in the same way as a traditional brainstorming session. After this, the workshop participants gather around a process map and eliminate/add/reorganize the notes on the map until they have reached a version of the process description that they can all agree upon, as shown in Figure 1.

Semi-structured interviews

Semi-structured interviews [3] are used to gather detailed information to complement and elaborate the process descriptions obtained in the workshops. This is be done by using a set of pre-defined questions (an interview guide), but allowing the interviewees to answer freely - there are no categories to select from and the interviewees are allowed to ask questions. An interview guide should start by explaining the interview motivation, and briefly explain the relevant terms. The interview guide should be based on the process maps.

Handbook part 3: Combining and presenting results

This part of the handbook describes how to combine and present the results from the survey methods. The most promising technique is the use of an extended version of UML[2] activity diagrams for modeling the process descriptions and information related to processes. An UML activity diagrams is well suited for describing processes and activities, both related to human and system behavior, because of a visual organization that is easily understandable by most people.

Discussion

The original reason for creating the iAccess handbook was to have an instrument for surveying and documenting real-life access control integration efforts of health care systems in Norway.

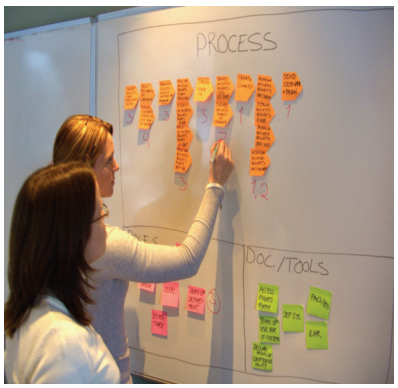

Figure 1 - Creating the process map by using sticky notes and active discussions

The results so far have mainly been used by the health care organizations themselves and by doctoral fellows researching how technical, legal and organization challenges should be solved. A survey gives a snapshot of today's situation, what has improved from the past and what is planned in the near and distant future. Just as interesting, some improvements may be negative for the majority of the users, and it is important to share that kind of information with the rest of the community in order to avoid reoccurrence.

Conclusion

We have presented the iAccess handbook, which consists of three parts relevant for analyzing planned or existing efforts for access control integration for health care systems. Representing multiple views from various stakeholders in unified diagrams eases the understanding on how things are and what should be done. The methods in this paper are first and foremost qualitative, and our future work will add methods that provide more quantitative results.

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2 The Unified Modeling Language, see http://www.uml.org

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An Concern-Oriented and Ontology-Based Approach to Constructing Informational Facets of Clinical Trials

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Abstract

The complexity of the clinical trial (CT) process involves high investments in the research of a new drug or procedure. To reduce costs and enhance the research quality more and more activities in the CT process need an IT support. To develop efficient automated solution first a conceptual modeling step should be carried out. To model the CT research partitioning criteria of the CT conceptual domain are required.

The main objective of our research is to identify effective partitioning criteria for modeling the CT research.

A concern-oriented analysis method for developing information systems is applied. The method uses the concerns of various stakeholders of the CT research for partitioning the CT conceptual domain in stakeholder-oriented subdomains. Mental representations description of stakeholder's beliefs and knowledge related to each concern are identified and on their basis, a concern-oriented ontology of the CT can be created.

Facets of the CT future information system are created based on the CT domain ontology. In this paper, an example of how such facets can be constructed for the subject selection section of the CT protocol is presented.

Keywords:

clinical trial, selection criteria, ontology, modeling, concerns

Introduction

The complexity of the clinical trial (CT) process involves high investments in the research of a new drug or procedure. The great amount of workload required to carry out a CT research as well as the request of high quality in data gathering and processing have led to increase the ICT support. To reduce costs and enhance the research quality many software products are available on the market (for example, CRF (Case Report Form) gathering and processing, electronic data capturing, Clinical Trial Management, Clinical Data Management, etc.). The current trend is to expand the ICT support and automatize as many as possible activities in the CT process. But some CT activities as protocol authoring [1], [2] remain largely manual because are highly creative and intensely knowledge-based.

The paper presents a method to interpret CT protocols which allows us a more systematic approach for automatizing of the protocol writing process.

Our solution is founded on the assumption that any automatization is based on an accurate conceptual model of the reality to be automatized. In the CT case many efforts were done to model the CT universe [3]. Generally, conceptual modeling requires partitioning the reality domain under study in loosely coupled parts and for each part a successive partitioning to be carried out until the resulting parts can be easily described. Finding suitable partitioning criteria is a challenge for any system analyst especially when the system under study is a complex one, as in the case of clinical trial.

Our method claims that the partitioning criteria are tightly related to the stakeholders' concerns in developing, operating or evolution of the information system (IS).

In the paper [4] we identify four perspectives from which an IS can be developed: social, functional, informational and technological. In this paper, we present the result obtained from the informational perspective. In this perspective, an IS is viewed as a distributed repository of data, information and knowledge that is used by the business agents.

Our concern-based approach allows us to divide the conceptual universe of the CT in a systematic manner. In this way an ontology of CTs information system can be constructed [5] and on its base we may construct facets of the IS of the future clinical trial, as we defined and exemplified in this paper.

Ontologies

An ontology is a formal specification of the intent of concepts and the intensional relationships that can exist between concepts. Using logical axioms, it is a declarative model of a domain. As a formal system, an ontology allows us to build proofs of assertions viewed as theorems or conclusions. In respect to other models, ontologies allow accurate expression of meaning of models.

According to Guarino's definition, "An ontology is a logical theory accounting for the intended meaning of a formal vocabulary, i.e. its ontological commitment to a particular conceptualization of the world" [6]. A conceptualization is

a set of conceptual (intensional) relations defined on a domain space [6].

In our research we use DOLCE (Descriptive Ontology for Linguistic and Cognitive Engineering) [7] with its extension D&S (Descriptions and Situations) [8] as a "foundational"[1] ontology where we "plug in" our ontology. DOLCE is an ontology of particulars, in the sense that its domain of discourse is restricted to particulars[2]. We adhered to the DOLCE+D&S ontology because: a) DOLCE captures the ontological categories belonging to natural languages and human commonsense; b) being a formal ontology [6], DOLCE and D&S precisely define its notions and relations used; and c) DOLCE and D&S contain all categories and relations we need for writing our ontology.

Concerns

In [9] we defined the concept of *concern of a stakeholder* (briefly *concern*) as a problem-related care of one or more stakeholders involved in the construction or operation of an information system in its natural environment.

Ontologically, a concern is a state of mind arising from preoccupation or interest in a problem that the stakeholder identified in the real world. In our case the stakeholder's interest derives frequently from a need or from his/her responsibility in the IS evolution process, but can also originate in a desire or another interest.

As it is known, on the one hand, in the process of development of an IS, the stakeholders are people who are directly or indirectly affected by it. On the other hand, they influence the system development and/or use. Examples of such stakeholders are direct users, managers of users, management staff members, customers, suppliers, internal departments that support the project, financial departments, and so on.

The problem specification is the pair: a) initial state description (of the current situation, as the stakeholder perceives it) and b) final state description (of the situation that matches expectations, interests, or desires of the stakeholder). These two elements are respectively considered as hypothesis and conclusion of the problem specification. If grouped with the role of the stakeholder who manifests interest or preoccupation about the problem, this pair becomes the high-level specification of a concern that the stakeholder will try to solve. We consider a problem's initial state containing all data, information, and knowledge necessary to obtain the final state of the problem.

In the case of CTs, applying the informational perspective with the objective of identification of subjects' selection criteria, the writing committee has nine concerns. For instance, the high-level specification of one of these concerns is presented in the Table 1.

Tabel 1 - The high-level specification of a concern

C4	*Name*: Care to find how the clinical manifestation of the disease is related to the objectives attainment and the selection criteria identification	
	Problem	*Hypothesis*: Following information is available: trial objectives, trial design, statistical considerations; previous CT projects and their scientific results
		Conclusion: How the disease in the stage treated in the study will be tested in order to get the diagnostic?
		What basic characteristics (gender, race, life expectancy, performance status) have the study population affected by the disease?
		How the clinical manifestation of the disease might affect the safety of the subjects and the attainment of the objectives?
		What particularities of the disease are important for the identifying the selection criteria?
		How the pathogenesis of the disease might affect the general clinical state of the subjects and the inferring of the selection criteria?
	Stakeholders: Writing committee	

In our approach, each concern has associated a rationale that we explain it in the next subsection.

Concern rationales

We define the concern's rationale a cluster of concepts and their conceptual relations used for the concern solving. In other words, the concern's rationale describes the semantic domain which the stakeholder should manage in order to solve the concern.

The concepts of such a rationale come from informal descriptions of the mental representations of the beliefs of the stakeholder (-s) during the concern's life cycle. The beliefs represent convictions a stakeholder holds for true in a given situation, independently of the nature of the source

1 A foundational ontology characterizes general terms (e.g. entity, event, process, spatial and temporal location) and basic relations (e.g. part-of, qua-lity-of, participation, dependence).

2 Particulars are entities that cannot have instances that are individuals, whereas universals represent ideas or abstract entities which can have instances.

of the conviction: either from perception or an inference from previous knowledge, or a verbally transmitted knowledge. Of course, a belief may be true for one or more stakeholders (thus a piece of knowledge for them), but false for others. When it is accepted as true by all of us (or in all possible worlds), it is a piece of general knowledge.

Regarding a concern, the beliefs to be considered are those associated to the concern's hypothesis and conclusion, but also those which represent milestones in the concern solving process, mainly the hypothesizes and conclusions of concerns the concern depends of. For instance, due to limited space, a belief and a piece of knowledge of the concern C4 are showed in the Table 2.

Table 2 - Mental representation descriptions of a piece of knowledge and a belief of C4

Code	Mental representation description in natural language
K1	The persons who have the disease in the stage considered by the study may be eligible
B10	The existence of the disease and its stage affect the life expectancy of a person

Methods

To obtain a multi-facetted ontology of an IS a concern-oriented method based on stakeholder analysis was proposed in [4] and [5]. The method has 12 steps: 1) identification of stakeholders; 2) identification of concerns; 3) concern classification; 4) identification of relations between concerns; 5) concern prioritization; 6) identification of rationales in concern specifications; 7) identification of the concepts used in the rationales; 8) ontological analysis of the intension of the concepts; 9) choosing a foundational ontology to be extended by our ontology; 10) classification of the concepts conforming the foundational ontology; 11) identification of conceptual relations in concepts' rationales; and 12) definition of the ontology using a formal logic language. The ontology we obtain with this method is structured according to stakeholders' concerns. Its components are vocabularies. In these vocabularies we find either specific and shared concepts. [5] presents how this method ws used to construct a domain ontology for CT subject selection criteria.

The method also includes guidelines for designing informational views of the IS under study from the obtained ontology. For this, other 3 steps should be added to the basic method: 13) construction of the UML ontological model of each piece of knowledge or belief; 14) construction of facets for each concern rationale; and 15) constructon of the informational view by grouping facets of some related concens.

Results

Views and facets

In our approach, a view is a model of an IS related to a particular, homogeneous from a logical point of view, set of concerns. The particularity is due to the fact that the concerns emerge from a particular perspective of the IS developing process: social, functional, informational, or technological. Therefore, depending on the perspective applied, we obtain social, functional, informational, or technological views. We consider the views as simplified models of the future or existing informational system. In this paper, we consider only the informational views.

In our approach an informational view is the structural model of the system to be modeled, basically a UML class diagram [10]. It contains the categories in the system's conceptual domain, their relations, as well as the constraints regarding the model interpretation. An informational view is a cluster of *facets*. Each facet is a simplified model of the informational view and represents a concern-driven projection of the informational view according to a stakeholder's point of view [11]. This point of view is shaped by the stakeholder's role or responsibilities in the future system, in this case, the CT information system. We can say that a facet describes the rationale of a concern. Technically, it is constructed according to a template that contains the following fields: the codes of the facet and concern, the dependency graph of beliefs and knowledge of the concern and the structure of the facet. The later is a UML class diagram that contains the concepts from CT conceptual domain and their ontological relations. In our approach, the structure of a facet is constructed on the basis of the UML ontological models of the knowledge and beliefs of a concern. In the followings, the UML ontological model is defined and some examples of such models are given.

UML ontological model

A UML ontological model is a class diagram that semi-formally describes the semantics of a piece of knowledge or belief of a concern's rationale. Such a model is constructed from the domain ontology of a CT information system by preserving its semantics. It uses concepts of the UML metamodel [10] like class, datatype, association, and dependence. In our research, we found that the correspondence between these concepts and the categories and conceptual relations of the domain ontology are expressed in the following rules:

- all categories of the domain ontology, excepting the abstracts, are mapped to classes; for instance, in the figures 1 and 2, all the categories from the CT domain ontology are mapped to classes.
- categories subsumed abstract category are eventually mapped to the datatype UML concept. As we know, a

data type is a type whose values have no identity [10]. For instance, in the Figure 3 the class AgeValue is a subclass of the AbstractRegion marked by the stereotype datatype, because the property doesn't carry an identity criterion, as it was defined by the methodology OntoClean [12]. In other words, knowing two occurrence of the same value of age they cannot be differentiated. But the time intervals can be differentiated after their duration and the time in which they occurred. That is why the TimeInterval class isn't marked with the stereotype datatype. In addition, TimeInterval is an association class is due to the fact that the corresponding ontological category participates in temporal ontological relations like *participateIn, sequences*, etc.

- all ontological relations, excepting parthood and constitution, are mapped in associations in UML ontological models. As it is known, an association is a relation that describes semantic connections between individuals that are instances of the given classes [10]. For instance, the *refer* association (Figure 1) between the classes DiseaseDescription and DiseaseState maps the ontological relation with the same name which denotes that the DiseaseDescription category, which is subsumed by the Description category, uses the course DiseaseStage, which sequences the referred perdurant DiseaseState.
- temporal and temporary parthood, also constitution relations are mapped in UML aggregation relations. For instance, the instances of the DiseaseDescription class contains as temporary part an instance of the DiseaseName class, but the later can appear in the CT objectives and also in the selection criteria of subject. As it is known, in the case in which the aggregate class has the responsibilities to manage its parts, the aggregation relation becomes a composition one [10].

In order to construct an UML ontological model of a piece of knowledge or belief, our approach proposes the applying of the abstraction mechanism and the following rules on its mental representation description in the natural language:

- if a concept from the mental representation corresponds to a category from the CTs domain ontology, we map this category and the category or categories from the foundational ontology which subsume it into the classes or datatypes. For instance, in order to construct the UML ontological model of the K1 (Figure 1), we applied this rule in the case of the categories Person, Disease, DiseaseStage, NewAdmissibleDiseaseStage and we add to the model the classes AgentivePhysicalObject, Process, Value.
- if a concept corresponds to a quality from foundational or CTs domain ontology, the model contains corresponding class and in addition the class or classes that map the category or categories in which the quality inheres in, because according to DOLCE, each quality is specifically and constantly dependent on the entity it inheres in [7]. For instance, in order to construct the UML ontological model of the B10 (Figure 2), we applied this rule in the case of quality LifeExpectancy and its quale, a value of Abstract Region category.
- in the case of a relation between two concepts, we check if it is an ontological relation. If so, we transform the relation into an UML one, according to the rules above enumerated.
- if the relation between two concepts, excepting the causality one, is not an ontological one, the CT domain ontology is traversed on the basis of the subsumption relation of the corresponding categories of concepts and, on the basis of the reasoning supplied by the ontology, we search the ontological relation that has the same meaning with the initial relation. For instance, in the K1 the relation *have* between Person and Disease is ontologically interpreted by the DOLCE relation of participation ("*x participates in y*" [7]) between those categories. That is why, in the UML ontological model of K1 the name of association between two classes is *participateIn*.
- the causal relation between two concepts is described in model by the dependence relation. For instance, the belief B10 supplies the meaning that the value of the life expectancy of a person depends on the stage of his/her disease. We show this semantics in the UML ontological model from the Figure 2.

In addition, in the UML ontological models of K1 and B10 we observe that these may contain incomplete information, namely those that are particular to the future CT. This information is described by subclasses whose names are prefixed by "New" or map categories from foundational or domain ontology, like AbstractRegion, Activity, and so on.

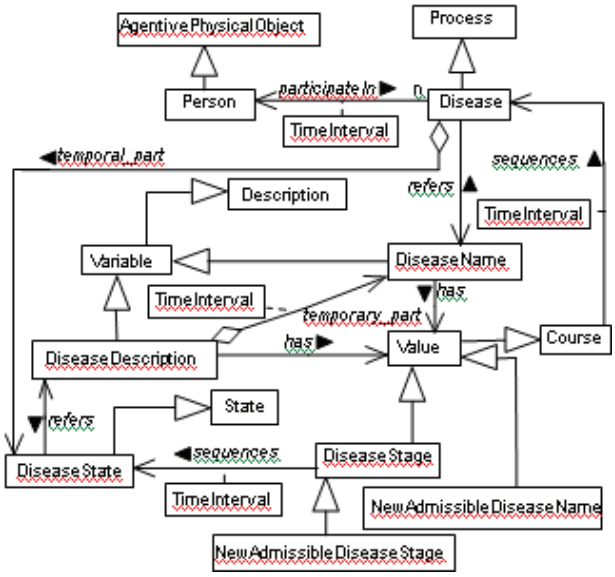

Figure 1 - The UML ontological model of K1

After we constructed the UML ontological models of beliefs and knowledge of a concern, we may construct its facet. In order to construct the facet structure, we again apply the abstraction mechanism on the UML ontological models and we take only the classes that will be part from the future informational system and the ontological relations between them. That is why the facet structure of the concern C4 (Figure 3) doesn't contain the classes that map the categories from the foundational ontology or other like Variable, Value, and so on, that is those have no direct correspondent in the future IS.

Discussion

In this paper, we showed the application in the case of CTs of a concern-oriented analysis method for developing information systems. The method uses the concerns of the writing committee for partitioning the CT conceptual domain in stakeholder-oriented sub-domains. Mental representations of stakeholder's beliefs and knowledge related to each concern are identified and on their basis, a concern-oriented ontology of the CT can be created.

Having the CT domain ontology, we showed how facets of the CT future information system could be created. In this paper, we give examples for a concern emerged from the need of identification of the subject selection criteria.

Some of the advantages supplied of our approach are: a) being a concern-oriented method, it allows to the system analyst to step by step resolve himself or with help of other stakeholders the concerns manifested by the stakeholders and identified from the perspectives of the IS developing. These facts also imply that the concerns of each stakeholder can be resolved in an independent way; b) by definition, the CT domain ontology can be reused in automatized constructing of the CT protocol; c) being constructed based on domain ontology, we think that facets can be automatically constructed using a software tool. In this way, the facets could be used as a verifying and validation tool of the beliefs and knowledge declared by the stakeholders of the future IS.

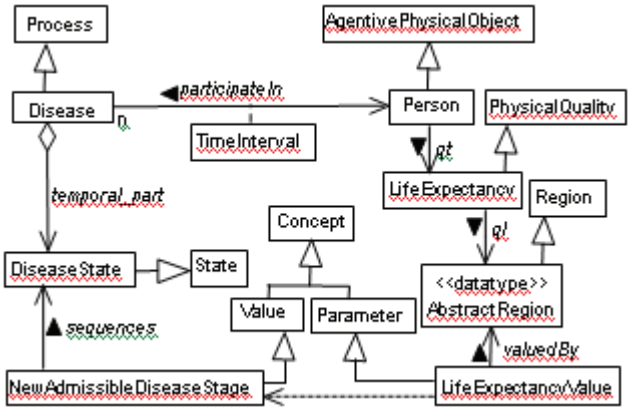

Figure 2 - The UML ontological model of B10

As future research we intend to identify the needed composition rules to construct the views of the information system, and in particular, of clinical trials.

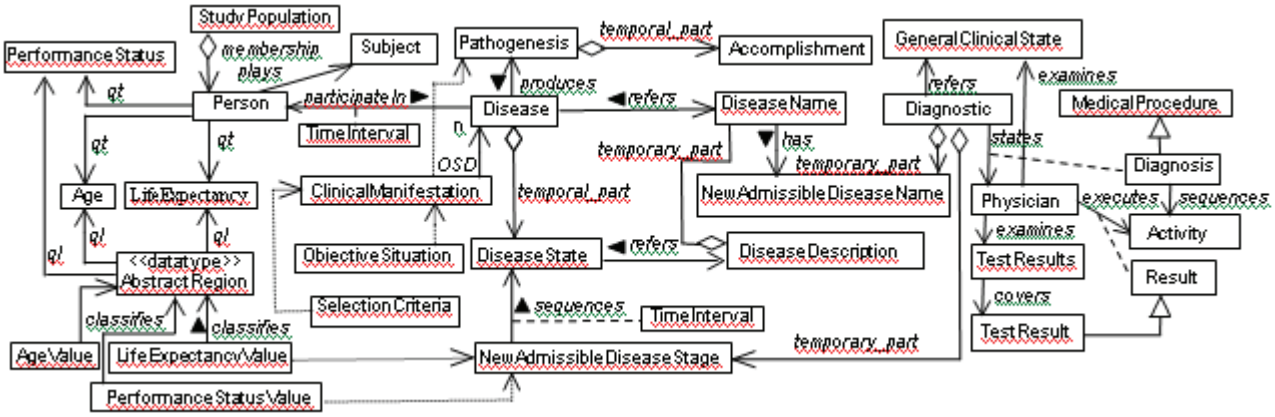

Figure 3 - The facet structure of the concern C4

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Cards in Health Telematics Applications – Tool or Token

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Abstract

Health Information Systems and Applications depend on the acceptance-based empowerment and involvement of all parties requiring secure and trustworthy communication and co-operation. Separating security services from medical information management allows for benefiting from different technologies including independent evolvement without ignoring their weaknesses. Using cards in healthcare raises the important question on whether a card shall be considered a token -a key to access functionality- or a tool with its own application functionality and data. The presented paper analyzes cards with regard to their usage in health information systems. The preferred way to deal with challenges of modern healthcare requirements shall be a balanced combination of cards as tokens and networks for information and functionality provision.

Keywords:

health card, patient card, security token, health network, health information system

Introduction

Healthcare is turning towards the shared care paradigm providing an integrated care approach. The paradigm change is bound to largely extended communication and co-operation between all healthcare providers involved in the patient's care as the challenge of increasing quality and efficiency requirements in the respective domains needs to be met. Thus, new ways for defining, designing, developing, and integrating future-proof and component-based health information systems are required. In that context, patient involvement and patient empowerment as well as education and training of health professionals are important pre-requisites for overcoming traditional ways of organization-centered treatment towards a person-centered approach called "Personal Health". Using token technology in general achieves an increasing importance. The present paper deals with specific benefits and weaknesses using cards either as a token or as real part of the application in healthcare [1].

Methods

Regardless whether using up-to-date card-related technology for identification, verification, and access purposes -the token functionality- or adding application-related functionality including data storage in terms of tools, both approaches have their specific benefits and weaknesses. For characterizing card usage in modern integrated information systems and networks, different aspects and views on tokens and tools need to be analyzed. Apart from awareness, confidence, acceptance, accessibility, and usability the scope of such an analysis ranges from interoperability, technical and organizational issues up to security, safety, privacy, usefulness, and reliability. At least a part of information stored in modern health information systems is intended to be possessed and used by human beings. Appropriate technical means and media are needed for reliable and liable storage of identity-related information, respective cryptographic keys, administrative and business data structures and even applications providing the functionality required including a directed exchange of data to the respective communication partners. Ranging from implementation of simple hardware tokens for restricted functions such as an identity-related service up to portable information systems carried by the information subject, requirements generally apply [2].

There are a number of basic security requirements which will allow the secure exchange of data in an open and distributed environment such as a network. They include authentication, authorization, confidentiality, integrity, non-repudiation, availability, and auditability. There are several security-related requirements that are also of interest for end users but can partly be met without reliance on symmetric or asymmetric cryptography. Organizations attach different importance to different types of security. In healthcare, however, great importance is attached to both availability and disaster recovery as safety of patients and access to information ranges first.

Results

Several European and national projects have defined scope, motivation and objectives as well as health-political aspects for the use of machine-readable cards in healthcare. As a short-term challenge, the reliable implementation of pilots has been mentioned to demonstrate the possible use of such cards and to rationalize time-consuming administrative work in the context of patient's request for health services. Health-political aspects concern facilities for de-centralized medical documentation, a coincidence with constitutional and data protection rights as well as with ethical principles in case

the Electronic Health Record is held by patients, a significant improvement of data quality, integrity and consistency by a unique document, and finally a significant improvement of quality and efficiency of health delivery procedures and processes in general [3].

Using a smart card as a tool means implementing application functionality along with data on the card. Such card-based health information system is characterized by the chance for optimization of medical and administrative workflow, the improvement of information flow between different healthcare providers within a shared care framework, the enhancement of information security using reliable, valid and in-time as well as in-location available data, the facilitation of emergency care by directly available emergency data set as well as a support of prevention and intervention. However, some weaknesses can be discovered, like the possible lost of information due to the restriction of data caused by storage capacity limitations or some unsolved legal problems of information ownership. Data stored on cards used as tools need to be permanently updated.

Using a card as an access token does mean storing and processing all information within extended networks based on an advanced identification and authentication framework. Such network-based health information system requires the provision of services and the existence of unique identifiers. Advantages can be found in a comprehensive level of interoperability and real interactions between all parties involved into the shared care as well as in the chance for a comprehensive, complete, high-quality electronic health record system. Information stored in networks accessed using smart tokens allow for facilitating emergency care by directly accessible emergency data right in time and an enhanced level of quality, integrity and consistency by provision of appropriate services. Availability, however, aims to be the most important service in this case as tokens only provide reliable authentication of principals. Any other service needs to be provided by the infrastructure.

Discussion

Apart from such plastic cards that are only used to physically access rooms, applications, systems or information sources respectively, smart cards in healthcare can be deployed in several different ways. On the one hand, the card can bear the vital information subset of a health record. In case of a patient data cards designed and used mainly as a storage card, e.g., relevant medical data can be stored there as parts (sub-sets, extracts) of an electronic health record [3], [4]. The card is then a tool.

On the other hand, the card may solely be seen as a pointer providing references and links to information stored in shared-care networked systems. This is true, e.g., for patient identification cards. The token approach seems to be the more promising one as medical data are dynamic data, and current cards can only bear parts of the information that is needed for a comprehensive EHR structure [2]. The card is then used as a token.

Confidence in and acceptance of the healthcare systems depend on the citizens' awareness, which needs yet to be raised. Citizens have to realize healthcare is a concern of theirs at all times. The shift from acute to life-long preventive healthcare has to be enforced and speeded up. Citizens shall and will have to form alliances and associations to advocate their interests.

Conclusion

The concepts of eHealth and personal(ized) Health (pHealth) see the citizen in the center of healthcare and welfare. Patient cards are first line communication tools. They carry limited medical data and improve the accessibility to information on health services as well as to personal data. Or cards serve as authentication token. They enable better health provision [4].

Smart cards are widely used as identification tokens not only in healthcare. Many European countries are scheduling the introduction of citizen cards, insurance cards, or just electronic ID cards. The European Health Insurance Card is being introduced in countries of the European Union. Both possession and appropriate use of cards can empower citizen. Furthermore, a card needs to support the collaboration with network-based systems. For that purpose, link information has been specified.

Cards have an impact on the related security infrastructure, certification of processes, process interoperability, and certification of state and relations of principals in longer terms. The use of cards as tokens and the use of networking systems have to closely be linked to each other. This allows for making extensive use of the benefits of both advanced technologies.

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Module for Easy and Interoperable Data Analysis in Electronic Medical Records

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Abstract

Data analysis in electronic medical records (EMRs) is crucial for patient treatment, quality management, administration and research. The widely used SQL queries quickly become complex in the medical domain resulting in difficult and time-consuming development and maintenance. The aim of this work is to develop a data analysis module using Java, XML and SQL, which eases development of analyses by utilising recurring patterns in SQL queries, minimises dependence of analysis on databases, makes analyses modifiable at runtime and visualises results as customisable charts and tables. The data analysis module developed is a first step toward easy-developing and interoperable data analysis in EMRs.

Keywords:

data analysis, medical records system, databases

Introduction

Data analysis in electronic medical records (EMR) and visualisation of its results is crucial for patient treatment, quality management, administration and research. Widely used, often complex, plain SQL queries are tightly bound to database schemas (DBSs) and database management systems (DBMSs) resulting in difficult and time-consuming development and maintenance. Current reporting tools avoid direct use of SQL, but they do not decrease complexity of queries nor do they reduce dependencies of queries on DBSs.

SQL queries in the medical domain often have recurring requirements with similar or identical patterns – e.g. patient classification regarding their habits (e.g. non-smoker, moderate smoker, chain-smoker) and average calculation of laboratory values (e.g. blood pressure) – which could be reused among queries. Greater flexibility can be obtained through parameterisation of SQL queries – e.g. selecting only female, only male or all patients (see Figure 1).

The aim of this work is to develop a data analysis module for integration in information systems, which

a) eases analysis development by providing abstractions for recurring patterns in SQL queries,
b) minimises dependence on DBSs and DBMSs,
c) makes analyses modifiable at runtime and
d) executes analyses and visualises results as customisable charts and tables.

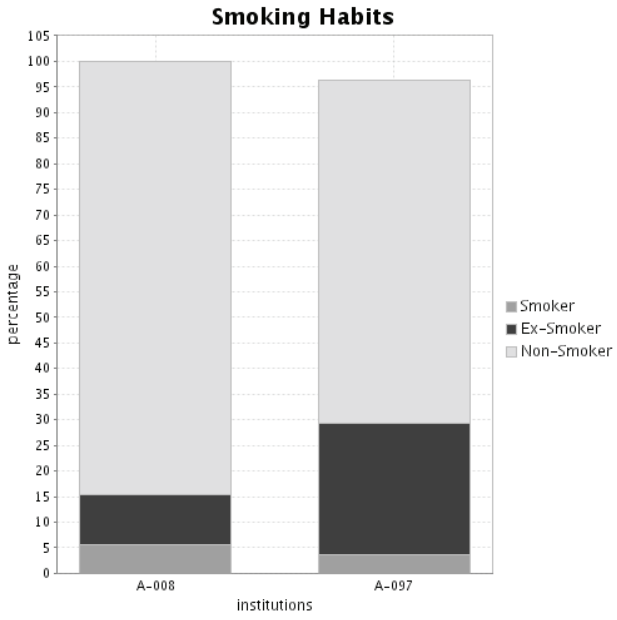


Figure 1 - Comparison of two institutions regarding the smoking habits of their female patients (100% are not reached for A-097 due to missing data). For this analysis the classification pattern was used classifying patients regarding their smoking habits. Additionally the analysis was parameterised in order to select only female patients

Methods

The module was implemented in Java using open source libraries. XML Schema was used to define valid mark-up for analysis and configuration instances. An analysis XML instance contains mark-up for

a) generalised SQL query patterns,
b) a parameter-based definition of the data to analyse referencing reusable sets of data in the configuration XML and
c) default visualisation properties.

A configuration XML instance has to be defined once per database and contains metadata about

a) DBMS,
b) DBS
c) reusable sets of data to analyse and
d) available parameters for parameterisation of the data to analyse.

It is used for runtime generation of database-specific SQL queries. A second configuration XML instance specifies which chart types are permitted for visualisation of analysis results depending on attributes of analyses. This configuration XML instance avoids meaningless combinations of chart types and analyses such as longitudinal trends of patients' blood pressures visualised as a pie chart.

Results

The data analysis module developed generates SQL queries from database-independent analysis XML instances and database-specific configuration XML instance, executes the SQL queries and visualises results with default visualisation properties (see Figure 2). Visualisation properties such as chart type, colour schemas etc. can be further modified. A web interface for query selection, execution and visualisation of results has been developed. Internationalisation was achieved by means of Java resource bundles.

Discussion and conclusion

The work presented is a first step toward faster and easier development and maintenance of interoperable analysis of data in EMRs. The analysis structure developed allows easier development, maintenance and reuse of analyses on a higher level of abstraction. Modularity of analysis structure simplifies parameter-based modifications at runtime. Visualisation of results can be easily customised. Analysis XML instances unify query and result visualisation in one place.

The module developed is currently integrated in quality management web applications for hepatitis and cardiovascular disease hosted at www.healthgate.at and in a module for generation of PDF reports.

Future work will focus on improving visualisation capabilities (sorting and filtering of obtained results), user interface integration using metadata (e.g. dynamically generated input elements for parameter values), adding dynamic analysis descriptions (i.e. descriptions which adapt to results) to analyses XML instances and further separation of database-independent components from database-specific ones.

Moreover to foster further development of the data analysis module practicability of an open source release will be explored.

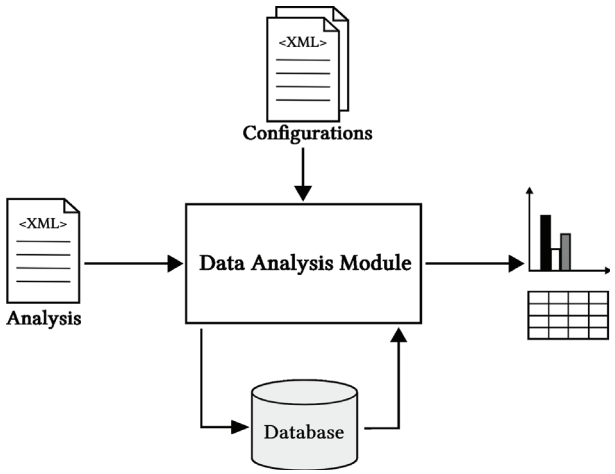
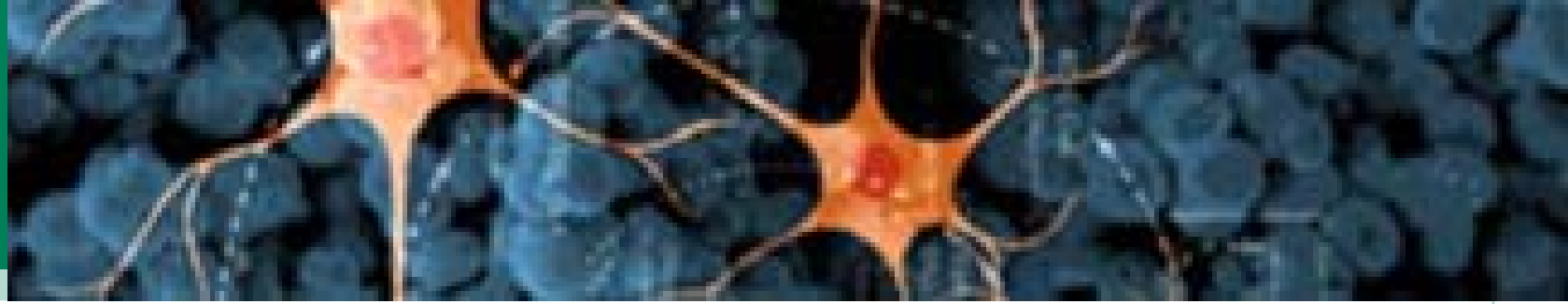


Figure 2 - Black box model of data analysis module



Module for Easy and Interoperable Data Analysis in Electronic Medical Records

Bruno Cadonna[a], Peter Beck[a], Ivo Rakovac[a], Thomas Truskaller[a], Thomas R. Pieber[a,b]

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JOANNEUM RESEARCH

Introduction

- **Data analysis** in electronic medical records (EMR) is crucial for **patient treatment, quality management, administration** and **research**.

- Nowadays **SQL** is **widely used** to accomplish this task

JOANNEUM RESEARCH

Introduction

Characteristics of plain SQL queries:

- **tightly bound** to **database schemas** (DBSs) and **database management systems** (DBMSs)
- in medical domain queries often have recurring requirements with **similar or identical patterns**
- **greater flexibility** can be obtained through **parameterisation** of SQL queries

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Introduction

The **aim** of developed data analysis module:

- to ease analysis development by providing **abstractions for recurring patterns** in SQL queries,
- to **minimise dependence on DBSs and DBMSs**,
- to make analyses **modifiable at runtime** and
- to visualise results as **customisable charts and tables**.

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Methods

Used technologies:

- The **Java** platform and **open source libraries**
- **XML Schema** to define mark-up for analysis and configuration instances
- **SQL** to query databases

Methods

Analysis XML instances contain:

- **generalised SQL query patterns**
- **parameter-based definition** of the data to analyse **referencing reusable sets** of data in the configuration XML instance
- **default visualisation properties**

Methods

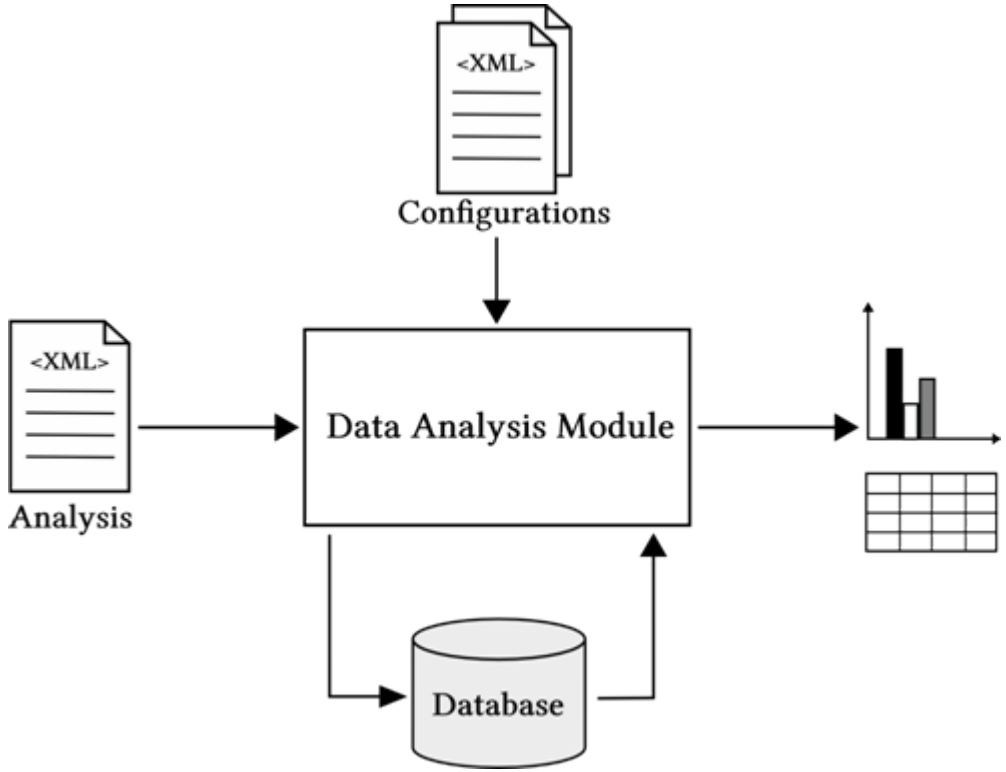
Configuration XML instances for queries contain:

- **metadata about DBMS**
- **metadata about DBS**
- **reusable sets** of data to analyse
- available **parameters for parameterisation** of the data to analyse

Configuration XML instance for visualisation contains:

- specification of which chart types are permitted with which kinds of analyses **avoiding meaningless combinations** such as longitudinal trends of patients' blood pressures visualised as a pie chart

Results

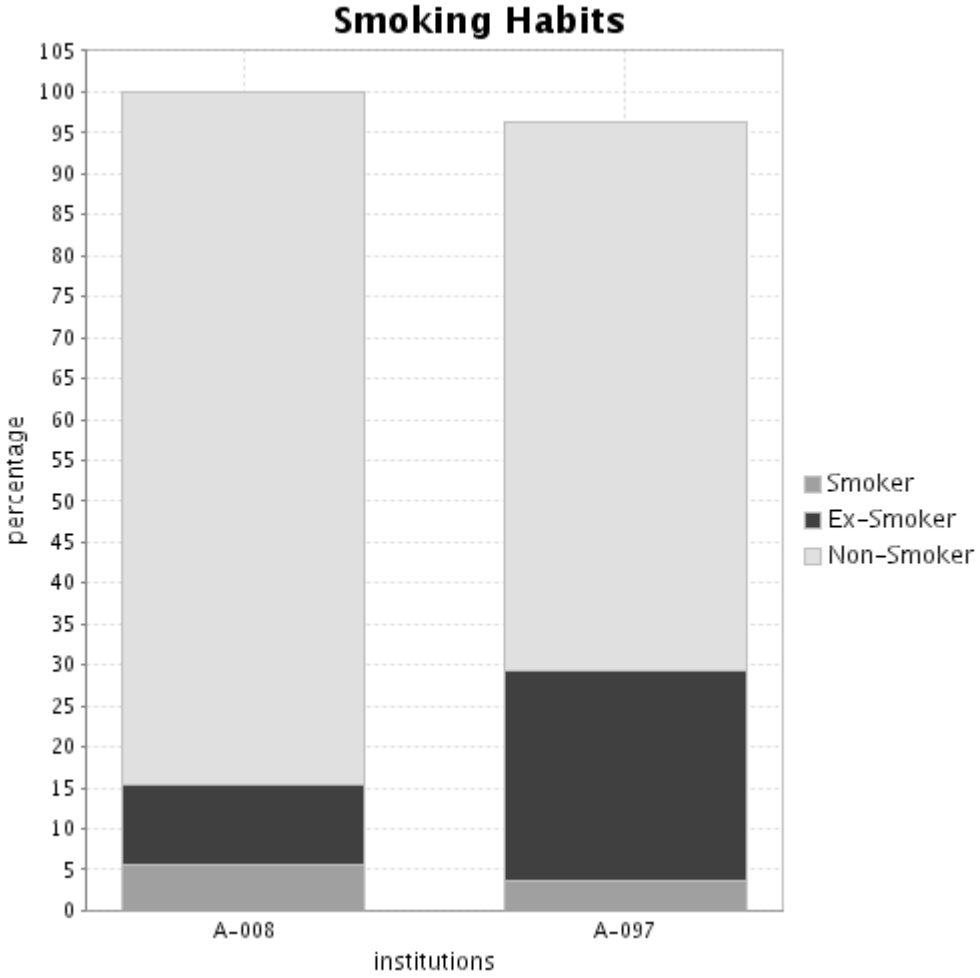


The data analysis module developed **generates** SQL queries from **database-independent analysis** XML instances and **database-specific configuration** XML instance, **executes** the SQL queries and **visualises** the results.

Configurations have to be defined **only once** per information system.

Results

Analysis results generated by the module



Comparison of two institutions regarding the smoking habits of their female patients. For this analysis the **classification pattern** was used classifying patients regarding their smoking habits. Additionally the analysis was **parameterised** in order to select only female patients.

(100% are not reached for A-097 due to missing data)

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Conclusion

Benefits:

- easier development, maintenance and reuse of analyses **on a higher level of abstraction**
- faster and easier development and maintenance of **interoperable analysis** of data in EMRs
- Modularity of analysis structure simplifies **parameter-based modifications at runtime**
- Visualisation of results can be easily **customised**
- Analysis XML instances unify query and result visualisation **in one place**

Conclusion

Data analysis module integrated in:

- **quality management web applications** for hepatitis and cardiovascular disease hosted at **www.healthgate.at**
- module for **generation of PDF reports**

Future work:

- improving **visualisation capabilities**
- **user interface integration** using metadata
- adding **automatically adaptable analysis descriptions** to analysis XML instances
- further **separation** of database-independent components from database-specific ones
- Exploration of practicability for **open source** release

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A Multiagent System's Proposal for Chronic Patients' Relationship Management

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Abstract/Objective

This paper presents the proposal of a multiagent system development for the Chronic Patient Relationship Management (CPRM) model. This model is proposed with the purpose to increase the adherence from the patients to their treatment. The CPRM model is based on the Customer Relationship Managemen concepts, which intends to leave the information on all the communication channels available. The datawarehouse, datamining and Distributed Intelligence's concepts play an important role on the CPRM model, once that one of its propositions is to guarantee an effective patient's follow-up, inter-relating information that are dispersed in institutions' departments as well as amongst institutions. To support the CPRM model execution, multiagent system is proposed once it can enable the use of models and techniques to deal with the model's complexity. For this purpose, it will be given a general view of the proposed system's, which tends to apply concepts on solving complex problems and on inter-systems integrations standardization for the model's success.

Keywords:

chronic disease, telemedicine, outpatient monitoring

Methods

Critical factors to a successful implementation of the model have been studied and it has become clear the need of a deeper study of the techniques and methodology to be adopted, including the examination of engineering softwares to implement an agent's software. At last, it has also become necessary to test performance, usability and portability to verify the resultant implementation.

Results

In the medical computering context, the telemedicine systems are composed by complex subsystems with dissimilar components, managing shared data and resources, and they occasionally require integration with the legacy systems.

This essential feature of the model should be kept and according to Booch, the agents technology has powerful characteristics to the complex softwares project.

In accordance with this, an agent is abstracted to solve a problem particularly, but it is able to interact with others in order to enable the resolution of a problem that, individually, it would not have been possible. Thus, the proposed system to the model is about an Agents Platform that can support the feature of a distributed intelligence guided to agents.

The proposed architecture implements the Agents' characteristics, in a way that each agent acts independently in his own health unity. Its rationalization is based on a rules shape through a subsystem based on the Jess framework that allows that new rules are put in, keeping the system operating even when expanding.

Finally, Service Oriented Architecture (SOA) is a mighty candidate to provide practical implementation to agents' system, and once its representation model of services and components esteems for communication standards and the independence in architecture, the integration between the various health unities is possible in a simple way.

Conclusion and discussion

The proposed implementation's aim is to provide the expansion of the CPRM model into a collaborative intra-institutions model using the agent's technology and new proposals of systems' integration, like the SOA.

Once there is an implementation able to support the requirement for the autonomy of the health unities at the same time that there is integration between them and availability of information on the necessary channels, its practical utilization becomes possible.

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Development of Computerized Adverse Drug Event Surveillance System in Korea: Retrospective and Prospective Patient Medical Record Reviews

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Abstract and objective

A computerized adverse drug events surveillance system (CADESS) was implemented in Seoul National University Bundang Hospital (SNUBH), Korea with advanced electronic medical record systems. For the purpose of system evaluation at the beginning stage of implementation, two months were randomly selected and patient medical records screened with ADE signals were reviewed in retrospective and prospective respectively. The knowledge base of CADESS was developed by clinical experts and the ADE identifications were reviewed by 6 clinical pharmacists. The incidences of ADEs were 4% and 3.4% in retrospective and prospective respectively. Rates of preventability and severity were different; however, most differences of our results were due to the system errors and the natural characteristics of the prospective information flow.

Keywords:

Clinical Decision Support Systems, Adverse Drug Events, ADEs, Computerized Medical Record Systems

Introduction

Adverse drug events are common, costly and often preventable. Monitoring ADEs is the most important part of ADE prevention. Computerized ADE surveillance systems using signals to detect potential ADEs have been reported more cost-effective than other types of ADE monitoring system. To identify and prevent ADEs, the Computerized Adverse Drug Event Surveillance System (CADESS) was developed in the hospital information system, SNUBH.

Methods

SNUBH is an educational hospital with 909 beds in Bundang, Korea and has been operated an computerized medical record system, BESTCare, since 2003. CADESS was implemented in the pharmacy information system in early 2006. Signals detecting ADEs were adopted from the previous studies and reviewed by clinical experts in SNUBH. Patient medical records screened with ADE signals were reviewed to identify ADEs by 6 clinical pharmacists for selected months. After the training of medical record reviewers, the reliability among reviewers was measured. The medical record of inpatient during April 2005 was reviewed retrospectively; from Jul. 18, 2006 to Aug. 17, 2006, prospectively. Severity, preventability, suspicious drugs, ADE mechanism, and so on were recorded in a structured format by trained reviewers.

Results

The total numbers of hospitalized patients were 3,608 for a month of April 2005 and 3,510 from August to July in 2006. The percentage of patient generated ADE alerts was 12.7% and 13.6%; the incidence of ADE, 4% and 3.4% of inpatient in retrospective and prospective reviews respectively. The preventability was 29% vs. 10%; the severity of significant, serious and life-threatening was 75.2%, 22.8% and 2.1% vs. 80.3%, 13.3% and 1.7%.

Conclusions

The difference between retrospective and prospective reviews was mostly due to simple computational errors. 4 signals were missing in the retrospective review and it caused the differences in the total number of ADE alerts, incidence and others. Preventability still significantly differs although the availability of information sources and the data completeness were considered. Lastly, sample size was too small to compare the predictive positive values of each signal. But the comparison between retrospective and prospective reviews was a meaningful at the beginning stage of system development process.

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Development of Computerized Adverse Drug Event Surveillance System in Korea

: Retrospective and Prospective Patient Medical Record Review

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CiEHR
Center for Interoperable EHR

Introduction

- Medication errors and health care costs
  - Common and expensive medication errors
  - Known issues on patient safety and health care costs
- Preventable medication errors & CDSS
  - Many medication errors known to be preventable
  - Many studies on medication errors and medication CDSSs in US and other countries
- However, still significant
  - In 2006 IOM reports, medication errors are reported still significant and costly
  - Few studies in Korea, very early stage of medication CDSSs
  - Need more opportunities to show how it works and it is effective to prevent with CDSS.

Methods (1/3)

- Computerized Adverse Drug Event Surveillance Program (CADESS)
  - Using 46 ADE signals including lab test, drug level, medication, & diagnosis codes
  - Screened EMR for patients with ADE signals checked
  - 6 pharmacists reviewed electronic medical records of ADE signal monitored patients to identify ADE occurrence
  - ADE identified patients data was recorded in a structured format to collect data for the statistical analysis

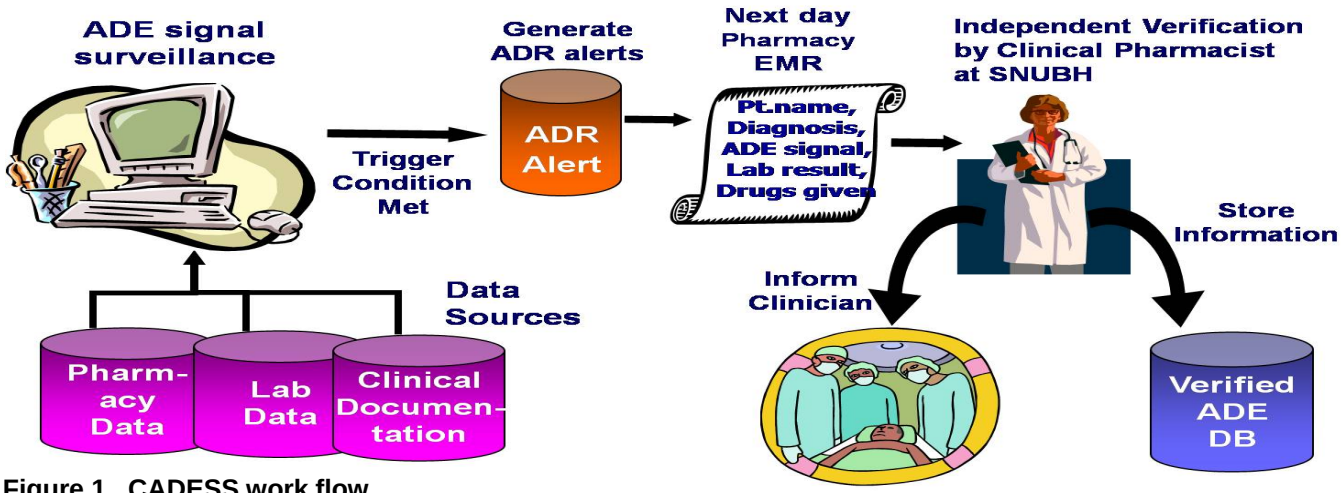


Figure 1. CADESS work flow

Methods (2/3)

- *Study settings*
  - Seoul National University Bundang Hospital, Korea
  - 990-bed, secondary, academic hospital
  - Advanced electronic medical record system and medication related CDSS in operation (order duplication checking, drug-drug interaction, contraindications, etc.)
- *Medical Record Reviews*
  - Training of reviewers & reliability test in advance of study
  - Retrospective & Prospective chart review for 1 month each
  - By 6 pharmacists under the supervision of clinical pharmacists and physicians
- *Statistical analysis*
  - SAS, SPSS ver.12.0
  - Descriptive analysis, kappa value for reliability test

Methods (3/3)

Reviewer's training
- ADE review manual & study reviews
- 6 reviewers reliability test
- Reviewed 30 randomly selected inpatients w/ ADE signals

Retrospective EMR review
- April. 2005 inpatients for a month
- EMR Reviewed by 6 pharmacists for suspected ADE
- Supervised by clinical pharmacists & physicians
- ADE identified

Prospective EMR review
- 7/18/2006 ~ 8/17/2006 inpatients for a month
- EMR Reviewed by 6 pharmacists for suspected ADE
- Supervised by clinical pharmacists & physicians
- ADE identified daily

Data Analysis
- Data collected in a structured format
- Kappa value for reliability test using SAS
- Descriptive statistics using SPSS 12.0

Figure 2. Study flow

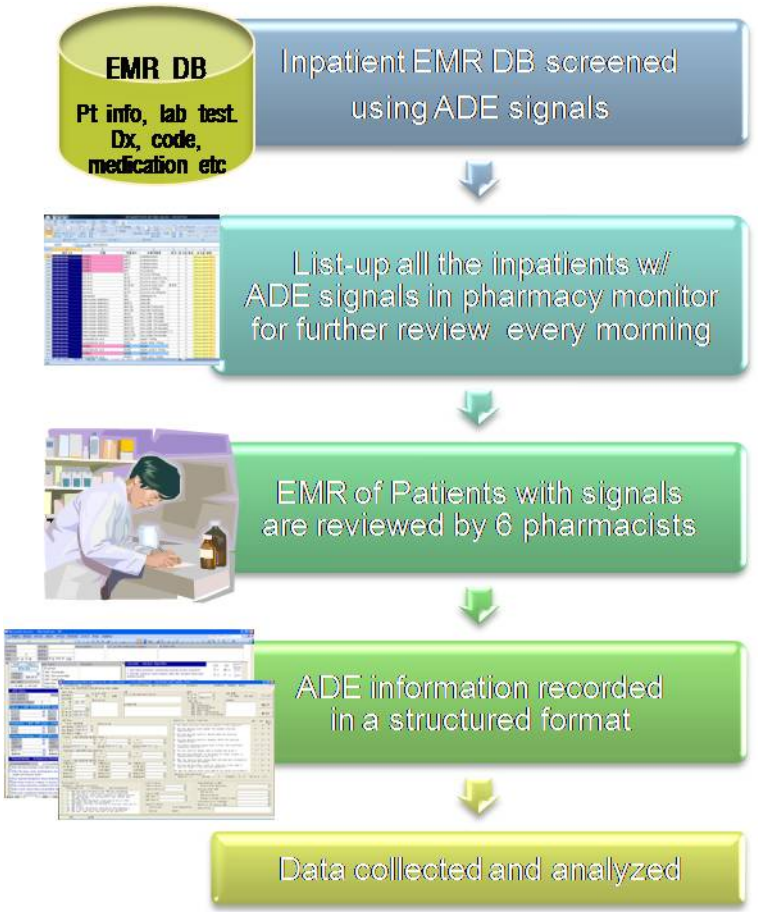


Figure 3. ADE identification process

Results (1/4)

- Reliability test among reviewers
  - Kappa value was .87 which meant almost perfect agreement among reviewers.
  - For 30 patients sample reviewed by 6 pharmacists
- Summary of study results

Methodology	Retrospective	Prospective
Study period	2005. 4/1~4/30	2006.7/18~8/18
total inpatients	3608	3510
Signal screened patients	457	478
Signal screened rate among inpatients	12.7%	13.6%
# of Signals detected	609	698
# of ADE during the study	145	120
ADE incidence among inpatients	4.0%	3.4%
PPV of ADE signal	23.8%	17.2%

Table 1. Summary of study results

Results (2/4)

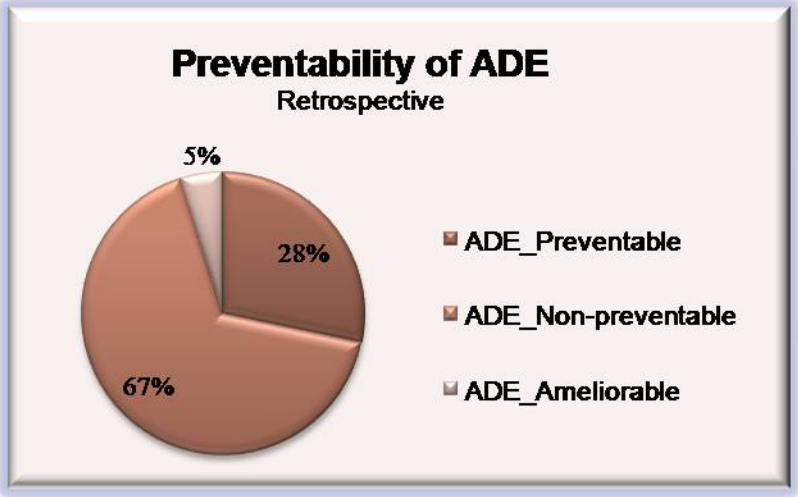
ADE signals with high frequency			
Retrospective		**Prospective**	
Antihistamine	116	Antihistamine	136
Antidiarrhea	74	Antidiarrhea	117
Glucose, fasting	82	Methlprednisolone	62
Methlprednisolone	56	ALT	46
ALT	32	AST	44
Anti-emetics	30	WBC count, Blood	38

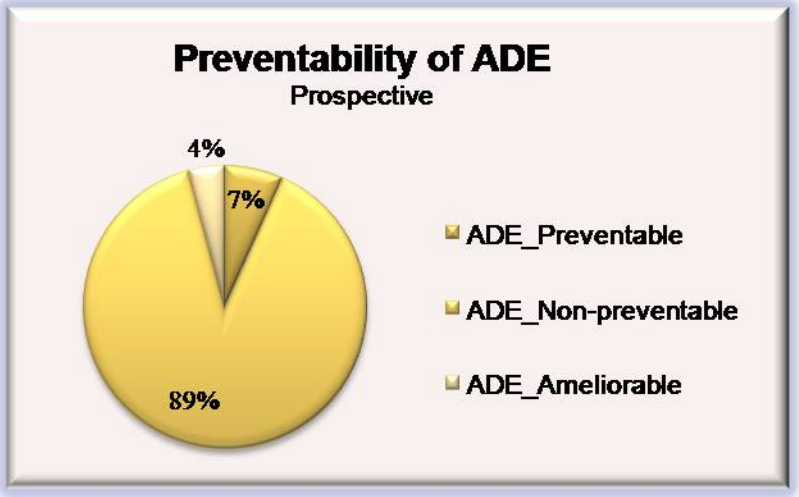
Table 2. ADE signals with high frequency (number of alerts)

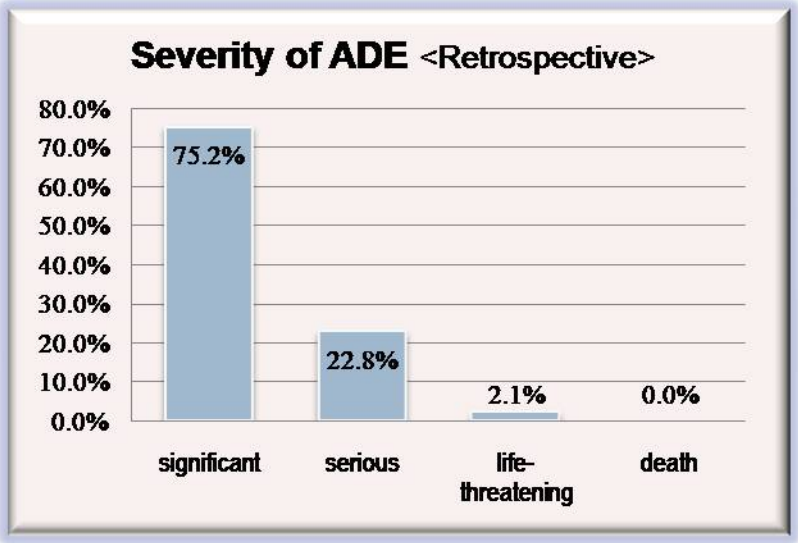
ADE signals with high PPV			
Retrospective		**Prospective**	
PT(INR)	100%	WBC count, Blood	45%
Vancomycin	100%	Anti-emetics	42%
Vitamin K	100%	ALT	41%
Methlprednisolone	100%	PT(INR)	33%
Naloxone	100%	Antihistamine	31%
Atropine	67%	Creatinine	26%
ALT	56%	AST	23%
Phenytoin	50%	Dextrose 50 & Glucose	20%

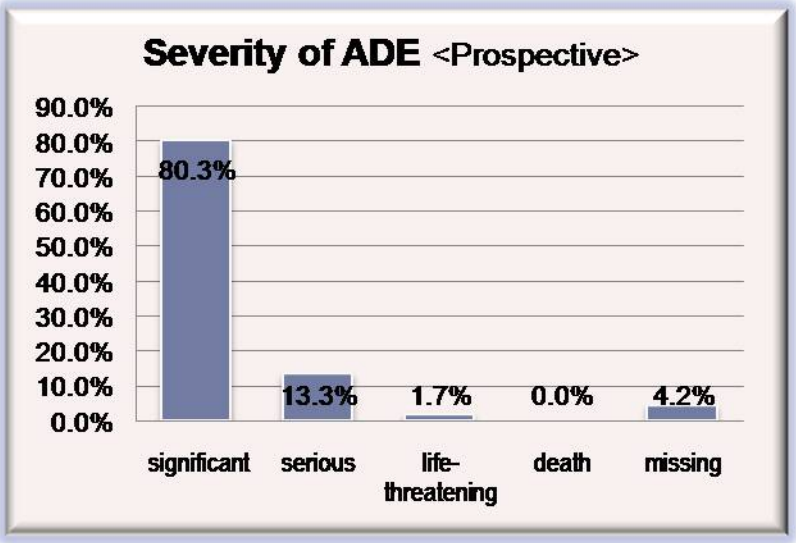
Table 3. ADE signals with high PPVs (percentage)

Results (3/4)


Preventability of ADE
Retrospective
5%
28%
67%
ADE_Preventable
ADE_Non-preventable
ADE_Ameliorable


Preventability of ADE
Prospective
4%
7%
89%
ADE_Preventable
ADE_Non-preventable
ADE_Ameliorable


Severity of ADE <Retrospective>
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
75.2%
22.8%
2.1%
0.0%
significant
serious
life-threatening
death


Severity of ADE <Prospective>
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
80.3%
13.3%
1.7%
0.0%
4.2%
significant
serious
life-threatening
death
missing

Results (4/4)

Table 4. Medications with high frequency of ADEs in retrospective chart review

Medications	Frequency	Percentage
antiinfectives	80	46.5%
NSAID	17	9.9%
anticonvulsant	14	8.1%
analgesic	14	8.1%
radiocontrast	14	8.1%
gastrointestinal	12	7.0%
cardiovascular	8	4.7%

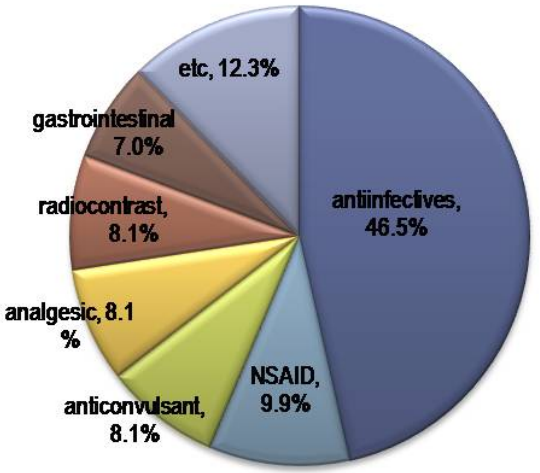
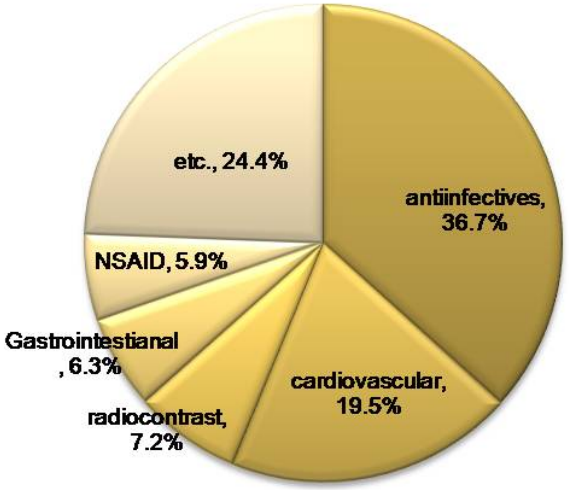


Table 5. Medications with high frequency of ADEs in prospective chart review

Medications	Frequency	Percentage
antiinfectives	81	36.7%
cardiovascular	43	19.5%
radiocontrast	16	7.2%
Gastrointestianal	14	6.3%
NSAID	13	5.9%
Diabetes medicatio	11	5.0%



Discussion

- Comprehensiveness of ADE signals
  - Lab and medication oriented signals
- Sample size of each signal
  - Statistically enough sample size for ADE incidence
  - However, not for each signal validation
- Technical errors
  - Missing signals in retrospective study
  - Signal errors by technical mistakes
- Medication CDSSs already in operation
  - Contraindications, drug-drug interactions, order duplication, etc in EMR system
- Methodology characteristics In nature
  - Since the care process was ongoing, ADE identification was ongoing in prospective chart review without conclusion.

Conclusions

- Failed to compare methodological differences
  - Better assumed to compare ADE reporting types
  - Not enough sample size to compare each signals
- Future direction for ADE surveillance system
  - ADE signals refined compared to previous studies
  - Model of ADE system for EMR hospitals to show what kind of EMR data collected in DB
- Further research needed
  - Evidence of clinical and economical benefits of the system
  - System usability
  - Physician attitudes to improve the practice patterns

- Acknowledgements

  This study was supported by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare, Republic of Korea. (Grant number: A050909)

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Sustainable Health Care Information Systems by Activity Driven ISD Model

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Abstract

The purpose of our project is to 'zip up' the distance between the different worlds of work improvement and information systems development. The initial premise for development activity comes from the needed improvements of services provided to e.g. health care customers. In addition to the suitability of the technology itself, the development activity should be participative and transparent through the organization. We have developed an applicable model for work and information systems developers to create sustainable information system. The model has been applied in several pilot cases in health care sector (in collaboration with researchers, system developers and health care practitioners). In this paper the basic idea of the model is presented and reflected to the aspects of sustainable information system.

Keywords:

work, information systems, program development

Introduction

The purpose of information system (IS) - which is a socio-technical system including technology and people - is to facilitate and help work activities. To develop effective health care services with the help of information and communication technology (ICT), we have to combine IS development with work development.

In the ZipIT-project[1] (2004-2007) we have participated as researchers on IS development projects in various health care organizations. The objective is to develop a model to be used when a health care organization needs to improve their information system. The model is based on activity theory, and participatory design. It is meant to be used for example by work developers in health care organization, data administration professionals in health care organization, and system designers and analysts in software companies. The purpose of this paper is to discuss the model in light of sustainable information system development by advocating the users' position.

1 www.uku.fi/zipit/english

Methods: Activity driven research approach and sustainability

In order to create appropriate, sustainable and usable information systems in organizations, the basic object of analysis should be activity system instead of information system [1] [2]. Activity theory cf. [3] has been elaborated and re-developed at the University of Kuopio and Savonia University of Applied Sciences for the needs of IS research in several research projects [1] [4].

The basic value of technology comes from the improvements achieved by technology and how these improvements are sustained and enjoyed over time in organization. Sustainable development means a process that meets the need of the present state without compromising the ability of future development. The criteria of sustainability must be considered during information systems development (ISD) that should empower user community, meaning user participation [5]. The aspects of sustainable IS are derived from appropriate technology, supportive activities and the real need of ICT [4].

Result: Activity driven ISD model

According to the activity driven ISD model (Figure 1) we have to analyze activity at different levels, and integrate the different levels to each other; individual level (actions), group/activity level (work processes), and organizational level (network of activities). At each level the work and information system, linked up with each other, are analyzed with different fineness of detail.

Level 1: Network of activities and information needs

This level of description provides shared understanding of the network or the chain of activities focusing on:

- Overview of activities: Networked health care service providers, stakeholders, patients, motivation.
- Overview of Information systems: Infrastructure, information entities, communication in the network.
- Sustainability factors: supportive activities (technical, system, intellectual, managerial), top management competence and commitment.

Level 2: Work activity and information system

This level zooms in to the essential activities focusing on:

- Work activities and processes**:** professionals' work, goals, inputs and outputs of processes, users, tasks, tools.
- Information systems and data flows: Means of communication and coordination**,** information needs and information tools in processes, information flows
- Sustainability factors: appropriateness to group work, operational and technical suitability of ICT, usability, affordability, flexibility.

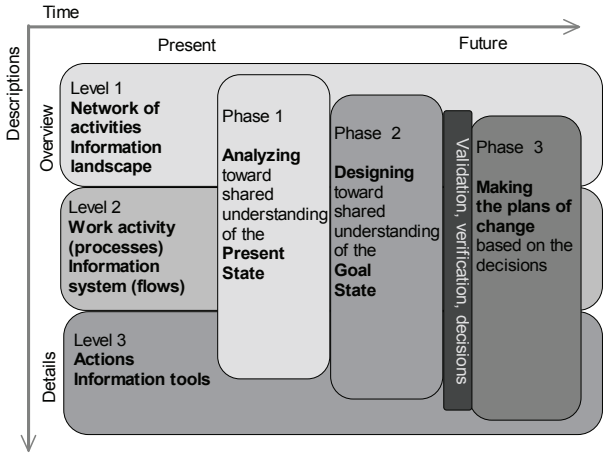

Figure 1 - Dimensions, levels and phases of the Activity Driven ISD Model

Level 3: Actions and information tools

This level of description provides shared understanding of the actions of individual actors focusing on:

- Actions: information processing tasks, interaction between user and information tools
- Information tools: data compositions, interfaces
- Sustainability factors: appropriateness to individual tasks, standards, usability.

On the other hand, the model has three main phases of development: analyzing the **present state** of an activity, defining the **goal state**, and **planning** how to reach the goal state. The phases do not follow each other like a water-fall, but the process is usually iterative. Also, depending on the case, the project can be restricted for example on the first phase if we only need to find out problems in our activity for decision making. The change actions can be in different scales. Sometimes it is necessary to take big steps, but also less dramatic gradual changes can be planned based on different time perspectives.

Discussion and conclusion

When it comes to requirements of appropriate and sustainable information system, user participation is one key element. Firstly, clinical staff, like nurses and doctors, is responsible to provide the nursing services as good as possible. As experts of their work, they are in key position to give requirements to appropriate tools, e.g. ICT.

The main responsibility of the service chain is for top management. Top management is in the position to realize the impact of new ICT in the service chain; what is the real need of ICT for better services. Top management should be able to set long distance and short distance goals, and decide the proper actions for next development phase. They should provide sufficient resources to development work, and create proper supportive activities for sustaining the use of IS.

We believe that the Activity driven ISD model can act as a tool in decision making and practical realization of IS development and work development. Top management can apply the two uppermost levels to decide the real need of ICT, the need for resources, and essential changes in work activities. With the help of the model it is possible to illustrate the real impact of ICT for services, and this way to improve ICT's suitability to work. On the other hand, clinical staff and people operating with development activity have a tool to analyze the present state and to decide the proper actions in ICT introduction. With the help of the model the management and the practical level have a common tool to see the development objectives and phases and thus achieve a common understanding of the development and make the development process more transparent.

Acknowledgments

This paper is based on a research funded by the National Technology Agency Tekes through the ZipIT project no 40426/04, 40354/05, 40252/06 and Finnish Work Environment Fund through the ActAD-HIS project no 104151.

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Activity Driven ISD Model

Sustainable Health Care Information Systems

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MEDINFO 2007:Building sustainable health systems

Brisbane, Australia, August 20–24, 2007

Abstract

The purpose of our project is to **'zip up' the distance** between the different worlds of **work improvement** and **information systems development**. The initial premise for development activity comes from the needed improvements of services provided to e.g. health care customers.

In addition to the **suitability of the technology** itself, the **development activity** should be **participative** and **transparent** through the organization.

In the ZipIT project, we have developed an **applicable model** for work and information systems developers to create sustainable information system. The model has been applied in several pilot cases in health care sector (in collaboration with researchers, system developers and health care practitioners). In this paper the basic idea of the model is presented.

MedInfo'07, Brisbane, Australia. August 20-24, 2007.

Activity driven research approach

Effective health care services with the help of information and communication technology (ICT)
=> **combine IS development with work development**

Activity Theory

Information Systems Research

Health Informatics

Software Engineering

Health Care Services

Work Development

Participatory Methods

MedInfo'07, Brisbane, Australia. August 20-24, 2007.

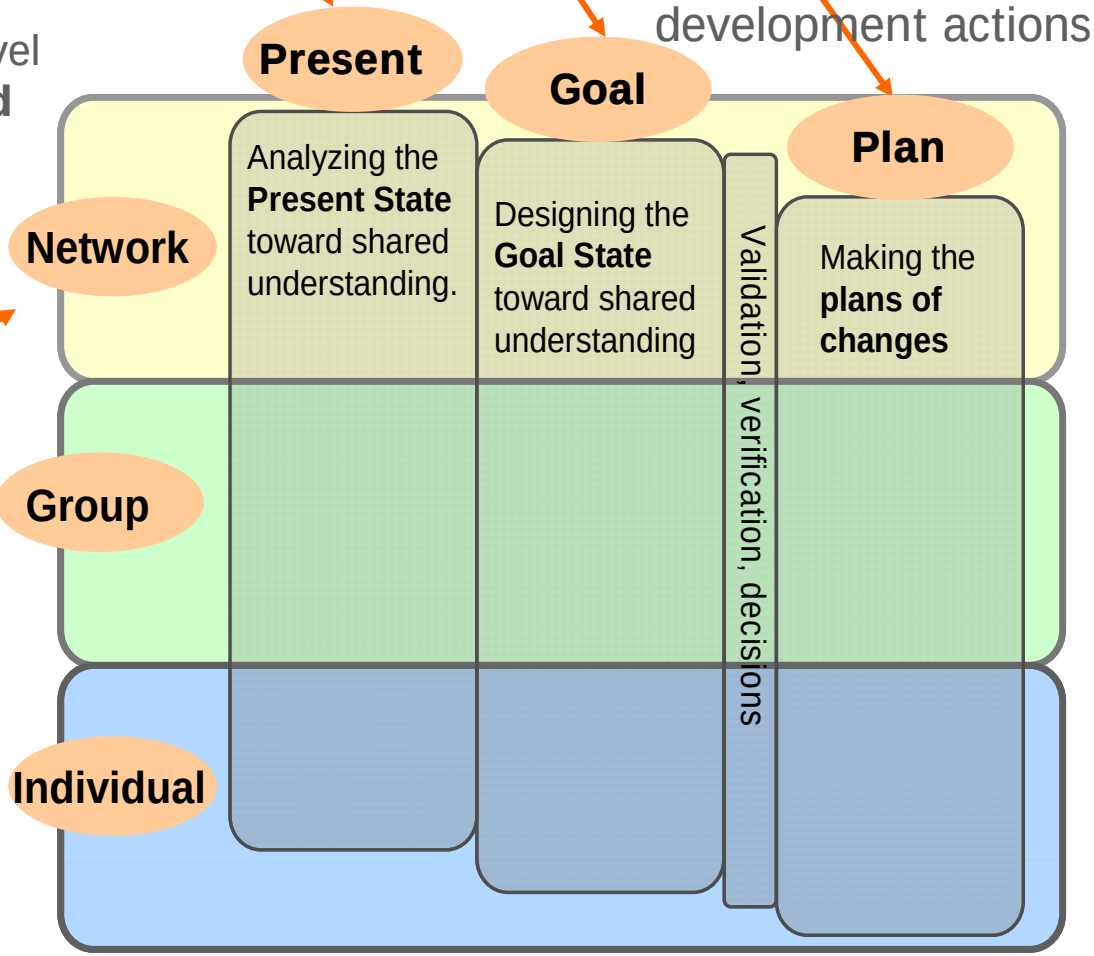
Activity Driven ISD Model

The process for activity driven requirements includes **three main phases of development**.

The idea is to **analyze activity at different levels**, and integrate the different levels to each other. At each level the work and information system, **linked up** with each other, are analyzed with different fineness of detail.

Three phases of development:

1. **Analyse** the present state
2. **Design** the goal state
3. **Make a plan** for development actions



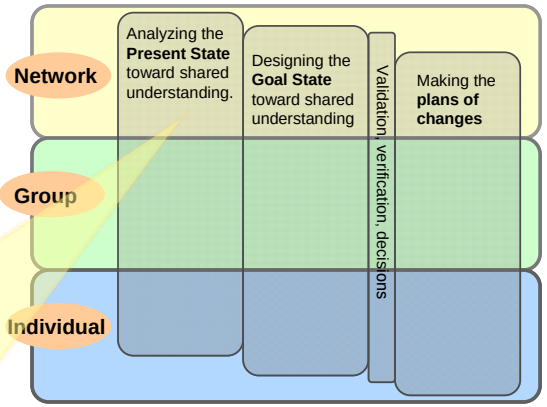
Three levels of analysis:

1. Organizational level
Network of activities & information landscape

2. Group/activity level
Work activity (process) & information system

3. Individual level
Actions and information tools

Level 1: Network of activities and information landscape

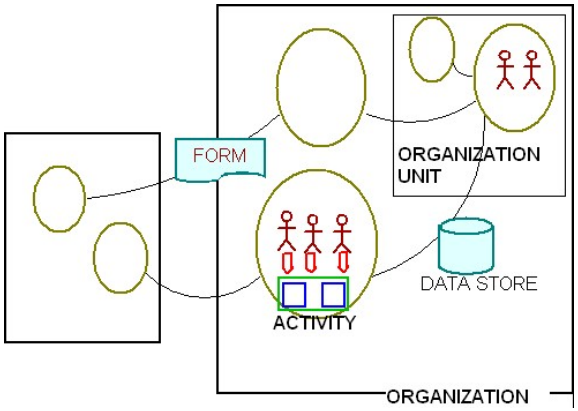


Level 1: Network of activities and information landscape. This level of description provides shared understanding of the network or the chain of activities focusing on:

Overview of activities:
Networked health care service providers, stakeholders, patients, motivation.

Overview of Information systems:
Infrastructure, information entities, communication in the network.

Sustainability factors:
Supportive activities
(technical, system, intellectual, managerial),
top management competence and commitment.



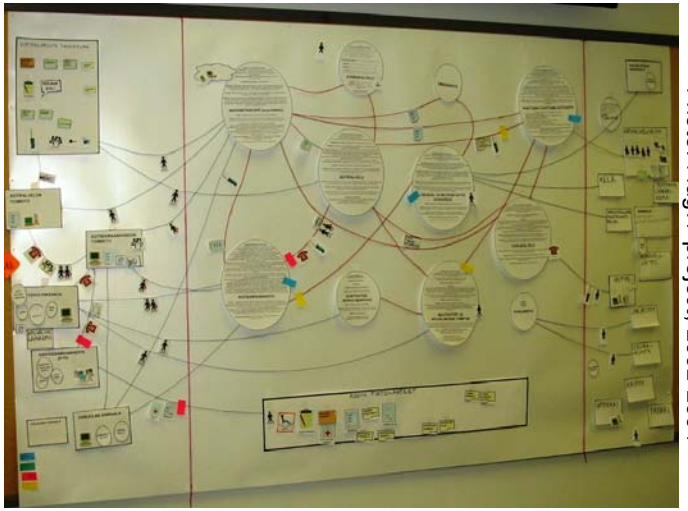


Photo: PlugIT project, 2001-2004

Mursu, Toivanen, Luukkonen & Ensio: Activity Driven ISD Model, MedInfo 2007

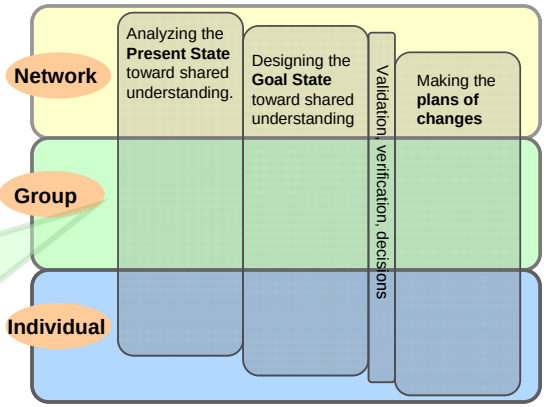
Level 2: Activity and information system

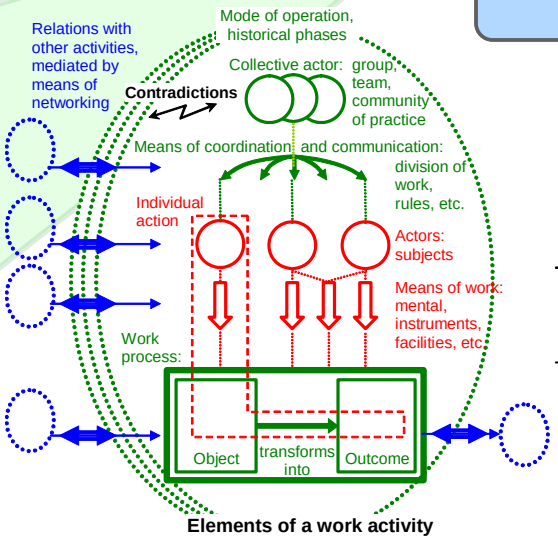
Level 2: Work activity and information system. This level zooms in to the essential activities focusing on:

Work activities and processes: professionals' work, goals, inputs and outputs of processes, users, tasks, tools.

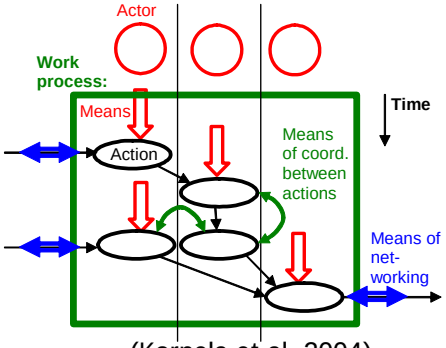
Information systems and data flows: Means of communication and coordination, information needs and information tools in processes, information flows

Sustainability factors: Appropriateness to group work, operational and technical suitability of ICT, usability, affordability, flexibility.





(Korpela et al. 2004)

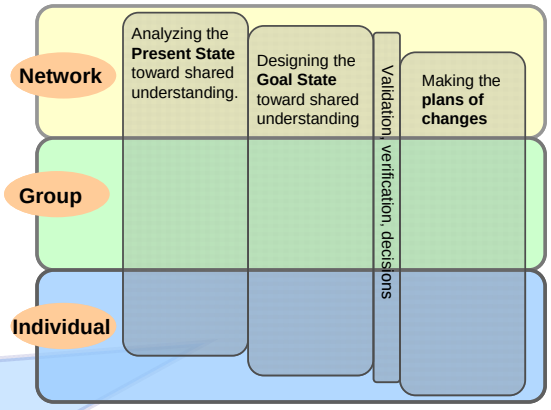


(Korpela et al. 2004)

Photo: ZipIT project

Photo: ZipIT project

Level 3: Actions and information tools

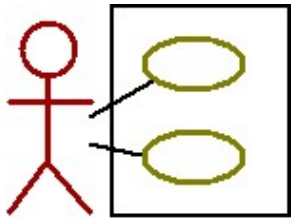


Level 3: Actions and information tools. This level of description provides shared understanding of the actions of individual actors focusing on:

Actions:
Information processing tasks, interaction between user and information tools

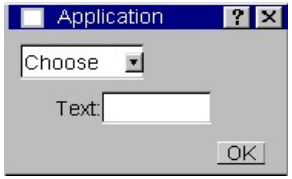
Information tools:
data compositions, interfaces

Sustainability factors:
Appropriateness to individual tasks, standards, usability.



USE CASES

Photo: ZipIT project



DRAFT OF USER INTERFACE

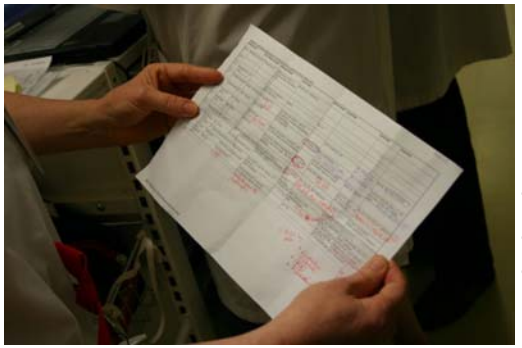
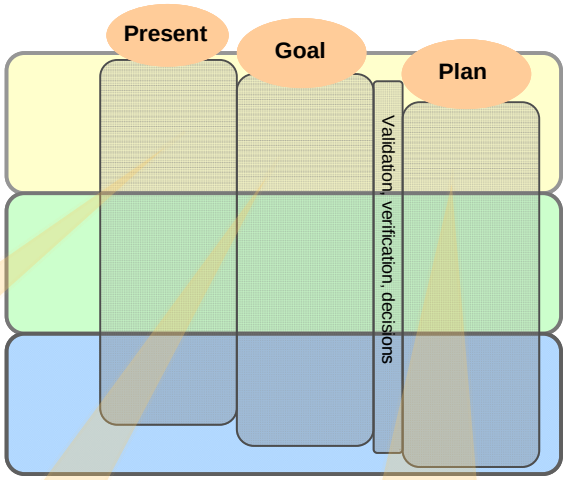


Photo: ZipIT project

Phases

The Activity driven ISD model has three main phases of development. The phases do not follow each other like a water-fall, but usually it is necessary to **iterate**.



1.Analyzing the **present state** of an activity

For eliciting data e.g. interviews, observation, guided work-tours.
For validating data e.g. workshops and focus group sessions.

2.Desining the **goal state**
For goal state elicitation e.g. brainstorming and workshops.

What would be the perfect world look like?
How would we like the information system to serve us?

3. **Planning** how to reach the goal state.

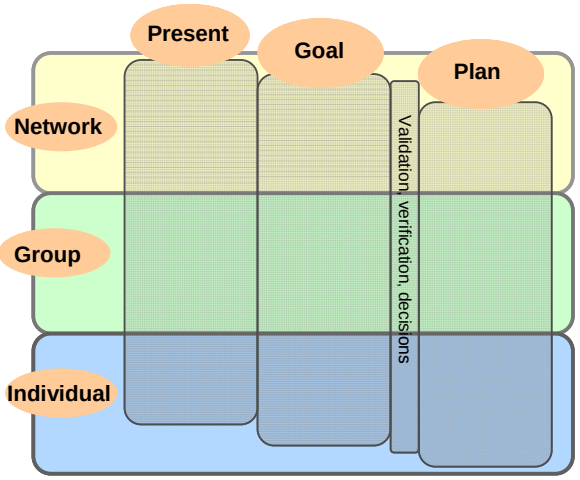
Based on the present state and the goal state the development actions need to be planned and organized.

Also, the project can be **restricted** for example on the first phase if we only need to find out problematic points in our activity for decision making.

The change actions can be in **different scales**. Sometimes it is necessary to take big steps, but also less dramatic gradual changes can be planned based on different time perspectives.

Sustainability

The basic value of technology comes from the **improvements achieved by technology** and how these improvements are **sustained** and enjoyed over time in organization. Sustainable development means a process that meets the **need of the present state** without compromising the ability of **future development**.



The criteria for sustainability are threefold:

- Firstly, the **capacity to sustain** the IS in use by the network of **supportive activities** and the possibility for **further development** must be ensured.

- Secondly, the **appropriateness of ICT** as means to use activity must be analyzed. New ICT must fit technically and be functionally correct.

- Thirdly, the demand of ICT for **improving the service** for clients must be real, and the impact of ICT for the service must be clear.

These criteria must be considered during information systems development that should empower user community, meaning **user participation**.

Participation

- advocating the users' position
=> **involving users** to the development process
- make the development process **transparent**
- **different** professionals have their own **viewpoints**
=> need to achieve **shared understanding**

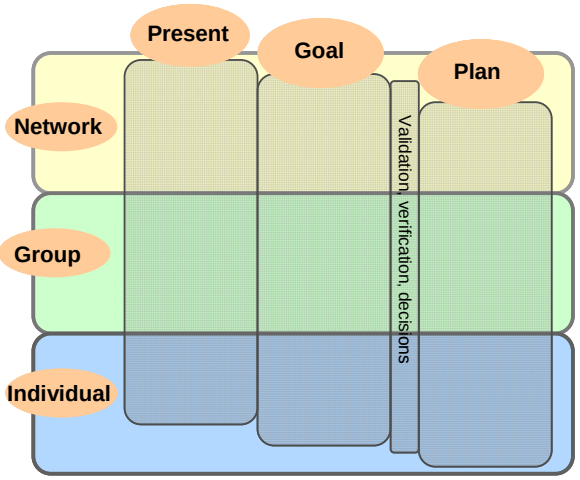


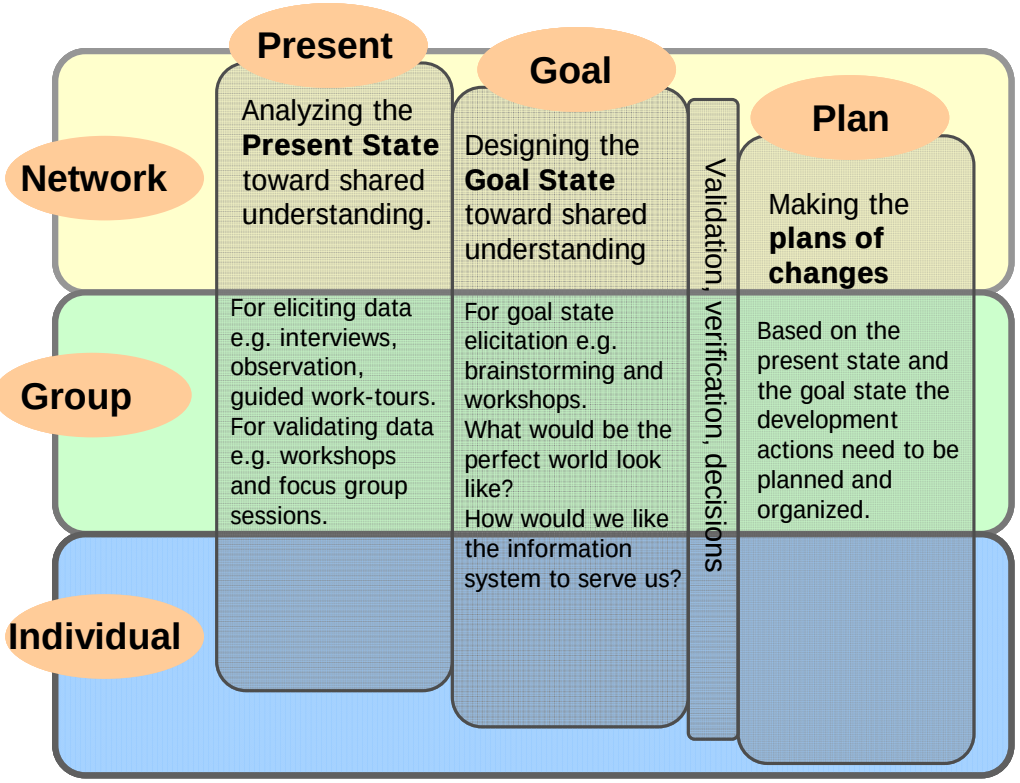
Photo: ZipIT project

As an example we had a pilot case where the task was to analyze how a new digital radiological imaging and archiving system would impact on activities in a health care centre, before purchasing any equipment. Radiological imaging unit produces services to other health care units, and information needs of those units do have impact on how radiological imaging should be arranged in future.

In couple of multi-professional workshops
the work flows and related information and information system were discussed.

With the help of the activity analysis,
- the changes were easy to locate,
- the goal state of an activity was possible to define and
- ensure the suitability of technical solution to the workflows.

Summary & Discussion



When it comes to requirements of appropriate and sustainable information system, **user participation is one key element**.

Activity driven ISD model can act as a **tool in decision making** and practical realization of IS development and work development. It is possible to illustrate the **real impact of ICT for services**, and this way to improve ICT's **suitability** to work.

Clinical staff and people operating with development activity have a **tool to analyze the present state**, **ideate the goal state** and to **plan the proper actions in ICT introduction**.

With the help of the model the management and the practical level have a common tool to see the **development objectives and phases** and thus achieve a **shared understanding** of the development and make the development process more **transparent**.

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Acknowledgments:

This paper is based on a research funded by the National Technology Agency Tekes through the ZipIT project no 40426/04, 40354/05, 40252/06, 790/04, 644/05, 644/06 and Finnish Work Environment Fund through the ActAD-HIS project no 104151.

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열린 마음, 나누는 사랑

The Implementation and Evaluation of Renal Function based Dosage Adjustment System in Seoul National University Bundang Hospital

Kyung Suk Choi[1], Soo Hee Hwang [2], Hyun Kyung Koo [2], Yoo Mi Cho [3], Eun Sook Lee[1], Sukhyang Lee [3], Hongbin Kim[5], Hojun Chin[5], Dongwan Chae[5], Yoon Kim[2, 4], Byung Koo Lee[1]

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[4] Center for Interoperable Electronic Health Record, Korea,
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분당서울대학교병원
SEOUL NATIONAL UNIVERSITY BUNDANG HOSPITAL

Introduction

- Electronic medical record (EMR) coupled with clinical decision support systems (CDSS) is highly effective in reducing the frequency of medication error, thereby improving the safety of the patients.

- A number of important therapeutics agents are excreted from kidney thus, renal patients are likely to necessitate the adjustment of the dosage for these agents.

- However, the implementation of such assistant function has not been reported nor evaluated in CDSS.

Objective

The purpose of this study is to develop knowledge based renal dose adjustment system which can be applied into electronic medical record at real time in Korean clinical practice

Methods

Establish drug dosing guideline

- Screening : all medications prescribed in patients with renal impairment
- 255 medications were finally selected
- The guideline reviewed by physicians
- The finalized guideline was then applied in the dosage adjustment system

Classification renal impairment

- Cockroft-Gault Equation **GFR(*mL/min*) <10, 10-50, >50**
- At the time of physician's prescription

  CLcr , dosing guideline, potential renal insufficiency
- Real-time displayed relevant dosing guideline
- Allows the physician to change or discontinue order or ignore

Methods

- Creatinine Clearance (ml/min)
  collecting 24 hour urine
  calculated by Cockroft-Gault equation
- Adjusted doses were decided by experts
- Produced dose adjustment system were applied into BESTCARE (Seoul National University Bundang Hospital Electronic Medical Record System)
- Efficiency in real practice was analysed retrospectively.

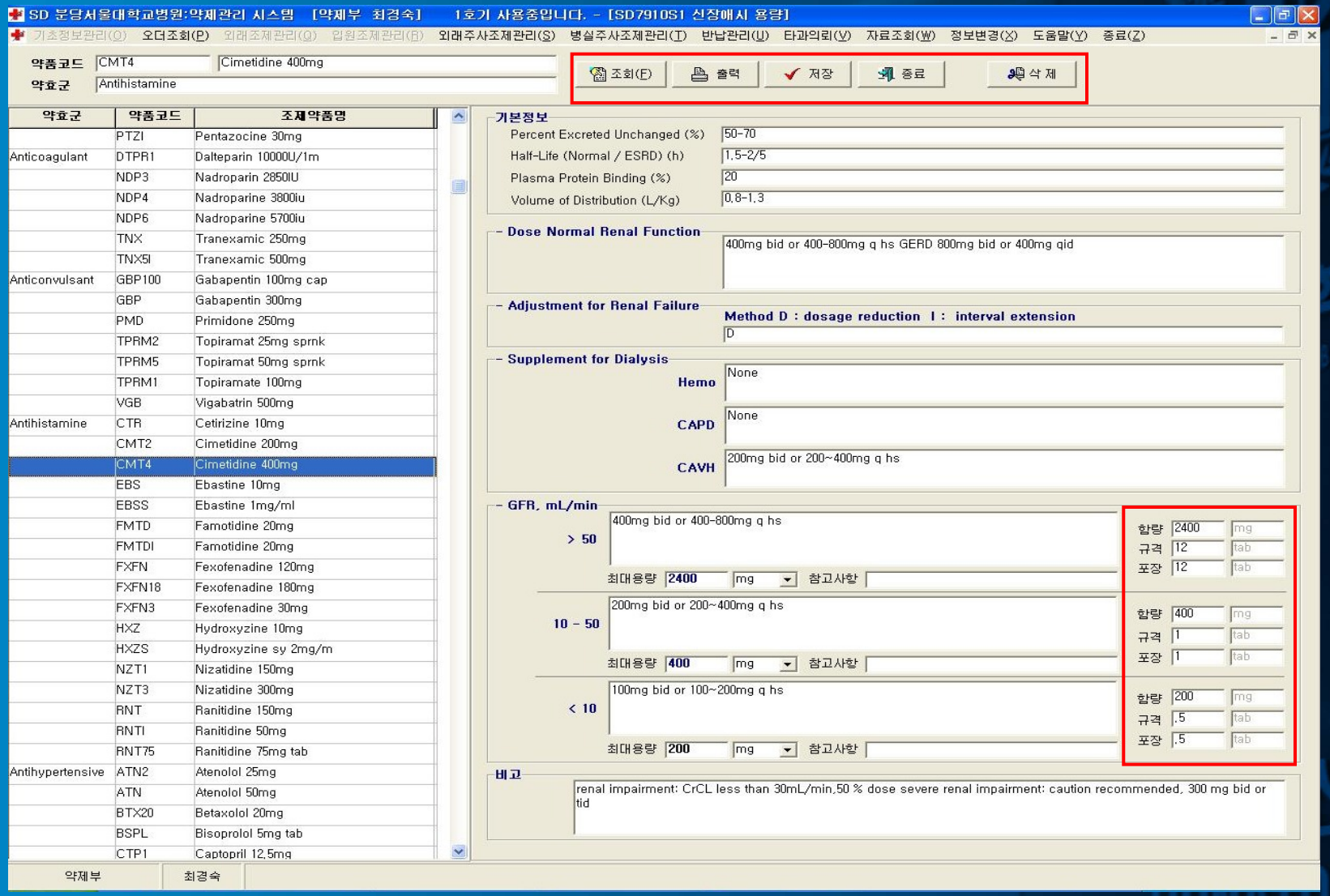
Results

The current system is operated from August of 2006.
Revised for the further reduction of the false positive alerts and the ratio for the override

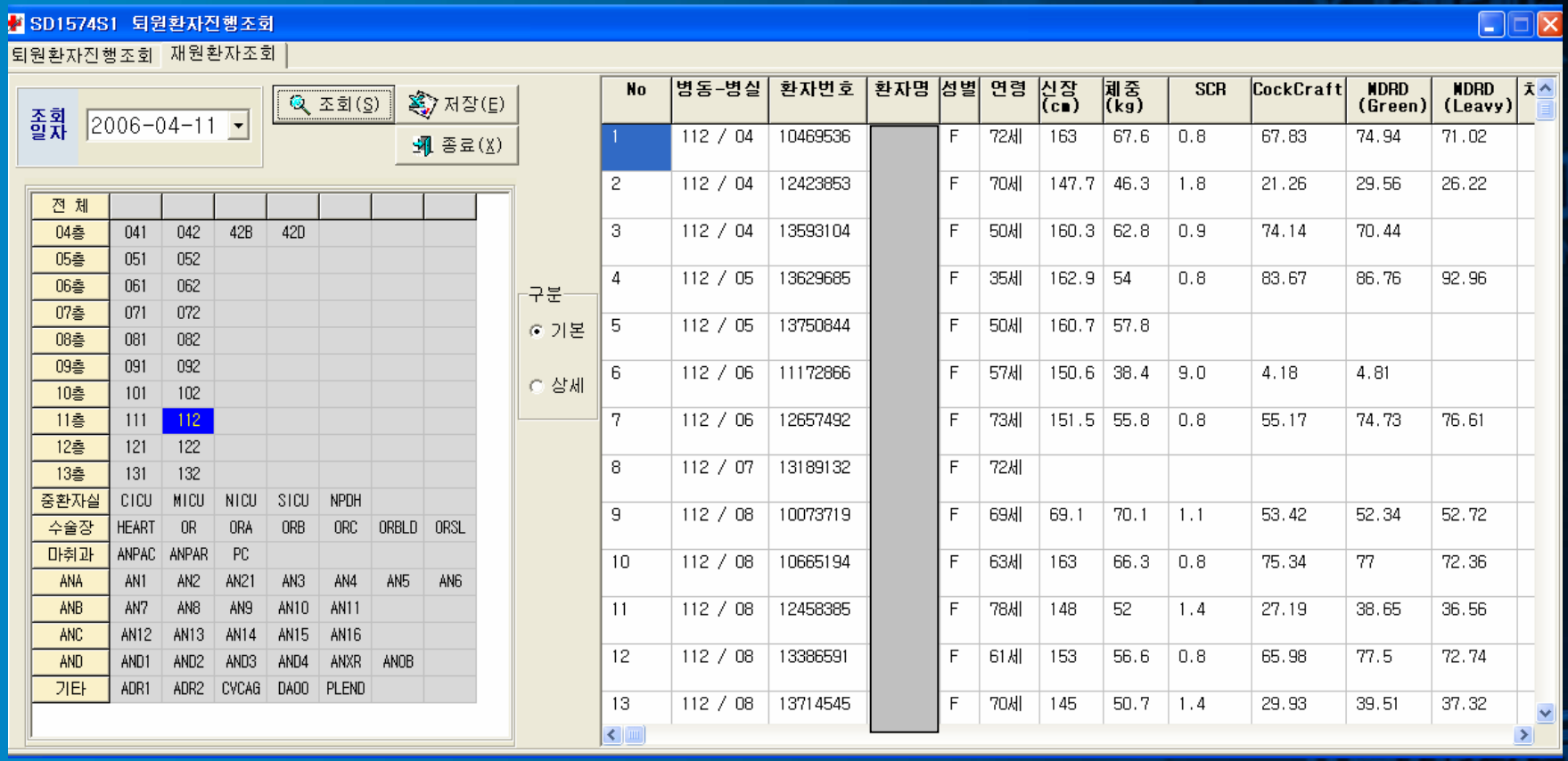
The Dosing guideline data

class	2005. 2. code	name of medicine	Percent Excreted Unchanged %	Half-Life (Normal/ ESRD) h	Plasma Protein Binding %	Volume of Distribution L/Kg	Dose for Normal Renal Function	Adjustment for Renal Failure Method	GFR, mL/mim >50	10-50	<10
Analgesics	CDI	Codeine	Hepatic	2.5-3.5/No data	7	3.0-4.0	30-60mg q4-6h	D	30-60mg q4-6h	22.5-45mg q4-6h	15-30mg q4-6h
	F1	Fentanyl	Hepatic	2-7/No data	80-84	2.0-4.0	Anesthetic induction	D	100%	75%	50%
	F5	Fentanyl									
	MP15	Morphine	Hepatic	1-4/Unchanged	20-30	3.5	20-25mg q4h	D	20-25mg q4h	15-18.75mg q4h	10-12.5mg q4h
	MP5I	Morphine									
	MPI	Morphine									
	MPS1	Morphine									
	MPS3	Morphine									
	PTZ2	Pentazocine	Hepatic	2-5/No data	50-75	5	50mg q4h	D	50mg q4h	37.5mg q4h	25mg q4h
	PTZI	Pentazocine									
	AAP3	Acetaminophen	Hepatic	2.0/2.0	20-30	1.0-2.0	650mg q4h	I	650mg q4h	650mg q6h	650mg q8h
	AAP6	Acetaminophen									
	AAR8	Acetaminophen									
	AAPS	Acetaminophen									
	ASAM1	Aspirin microcoated	Hepatic(renal)	2-3/Unchanged	80-90	0.1-0.2	650mg q4h	I	650mg q4h	650mg q4-6h	Avoid

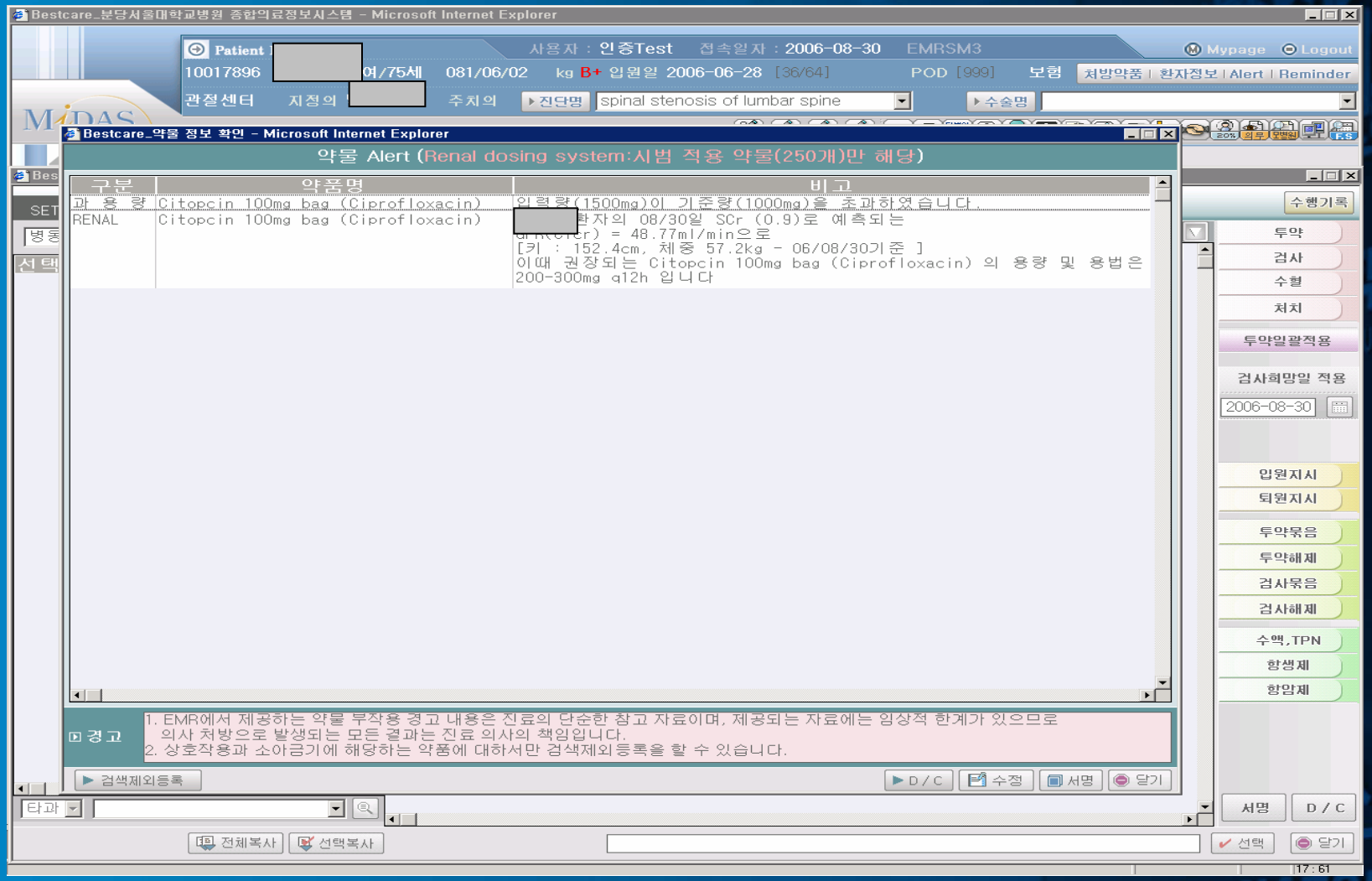
The Dosing guidelines in pharmacy master



Dose adjustment system in Ward as a unit



real-time alert window



Conclusions

- Produced dose adjustment system were successfully applied into BESTCARE (Seoul National University Bundang Hospital Electronic Medical Record System) from August, 2006.
- Real-time alert window was effectively realized to clinician's monitor at office simultaneously if inadequate doses were prescribed.
- This help physician's dose adjustment and prevent overdose in renal patients.
- The current system may be practically useful in the improvement of the safety in renal insufficient patients resulting in the realization of the effective Pharmacotherapy.

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[a]Department of Pharmacy, Seoul National University Bundang Hospital, Korea
[b]Department of Health Policy and Management, Seoul National University College of Medicine, Korea
[c] Graduate School of Clinical Pharmacy, Sookmyung Womens's University, Korea
[d] Center for Interoperable Electronic Health Record, Korea

Abstract and objective

It is now widely accepted that the electronic medical record (EMR) coupled with clinical decision support systems (CDSS) is highly effective in reducing the frequency of medication error, thereby improving the safety of the patients. A number of important therapeutics agents are renally excreted from the body and, thus, a renal insufficiency of a patient is likely to necessitate the adjustment of the dosage for these agents. However, the implementation of such assistant function has not been reported nor evaluated in the literature for the case of CDSS. Therefore, the objective of the current study was to develop, implement and evaluate the renal function based dosage adjustment system in the CDSS, SNUBH

Keywords:

computerized prescription order entry,
renal dosing system, clinical decision support systems

Introduction

Seoul National University Bundang Hospital (SNUBH) represents one of the first medical institutions in Korea that has the full implementation of EMR-CDSS. The current system allows additional implementation of computerized prescription order entry (CPOE), e.g., CDSS for the identification of drug induced allergic reaction, drug-drug interaction, therapeutic duplication and assistant functions for the rationale prescription of antibiotics/anticancer agents. We were particularly interested in, if necessary, the provision of appropriate dosage and the dosing interval to the physician at the time of the completion of the order entry.

Methods

The Dosing guidelines were compiled for all medications used in our institution that are renally excreted. The guideline was then reviewed for the appropriateness by the physicians in the Departments of Nephrology and Infectious Diseases. The finalized guideline was then applied in the dosage adjustment system. Depending the availability of patients' measured creatinine clearance (Ccr) values, the system may use Cockcroft-Gault equation, if necessary for the evaluation of the renal insufficiency. Upon the completion of the order entry, the system checks for Ccr value of 50 mL/min or higher and the daily dose. Depending on the dosing guideline and the potential renal insufficiency, a warning message, along with the Ccr value and the relevant dosing guideline is real-time displayed. The system allows the physician to change or discontinue the order or ignore the alert to complete the order as it is.

Results

The current system is operational in our institution from the August of 2006. The initial evaluation has been completed and the system revised for the further reduction of the false positive alerts and the ratio for the override.

Conclusions

The current system may be practically useful in the improvement of the safety of the renal insufficient patients and the realization of the effective pharmacotherapy.

Acknowledgments

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Developing a System to Provide Patient-centered Information Handouts about Laboratory Tests

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Abstract and objective

The explanations given to patients scheduled for laboratory tests tend to be inadequate because medical doctors are faced with too much work and too little time. To improve this situation, we developed a system to provide printed handouts using a hospital information system (HIS). First, we conducted a questionnaire survey to clarify the patients' needs for explanations regarding specific blood tests. Next, we developed a system that generated explanation handouts for those blood tests. The results showed that patients have high demands for sufficient blood test information and preferred printed explanations. As our system required only 1.36 sec after receiving an arrival message from the server to the start of printing, we believe that our system is practical.

Keywords:

information disclosure, hospital information systems, information services, patient handout

Introduction

While providing patients with sufficient explanations about medical practices is important, those given to patients scheduled for laboratory tests tend to be brief. The main reason in Japan is that physicians are constrained by heavy workloads that leave too little time [1, 2]. This study clarified patients' needs using a questionnaire survey and developed a system to provide patients with handouts that explained blood tests.

Methods

We surveyed outpatients on their needs for information about specific blood tests. Outpatients at the University of Tokyo Hospital were asked to complete a questionnaire consisting of 27 questions. Based on the results, we chose paper as the information medium because it has the advantages of being able to be 'read anytime, anyplace, without any tools' [3]. We selected 72 items for the handout content, which covers about 70% of the target orders, and wrote an explanation for each These explanations were verified by a physician and the staff of the clinical laboratory center. We developed a system for printing the handouts explaining laboratory tests (Figure 1) and evaluated its performance by measuring the operational time.

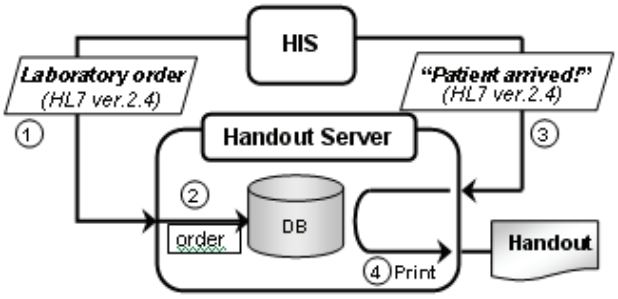

Figure 1 - An overview of our system (1) The HIS sends a laboratory order to the Handout Server. (2) The Handout Server parses the order and saves the information. (3) The HIS sends the patient's arrival message to the Handout Server and (4) the Handout Server prints a handout for the patient

Results

The results of our survey indicated that over 80% of the respondents demanded that information and handouts be provided before blood tests. They were particularly interested in the purpose and subitems of the test (Fig. 2).

The response time speed was shown in figure3. Since it was on average 1.36 sec from receipt of a patient's arrival message to the start of printing (Fig 3), our system was shown to be practical.

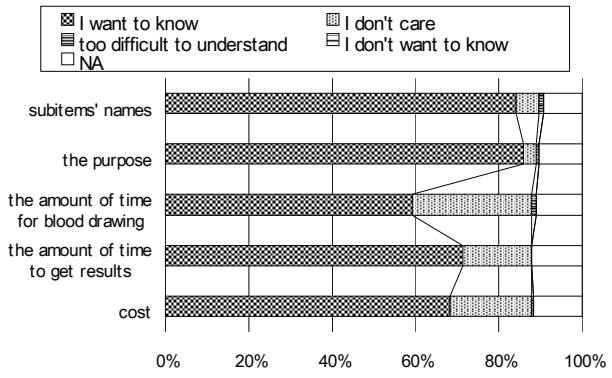

Figure 2 - "Would you like to know this information of the test?"

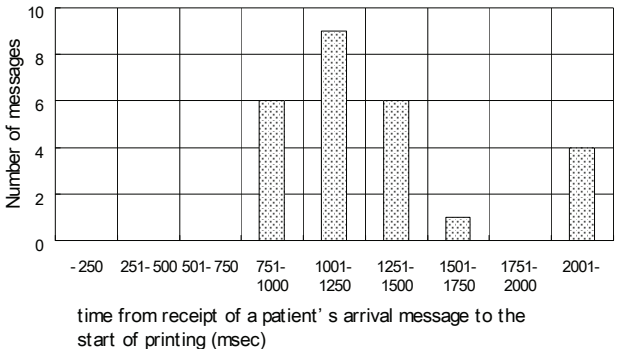

Figure 3 - The response time speed of our system

Discussion

Since the handout server is connected to the HIS over HL7, one can easily introduce it in another hospital.

Both the amount and the quality of information are limited as long as using paper as the information medium. One could direct patients who need more information to other information sources (e.g. web pages and books) and our system serves to provide minimal information.

Conclusion

So far, we have seen that many patients have needs for information about specific blood tests, and developed a system to provide them with handouts that explained blood tests. A further evaluation on the usefulness of the handouts is scheduled in 2007.

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[2] Yamauchi K, *et al.* Communication between medical consumers and doctors. http://www.jpma.or.jp/opir/research/paper-29.pdf. Accessed: Dec. 4, 2006. (in Japanese)

[3] Tang PC, Newcomb C. Informing patients: A guide for providing patient health information. J Am Med Inform Assoc 1998;5:563–570.

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Developing a System to Provide Patient-centered Information Handouts about Laboratory Tests

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Introduction

Explanation given to patients scheduled for laboratory tests tend to be insufficient

- Physicians' workload
  - Too busy [1,2]
  - Laboratory tests is less invasive

Purpose

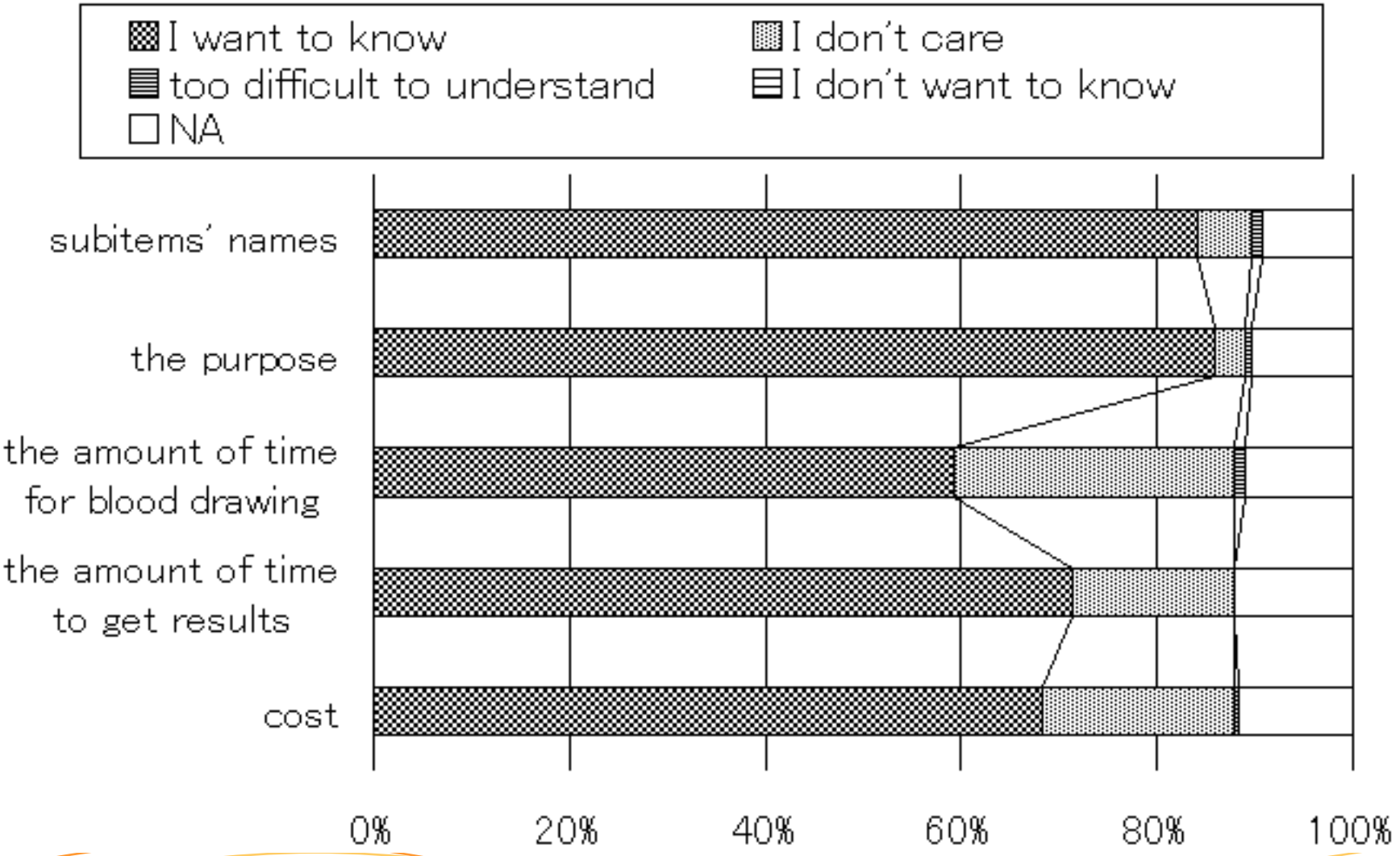
1. Clarify patient's needs for information about blood test
   - a questionnaire survey

2. Develop a system to provide handouts
   - Make use of Hospital Information System

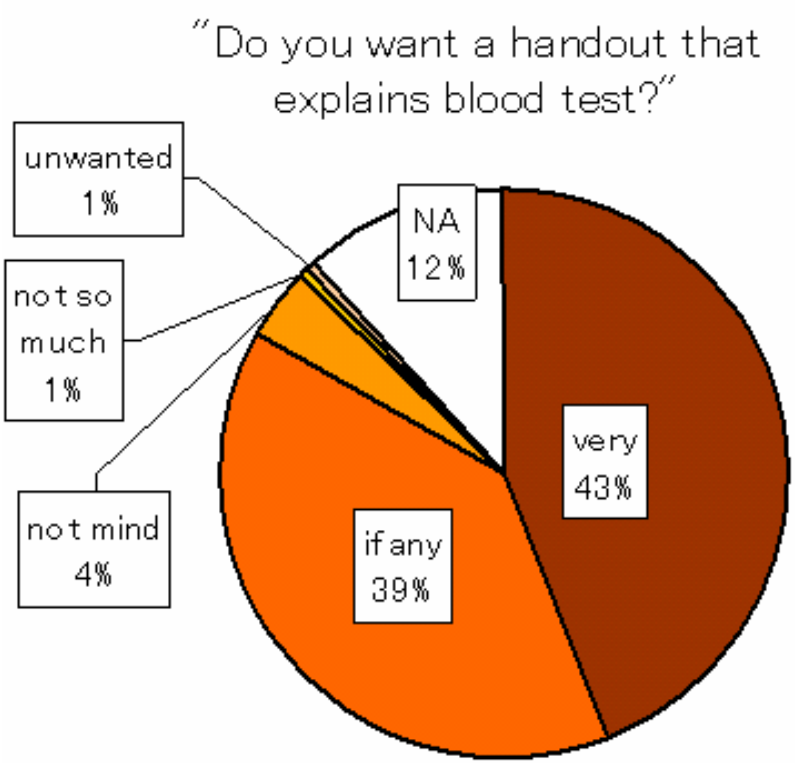
A Questionnaire survey

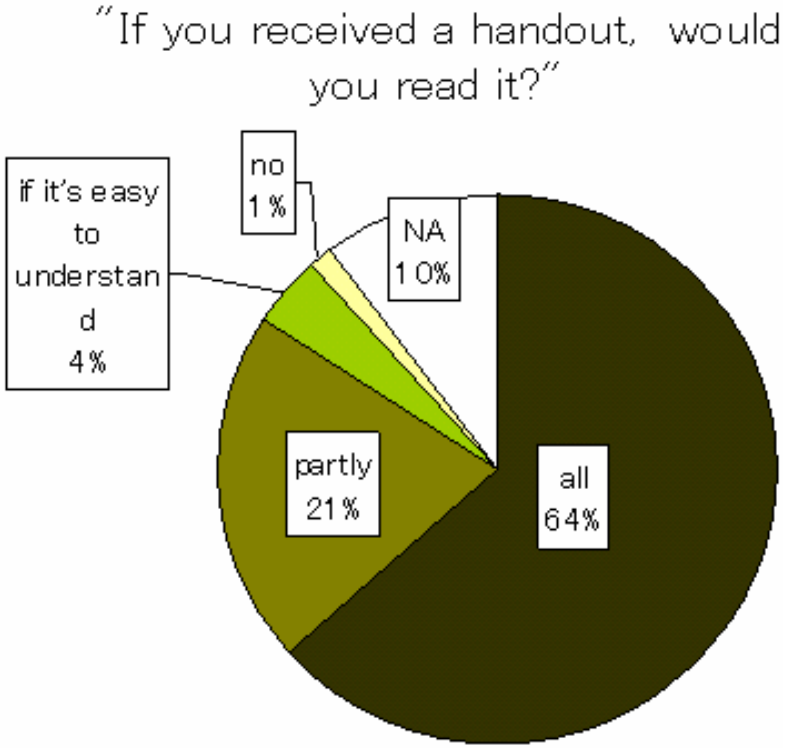
- Purpose
  - Which information of blood tests do patients need?
  - Do patients need handouts that explain blood tests?
- Method
  - Self-administering method
  - Period : 2005/7/1, 2005/7/2 (2 days)
  - Outpatients at the University of Tokyo Hospital
- 164 respondents

“Would you like to know this information?”



Do patients need handouts?

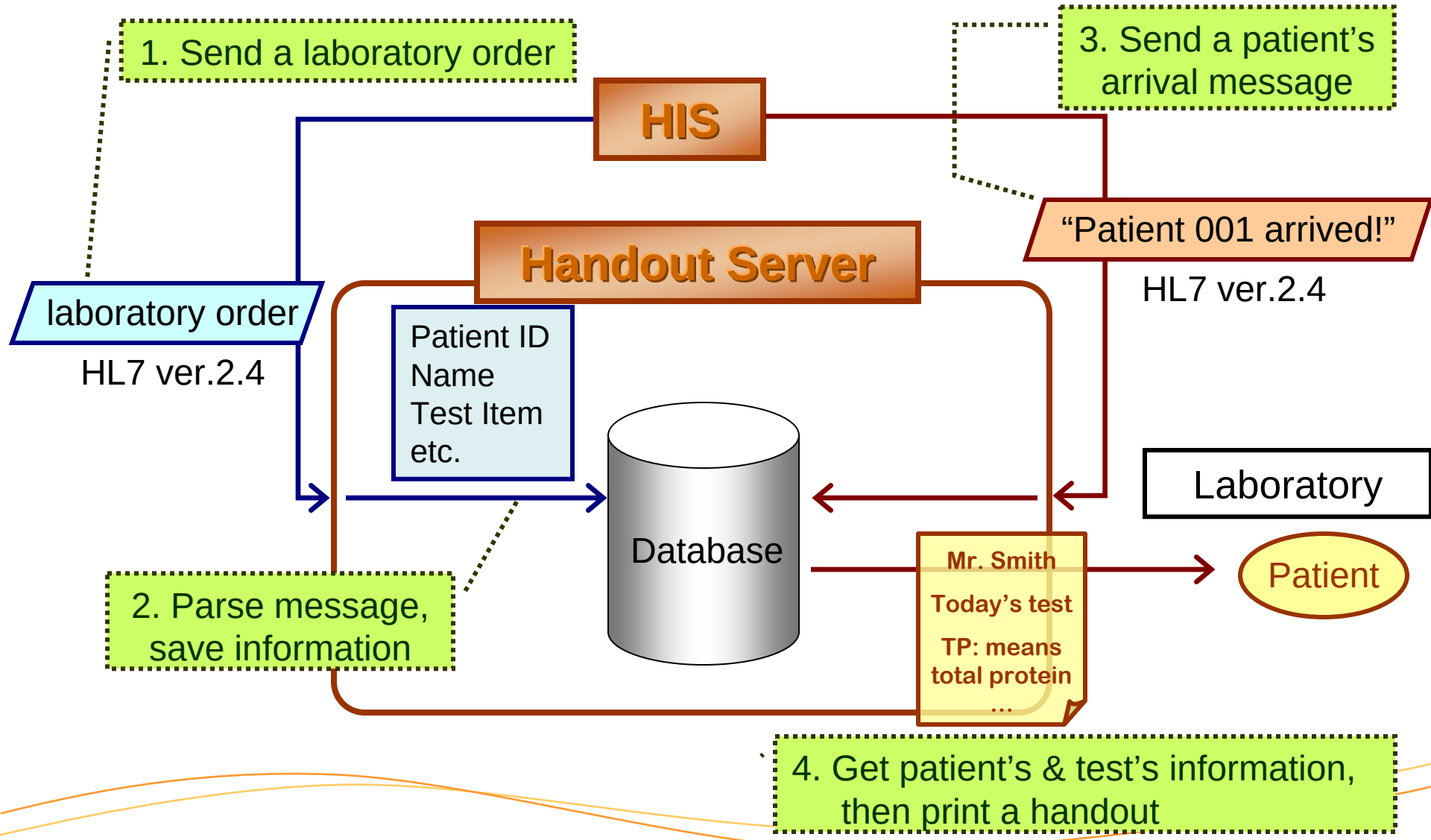




System development

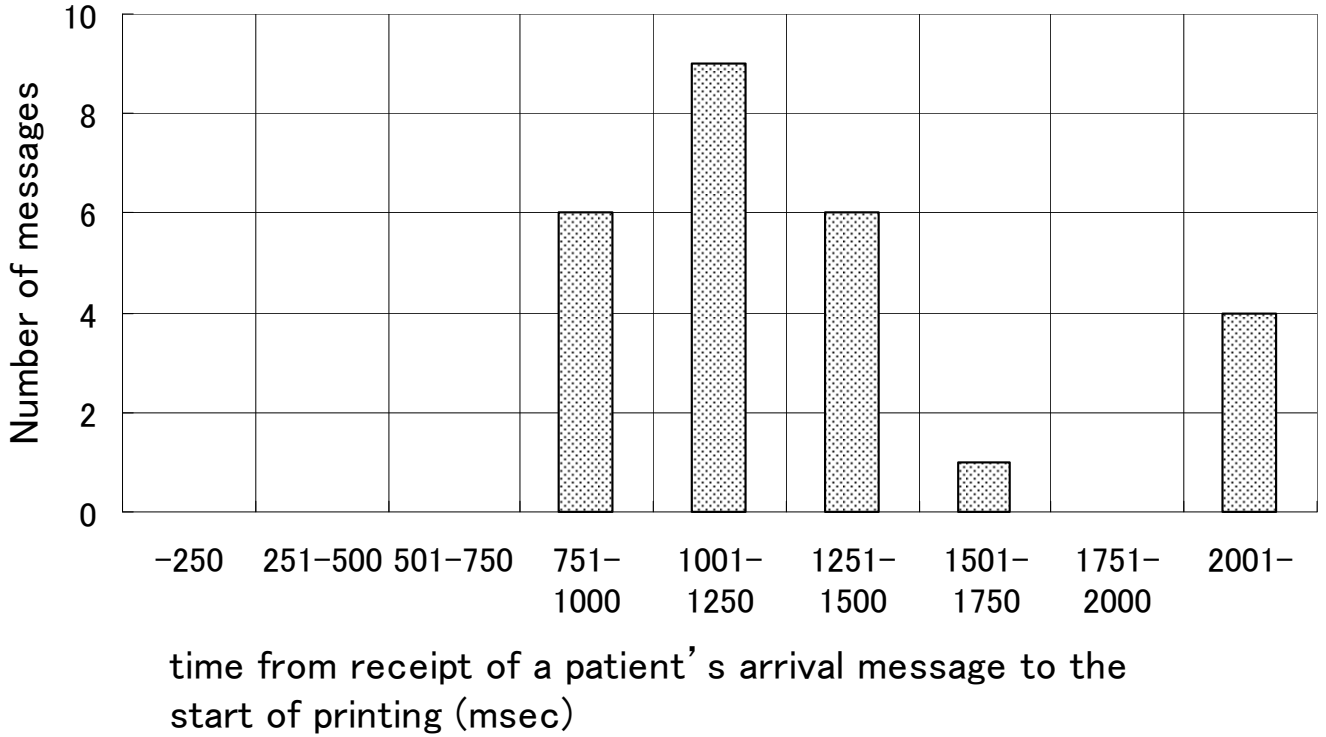
- The information medium : paper
  - Able to be ‘read anytime, anyplace, without any tools’ [3]
- The handout server
  - The HIS sends a laboratory order
  - Print a handout when a patient arrived at the laboratory
    - Connected to the HIS over HL7
- The handout
  - Patient’s name, date
  - Explanation of blood test
  - Names and the explanations of each items
    - Verified by a physician and the staff of the clinical laboratory center

System architecture



system evaluation

- The response time speed from receipt of a patient's arrival message to the start of printing (1.36 sec on average) ⇒ ***practical***



Discussion

- High connectivity
  - HL7
  - Easy to introduce the handout server in another hospital
- The information medium
  - Paper: limited quality and quantity of information
    - Provide minimal information
  - Compensate by directing patients to other information sources (e.g. Books, web pages)

Conclusion

- We have …
  - seen that many patients have needs for information about specific blood tests
  - developed a system to provide them with handouts that explained blood tests
- A further evaluation on the usefulness of the handouts
  - scheduled in 2007

- **References**

1. Ministry of Health, Labour and Welfare http://www.mhlw.go.jp/toukei/saikin/hw/jyuryo/02/. Accessed: Dec. 4, 2006. (in Japanese)
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Development and Evaluation of PACS, a Parallel Operation System with Improved Fault-tolerance

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Abstract

We developed the dual PACS to enforce the robustness and the redundancy. These PACSs were made by two different vendors. We assumed that we had to continue the service without serious problems. By the different systems, users can select the suitable interface, and the systems become inevitable for the hospital information system.

Keywords:

PACS, filmless, fault-tolerance

Introduction

The Research Center of charged Particle Therapy Hospital, affiliated to the National Institute of Radiological Sciences (hereinafter called "this hospital"), began archiving digital medical images from 1995, and launched film-less operation from the summer of 2005. Image data obtained by inspection have been stored without being deleted because they are necessary for following up radiation therapies on a long-term basis. As of October, 2006, approximately ten million images obtained from approximately 120,000 cases of inspection are available, and all of them are stored on hard disks.

This time, with the expiry of the lease period of the former version of PACS, we changed PACS's configuration into a duplex one to upgrade equipment and avoid problems. This paper reports our experiences from this system's introduction together with the current operation status.

We set the following goals as the basic premise of the system upgrade. The first goal was to maintain the volume of work procedures to be performed by engineers or medical physicians at sites where images are created. Then, for the system to be used, we judged it was difficult to immediately switch over the system because terminals exclusive to viewing images coexist with researchers' individual workstations. The second goal was therefore to allow more than one systems to operate in parallel at any time.

Methods

As the systems, the first PACS was TechMatrix's "SDS-ImageServer," and the second PACS was Fuji Film Medical's "SYNAPSE."

For the former version of PACS, image data flowed as follows: 1) Images shot by inspection equipment (modalities) are sent to an intermediate server called, "AQGW (Acquisition Gateway)." 2) AQGW checks consistency between received images and patient master images, and then sends ones from which no problem was detected to a registered image server. The sent data are saved for a particular period, and then deleted automatically. 3) The image server makes it possible for users to view saved images using the viewer function as target images to be referred to. Thus, we designed a transfer procedure as follows: 1) Expand the functions of AQGW on the network for storing images so that images can be stored in more than one servers in parallel. 2) Start up a new PACS server (the first PACS) as a server exclusive to image viewing together with the former image server. Then, transfer image data using DICOM C-STORE along the course from transfer source to transfer destination. 3) Start up the second PACS server while maintaining parallel operation with the first PACS server when possible, and transfer image data using DICOM Q/R from transfer destination to transfer source. Figure 1 shows a schematic of the current system configuration.

Results

The system transfer finished without causing major problems such as long discontinuation of services or deficiency of data. At the end of August, 2006, approximately 20,000 images obtained from 60 cases of inspection were stored a day. Images stored in the first and second PACS servers become ready to view in five to fifteen minutes after a case of inspection has ended (this depends on the category of the inspection).

For users, the range of options was broadened because it became possible to use the viewer function according to uses. For the status of system use, we observed a trend that cases were classified into two types: One is viewing images obtained from more than one patients simultaneously, such as at a conference, and the other is viewing images obtained from one patient at a session of image interpretation.

Before the system transfer, a method to set up the viewer function on each workstation should have been simplified.

For the data transfer, approximately seven million target images were transferred in 32 days when the first PACS server was started up. On the other hand, it took approximately two and a half months to transfer approximately eight million images when the second PACS server was started up. This indicated that image storing can be completed from transfer source to transfer destination in a shorter time if a suitable work environment can be prepared.

For the current operation, it is necessary to check images by comparing them to each other based on the number of the user IDs assigned to images to maintain the consistency among multiple servers.

As future issues, for the first PACS, we are considering operation transfer to image-saving using a reversible compression method to effectively use disk space for image-saving. For the second PACS, we are going to allow authentication using individual user IDs to ensure correct audit trail.

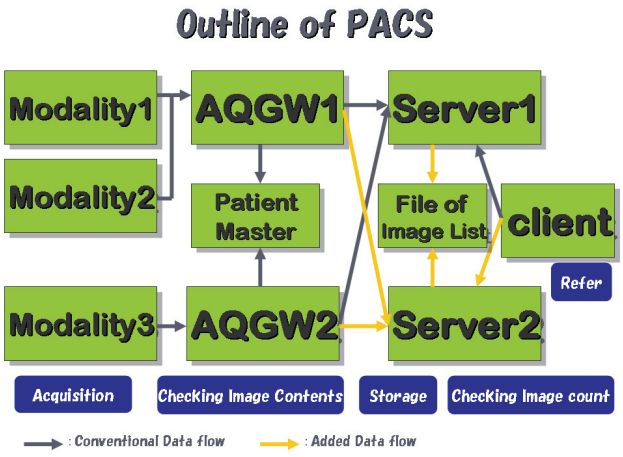

Figure 1 - Outline of PACS

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Development and Evaluation of PACS —a Parallel Operation System with Improved Fault-tolerance—

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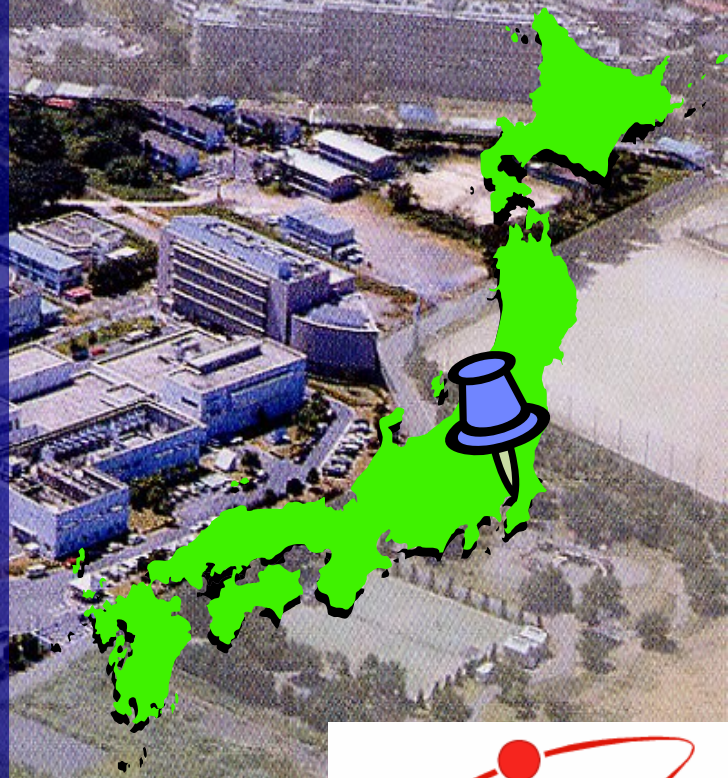
Research Center for Charged Particle Therapy

National Institute of Radiological Sciences , JAPAN

- Located at Chiba , JAPAN
- Inpatient: 100 beds
- Outpatients: 70-100 patients/day
- Specialized for a radiation therapy with a Carbon heavy particle

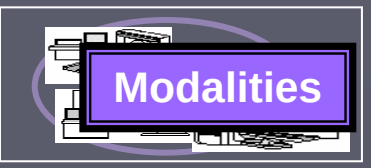


NIRS

Current Status of PACS

- Modality
  - CT, MRI, CR, DR, Ultra-Sound, endoscope
  - NM (PET, PET/CT, Gamma, SPECT)
- Actual results
  - Number of study : 90 /day
  - Number of image : 20,000 /day（May 2007）
  - Total : 121,000 studies, 12.5 million images
- Topic
  - Archiving DICOM images since 2000
  - Permanent archiving for the long term follow-up
  - All Images are stored on on-line hard disks
  - August 2005: Film-less environment started
  - October 2006: EMR system started

Configuration of PACS



CR

DR

Angio

MRI

CT

CT-simulator

PET/CT

SPECT

Gamma

Endoscopy

Ultra Sound

PACS-Gateway

PACS Server-1

RAID 8TB

PACS Server-2

RAID 7.5TB

WEB Server

RAID 100GB

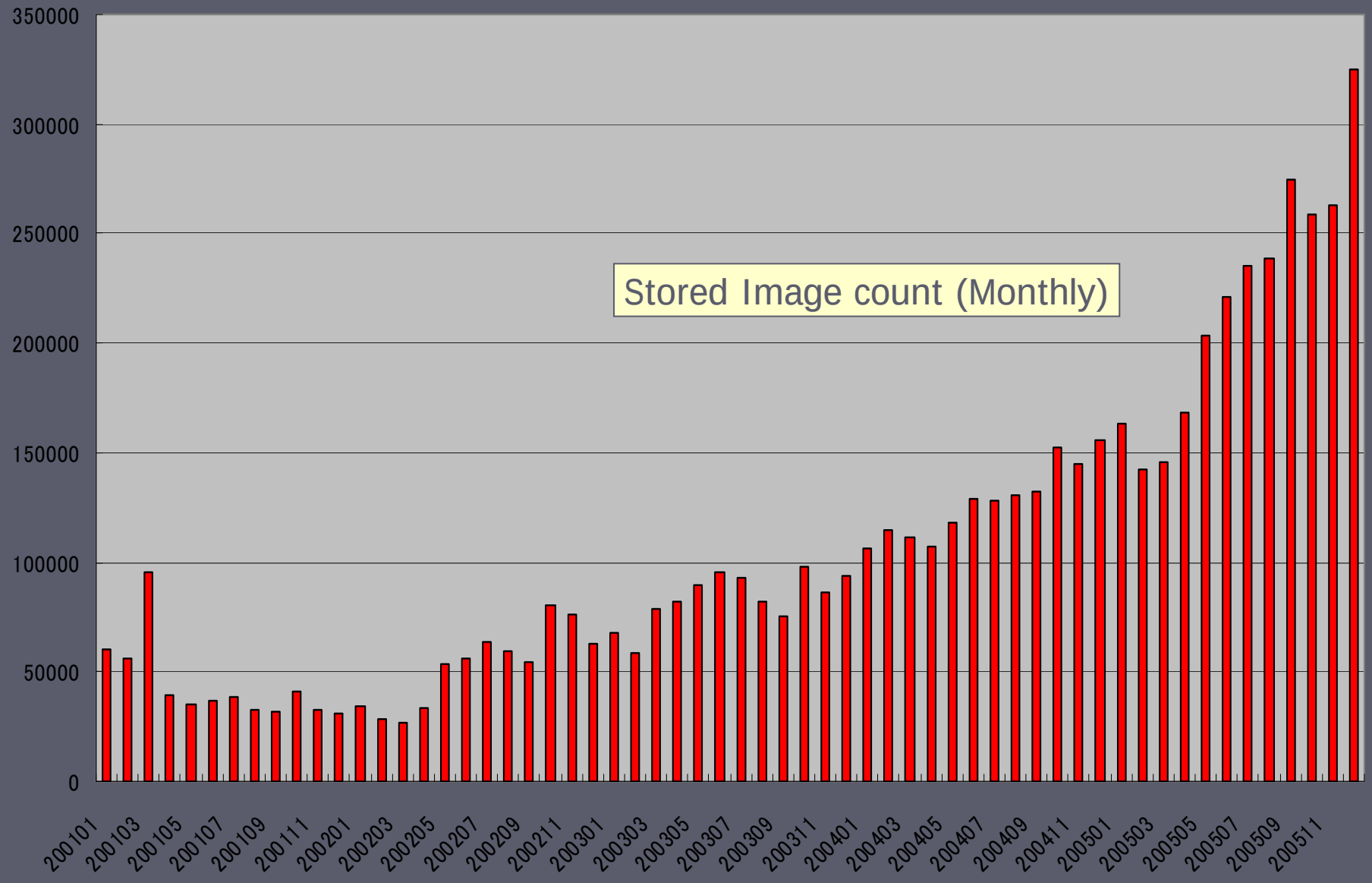
Patient History DB

Client-Viewer
70 terminals

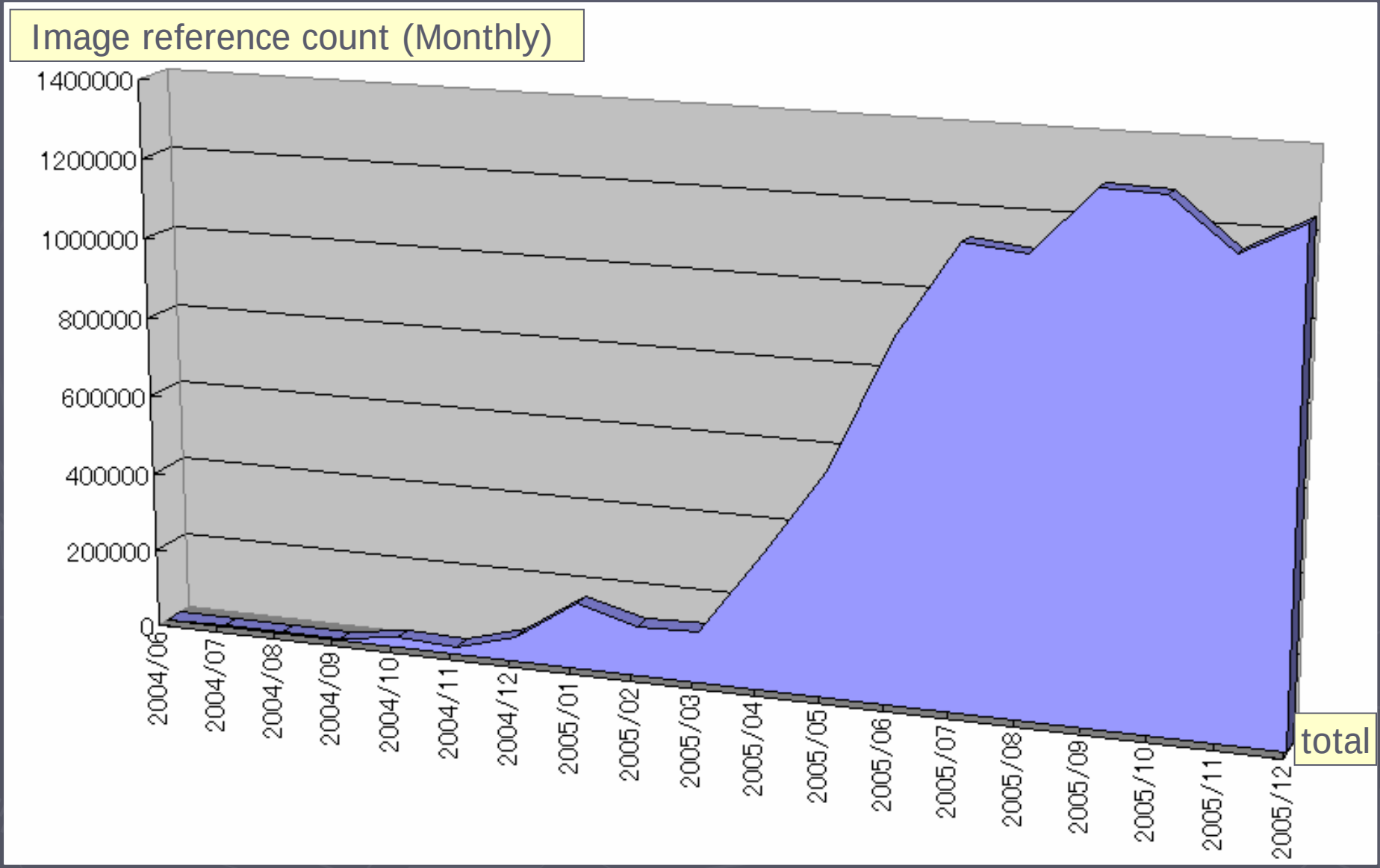
Client-EMR
100 terminals

Parallel PACS with Fault-tolerance

Number of images stored in PACS



Number of Image References



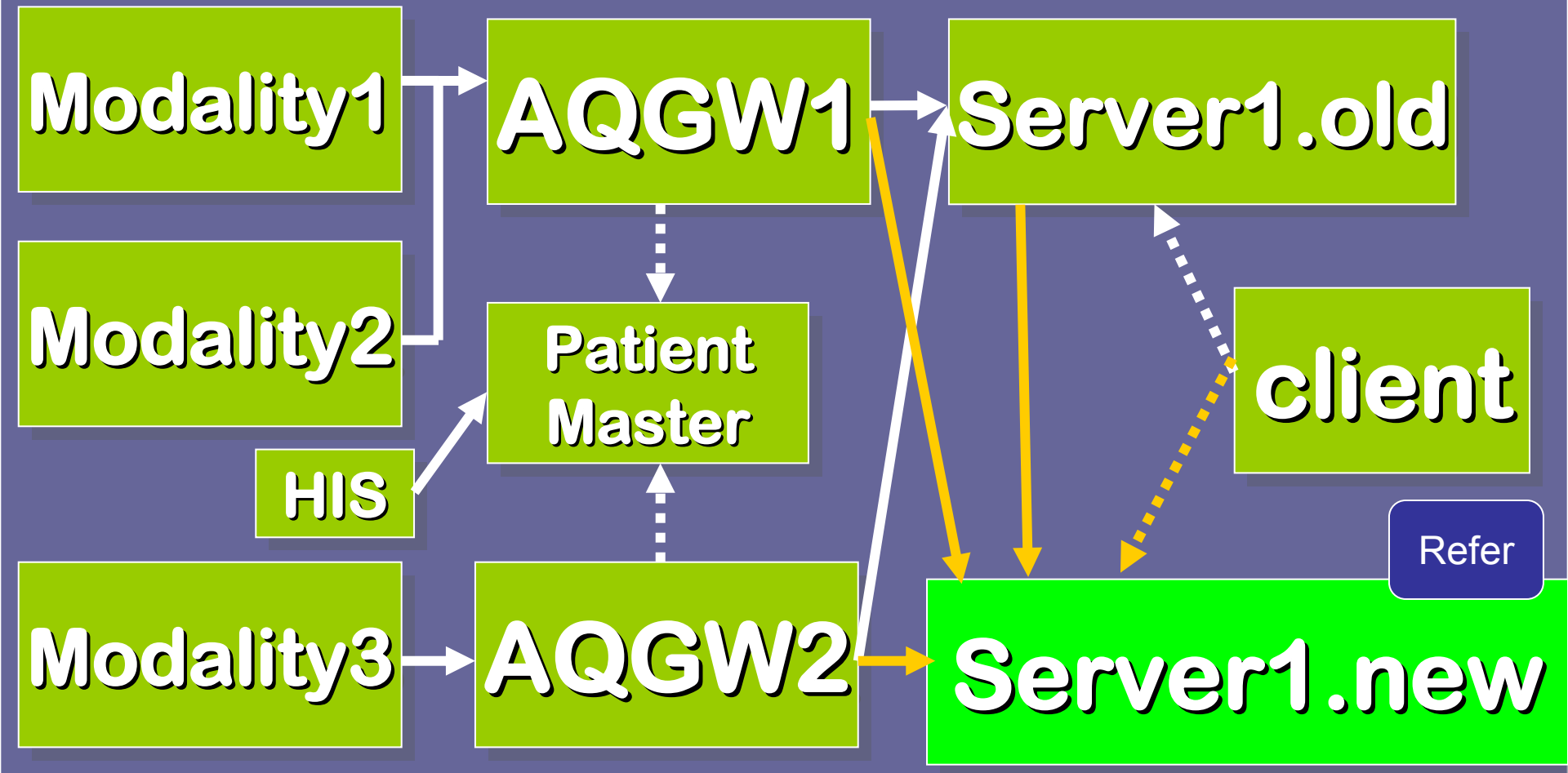
Flow of Image Archive

1) Images were sent from modalities to the AQGW (Acquisition Gateway), an intermediate server.
2) AQGW was to ensure the consistency of patient information of images with that of the master information. If the patient information were matched, images were stored to PACS servers. The images were also remained on AQGW for a week, and then automatically deleted.
3) Physicians could refer the images from the PACS server using the two kinds of viewer applications.

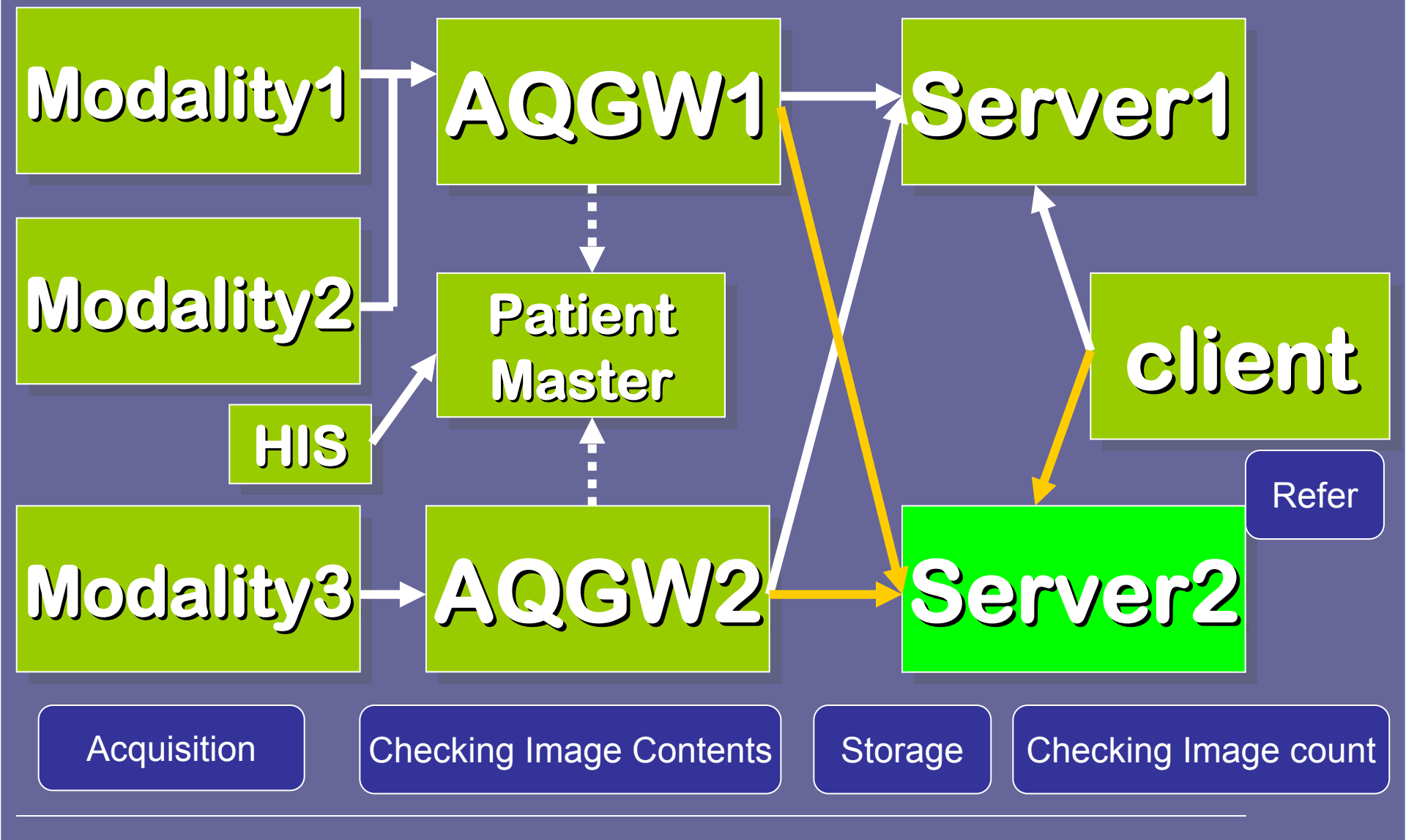
Transfer Procedure

1) When the PACS-1 server was started up, the server was used only for viewing images which was transferred from the former PACS server. DICOM C-STORE was used to transfer image data from transfer source to transfer destination.
2) When the PACS-2 server was started up, DICOM Q/R（Query and Retrieve） from transfer destination to transfer source was used for transfer image data in order to maintain a parallel operation with the PACS-1 server.
3) Then AQGW had also extended function to send multiple servers on the network in parallel.

Outline of PACS （During a shift）



Outline of PACS (Goal)



Results and Future Issues

- The system migration was finished without problems such as long discontinuation of services or data deficiency.
- Users can select the viewer applications on their demand.
- As future issues
  - PACS-1:For effective disk management, a reversible image compression may be applied to image store.
  - PACS-2: User authentication may be ensured for correct audit trail.

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  - TechMatrix Corporation
  - FUJIFILM MEDICAL Corporation

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An Evaluation of the Usability of Accessing MEDLINE over Short Messaging System

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Abstract

The Philippines is the texting capital of the world with over one billion messages exchanged every day. With the increasing ubiquity of cellphones in this country, it becomes a popular tool for accessing many types of information. This study aims to determine the usefulness of short messaging system (SMS) for accessing the bottom line of articles in MEDLINE. Two groups of residents at one of the largest tertiary government hospitals in the country were trained on the SMS interface for txt2MEDLINE. After four weeks of interactions, their responses were analyzed and they were given survey on the usability of the interface as well as their ability to comprehend the abridged text-speak of txt2MEDLINE. Results showed that residents did not find additional usefulness with txt2MEDLINE over SMS but cited convenience of access from any point of care as one of its benefits.

Keywords:

Short messaging system, text, Philippines

Introduction

In the Philippines, over 22 million of the total 80 million Filipinos have mobile phones. In contrast,

only 5 million Filipinos have access to the Internet. Overall, there are only 1.53 million PCs in the country.[1]

Immediate access to current information is a must in today's rapidly evolving practice of health care. Both health care personnel and their patients have gained access to a wealth of information available on the World Wide Web. In this new arena, access to a knowledge-base must be at the point-of-care. However, available online access through a computer terminal is not always present, even in tertiary hospitals. The ubiquity of SMS on mobile phones provides an alternative way of accessing health care information. More importantly, health care practitioners have begun to appreciate the value of using mobile devices in practicing evidence-based medicine. [2]

The BBC reports that the Philippines is the SMS text messaging capital of the world. More than 200 million text messages are sent daily in the Philippines. The use of text messaging is major social phenomenon, widespread and pervasive. It is woven into the day-to-day activities of the people. Mobile phones are used in every aspect of life-media, religion, education, commerce and health care. English is an official language of the Philippines. More than a third of Filipino own mobile phones. Doctors and health care providers actively use SMS in daily clinical practice. Doctors regularly exchange information with patients via SMS. Residents use text messaging and multimedia messaging to refer patients to their attending physicians. Because of this, the local study participants--attending physicians, post-graduate trainees and other health care providers are already experts in the technology, no training is required. This will facilitate the implementation of the project. It is the ideal laboratory to evaluate this application.

Methods

An SMS gateway to MEDLINE was established in the Philippines, and two groups of residents (otorhinolarygology and family medicine) were trained to use the SMS interface of txt2MEDLINE [3]. In order to eliminate the effect of individual differences in comprehending text-speak (abridged words), they all underwent baseline assessment where they were asked to back-translate sample messages from the txt2MEDLINE system into conventional English. For the clinical aspect of the evalaution, they were also asked to fill out a survey that determined the usefulness of the service to their daily needs.

The Txt2MEDLINE architecture used by the National Library of Medicine in a previous study was modified to adapt the system to local needs and services. [3]. A TER-GX101 TriBand (900/1800/1900 MHz) GSM modem (Round Solutions Ltd) connected to a Linux computer (Ubuntu Server ver. 6.10) comprises the Txt2MEDLINE server. A Subscriber Identity Module from SMART Philippines mobile phone network, and SMStools interfaces between the GSM modem and MySQL database. The SMStools [4] (SMS Server Tools for GSM modems) was used instead of UltraSMS. This modification was done because of the flexibility of SMStools. Segmentation of long messages is handled by SMStools easily instead of passing the burden to the scripting language. PHP was

used as the scripting language that processes data coming in and out of the server.

Results

The clinical evaluation was done in two phases. Each phase lasted approximately two weeks.

Mean number of queries, evaluations and comments sent per day for the first phase was 40.5 messages per day. The queries done and the corresponding evaluations were grouped according to five main categories: Diagnostics,

Etiology, Prognosis, Treatment, and Prevention. The categories were adapted from a previous study by Florance [5] where the author did a structural analysis of clinical questions by physicians. This categorization is important to determine how the participants are using the Txt2MEDLINE system and to better explain the results of the study.

Conclusion

The txt2medline system succeeded in bringing immediate access to MEDLINE resources in a convenient and portable package. However several innovations in technology had intervened that made the SMS interface as costly or less cost-effective as online cellular communications protocols such as general packet radio services (GPRS) or 3G. An SMS-based information access facility given this environment may not be the most appropriate solution.

Information requirements in terms of usefulness and reliability of information were not satisfied. Given the larger volume of data that can be sent through GPRS or 3G, it appears an SMS based interface to MEDLINE such as txt2MEDLINE will be difficult to promote. This is especially true when participants had to make several

attempts in sending and reformulating queries before receiving the appropriate citation. Furthermore, the information available to the SMS system is very limited even with the longer messages used. A mobile phone browser-compatible website of PUBMED may be able to give more information at a lower overall cost.

There are more things to consider in developing a mobile information retrieval solution. We have to take into account the culture of research and information source biases found among our health professionals.

Studies suggest that doctors tend to rely on other sources of information for their practice other than Medline [6]. We may try to develop more appropriate information systems for physicians, but if the culture for using these are not present, we will inevitably fail.

Txt2MEDLINE is a novel idea for bringing EBM information closer to health care professionals. However, given the complexity of information needs of these health care professionals and the governing costs of communications in a specific area, it may not appear to be the best solution in the current configuration of this study.

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An Evaluation of the Usability of Accessing MEDLINE over Short Messaging System

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[b] Office of High Performance Computing and Communications, National Library of Medicine, Bethesda,MD

Abstract

- Short messaging system is one of the most popular messaging protocols especially in developing countries
- MEDLINE is a resource that provides health workers access to peer reviewed articles that can help in the care of patients

Introduction

- The Philippines is the texting capital of the world
- One billion SMS messgaes pass through its three cellular networks
- Cellphones and SMS is a convenient, portable protocol for accessing information
- Can MEDLINE be delivered effectively to cellphones over SMS?

Methods

- Fontelo et al created a special portal to MEDLINE which delivers The Bottom Line (TBL) in text-speak
- Examples of text-speak
  - preprtv --> pre-operative
  - muscl --> muscle
  - intensv --> intensive
- A pilot (first phase) was done which was followed by the formal second phase of the study.

Results

Categories of Queries	Evaluation Scores				
	1	2	3	4	5
Diagnosis	10	2	1	1	1
Etiology	7	0	1	0	0
Prognosis	1	1	0	1	0
Treatment	139	19	17	21	13
Prevention	0	0	0	0	0

Table 3-1: Summary of evaluation scores according to category during the second phase

- Most of the queries were for treatment options.

Results

Comments:	Hits:
More relevant journals	19
Delays in delivery	15
Responses not matched/unrelated to query	13
No available literature	13
Limit results within previous query	6
Abbreviations cannot be understood/too ambiguous	5
Others	4
Total	75

Table 3-2: Summary of comments during the second phase

- Qualitative results of the study.

Conclusions

- SMS most convenient communications protocol.
- SMS limited in display area and limits viewability of result set.
- Participants can understand text-speak.
- Lower costs for online access to MEDLINE (GPRS/3G) makes the limited interface of SMS of txt2MEDLINE a less practical solution to information seeking.

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The Rhône-Alpes Health Platform

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Abstract

As a consequence of recently passed governmental policies, medical information systems must now comply to new standards aiming at improving communication between as yet very different platforms. On a large scale, differences between IS are observed within medical subspecialties as well as medical IS structures.

Taking into account all specific features of the health information systems in current use in Rhône-Alpes, we present here the way we achieve the Rhône-Alpes health platform currently in use by numerous physicians and caregivers and the choice we took to make the electronic patient record flexible and efficient.

This solution is based on a bottom up model to insure an evolvement of practitioners. The method we used to aim this goal was based on this bottom up model for each component of the project: analyzing the level of computerization, find a solution for every hospital, develop our own patient identification liking local patient numbering systems, no centralization of data but creating a link to these information stored in each hospital repository.

The platform is currently considered as the consolidated shared health record and has received approval from French supervision authorities. Eleven healthcare facilities and 15 community health networks are now connected, sharing more than 80 000 records with 1.2 million medical items indexed.

Keywords:

medical informatics, medical record linkage,
medical record systems, health networks

Introduction

Rhône-Alpes is the second largest administrative region in France. As large as Denmark in size and with 6 million inhabitants, Rhône-Alpes has 300 healthcare facilities, one regional comprehensive cancer center, three academic medical centers, more than 20 000 physicians and over ten thousand caregivers. The concept of a universal electronic patient record (DPPR) was initiated in 2000 by health professionals from the ONCORA community cancer network (ONCOlogy Rhône-Alpes). Cancer care implies indeed a multidisciplinary and multicenter organization.

Health networks currently represent the most friendly and innovative concept in terms of coordination of patient care between health practitioners. The concept of a health platform at the state level dates back more than ten years where many differences between IS were observed within medical subspecialties (e.g. cardiology, nephrology, emergency care, ambulatory medicine, etc.) as well as medical IS structures (e.g. departmental IS, distributed IS, etc.).

Methods: Reference knowledge and former experience

Several major issues are at stake: the type of Regional Health Record system depends on the level of computerization in the health sector, the suitability of existing information systems for elaborating the new regional system. To answer those questions, we used a bottom-up model allowing to involve key health actors in the implementation of the record. All ideas started from observations in the field by practitioners themselves. Involvement of end users was a key aspect of our project.

Oncora was originally confronted with the incredible heterogeneity of existing IS, the management and consultation of local patient records depended entirely on the type of institution. We decided to conduct a preliminary appraisal of the computerization level of hospitals and existing information systems. Our major goal was to identify organizational differences between facilities, which would help elaborate connections adapted to each type of structure. We built a scale of 6 different levels of computerization and asked the 300 facilities in Rhône-Alpes to position themselves on this scale. The span of the survey and proportion of responses (more than 86%) ensured the credibility of the results and their relevance for determining our current development strategy. Consequently, we decided to work on two different connections taking into account the specificity of each hospital.

We also draw inferences from a former experience of centralized specialized cancer record that was stopped a few years ago because it was found unsuitable for use in the healthcare environment. We decided to go the opposite way to avoid repeating the same problems. The regional IS described in this paper is a fully distributed, multi-disease model.

Results: Architecture of the Rhône-Alpes platform (SIS-RA)

The first part of the project consisted of making hospital document repositories connectable. Connection was achieved through connectors developed in partnership with software editors in each hospital (for 48% of them). For scattered members (52%) of the health community network, SIS-RA provided a communication tool that also ensured connections with the regional IS. Finally, all health facilities in Rhône-Alpes became able to share their data, whatever their computerization level.

An essential requirement for SIS-RA is patient identification, which allows to organize data. French law does not permit to use national patient identifiers, so every legacy IS has developed its own local patient numbering system. The challenge was to match all the local records available for a given patient.

Then the DPPR federates all regional health repositories and serves as a unique web-based portal to health information in Rhône-Alpes. The system handles the authentication of users, authorizations for record queries and displaying of structured or unstructured data. On each record query, the system generates a new query to the hospital repository known to store the information needed. In this decentralized system, hospitals are responsible for updating the information they produce. The DPPR is just a pointer system and authorization manager.

The Rhône-Alpes Health Information System (SIS-RA) was possible because Rhône-Alpes doctors have been involved in the project and have understood what benefit they would derive from it (patient medical information available in a very short time). The system is also exclusively based on medical documents, which facilitates its use by medical teams. The universal interface which is proposed allows very simple retrieval of medical information. At least, this project was possible because there has been a total consensus between the three university medical centers, Léon Bérard cancer center and the 53 hospitals from the ONCORA community network regarding the direction of the project.

Conclusion

The DPPR is currently considered as a consolidated shared health record and has received approval from French supervision authorities. Eleven healthcare facilities and 15 community health networks are now connected to SIS-RA, sharing more than 80 000 records with 1.2 million medical items indexed.

The third generation development plan for the organization of health foresees that, in 2010, all healthcare facilities of the region should be connected to the DPPR.

Many other French of foreign healthcare organizations are interested in the functionalities of the system, all the more so as many other projects should shortly be incorporated: development of information flows in emergency care, introduction of medical items by independent physicians.

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Information Portal – An Important Tool for Health Registries

Chavan Shaila, Forero Marcela, George Carol

For the Australian and New Zealand Intensive Care Society Database Management Committee

Abstract

Information portals are largely perceived as web sites which display information to the general public. Although this is true to a certain extent, portals are much more interactive and provide a gateway to a data repository. Access to information on these portals is channeled through an intricate network layer of assigned permissions. In healthcare, such information access is not often heard of - mainly because of the need to ensure an appropriate security system is in place to protect health information at a patient and hospital level. Overcoming the abovementioned shortcomings, ANZICS is successfully running a secure portal with over 200 users and 130 different channels for individual contributing units and governance groupings.

Keywords:

Health Registry ANZICS Portal audit research intensive care

Introduction

Easy and quick access to data in registries is often a complicated procedure for health researchers. Use of an information portal could prove to be an answer to this time consuming and complicated process. The Australian and New Zealand Intensive Care Society (ANZICS) commenced implementation of its information portal for contributing hospital adult intensive care units (ICUs) in 2005. In this paper we will discuss the methods used by ANZICS to achieve the results as well as the benefits and difficulties in setting up a secure portal for a health registry holding a large amount of confidential data and requiring multiple levels of access dependent on user status.

Information portals are largely perceived as web sites which display information to the general public. Portals are capable however, of much more interaction and provide a gateway to a data repository. Access to information on these portals is channeled through an intricate network layer of assigned permissions.

Method/Process

The ANZICS Databases Web portal was established for contributing units to have direct access to their data. This access is provided by using a unique combination of username and password. Following are the steps in creating the security layers for controlled access to the information:

- Subset the database into datasets for each contributing units
- Save the subsets to a location on public domain
- The security layer is put on these subsets to create channels for each set of data
- User management should be put in place with username and password allocation
- Usernames are assigned to a respective group for specific information access

Issues of concern

Several problems were identified in the process of setting up and managing the ANZICS portal :

- Creation and maintenance of programs to subset the data based on user and group profiles
- Monitoring and optimization of server performance to provide appropriate speed in the delivery of web based information
- Sharing of password and other confidential information by users
- Information security in a closed network computer laboratory setup

Results

Overcoming the abovementioned shortcomings, ANZICS is successfully running a secure portal with over 200 users and 130 different channels for different contributing units.

The wide geographical spread of ANZICS contributing units which are connected using the portal is shown in figure 1.

Acknowledgements

Australian and New Zealand Intensive Care Society

SAS Institute, USA

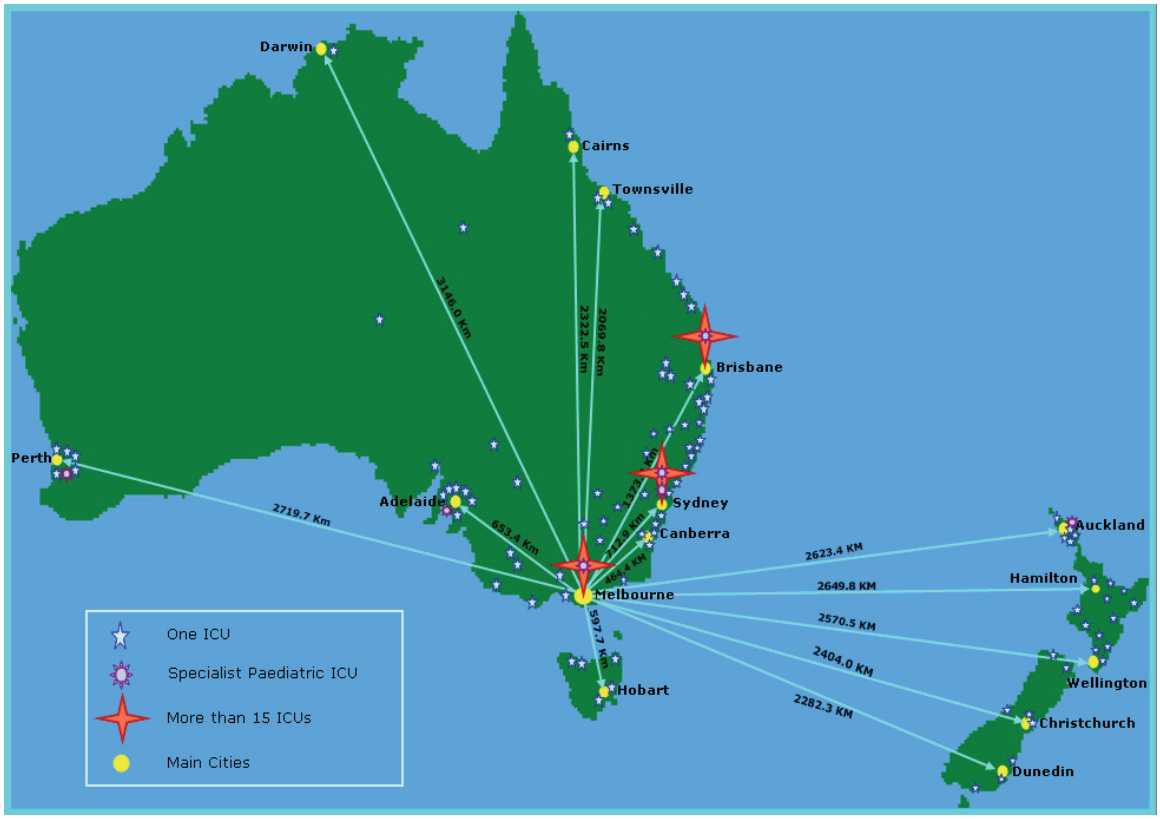


Figure 1 - Australian and New Zealand sites connected by ANZICS portal network

Web based Information Portals

Important tools for health registries

- Shaila Chavan
- Carol George
- Marcela Forero

For the Australian and New Zealand Intensive Care Society Database Management Committee

ANZICS Health Registries

- ANZICS Registries
  - Adult Patient Database
    - 730,000 individual patient records from over 140 individual intensive care units (ICUs) across Australia and New Zealand
  - Paediatric Registry
    - Individual patient records from 8 dedicated paediatric units and admissions from 8 adult/ paediatric ICUs – 7203 admissions in 2005 [1]
  - Research Centre for Critical Care Resources
    - 15 years of physical and human resource usage information on Australian and New Zealand ICUs
- Purpose
  - Intensive care quality assurance, epidemiological research and information provision to government for future health planning and resource management

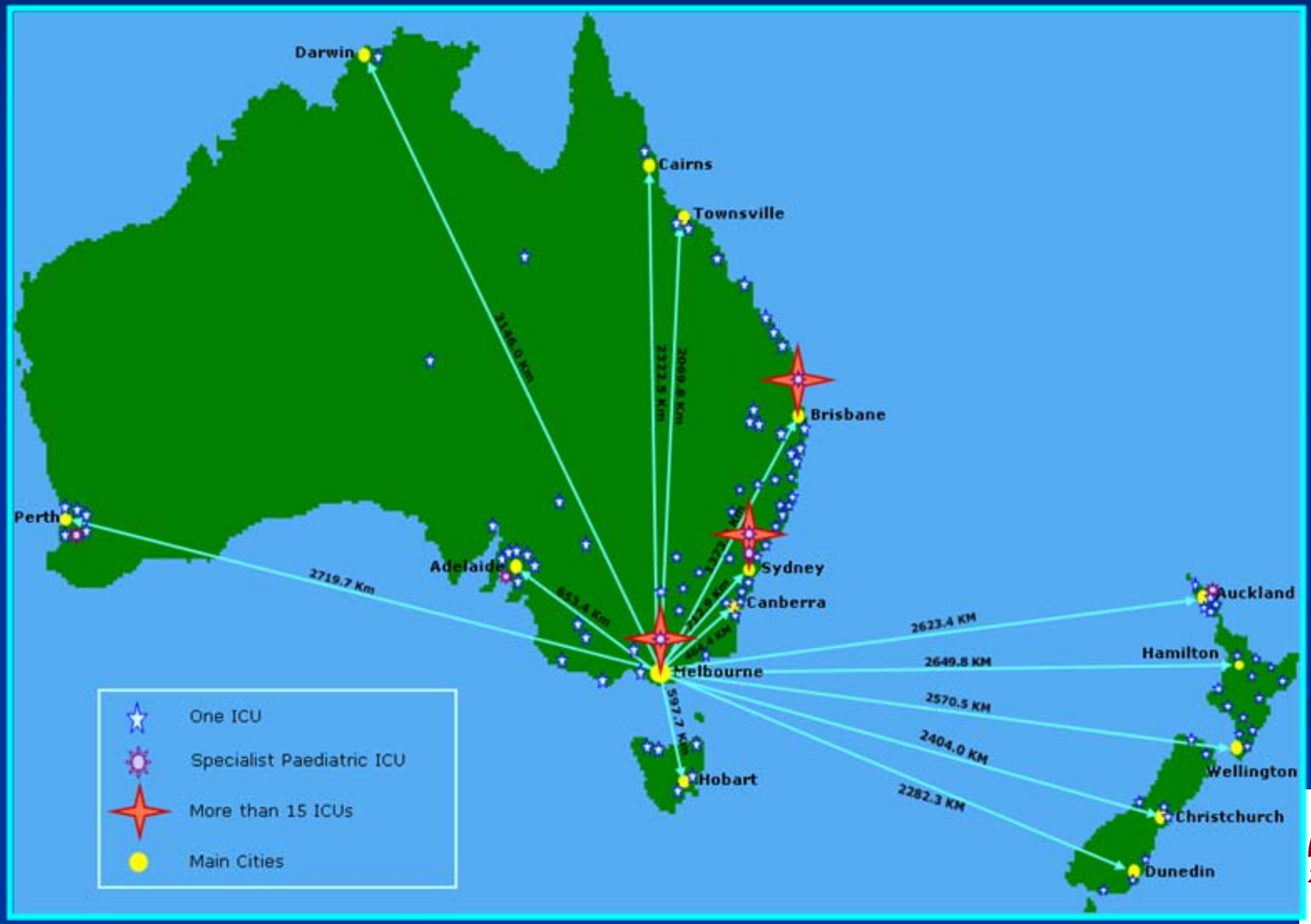
Data warehousing

- The data is held at ANZICS house on a secure server and is appended with new records after every submission round (quarterly submissions) from Adult Intensive Care Units
- This data is then used to create comparative reports for individual units
- Data is appended annually from ICUs surveyed by the ANZICS Research Centre For Critical Care
- In 07 / 08 data admission data collected by paediatric units will also be added and made available through the information portal

Why need for portal?

- Geographically vast area for coverage
- Time zone differences 4 – 6 hrs
- Increasing demand of medical data for research purpose
- Improved timely delivery of reports to contributors
- Increase utilisation of data by contributors and other stakeholders
- Improve data quality and stakeholder participation

ANZICS contributors : Geographical spread



Method

- Implementation of SAS BI Enterprise Server software
  - Acquisition of hardware in consultation with SAS vendor
  - Loading of the multi tier software [2]
    - Server tier including: Metadata server, Workspace server, Stored process server, OLAP server
    - Mid tier including: WebDAV server and the SAS Web Infrastructure Kit
    - Presentation Client Tier
  - Modification of existing the SAS (AF)application to allow delivery of electronic reports to publication channels within the portal software

Method

- Security
  - Planning and implementation of user and group hierarchy
  - Thin Client reporting tools - Web report Studio, Information portal
    - Security applied at the Information map level through the use of stored processes to subset data according to group and individual user permissions
    - Folder permissions defined within SAS Management console to limit navigation of users to appropriate reports
  - Full Windows clients – Enterprise Guide, Add in Tools for Microsoft
    - Security must be defined at the data source level
    - Implementation of security by creating a separate workspace server for these clients to occur in the near future to allow distribution and use by external users

Method

- Report development
  - Development of web reports in Web report studio – security provided through stored processes allowing one data source with one defined information map and one WRS report to deliver individual reports to multiple sites
  - Design of portal pages and publishing of web site (http://sas.anzics.com.au)
- Training
  - Internal employee training in SAS Management Console, Information Map, Enterprise Guide, Add in Tools for Microsoft
  - Establishment of online education (http://education.anzics.com.au) and training for end users through use of the web and face to face workshops

SAS Web Portal

Log On | Help

Portal for ANZICS Databases

- ADULT PATIENT DATABASE
- ------ Data submissions
- ------ Workshops
- ------- APD Discussion Mailing List
- ------ AORTIC software
- ------ Attention Software Developers
- ------ Data Audit Project
- ARCCCR
- ------ ARCCCR Discussion Mailing List
- ANZPIC
- ---- ANZPIC Discussion Mailing List
- WEB REPORT STUDIO
- ANZICS WEB EDUCATION
- SPECIAL INTEREST GROUPS
- LATEST ANNOUNCEMENT
- PUBLICATIONS

Created from PUBLIC Sticky

Australian Contributing sites - click on region for detail

All Australian and New Zealand Intensive care units are invited to contribute to the Adult Patient Database.Free software is provided to units to assist in the collection of data.
The project is funded by all Australian states, territories and New Zealand.
For further information, please contact us.

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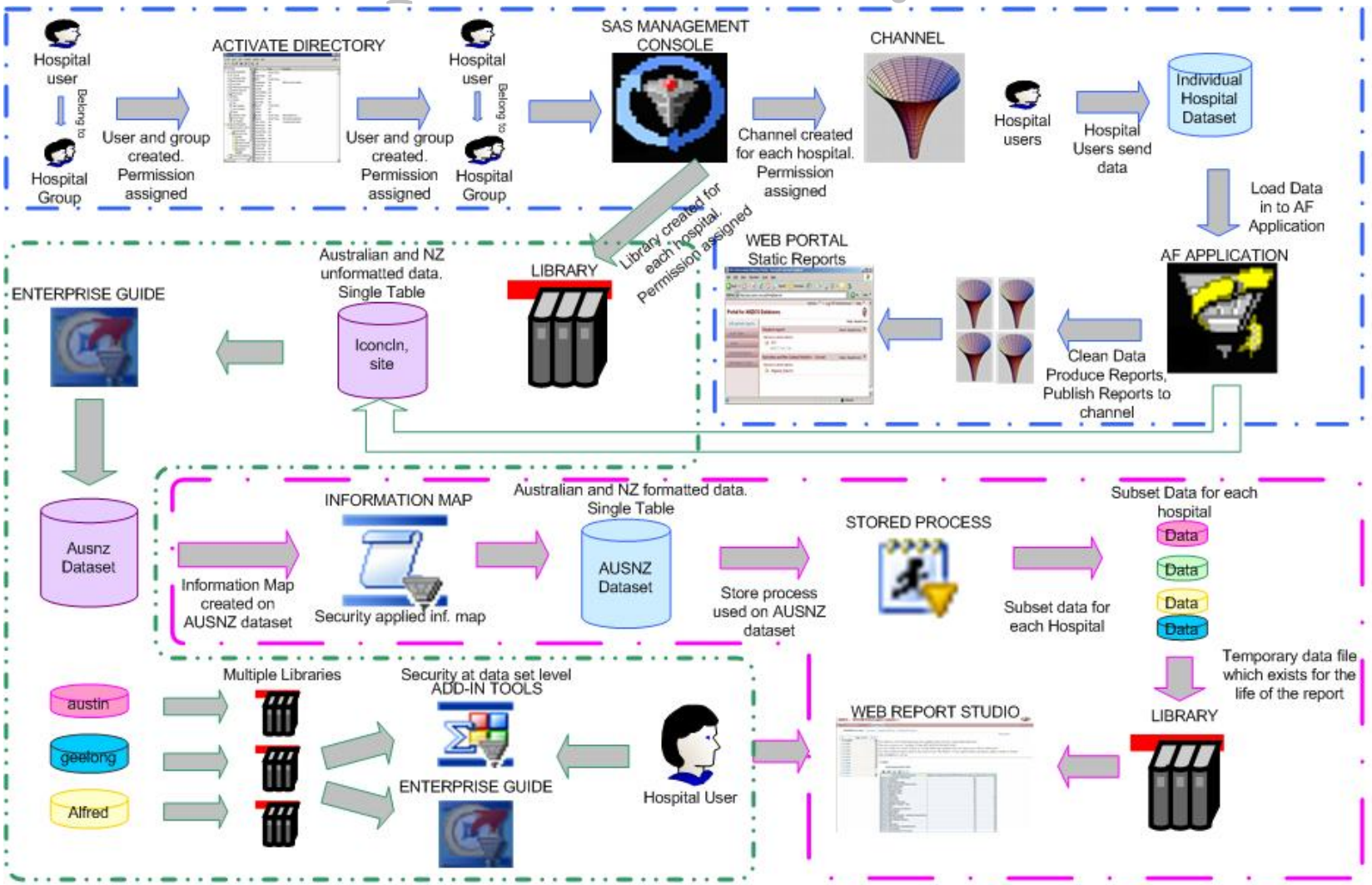
Administrative Assistant
Louise Clark

■- Public Information access point
- Log in point for contributing sites

http://sas.anzics.com.au

Implemented system



Lessons learnt

- The SAS BI enterprise software should be regarded as a developmental tool and requires a high level of resource to implement, develop and maintain as an information portal and analytical application for multiple users
- Implementing SAS BI on a single server architecture resulted in the web portal performance not meeting response time expectation.
- Future architectures under consideration include:
  - Separation of the mid tier onto a second server
  - Upgrading the current two CPU server processor to multiple quad core Intel processors
- Security – unresolved issue
  - User and group security failed to work during training sessions utilising the Information portal and Web report studio at two hospital based computer laboratories – The problem is not replicated outside this environment

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Patient-Safety Improving Medication Information System for Care Workers in Taiwan

Tun-Yang Lawrence Sung[a], Chung-Lei Huang[b], Woei-Chyn Chu[b], Hung-Wen Chiu[a]

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Abstract

In Taiwan, 23% of medical errors come from medication error, however, pharmacists are barely possible to prevent or correct these errors at present. To reduce them, we constructed a computerized drug deliver cart with a drug information system plus drug image and a Web-based intravenous drug incompatibility system to assist first-line care workers practicing medication monitoring such as adverse drug reactions (ADR), educating patients correct medication usage, and reducing medication errors which are preventable. Both of these two systems are passive systems, and we think that maybe we could increase the frequency of using these systems by fixing them become more active, increases the rate of systems usage, and raise the pharmaco-vigilance of care worker in Taiwan.

Keywords:

drug information system, drug image, intravenous drug incompatibility system, care workers, adverse drug reactions, medication monitoring, pharmaco-vigilance

Introduction

Medication error is one important kind of medical errors. In America, at least 4,000 patients died due to medication errors every year, furthermore, 42% of medication errors were caused from anthropogenic source. Same as America, a study made in Japan shows that 16% of care workers had ever administrated drug to wrong patients, as a result, many computerized assistive system are provided, but few of medication administrating.

In Taiwan, especially for hospitalized patients, administrating and monitoring of medication are often executed by nurses. Care workers use paper-based drug administration records and IV solution administration records to insure if medications fit to physician's order sheets or not, which is a complicated but an important job. And the truth is, the currency of medication errors for inpatients is approaching 2%, which is very serious. To reduce this kind of error, we designed a computerized drug deliver cart combined with drug information system which could help checking these looks of drug, and let it be much easier for nurses to identify if adverse drug events occurred.

Another important issue for care workers in Taiwan is language problem, lots of medical and drug information were written in English, whereas information written in traditional Chinese form will be much easier for nurses to comprehend, therefore, to build a traditional Chinese-based drug information system seems to be a requisite.

Last but not the least, intravenous drug incompatibility is an important drug information for care workers in medication administrating, especially when dispensing intravenous mixture, therefore , we constructed an intravenous drug incompatibility system which would provide nurses an easy way to check when mixing different intravenous medicines, it could also reduce the working load of pharmacists.

Materials and methods

In our study, we designed three assisting systems to reach our goal to reduce medication errors caused by care workers, figure 1 shows these three structures of our system.

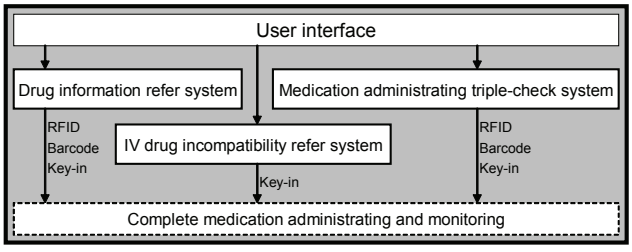

Figure 1 - Flowchart of computerized drug deliver cart

The first part is a drug deliver assisting system with RFID and bar-code devices which could help care workers practicing such as three-read five-right checks. The second part is to construct a drug information system with drug image for care workers. To build an easy-to-use drug information system for care workers in Taiwan, drug information have to be written in Chinese form, drug images is also added, moreover, we use bar-code and RFID query interface. Automatic update process is a necessity for our system, once a hospital changed their brand of a medicine, our system could respond immediately. Language translating is never an easy job, especially when it's in medical specialty, to find the way out, we cooperated with MIMS poc, MIMS poc have a complete drug information database

written in mandarin, it could also provide us accessible up-to-date drug information, and images of Taiwan's currently used medicines.

The last part is to construct an intravenous drug incompatibility system, in this system, we use key-in from touch panel instead of RFID or bar-code devices as input, care workers will choose two to three medicines' generic name by their fingers to check if intravenous incompatibility occurred, then the system will show four kinds of results to present if there is any problem adding them together.

Results

Figure 2 shows the prototype of our computerized drug deliver cart we'd constructed and the information display result of our drug information system with drug image. Ten kinds of drug related issues are chosen to provide care workers adequate drug information, they include brand name, generic name, usage, package, contraindication, precaution, side effects, drug interactions and drug image.

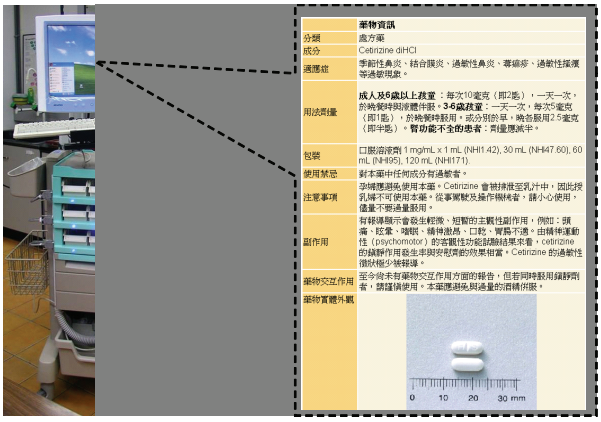

Figure 2 - The prototype of our computerized drug deliver cart and a Chinese translated drug information chart with drug image

Another function of our drug information system is MIMS poc SDK, combined with EMR information, four kinds of Alerts are provided, drug alert could find if any drug prescribed conflict with another, health alert also finds if any disease is contraindicated with those drug prescribed, allergy alert finds drug allergic problems, duplicate alert warns users when any medication is duplicate ordered. Figure 3 shows the drug decision support module.

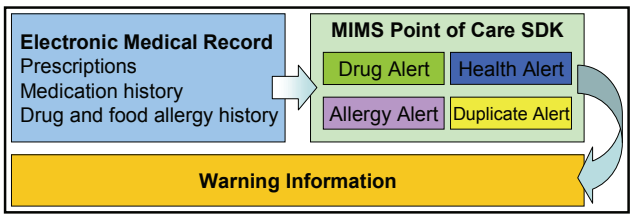

Figure 3 - The drug decision support module, based on patients' information in EMRs, this module could find preventable medication errors

The Web-based intravenous drug incompatibility system could also assist care workers dispensing intravenous mixture, they could simply find the answer by choosing drug's name through touch screen to check if incompatibility occurred. Since draw-down lists are not suitable when using on touch screen, we designed another kind of drug list to make it easier to choose form. Four kinds of answers would be displayed as the result, they are compatible, incompatible, variable results and no result. Nurses could then check the details of the result displayed which is written in traditional Chinese form. This system could also reduce the work burden of clinical pharmacists in Taiwan. Figure 4 shows the drug list we designed and the result of this system.

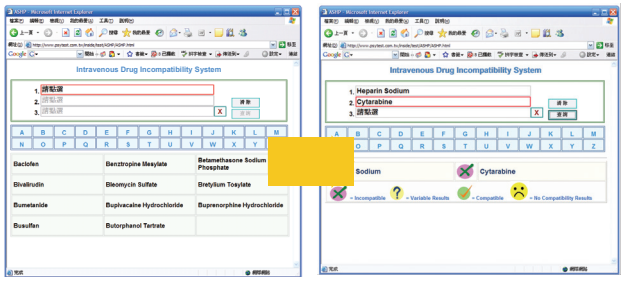

Figure 4 - The drug list of intravenous drug incompatibility system designed for touch panel (left side), larger items could make it much easier to choose by fingers, on the right side is the result displayed of the system, four different icons represent different results

Discussion

The main purpose of our study is to promote patient safety by reducing medication errors caused from care workers, however, nurses in Taiwan seems too busy that the rate of using of our system were lower than our expectation. A key question is that shall we make our system acts from passive to active? Will this

action raise the rate of using, help reducing medication errors or actually nurses would be even bothered? In the other sub-project, they used active way instead of passive one's, somehow nurses think it's too clumsy. To find the threshold that would both reduce medication errors and

with good usability would be an interesting part that we might study in the future.

Another issue is some of workers in the field of medical informatics seem lack of clinical experiences, in this situation the program designed might have low usability, to avoid trapping in the plight, maybe we have to spend more time communicating and observing. The most efficient way is to stay in a unit where we're going to cooperate for a period of time. After increasing the real experience, the design should be far more functional.

Conclusion

Care workers in Taiwan are medication administrators who play important roles in adverse drug reaction (ADR) reports. The adequate and easy-to-get drug information provided to nurses could raise their pharmaco-vigilance. Further more, it improves patient safety. Intravenous drug incompatibility system would also provide nurses an easy way to check when dispensing intravenous drug mixture, and reduce avoidable errors. Both of our programs exists as passive systems, we wonder that if they change to be more active, would the using rate raises or falls. It seems that we need to know clearly from their work and with our own experience, the design of assisting systems would be more acceptable.

Patient-Safety Improving Medication Information System for Care Workers in Taiwan

Tun-Yang Lawrence Sung [a], Chung-Lei Huang [b], Woei-Chyn Chu [b], Hung-Wen Chiu [a]

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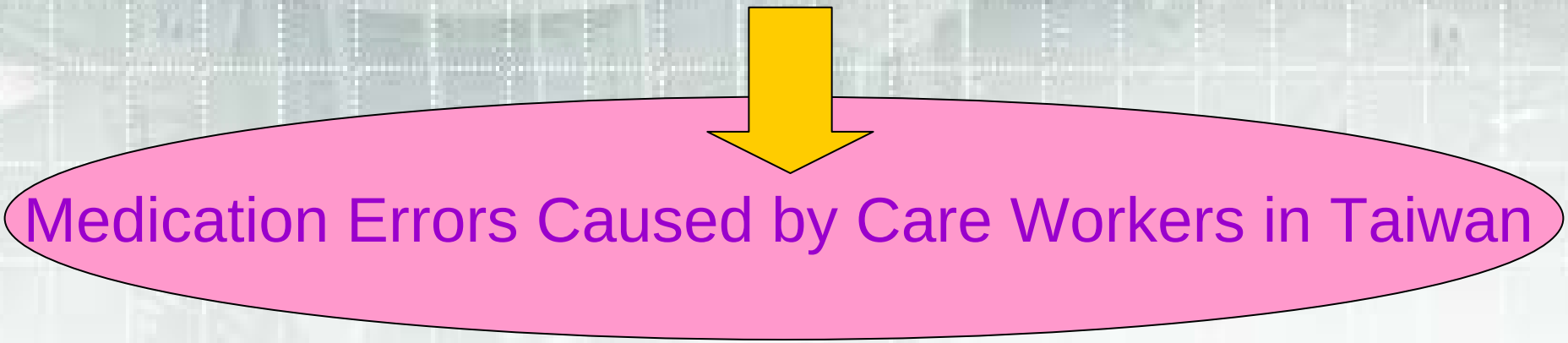
Introduction

- Medication errors
  - Most important kind of medical errors [1]
  - Killed 4’000 patients per year [2]
  - 42% of medication errors → anthropogenic source (USA) [3]
  - 16% nurses had given wrong drug to wrong patients (Japan)
- CPOE → Medication errors caused by physicians and pharmacists



Introduction (cont.)

- To reduce medication errors caused by care workers in Taiwan:

1. A computerized Drug Deliver Cart
   - ✓ With Bar Code & RFID devices
2. Drug Information System including Drug Image
   - ✓ Help nurses checking such as adverse drug events, educating patients right usage, etc.
3. Intravenous Drug Incompatibility System
   - ✓ To check if it's proper to mix different intravenous medicines

Language Problem

- Nurses in Taiwan:

English Information:
Have difficulty to read and comprehend

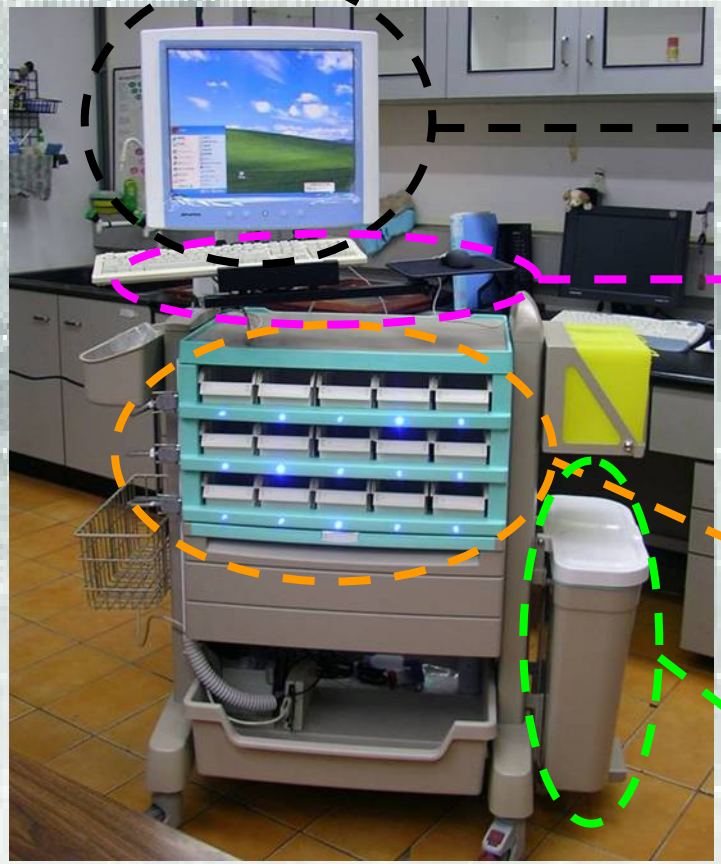
Chinese Information:
Easier and more friendly to use

Use Graph instead of script
Ex. Drug image

Language Translation:
Cooperate with MIMS poc
(Up-to-date Drug Information)

CMP
United Business Media

Result - Drug Deliver Cart with RFID and Barcode Devices



Touch Screen:
Instead of keyboard to increase usability

RFID & Bar Code devices:
Help nurses identifying patients and medications

Drug Drawers:
With patients' medication dispensed by pharmacists

Trash Can

Results – Drug Information System

Brand name &generic name:
Basic Drug information

Indications:
To show if the drug fits to the patient's diagnose

Usage:
To show if there is any special using way of this medicine.

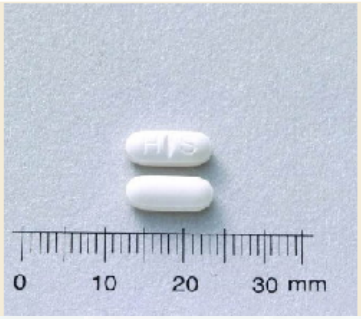
Package:
To show the package and form of the drug.

Contraindication:
To show some diseases or other special conditions that are contraindicated to the drug

Precaution:
To show that some patients with these special conditions should be closely monitored or consider withdraw this drug

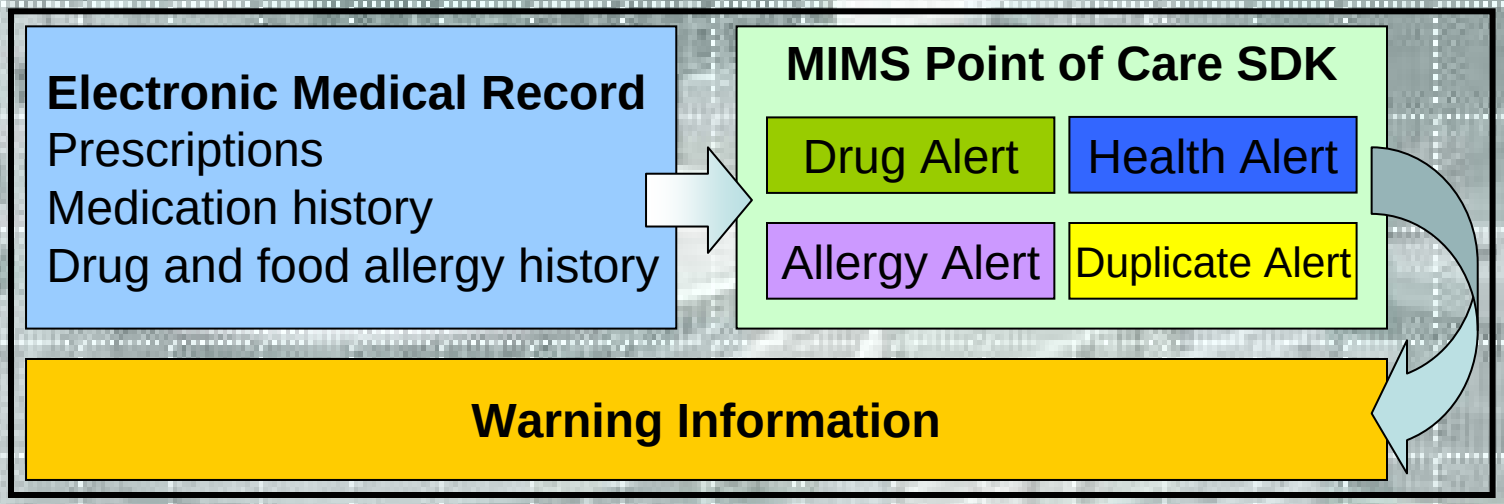
Side effects:
To show some side effects that patient would complained, nurses would note them and inform pharmacists and doctors

Drug interactions:
To show which drugs are forbidden to use with this medicine.

	藥物資訊
分類	處方藥
成分	Cetirizine diHCl
適應症	季節性鼻炎、結合膜炎、過敏性鼻炎、蕁麻疹、過敏性搔癢等過敏現象。
用法劑量	**成人及6歲以上孩童**：每次10毫克（即2匙），一天一次，於晚餐時與液體伴服。**3-6歲孩童**：一天一次，每次5毫克（即1匙），於晚餐時服用。或分別於早，晚各服用2.5毫克（即半匙）。**腎功能不全的患者**：劑量應減半。
包裝	口服溶液劑 1 mg/mL x 1 mL (NHI1.42), 30 mL (NHI47.60), 60 mL (NHI95), 120 mL (NHI171).
使用禁忌	對本藥中任何成分有過敏者。
注意事項	孕婦應避免使用本藥。Cetirizine 會被排泄至乳汁中，因此授乳婦不可使用本藥。從事駕駛及操作機械者，請小心使用，儘量不要過量服用。
副作用	有報導顯示會發生輕微、短暫的主觀性副作用，例如：頭痛、眩暈、嗜眠、精神激昂、口乾、胃腸不適。由精神運動性（psychomotor）的客觀性功能試驗結果來看，cetirizine 的鎮靜作用發生率與安慰劑的效果相當。Cetirizine 的過敏性徵狀極少被報導。
藥物交互作用	至今尚未有藥物交互作用方面的報告，但若同時服用鎮靜劑者，請謹慎使用。本藥應避免與過量的酒精併服。
藥物實體外觀	

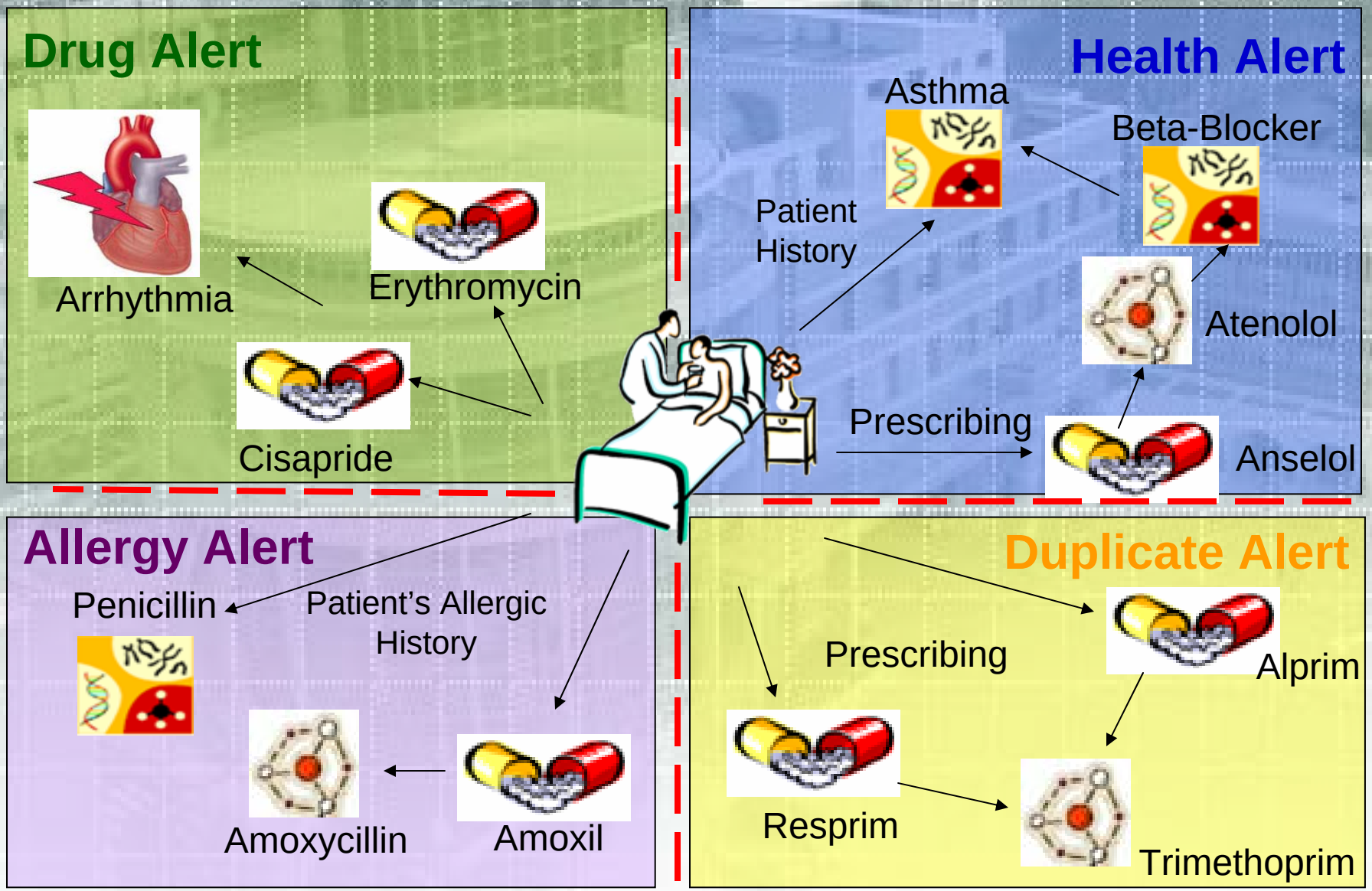
Drug Image:
Help recognizing the appearance of medicines

Drug Decision Support Module

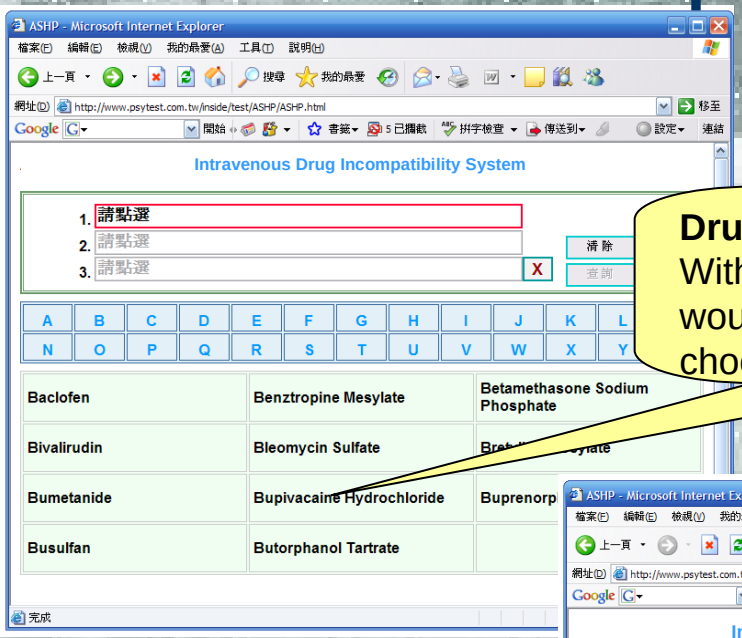


- ✓Drug Alert:
  - ✓ To find if any drug prescribed conflict with another
- ✓Health Alert:
  - ✓ To find if any disease is contraindicated with those drug prescribed
- ✓Allergy Alert:
  - ✓ To find drug allergic problems
- ✓Duplicate Alert:
  - ✓ Warn users when any medication is duplicate ordered

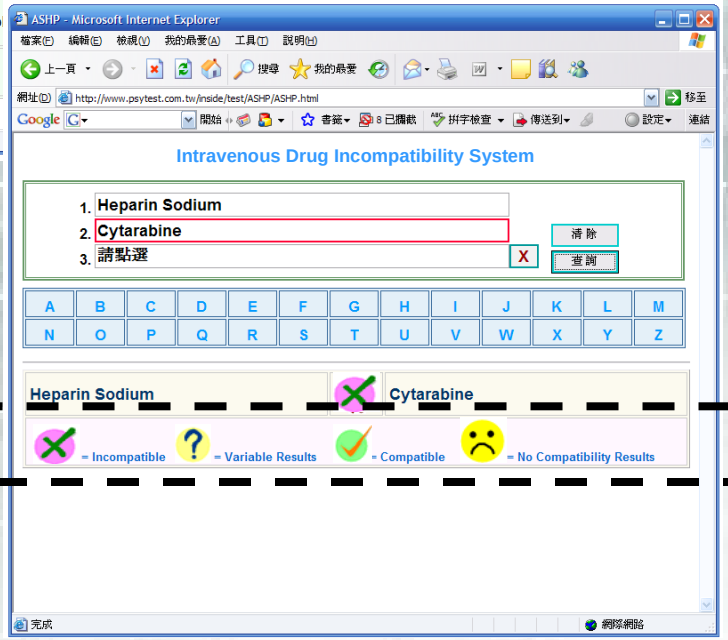
Drug Decision Support Module



Results - Intravenous Drug Incompatibility System



Drug list designed for touch panel: Without draw-down drug lists, it would be much easier for nurses to choose drug from touch panel.



Incompatible: Two drugs could not added together

Compatible: Two drugs could added together

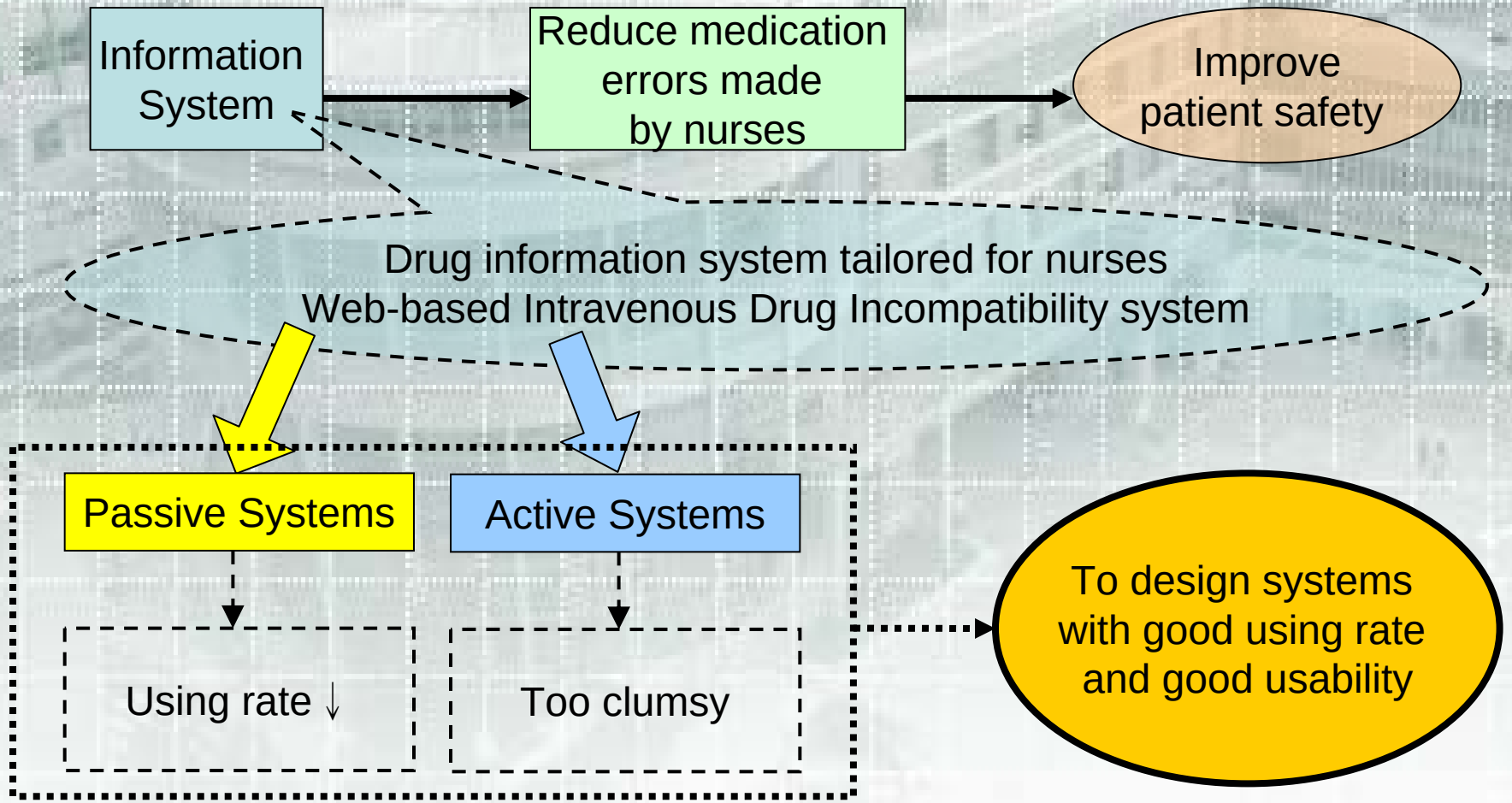
Variable results: Consult pharmacists to insure.

No results: No data available

Four kinds of results would show

Discussion

- The main purpose:



Conclusion

- Care workers in Taiwan
  - Medication administrators who play important roles in adverse drug reaction (ADR) reports where physicians and pharmacists would hardly to.
- Two of our systems:
  - The adequate and easy-to-get drug information system
    - ↑ Pharmaco-vigilance [11]
    - ↑ Patient safety
  - Intravenous drug incompatibility system
    - An easy way to check when dispensing intravenous drug mixture, and reduce avoidable errors
- Both of our systems exist as passive systems
  - Change to be more active, would the using rate raises or falls?
  - To know clearly from their work, and with our own experiences, then the design of assisting systems would be more acceptable.

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Acknowledgements

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MEDINFO 2007
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Computer-assisted Cancer Chemotherapy Planning and Alerting System

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Abstract and objective

Chemotherapy misadministration can be serious devastating to patients. One reason for iatrogenic injury during chemotherapy is the information management is complicated. The use of computerized chemotherapy management system has been proposed to improve patient safety and quality of care. To develop a computer-assisted chemotherapy planning system, we set two requirements. i) Creating the chemotherapy planning model emphasized on the physician's decision-making process. ii) Building up expressions to reason about particular knowledge associated with each decision-making process. Based on the requirements, we have developed the model of chemotherapy planning. In this paper, we present development of web-based prototype system of chemotherapy planning and alerting system. Through the inspection by implementing prototype system, it seems to be useful from the viewpoint of preventing physician from overlooking the information about patient.

Keywords:

chemotherapy, decision support system, alerting system

Methods

We have developed the model[1] of chemotherapy planning, emphasized on the decision making process of the physician. This model consists of entity model of chemotherapy, process model of chemotherapy planning, and expression language to reason about particular status of the patient. Based on this model, we structured chemotherapy regimen into computer readable form. Figure 1 shows a part of structured regimen.

Results

We constructed a knowledge base that includes several kinds of structured-regimen, and developed web-based prototype system. Overview of the system architecture is shown in Figure 2. There are two functions in this system. 1) Providing decision support for the physician to create administration schedule. In each decision point such as pretreatment evaluation and dosage modification, system evaluates decision criteria based on the patient data, and shows the result to the physician. 2) Providing notification support all day long. When dosage should be modified depending on the additional patient data, system sends a recommendation message to physician. Through the inspection by implementing prototype system, it seems to be useful from the viewpoint of preventing physician from overlooking the information about patient.

```
<regimen name="CHOP" code="001" cycle_frequency="5">
  <cycle duration="21">
    <pretreatment_evaluation>
      <lhs> phenomenon(NCICTC_Leukocytes_Grade).greaterThan(3) </lhs>
      <rhs> Recommend beginning at the cycle to be postponed </rhs>
    </pretreatment_evaluation>
    <drug name="vincristine" standard_dosage="1.4" max_dosage="2.0" dosage_unit="mg">
      <date_allocation> 1 </date_allocation>
      <administration_method route="iv">
        <division unit="min">60</division>
      </administration_method>
      <dosage_modification time_context="14" unit="day">
        <lhs> phenomenon (NCICTC_Leukocytes_Grade).greaterThan(2) </lhs>
        <rhs> Recommend reduce to 80% dose </rhs>
      </dosage_modification>
```

Figure 1- Example of a structured chemotherapy regimen. Element of "pretreatment evaluation" is a decision criteria of start of the therapy cycle. Element of "dosage modification" is a decision criteria of modification of a drug dosage

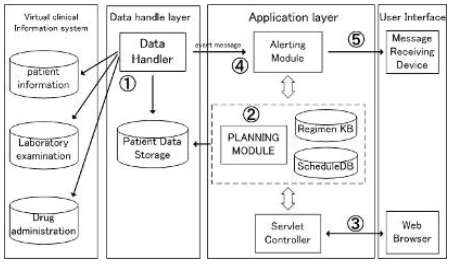

Figure 2 - Overview of the system architecture. 1) Different kind of patient data are collected and unified into the data storage. 2) Planning module provides an administration schedule while evaluating decision criteria based on the patient data. 3) Physician can operate planning module to create an administration schedule. 4) Alerting module is evoked by data handler and evaluates drug dosage using planning module. 5) If dosage should be modified, alerting module sends recommendation massage to the physician

1 We contributed the article of this model to MEDINFO 2007.

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Interaction between Clinical Departments and Express Laboratory in the Context of Information System of Multifield Hospital

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Abstract

Interaction between clinical departments and express laboratory of big multifield hospital is provided by integration of CIS and LIS. It comprises test order entering in clinical departments and their transfer to laboratory system, immediate acknowledgment of clinical departments of the status of running orders, sending of generated result reports to clinical departments, planning bio-substance collection. The systems integration resulted in saving the order running time, reducing redundant orders, improvement of informational provision of physicians and planning the work of laboratory.

Keywords:

laboratory information systems, clinical information systems, systems integration, medical order entry systems

Methods

Laboratory tests are among the most requested and informative diagnostic studies. The overall output of Central Clinical Hospital laboratories is 2 mln. tests of more then 400 parameters per year. About 25% of all tests are urgent. These studies are carried out by the express laboratory. Usually running of such a test takes not more then an hour. Mostly they are requested by intensive care departments (reanimation, post-surgery, cardio-reanimation etc). Capillary blood sampling is done by the laboratory personnel, other kinds of sampling and their dispatch is done by the personnel of clinical departments.

Until interaction between clinical departments and laboratory was automated there were certain problems of different kinds: order forms for express laboratory had been filled in manually, personnel of clinical departments and the laboratory had to dispatch and receive requests, and often redoubling of requests sent to express laboratory and other labs by different physicians had taken place.

Cooperation of clinical departments and the laboratory is provided by integration of Clinical information system (CIS) and Laboratory information system (LIS). CIS combines about 200 workplaces in clinical departments, and is designed for entering orders and receiving test results, and entering medicaments orders. LIS combines 40 workplaces and provides automatic fulfillment of all working cycles of the laboratory.

After integration of CIS and LIS entering of test orders is performed by physicians via their computers in clinical departments. During this procedure a doctor can look through the already planned patient orders, and ready test results. It will be of great help in making a reasonable decision to select this or that test, and to avoid redundancy. Immediately after entering into CIS the new order is transferred into LIS of express laboratory; and the laboratory personnel is informed by a special sound signal. A person in charge receives the orders, print them, and if necessary fulfill the bio-substance sample collection according to the state of urgency of the order. The system provides grouping of orders in dependence of their urgency, and develops a schedule of collecting bio-substance samples. Accuracy and validity of the running test is improved by the possibility for laboratory personnel to review previous tests results, clinical diagnosis, and other parameters of the patient. Test result is transferred to clinical departments electronically (preliminary result) right after the running is completed, and as a paper result report signed by a doctor of laboratory (final result). System also comprises electronic digital signing of the test result. Physician is informed by a special message on the screen of his computer when the result report is in CIS, and can review test results in the form of result report page, histogram or in dynamics.

Delphi and SQL Server were used for system implementation. Exchange of orders and test results is implemented in XML-format files.

Results and conclusions

As a result of CIS and LIS integration the automatic interaction of clinical departments and express laboratory in the process of order and test result transfer was provided. It helped to reduce the total time of fulfilling orders by 20% and eliminate redundant orders. Informational provision of physicians was improved. Man-hours for paper work, transfer or reception of orders and for bio-substance collection were substantially reduced.

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The Integration of the Radiation Therapy Information Systems - Activities of IHE (integrating the healthcare enterprise) - Japan Radiation Oncology

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Abstract

The IHE-Japan RO(IHE-J RO) working group is started in February 2006 by JRS, JASTRO, JSRT, JIRA, four university, and eleven vendors, and the necessity of a Japanese extension to digging up and Japan of standard work flow models in Japan is examined. The consideration of special steps in approval is necessary for QA, and systematization for safety is important.

Keywords:

IHE, radiation oncology, DICOM, HL-7

Introduction

The Integrating the Healthcare Enterprise (IHE) is started by Radiological Society of North America (RSNA) and the Healthcare Information and Management Systems Society (HIMSS) in 1999, and it is wide to Europe and Asia. The object field has extended to not only the radiology but also the heart decease and the endoscope, etc.

It is necessary to approach the radiation therapy, too. In the radiation therapy field and IHE Radiation Oncology(IHE RO) started operations from 2005 in North America. And they are making the guideline of the information exchanges of standard work flows that used HL7 and DICOM-RT. Actor and the transaction in the irradiation of the treatment planning and radiotherapy treatment delivery, and the standards are proposed. Also in Japan The IHE-J RO working group is started in February, 2006. We reports the activity of IHE-J RO.

Activities of IHE-J RO

It is enumerated that facilities where a full-time radiation oncologist doesn't exist are not few in Japan. The radiation oncologist or other department physician makes treatment plans, and the oncologist or radiation technologist designs the irradiation beam. And radiation technologist executes the treatment. The process is divided by two occupations (the oncologist and the technologist). The Physicists are very few in Japan, the oncologist or the technologist design the beams, and make dose calculation. There are actually a lot of facilities to which the technologist design the beams. This situation especially influence the approval procedure. When the oncologist design the plan and beams by self, The possibility of making a mistake increases. Recently the mistakes were reported in the calculation with RTP, and the overdose and the underdose accident happened frequently in Japan. It is recommended for safety to compare the MU units of RTP and that of the hand calculation or other dose calculators. This recommendation should be taken in the integration profiles.

Conclusion

The workflow: Common workflow to most of facilities in Japan has been extracted by the scene of the examination, the irradiation, and the treatment plan. The mechanism that progress is managed a lot and the cooperation of the hospital information system and the electric medical record become it. Not a one-sided flow but the repetition and the divergence : the flow of the radiation therapy.

Peculiarity of Japan: It is enumerated that physicists are very few, and facilities where a only part-time radiation oncologist works are not few. This has the influence in the approval procedure. The consideration of special steps is necessary for QA, and systematization for safety is important.

Application of an RFID tag to medical equipment management support - Construction of an operation manual system for medical equipment

Atsuko Matsuda[a,c], Akiko Shindo[b], Terutaka Marukami[a], Shoko Tani[a], Masaki Miyamoto[c], Hiroyuki Horio[a], Hiroshi Inada[a]

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Abstract and Objective

Operation confirmation of medical equipments is indispensable for safe and accurate operation in medical care. In Japan, the standardization of information for medical equipments is in progress and some information such as operation manual one is offered. We already developed a medical equipment management system with an RFID. In the present study, a manual information referring system for operation was developed as one of the system by converting the manual information offered in SGML into an XML file and a PDF file. The manual information is able to be obtained on the bedside by using a PDA with an RFID reader. It was expected that the newly developed system contributes to safety operation of medical equipments.

Keywords:

medical equipment management system, manual information referring system for operation, XML file, PDF file, PDA

Introduction

It is important to manage medical equipments to prevent medical accidents because frequent accidents originated from inadequate management of equipments have occurred recently. Therefore, we intended to develop a safety management support system for medical equipments and started study on construction of the system by which the maintenance and inspection management and alibi management of the equipments can be supported by using an RFID tag. In this study, a manual information referring system for operation of medical equipments was constructed by using an RFID tag and a PDA with an RFID tag reader as operation confirmation is indispensable for safe and accurate use of equipments.

Methods

In Japan, the standardization of information for medical equipments is in progress and a manual information for operation of equipments can be offered by SGML. We converted the information to a PDF file via an XML file and the PDA terminal was used for convenience. In designing a form in the PDF file, opinions of nurses and clinical engineers were adopted, considering that they are major users of equipments. We made the file by calling the form from the browser software on a PC. The XML files for the manual information with the illustration were made by entering the additional information to the form.

Results and Discussion

The safety of medical equipments could be executed by making it possible to grasp detailed information on operation and control by the medical equipment management system constructed by us. In this study, attached document information besides essential information was included in the created PDF file for the operation manual. We could make the input work for the manual efficient by taking the information included an RFID such as ID information to access a medical equipment database, lending and inspection records etc. into the manual. The PDA terminal with small screen size became possible easy to obtain the necessary information by adopting the PDF file with the tab for the tap operation. In addition, it was considered that the efficiency of the reorganization work of the manual has been improved by preserving former information that made the manual as an XML file. The constructed system enabled medical personnel to refer to the operation information, the history of use, repair and check of medical equipments on the bedside by adopting the PDA.

Conclusion

In this study, a manual referring system for operation as one of the safety management system for medical equipment was successfully developed by applying an RFID and the system was thought to be useful from the result of a trial. In the next place, we have a plan to build the system on a full scale and confirm the utility of the system by installing it in a hospital.

Application of an RFID tag to medical equipment management support

- Construction of an operation manual system for medical equipment -

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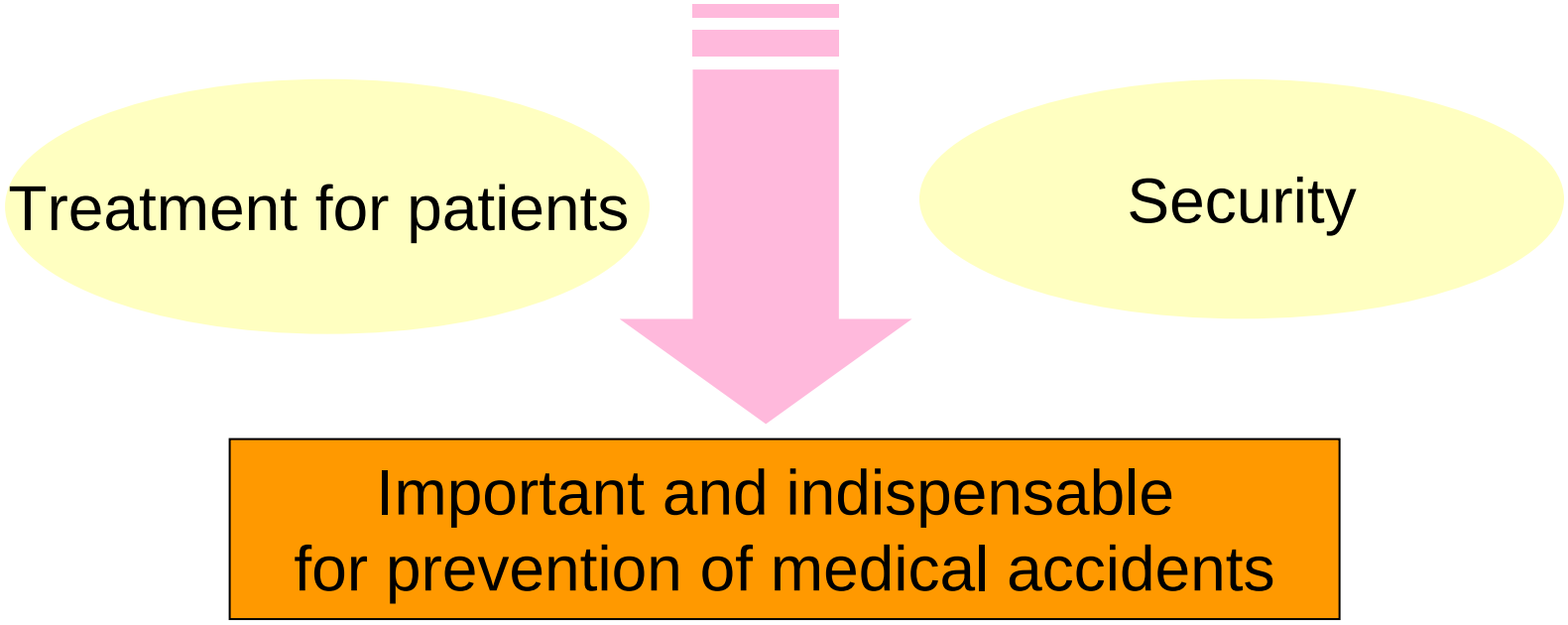
Introduction

Medical equipment is essential for present medical services.

Safety management of medical equipments in a perfect state



Targets of the development system

1. Centralized management of information of medical equipments
2. Recording use / maintenance histories of medical equipments → **Improvement of accidents Prevention accidents**
3. Making a database for medical equipments
4. Managing sterilization / disinfection of medical equipments by patient information → **Quick and efficient works**
5. Lending / return works of machinery in a lump → **Improvement of safety in use**
6. **Reading of information such as manual one**
7. Traceability → **Alibi management**
8. Planning assets management → **Rationalization of hospital management**

Hardware 1

- **RFID tag reader/writer**
  - (a) Table type
    (made by OMRON - V720-HS03)
  - (b) PDA type
    (made by OLYMPUS - pt1016 ticzizjp-c)


(a)

(b)

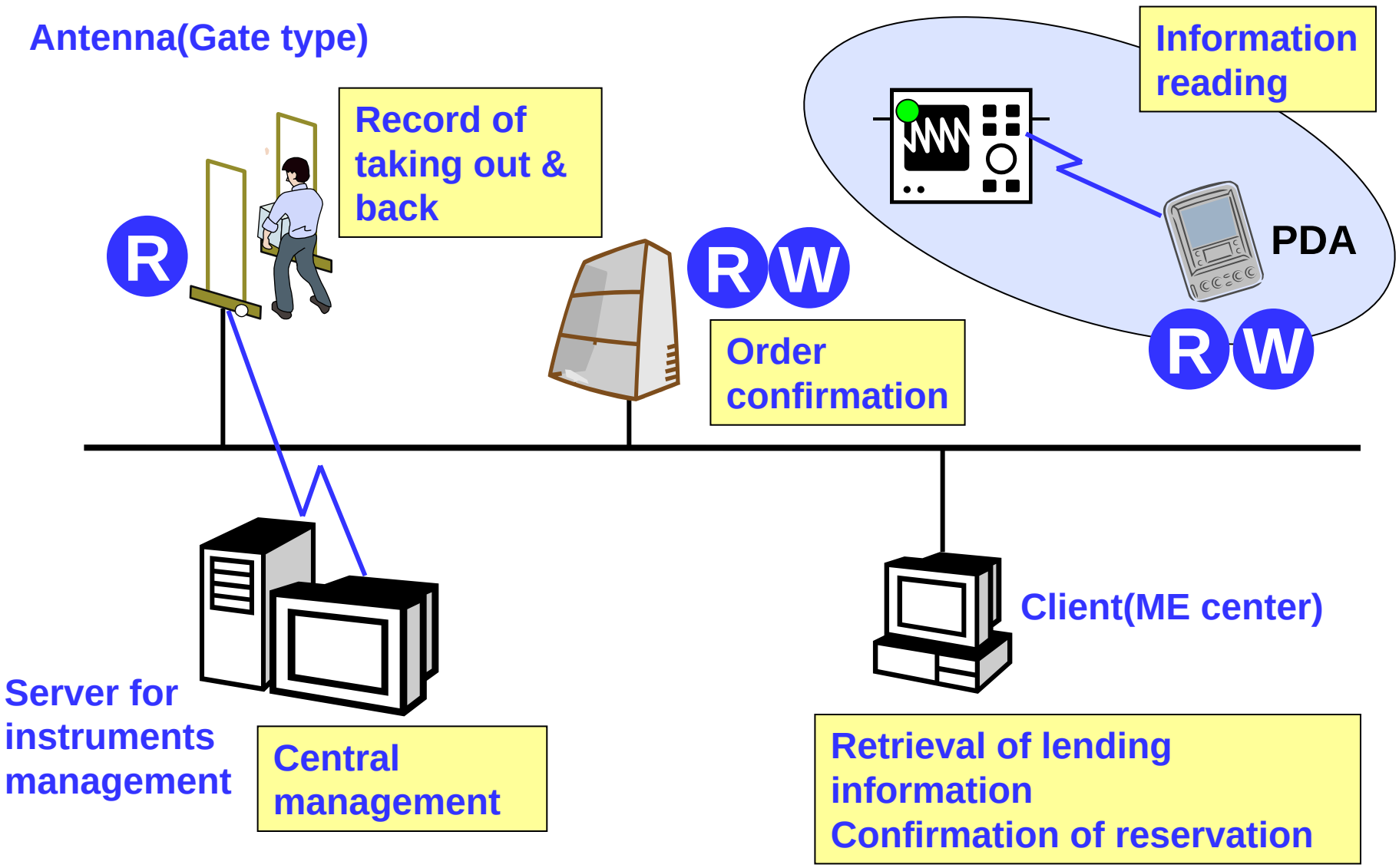
- **RFID tag**

  - Use for medical equipment ･･･13.56MHz / Label type for metal
  - Nameplate for medical personnel ･･･13.56MHz / Card type

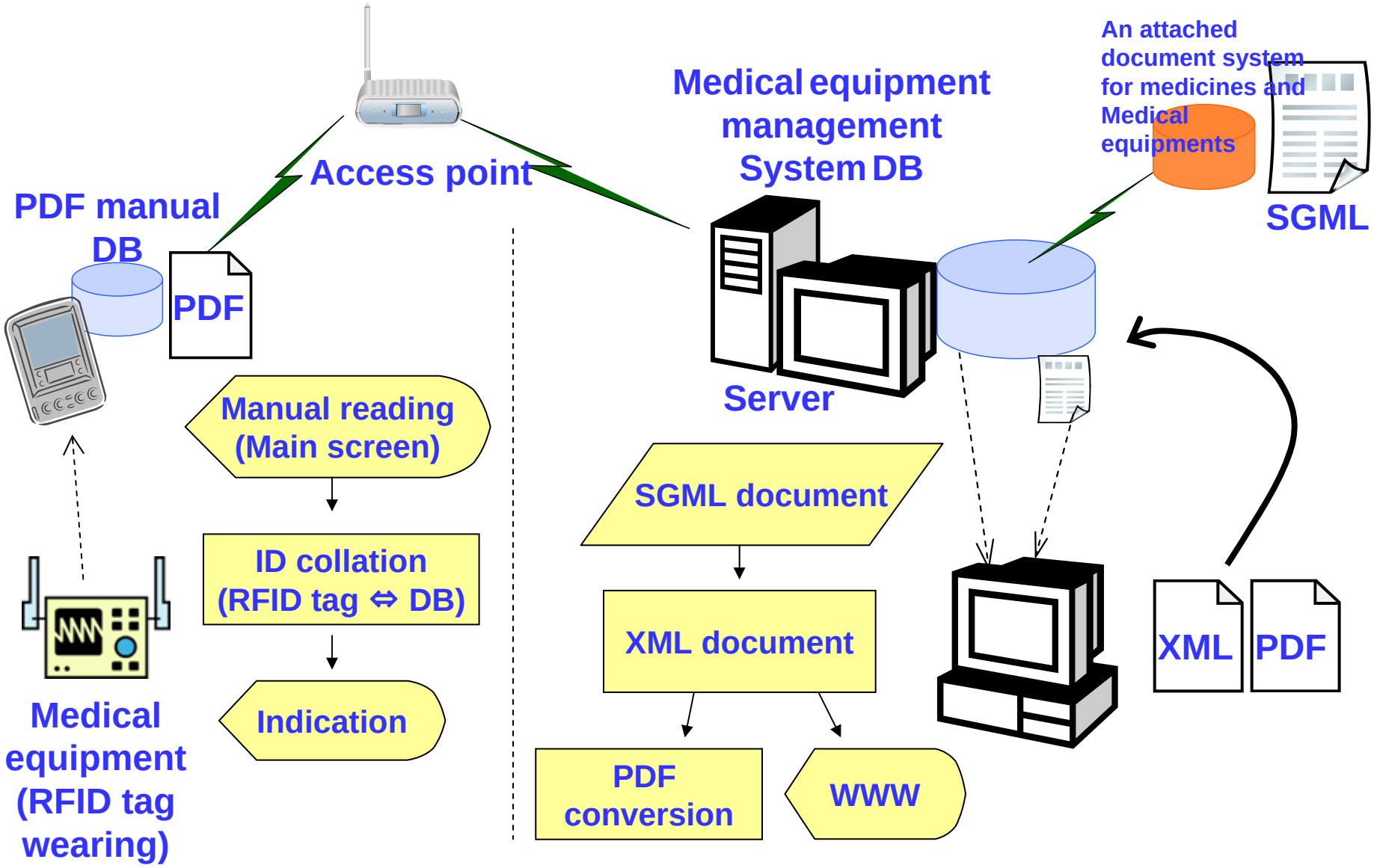
Software and Others

- An operation manual system for medical equipments

- **Form design**
  - Adoption of nurses' opinions
  - Choice of the information for the manual by clinical engineers
- **PDF file**
  - Use of Adobe Reader for Pocked PC2.0
  - The file made with the tag (A bookmark function)



System composition (ME Center)



Manual information referring system for operation

Results

Investigation of the function of the basic system - PDA terminal operation -

- Operationability / Function …Good

  A check function of equipments at the opening work promotes careful operation.

- Operation manual …Referable at the bedside

  The screen is small, but necessary information can be read

Improvement of safety by the developed system

- Reference of an operation manual at the bedside with a PDA terminal
- Check operation at the opening / closing work with a PDA
- Information for sterilization / disinfection of equipments from the infectious disease information of the patient

Advantage of an operation manual system for medical equipments

- **Improvement of Efficiency of the manual making work**
  - Using the information of machinery DB and the attached document information
  - Facilitating reedition work by adoption of XML
- **Improvement of the screen operation**
  - Realizing the quick and efficient screen operation by the PDF file with the tag
- **Reading manual information in the area available for a wireless LAN**
- **Acquirement of every information at the bedside**

Conclusion

In this study, a safety management system for medical equipment including a manual referring system for operation was successfully developed by applying an RFID and the system was thought to be useful from the result of a trial.

In the next place, we have a plan to build the system on a full scale and confirm the utility of the system by installing it in a hospital.

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Implementing and Evaluating a Laboratory Information System to Optimize the Treatment of Tuberculosis Patients in Peru

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Abstract and objective

Multi-drug resistant tuberculosis patients in resource-poor settings experience large delays in starting appropriate treatment and may not be monitored appropriately. A web-based laboratory information system "e-Chasqui" has been deployed in three laboratories and 12 health centers in Peru to reduce communication delays and missing or error-prone laboratory. Since November 2005, 30696 culture and 7237 drug sensitivity test results have been entered with 99% viewed online by health personnel. High user satisfaction and heavy use led to e-Chasqui being expanded to more institutions. In total, e-Chasqui will serve institutions providing medical care for over 3.1 million people. A study is being performed to measure its impact and generalizability.

Keywords:

Clinical Laboratory Information System, Computerized, Evaluation Studies, Developing Countries

Introduction

Treatment for MDR-TB in Peru is often delayed by over three months after initial presentation.(1) These potentially dangerous delays occur because of long test processing time, cumbersome communication procedures, and loss of specimens and test results. Similar problems are prevalent in other settings including South Africa.(2). An electronic information system can improve the handling of these data between institutions. Decreasing treatment delays and ensuring an appropriate drug regimen should improve outcomes and reduce transmission.

Methods

Partners In Health has developed a web-based medical record system (PIH-EMR)(3) to support the treatment of TB, with data on 15523 patients. We created a web-based laboratory information system, "e-Chasqui" to connect laboratories to health centers to reduce delays and facilitate communication and analysis. e-Chasqui includes tools to improve data quality, notify health centers of new results, alert physicians and create laboratory reports. Here we report on the system's implementation, use, and preliminary results from its evaluation.

Results

e-Chasqui has been implemented in the national reference laboratory, two of five regional laboratories in Lima and twelve health centers. Since its implementation in November, 2005, 28600 smear, 30696 culture and 7237 drug sensitivity test results have been entered. In 2006, 99.5% of all DST results and 98.8% of all culture results for the 12 pilot HCs were viewed online. Due to user satisfaction and heavy use, public officials have asked to expand the system to 3 other laboratories and over 10 other health centers. In total, e-Chasqui will serve a network of institutions providing medical care for over 3.1 million people.

Conclusions

This experience demonstrates the possible benefits of a web-based laboratory information system in a low resource setting. A retrospective and prospective randomized study is being performed to measure its impact on delays, errors, and quality of care, including time to prescribe an effective drug regimen. Using this experience we are developing a module to manage lab data for MDR-TB treatment in Lesotho and Rwanda, based on a new EMR architecture, OpenMRS (www.openmrs.org).

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Problem Statement (1)

- Peruvian National Tuberculosis Program
  - One of the largest MDR-TB programs in the world
- Laboratory data are essential for treatment
  - Drug Sensitivity Test (DST):
    - Determines appropriate drug regimen
  - Monthly bacteriology tests (smear & culture)
    - Clinical measure to monitor treatment response
- Timely and accurate data are essential through the 2 years of MDR-TB treatment

Problem Statement (2)

- Metropolitan Lima
  - 3 times land area of NYC
  - Population of 8.2 million
- Challenges
  - Among highest TB rates in the world
  - Poor Transportation
    - 3 hours to cross city
  - Lack of Public Health Funding
    - Require external support

Clinical TB System
PIH-EMR

- Secure web-based Electronic Medical Record (EMR)
- Open source software, open data standards
- Usable over low-speed dialup connections
- Bilingual: English/Spanish
- 13,000+ patients, 5,700+ received MDR-TB treatment
- Also used in Philippines (Tropical Disease Foundation)

- Developing Version 2 (OpenMRS) for wider use
  - Supports HIV and TB

Fraser et al. Proc AMIA Symp 2002

PIH-EMR

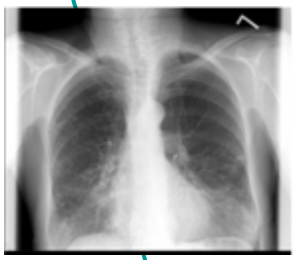
Handheld Data Collection

E-Chasqui System

Smears
Cultures
DSTs

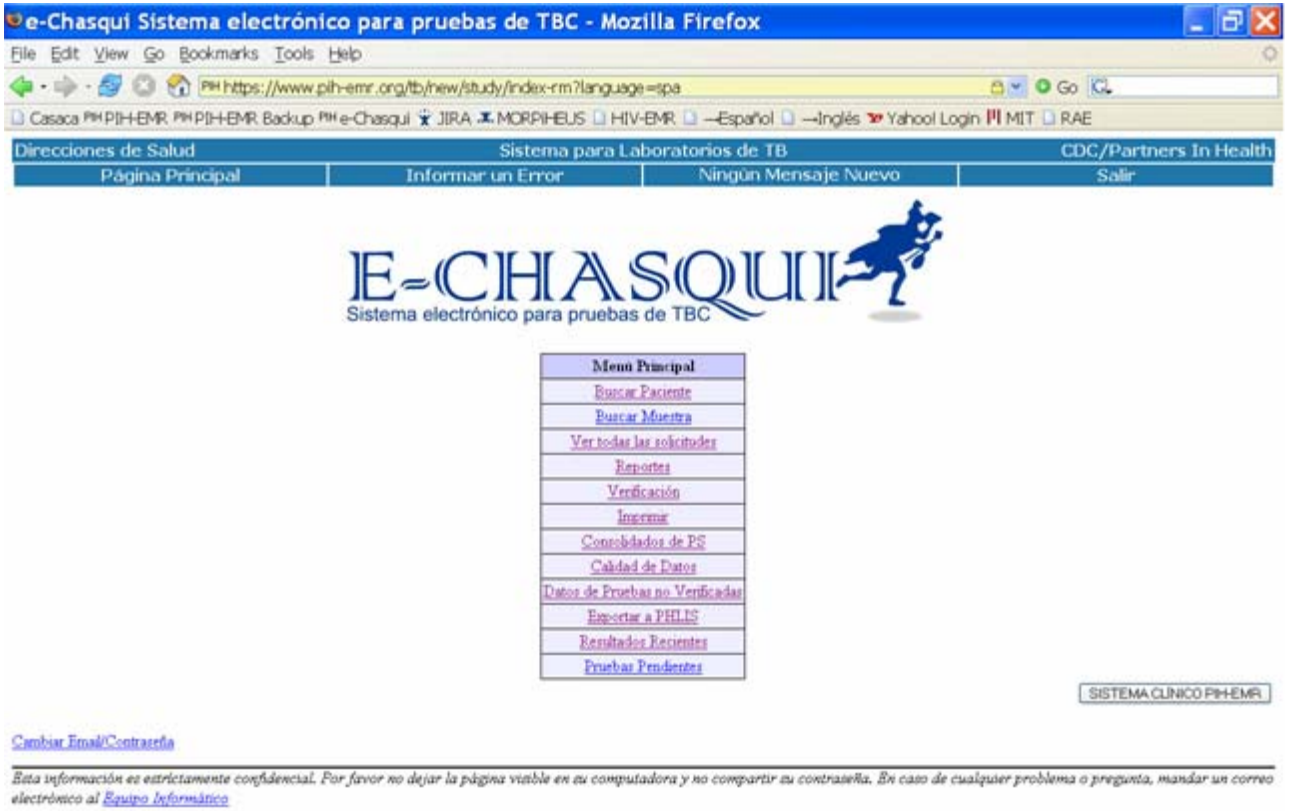
Biochem
Hematology

Registration form
History/exam
Previous Rx
Previous Dx
Contacts



Follow up
Chest X-ray

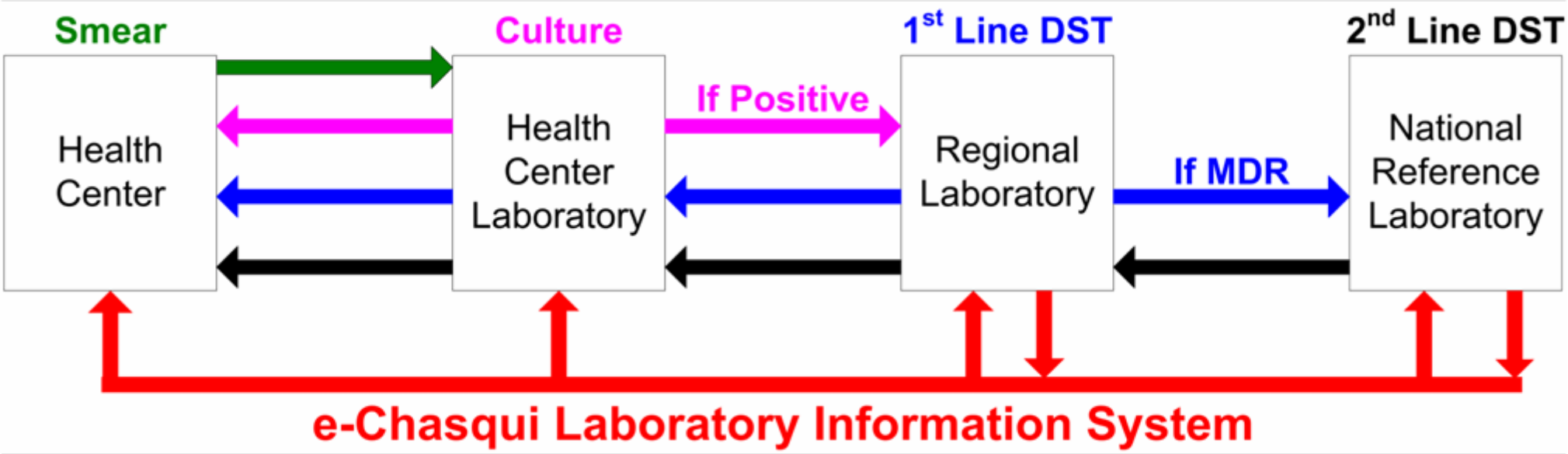
Drug regimens
Pharmacy



- Laboratory information system, e-Chasqui, extends the functionality of the PIH-EMR
- Web-based system to connect all TB treatment institutions

Lab Results Communication

Paper & e-Chasqui System Workflows



– 10% of results took > 60 days to arrive at clinic

– 16% of patients waited > 100 days to start treatment

Yagui et al. Int J Lung Dis 2006

Advantages of e-Chasqui

1. Automatically connects laboratories to health centers
   - Email notifications to health center personnel
   - Constant access to all information
2. Tools to improve data quality
3. Reporting functions for laboratory personnel
4. Alert clinicians & coordinators of high-risk patients
   - Patients with MDR-TB not on appropriate treatment

Implementation of e-Chasqui

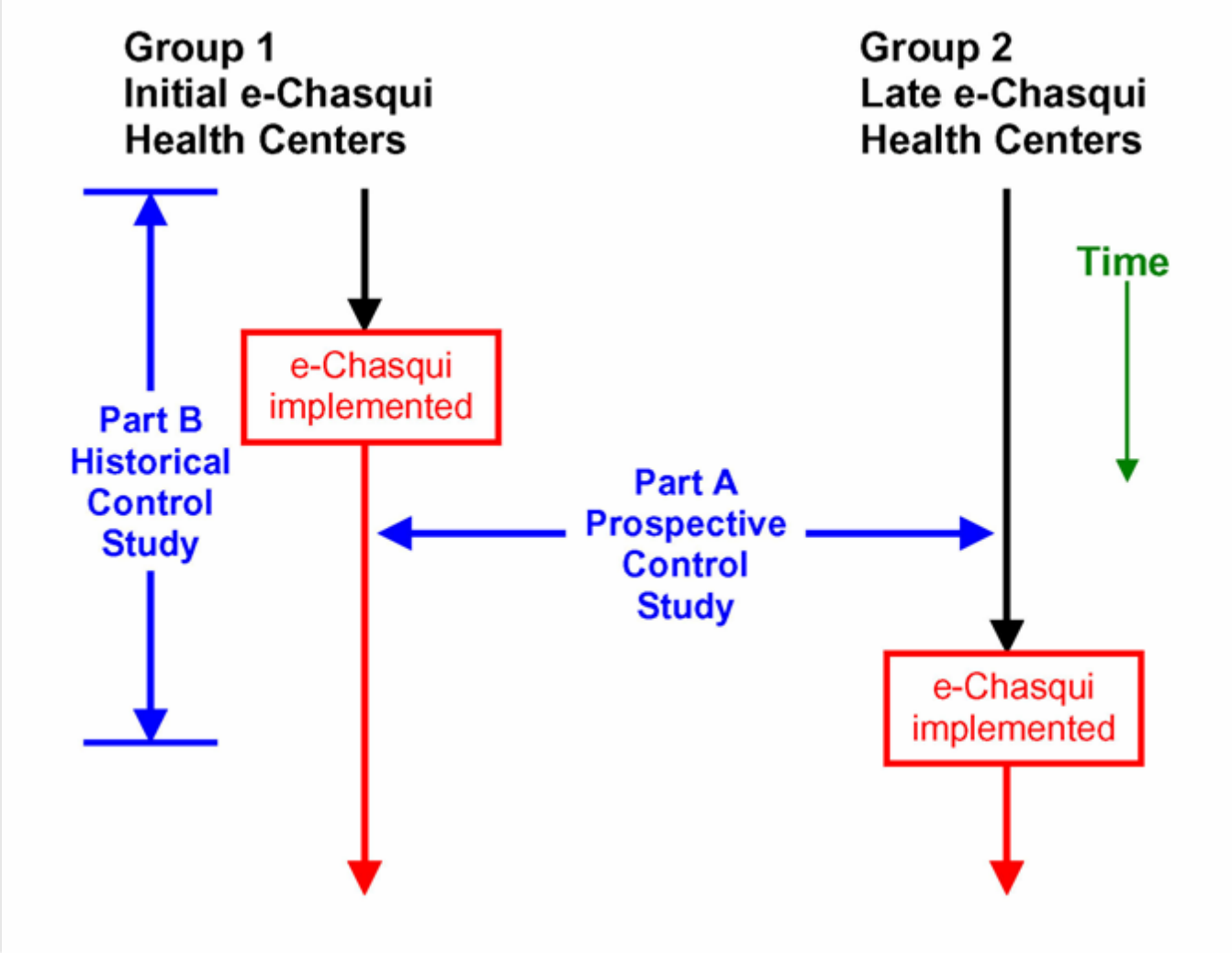
- Data Entry
  - National Reference Laboratory (INS)
  - 2 of 5 Regional Laboratories
    - Smears (28,000+), Cultures (30,000+)
    - 1st Line (7,000+) and 2nd Line (350+) DSTs

- Data Viewing
  - 20 health centers in 2 health districts
  - ~100 users including clinicians, nurses and lab staff
  - Connect centers providing care for 3.2 million people

Evaluation of e-Chasqui

- Prospective **(A)** & historical **(B)** controlled study

- Controls
  - **A.** Later access establishments
  - **B.** Self Controls



Evaluation of e-Chasqui

- Outcomes of Interest:
  1. Average communication delays
  2. Frequency of "Lost Results"
  3. Quantity of laboratory errors
  4. Approximate cost of the intervention
  5. Users' perception of e-Chasqui and nation-wide EMR
  6. Reduction of duplicate DSTs performed

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Evaluating Bilingual Medical Terminologies with Word Alignment Methods

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Abstract

Automatic word alignment in parallel texts can be used to generate lexicons, but the lexicons' quality is depending on the quality and type of the input resources. In this study the English and Swedish versions of the medical terminology systems ICD-10, ICF, NCSP, KSH97-P and MeSH are automatically word aligned and the influence the different systems have on the quality is evaluated. The most generally useful resources were generated from ICD-10 and the size of the partitions used to generate the resources only partly affects the quality.

Keywords:

classification, linguistics, medical informatics computing, terminology, medical terminology systems, word alignment

Introduction

One solution to cut costs for manual translations of medical terminology systems are to reuse already translated systems. In word alignment the task is to find correspondences on the word or phrase level between a source text and its translation, and the result can be reused in new translations. In an earlier study we word aligned a union of ICD-10, ICF, MeSH, NCSP and KSH97-P [1]. In this study we explore the influence the different terminology systems have on the recall and precision by varying how the systems are utilized in word alignment.

Materials and methods

Alignment tools

The ITools suite is used in this study for the word alignment [2]. First the user creates word alignment training data in an interactive environment. Then automatic alignment is done in a primarily linguistically oriented manner where different types of resources are combined in a voting procedure to select the best possible alignments. The static resources used are dictionaries and pattern resources for common and unwanted parts-of-speech correspondences and standard punctuation. The dynamic resources used are generated during the training stage. The statistic resources used are dictionaries produced using statistical analysis on the parallel texts.

Used terminologies and terminology partitions

The rubrics of the medical terminology systems ICD-10, ICF, MeSH, NCSP and KSH97-P that exist in parallel in both English and Swedish have been extracted for use in the study. A manual exploration divided the terminology systems into partitions with similar content and ordered the partitions from partition 1 with the highest assumed quality to partition 8 with the lowest. The exploration found the partitions 1: MeSH one word in English or Swedish rubric (13,514 rubrics), 2: MeSH more than one word in English and Swedish rubric (5,568 rubrics), 3: ICF (1,496 rubrics), 4: KSH97-P (968 rubrics), 5: ICD-10 except chapter 2 level 4 (10,791 rubrics), 6: NCSP except chapter N (4,137 rubrics), 7: ICD-10 chapter 2 level 4 (713 rubrics), 8: NCSP chapter N (1,388 rubrics). Partition 1 was used as a static dictionary for the alignment of partition 2–8.

Preparation and manual word alignment

Statistical resources were generated from each of the partitions 2–8. Then from each of the partitions 2–8, 5 % were randomly sampled to a training set and 5 % to a test set. These sets were interactively aligned by one of the authors following a style guide. The training sets were used to build training resources and the test sets as gold standards for evaluating the automatic word alignment's recall, precision and F-score.

Automatic word alignment

The test sets were automatically word aligned and the partitions used for building the statistic and dynamic resources and to automatically word align were altered according to Table 1. The main assumption to examine in batch 1 was similarities and differences inside each partition, in batch 2 the similarities and differences between a partition and the union of all partitions, in batch 3 if the performance of the automatic word alignment improves monotonously when resources from more and more partitions are used or if some partitions worsen the performance and in batch 4 the similarities and differences between the union of all partitions and a partition.

Results

The results of the word alignment are presented below.

Table 1 - Word alignment configurations and results

Batch	Run	Resource partition	Align partition	Recall	Precision	F-score
1	1	2	2	0.72	0.70	0.71
	2	3	3	0.80	0.80	0.80
	3	4	4	0.71	0.68	0.69
	4	5	5	0.80	0.78	0.79
	5	6	6	0.83	0.78	0.80
	6	7	7	0.63	0.58	0.60
	7	8	8	0.84	0.85	0.84
2	1	2	2–8	0.65	0.65	0.65
	2	3	2–8	0.62	0.63	0.62
	3	4	2–8	0.64	0.64	0.64
	4	5	2–8	0.75	0.73	0.74
	5	6	2–8	0.67	0.67	0.67
	6	7	2–8	0.64	0.65	0.64
	7	8	2–8	0.64	0.65	0.64
3	1	2	2–8	0.65	0.65	0.65
	2	2–3	2–8	0.67	0.66	0.66
	3	2–4	2–8	0.69	0.67	0.68
	4	2–5	2–8	0.77	0.74	0.75
	5	2–6	2–8	0.80	0.76	0.78
	6	2–7	2–8	0.80	0.77	0.78
	7	2–8	2–8	0.81	0.77	0.79
4	1	2–8	2	0.73	0.71	0.72
	2	2–8	3	0.81	0.81	0.81
	3	2–8	4	0.81	0.76	0.78
	4	2–8	5	0.81	0.78	0.79
	5	2–8	6	0.84	0.79	0.81
	6	2–8	7	0.74	0.65	0.69
	7	2–8	8	0.85	0.85	0.85

Discussion

In batch 2, all partitions except partition 5 have quite a similar recall and precision despite their varying sizes. This indicates that the sizes of the partitions used to generate the resources only partly influence the alignment results.

In batch 3, the recall and precision increase or remain unchanged for each added partition. This implies that none of the added resources decreases the word alignment quality.

Batch 4 has better results than the other batches, but compared to batch 1 the improvements of using resources generated from all partitions are in general small.

Partition 2 gives not as good results as most of the other partitions in batch 1 and 4, which indicates that there might be content-related aspects that make the alignment difficult.

The best resources are generated from partition 5, and this partition seems to cover the medical domain, represented as the union of all partitions, best of the single partitions. This is probably because it contains the highest number of rubrics of the partitions. This result is interesting because the partition contains ICD-10 and most of the other included terminology systems cover other sub-domains of medicine than diseases. Resources from partition 5 show in general better result than partition 4. Both partitions have similar content and structure, but partition 5 is eleven times larger than partition 4. The large difference in size and the moderate difference in results show that only adding larger resource partitions can be an expensive way to improve the results.

Partition 7 is difficult to align according to the results of batch 1 and 4. This can probably be explained by structural and semantic differences between the Swedish and English versions.

Conclusions

A larger resource partition generates resources that only to some extent have higher quality, so only adding larger resource partitions can be an expensive way to improve the results. ICD-10 seems to cover the medical domain best of the included terminology systems and generated the best general resources. Systematic differences in structure between rubrics and their translations make the rubrics harder to align.

Acknowledgments

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[1] Nyström M, Merkel M, Ahrenberg L, Zweigenbaum P, Petersson H, Åhlfeldt H. Creating a medical English-Swedish dictionary using interactive word alignment. BMC Med Inform Decis Mak. 2006 October 12;6(35).

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Evaluating bilingual medical terminologies with word alignment methods

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Introduction

Translations of medical terminology systems are necessary if the systems are used in countries with different languages.

Manual translations are expensive, but one solution to cut costs are to reuse already translated medical terminology systems for translation of new systems. The systems already existing in two languages are word aligned to generate lexical resources for reuse in new translations. The translation of new systems can then be semi-automatic instead of manual.

Terms in medical terminology systems have a more repetitive structure than natural language texts and the quality of the generated resources are therefore expected to be higher for medical terminology systems.

In an earlier study we used word alignment to generate a medical English-Swedish dictionary from a union of medical terminology systems[1]. In this study we explore the influence the different terminology systems and resource types have on the results.

Objective

The method used for the automatic word alignment of the terminology systems uses resources generated from the terminology systems.

In this study the aligned partitions and the partitions used to generate the resources of the terminology systems are varied. The variations give the possibility of evaluating similarities and differences within and between the terminology systems.

The similarities are mainly based on whether the contents in the rubrics consist of unique words or not, if the structures of the rubrics are repetitive and if the structure in the translated rubrics remains unchanged compared to the original rubric.

Background - Word alignment

Word alignment is the task of finding correspondences on the word or phrase level between a source text and its translation. Languages are not structured in identical ways across language borders and translations contain additions as well as omitted information. It is therefore no straightforward mapping techniques between two languages.

The standard approaches to word alignment in parallel corpora are statistical approaches and linguistic approaches. The statistical approach use probabilistic translation models. The linguistic approach often use rules for segmentation into lexical units, bilingual dictionaries and rules on word order and positions, as well as rules on corresponding part-of-speech labels.

The primary usefulness of word alignment is that it will recover and present candidate word and term pairs from a potentially previously unknown domain through a text corpus.

Methods - Alignment tools

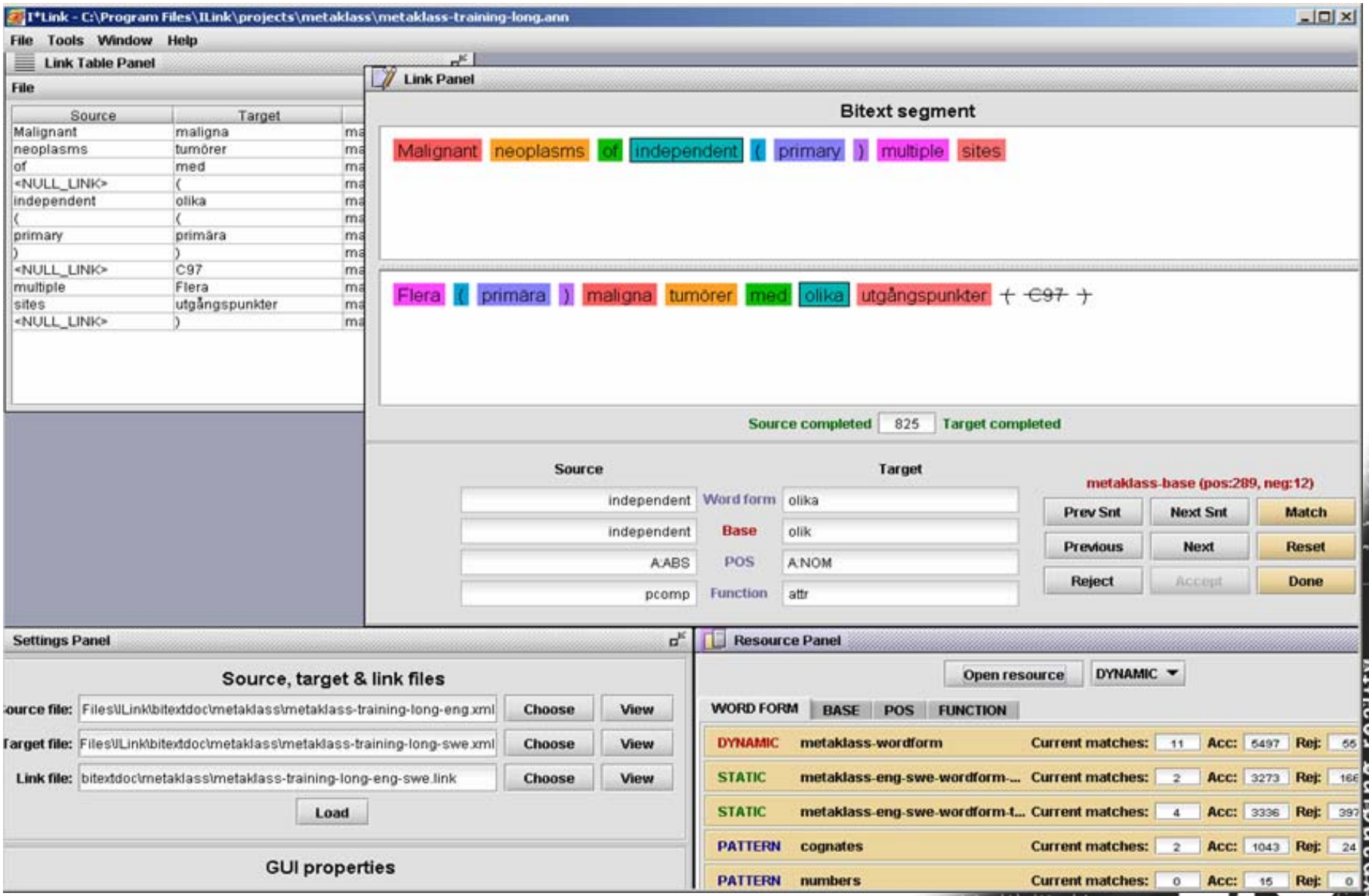
The ITools suite is used for the word alignment [2-4]. First morpho-syntactic tagging and statistical processing are performed. Then the user creates word alignment training data in an interactive environment. After that automatic alignment is done in a primarily linguistically oriented manner where different types of resources are combined in a voting procedure to select the best possible alignments.

The static resources used are dictionaries with a total of 22,500 general English-Swedish entries and pattern resources for common and unwanted parts-of-speech correspondences and standard punctuation.

The dynamic resources used are generated during the training stage. These resources are supposed to reflect the specific characteristics of the used material. The dynamic resources are built on four levels simultaneously, namely word form, lemma form, parts-of-speech and syntactic function levels.

The “statistic resources” used are probabilistic dictionaries produced using statistical analysis on the parallel texts with the GIZA++ tool kit.

Methods - Interactive word alignment tool



Evaluating bilingual medical terminologies with word alignment methods, Mikael Nyström et al.

Methods - Preparations

The preferred English and officially translated Swedish rubrics were extracted from the used medical terminology systems. An exploration was then carried out to find partitions of the systems with assumed similar quality for the word alignment.

Considering the exploration the systems were divided into 8 partitions and ordered from partition 1 with the highest assumed quality to partition 8 with the lowest. Partition 1 was selected to be included in the static resources as a dictionary.

Statistical resources for the automatic word alignment were generated from each of the partitions 2–8.

From each of the partitions 2–8, 5 % were randomly sampled to a training set and 5 % to a test set. These sets were interactively aligned following a word alignment style guide. The training sets were used to build training resources and the test sets as gold standards for calculating the automatic word alignment's recall, precision and F-score.

Materials - Terminology partitions

Parti-tion	Content	Rubrics	English rubric average number (standard deviation) of words	Swedish rubric average number (standard deviation) of words
1	MeSH, one word in English or Swedish rubric	13,514	1.5 (0.7)	1.0 (0.1)
2	MeSH, more than one word in English and Swedish rubric	5,568	2.6 (0.8)	2.3 (0.7)
3	ICF, whole	1,496	4.7 (2.5)	4.2 (2.8)
4	KSH97-P, whole	968	4.0 (2.5)	3.5 (2.4)
5	ICD-10, except chapter 2 level 4	10,791	5.2 (3.0)	5.2 (3.4)
6	NCSP, except chapter N	4,137	5.8 (2.7)	5.0 (2.5)
7	ICD-10, chapter 2 level 4	713	3.6 (2.2)	6.3 (2.7)
8	NCSP, chapter N	1,388	9.4 (2.6)	7.7 (2.3)

Methods - Automatic word alignment

The test sets were automatically word aligned in 4 batches and the partitions used for building the resources and to automatically word align were altered. The same partitions were used to generate the statistic and dynamic resources. The main assumptions to examine in the batches are

1. The performance of the automatic word alignment when a partition is aligned with resources generated from the same partition. The performance reflects the similarities and differences inside each partition.

2. The performance of the automatic word alignment when generalizing resources from one partition to other partitions. The performance reflects the similarities and differences between a partition and the union of all partitions, which can be seen as an approximation of the medical language in healthcare records.

3. If the performance of the automatic word alignment improves monotonously when resources from more and more partitions are used or if some partitions worsen the performance.

4. The performance of the automatic word alignment for the different partitions when resources from all partitions are used. The performance reflects the similarities and differences between the union of all partitions and a partition.

Results

Batch	Run	Reso-urce parti-tion	Align parti-tion	Recall	Preci-sion	F-score
1	1	2	2	0.72	0.70	0.71
	2	3	3	0.80	0.80	0.80
	3	4	4	0.71	0.68	0.69
	4	5	5	0.80	0.78	0.79
	5	6	6	0.83	0.78	0.80
	6	7	7	0.63	0.58	0.60
	7	8	8	0.84	0.85	0.84
2	1	2	2–8	0.65	0.65	0.65
	2	3	2–8	0.62	0.63	0.62
	3	4	2–8	0.64	0.64	0.64
	4	5	2–8	0.75	0.73	0.74
	5	6	2–8	0.67	0.67	0.67
	6	7	2–8	0.64	0.65	0.64
	7	8	2–8	0.64	0.65	0.64

Batch	Run	Reso-urce parti-tion	Align parti-tion	Recall	Preci-sion	F-score
3	1	2	2–8	0.65	0.65	0.65
	2	2–3	2–8	0.67	0.66	0.66
	3	2–4	2–8	0.69	0.67	0.68
	4	2–5	2–8	0.77	0.74	0.75
	5	2–6	2–8	0.80	0.76	0.78
	6	2–7	2–8	0.80	0.77	0.78
	7	2–8	2–8	0.81	0.77	0.79
4	1	2–8	2	0.73	0.71	0.72
	2	2–8	3	0.81	0.81	0.81
	3	2–8	4	0.81	0.76	0.78
	4	2–8	5	0.81	0.78	0.79
	5	2–8	6	0.84	0.79	0.81
	6	2–8	7	0.74	0.65	0.69
	7	2–8	8	0.85	0.85	0.85

Discussion and Conclusion

Larger resource partitions generate resources that only to some extent have higher quality, so only adding larger resource partitions can be an expensive way to improve the results.

Partition 5, which contains the major parts of ICD-10, seems to cover the medical domain best of the included terminology systems. It can also be used to generate the best general resources of the included partitions. The large size of partition 5 is probably the main reason.

Systematic differences in structure between rubrics and their translations make the rubrics harder to align. The automatic word alignment can be improved by filtering out these rubrics.

Of the investigated partitions, two of them are harder to align than the others, namely partition 2 and 7.

References, acknowledgments and contact

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Online Transmission of Clinical Data for Disease Management and Registers

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Abstract

There is growing demand for collection of structured clinical data for administrative and medical purposes such as quality management, registers and health care system planning. Especially integrated care concepts for chronic diseases put higher requirements on the availability of longitudinal common data. The aim of this work was to provide a flexible system to collect clinical data from routine care, available area-wide across institutional borders in Austria and Germany. It was our goal to implement plausibility checks and manual data revision while keeping the technical entry-barrier as low as possible. Data could be collected from various sources: a) paper forms made available electronically using an OCR scanner, b) online data entry through a web browser, c) data extracted from EPRs. A text-based comma separated file format was defined for data import from scanner and EPRs and made public. Until February 2007 more than 275.000 data-sets have been collected. Online data import was widely accepted: Between 2002 and 2006, 78 % of data were imported online by 34 different centres for 206 participating centres. EPR data import gained importance recently due to a physician incentive by a certification programme, which lead to an escalating increase of transmitted data sets.

Keywords:

data collection, quality assurance, health care, information systems

Introduction

Administrative and medical purposes such as quality management, registers and health care system planning create a growing demand for collection of structured clinical data in primary and ambulatory care, especially in the management of chronic diseases. Effective quality improvement strategies have been identified and published [1,2]. Many of these strategies such as audit and feedback [3] rely on clinical data collected by physicians. We report experiences with data acquisition implemented in our online web application Healthgate BARS over 5 years.

The aim of this work is to provide a flexible system to collect clinical data from routine care for quality management and patient registry in diabetes care, available area-wide across institutional borders. Plausibility checks and manual data revision had to be provided to make structured data available at a required minimum quality level to sub-

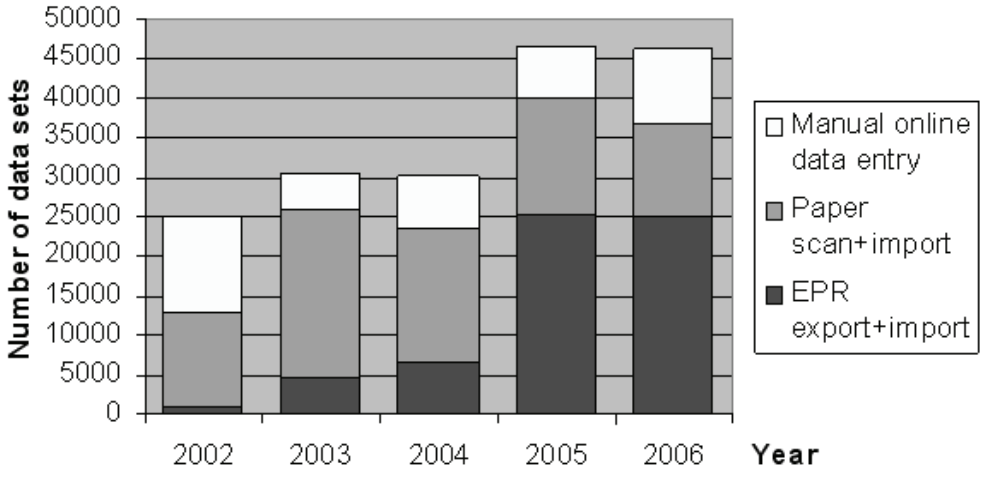

Figure 1- Data entry per year by input method

sequent data analysis. As the system was introduced in 2002 in Austria and Germany, common infrastructure such as electronic health record systems or health information networks were not available. In both countries, electronic patient records (EPR) in GP (general practitioner) practices often were available in very basic form only or not present at all. It was therefore our intention to fulfil the above requirements while keeping the technical entry-barrier as low as possible.

Material and methods

Data could be collected from various sources: a) data from paper forms made available electronically using an OCR (optical character recognition) scanner, b) online data entry through a web browser, c) data extracted from EPRs. A text-based comma separated file format was defined for data import from scanner and EPRs and made public. Data import was carried out through a Java 2 Enterprise web application and split into two sequential steps: Upload and revision. Files were uploaded and imported asynchronously using Message Driven Beans. All records passing plausibility checks were immediately stored in the database and remaining records marked for revision. Users were notified by email about import status. All data-sets not yet imported could be revised online and saved to the database. Data extracted from EPRs typically required only minor or no revisions. For this study, changes in data entry behaviour and data sources were analyzed over time.

Results

Until February 2007 more than 275.000 data-sets have been collected. Since 2002, 78 % of data have been imported online by 34 different centres for 206 participating centres in Germany and Austria (Figure 1). The web-based approach made the system easy to reach, use and administer. Data collected on paper was scanned and imported in two centres and could be revised locally in physicians' offices. The system was used in Austria and Germany by the voluntary quality management initiative “Forum for Quality Systems in Diabetes care”, as well as in routine care in Diabetes education projects in four Austrian provinces (Styria, Salzburg, Carinthia, Vienna). Since 2005 a certification programme introduced by the German Diabetes Association is supported by Healthgate, which increased demand for EPR interface development and lead to a dramatic increase of data imported from EPRs in Germany. Particularly specialized centres (9 hospitals, 22 diabetes clinics and 1 GP) managed to adopt EPR data extraction. These 32 centres contributed more than 40 % of overall data.

Discussion and conclusion

Our experiences show, that data acquisition tools for quality management are required and accepted by physicians. Automatic extraction of data entered in EPRs is the most practical solution to establish regular and high volume data transmission. However, this alternative has the highest entry barrier, because it requires development and modification of existing software systems in physician’s offices, achievable only by regulations or incentives for physicians.

In Germany, the HL7 based Sciphox (Standardized Communication of Information Systems in Physician Offices and Hospitals using XML) standard [4] is currently used in a follow-up project, to make data collected in the nation-wide Disease Management Program available for open benchmarking. In Austria, health information network and health smartcard, which have been rolled out about a year ago, provide a promising infrastructure for secure and high-performance data transmission and seamless system integration. In both countries, especially on the GP level, standards for data transmission only exist for administrative purposes and separation of healthcare sectors is prevalent. Introduction of a national Electronic Health Record (EHR) is discussed [5], which could reduce many of the existing barriers. However, presumably several years will pass until the fragmented market for EPR software on GP level will be penetrated by these initiatives. Meanwhile, as a step by step approach towards common EHR standards for connectivity and semantic interoperability, in both countries there is a strong need for harmonization and standardisation of data transmission as well as for algorithms to extract structured data from EPRs. Harmonization and Standardization on a national level as well as incentives and support for clinics and physicians are more important than technical innovation to achieve positive short and medium term results.

References

[1] Shojania KG, Ranji SR, McDonald KM, Grimshaw JM, Sundaram V, Rushakoff RJ, Owens DK. Effects of quality improvement strategies for type 2 diabetes on glycemic control: a meta-regression analysis. JAMA, 2006, 296, 427-440

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[5] Austrian eHealh Initiative. Recommendation for an Austrian eHealth Strategy (German). http://ehi.adv.at/fileadmin/user_upload/adv_author/pdfs/konferenz20070126/Strategie_Empfehlung_der_e-Health-Initiative_Oesterreich_20070126_v2_02.pdf
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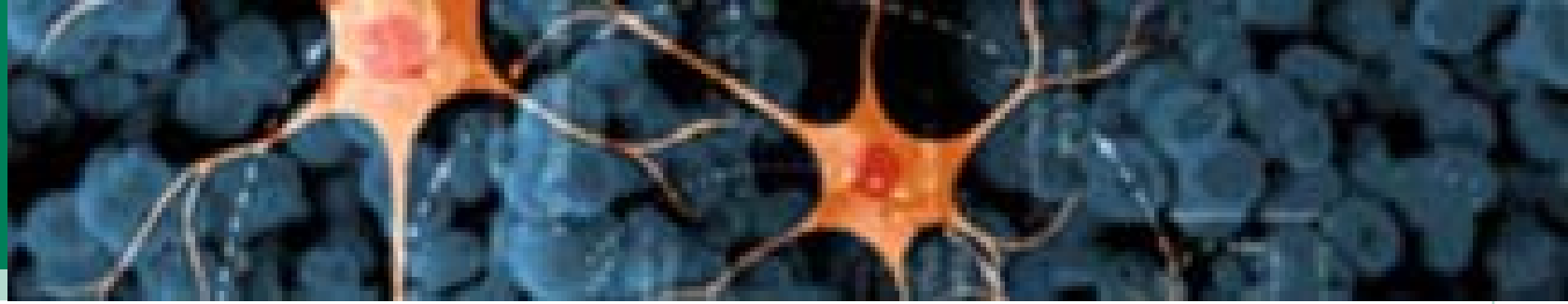

Online Transmission of Clinical Data for Disease Management and Registers

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Introduction

- **Growing demand for collection of structured clinical data in primary and ambulatory care**
  - ➔ Administrative and medical purposes such as
    Quality management,
    Registers and
    Health care system planning
  - ➔ Especially in the management of chronic diseases
- **Effective quality improvement strategies have been identified and published [1,2].**
- **Many of these strategies such as audit and feedback [3] rely on clinical data collected by physicians.**
- **We report experiences with data acquisition implemented in our online web application Healthgate BARS over 5 years.**

Project Aims

- **Provide a flexible system to collect clinical data from routine care for quality management and patient registry in diabetes care**
  - ➔ Area-wide availability across institutional borders
  - ➔ Provide plausibility checks and manual data revision to make structured data available at a required minimum quality level to subsequent data analysis
- **Keeping technical entry-barrier as low as possible**
  - ➔ The system was introduced in 2002 in Austria and Germany.
  - ➔ Common infrastructure such as electronic health record systems or health information networks were not available.
  - ➔ In both countries, electronic patient records (EPR) in GP (general practitioner) practices often were available in very basic form only or not present at all.

Data collection

- **Available data sources**

  a) data from paper forms made available electronically using an OCR (optical character recognition) scanner

  b) online data entry through a web browser

  c) data extracted from EPRs.

- **A text-based comma separated file format was defined for data import from scanner and EPRs and made public.**

JOANNEUM RESEARCH

Data Import

- **Carried out through a Java 2 Enterprise web application**
- **Two sequential steps: Upload and revision.**
  - ➔ Upload
    - *Files imported asynchronously using Message Driven Beans*
    - *All records passing plausibility checks immediately stored in the database*
    - *Remaining records marked for revision*
    - *Users were notified by email about import status*
  - ➔ Revision
    - *Revision of data-sets not yet imported via online interface*
    - *Valid data sets saved to the database*
    - *Data extracted from EPRs typically required only minor or no revisions*

Use of the system

- **In Austria and Germany used by the voluntary quality management initiative "Forum for Quality Systems in Diabetes care"**
- **In routine care in Diabetes education projects in four Austrian provinces**
  - ➔ Styria, Salzburg, Carinthia, Vienna
- **Difference:**
  - ➔ Germany: Mainly specialised diabetes clinics and hospitals
  - ➔ Austria: All health care system levels, also many GPs
- **Data collected on paper was scanned and imported in two regional offices and could be revised locally by the physicians.**

JOANNEUM RESEARCH

Objective of this Study

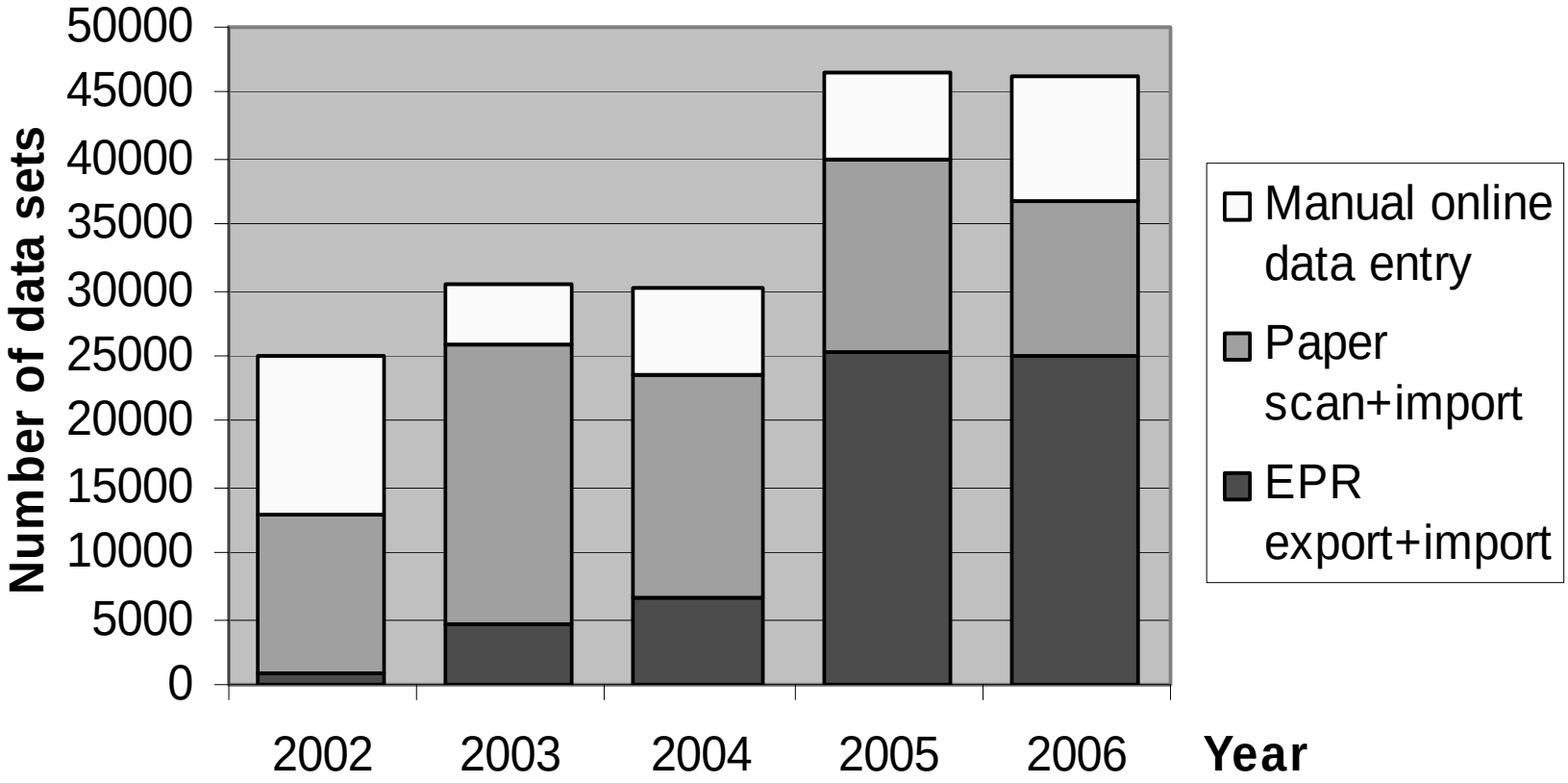
- Which data input methods are accepted and used in practice by physicians?
- Are there differences in smaller / bigger centres?
- Did data entry behaviour and data sources used change over time?

Results

- **More than 275.000 data-sets collected in Germany and Austria (February 2007).**
- **Since 2002, 78 % of data imported online**
- **Imports were performed by 34 different centres for 206 participating centres.**

- **32 specialized centres (9 hospitals, 22 diabetes clinics and 1 GP) managed to adopt EPR data extraction.**
- **These centres contributed more than 40 % of overall data.**
- **A certification programme introduced by the German Diabetes Association in 2005 is supported by Healthgate**
  - ➔ This increased the demand for EPR interface development
  - ➔ and lead to a dramatic increase of data imported from EPRs in Germany

Results
Data entry per year by input method



Discussion

- **Data acquisition tools for quality management are required and accepted by physicians**
- **Automatic extraction of data entered in EPRs**
  - ➔ is the most practical solution to establish regular and high volume data transmission
  - ➔ has the highest entry barrier, because it requires development and modification of existing software systems in physician's offices.
  - ➔ Incentives for physicians or regulations are required
- **The web-based approach made the system easy to reach, use and administer**
- **Germany**
  - ➔ HL7 based Sciphox(*) standard [4] currently used in a follow-up project for data collected in the nation-wide Disease Management Program
- **Austria**
  - ➔ Promising infrastructure provided by health information network and health smartcard

(*) Standardized Communication of Information Systems in Physician Offices and Hospitals using XML

Discussion
Need for standardisation

- ➔ Especially on the GP level, standards for data transmission only exist for administrative purposes and separation of healthcare sectors is prevalent
- ➔ Introduction of a national Electronic Health Record (EHR) is discussed [5], which could reduce many of the existing barriers
  - *Presumably, several years will pass until the fragmented market for EPR software on GP level will be penetrated by this initiative*
- ➔ Strong need for harmonization and standardisation
  - *As a step by step approach towards common EHR standards for connectivity and semantic interoperability*

References

[1] Shojania KG, Ranji SR, McDonald KM, Grimshaw JM, Sundaram V, Rushakoff RJ, Owens DK. Effects of quality improvement strategies for type 2 diabetes on glycemic control: a meta-regression analysis. JAMA, 2006, 296, 427-440

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[5] Austrian eHealth Initiative. Recommendation for an Austrian eHealth Strategy (German). http://ehi.adv.at/fileadmin/user_upload/adv_author/pdfs/konferenz20070126/Strategie_Empfehlung_der_e-Health-Initiative_Oesterreich_20070126_v2_02.pdf (last accessed May 31st, 2007).

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Developing a Health Information Integrated Web Service With a Concept of "Mash up"

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Abstract

By using the concept of Mash up of the Web 2.0, we integrated search engines ,and show the results by tabs in the same page, our purpose lies in leading users to find out the desirous information ,and to provide some searching guidelinefor people who without professional health knowledge, and finally we reach the goal to perform the satisfying information web-pages with tabs.

Keywords:

Web 2.0, Mash up, health information, ASP.NET 2.0

Introduction

With the knowledge exploring time arriving, the demand of health information getting more and more, in order to satisfy this demand, we use the concept of Web 2.0 to design a system, the concept of Web 2.0 is very popular in recently years, especially in providing interaction between websites and users, open resources and sharing wisdom with each other, in brief, it offers better experience for user to use .One of the concepts is Mash up, through many web procedures combine outside resource in a easy way, The brand-new integrated service helps users to omit some unnecessary steps and reach the goals more effectively while they're browsing, for example: flickr(the largest photo-sharing website in the world)is "Mash up" by ThinkFree(the document-editing website), users can obtain the photos from flickr and put them into their own document by some simple steps, and Google Map is quoted to some websites as geographical information, Thus, we choose the program language of ASP.NET 2.0 and Google AdWordsyahoo and Google search engineWikipedia...etc integrated into one service for health information, therefore we use the concept of Mash up to design such service for the general people.

Methodology

We offer the "keyword suggestion" button (this part is top in Figure1.) for users by using the AdWords keyword tool in Google, which can count and show the other related keywords used by other users when they looking for information, and therefore guiding a searching direction for users , especially for those people without general sense of health.

There are always too much disorderly information to read at the same time , we use google search api to integrate better health web information which were elected by DOH in Taiwan.

Users can select which database they want to look for information and present the information be found in the first tag, and then the second tag present the other information which is not presented in first tag. The third tag present videos related with keywords from Youtube. This system uses component of an adjustable transparency of technical design of Ajax, this component can turn on the webpage that the user want to browse through among them, and can adjust the component position and size by oneself in mother's page. Advantage : 1. Preventing users from opening too many webpages at the same time and lead to inconvenient browsing. 2.By using Ajax technology, this design automatically recording the users' browsing time and report to the server in the situation of interference the users'reading . 3.When the user want to compare with the browsing time of all webpages, the system would present these webpages with different transparency. 4. When the mouse move over the keyword of searched abstract, the system would present related keyword information with a frame. This information provide a reference of definition for users, and the source of these data are from http://hospital.kingnet.com.tw/

Figure 1 - By using the user-friendly interface, it is convenient for users friendly to search and view the health information

Discussion

Nowadays the search of health information in the internet network in Taiwan ,the users may probably be confronted by two questions: 1.Beacause of lacking common health information people don’t know how to quiz and obtain the desirable information 2.There is too much information searched out through the internet search engine and telling apart which is the correct and helpful information is difficult for general people.

By using the concept of Mash up of the Web2.0, and the ASP.NET 2.0 technology, we design a well performed web-based system with good user interface to reach the main goal that can help users to screen and integrate the desirable information into this page, the same as all network services of utilizing Mash up, the copyright of WebPages is a topic to be discussed, too. But what we can make sure is, the more the websites be quoted as source references, the more valuable they would be, This tool with providing searching and integrating function of these websites will have the existing value because of saving user's time of searching satisfying information.

References

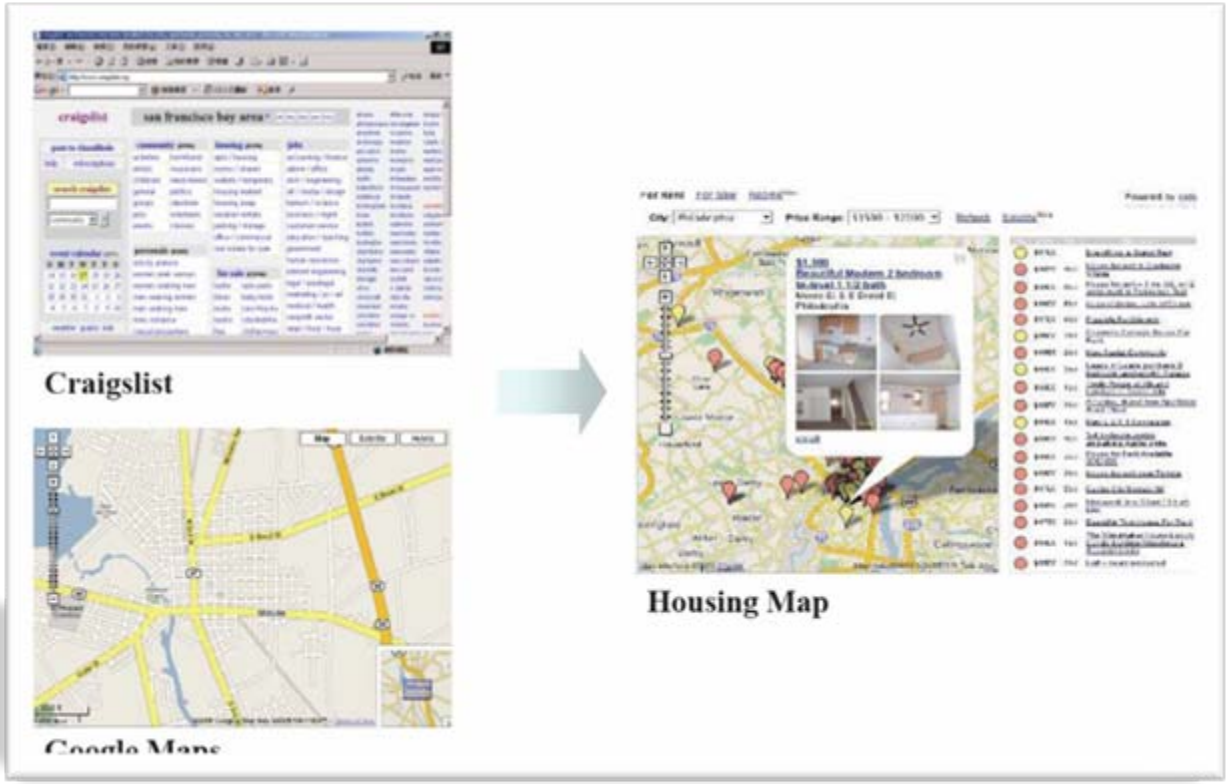
[1] McCormack, Dermot A. Web 2.0. Aspatore Books; 2002.

Developing a Health Information Integrated Web Service With a concept of “Mash up”

Po-Yen Li1, MS, Hui-Jou Chang1, BS, Dau-Jeng Huang, BS, Polun Chang,PhD1

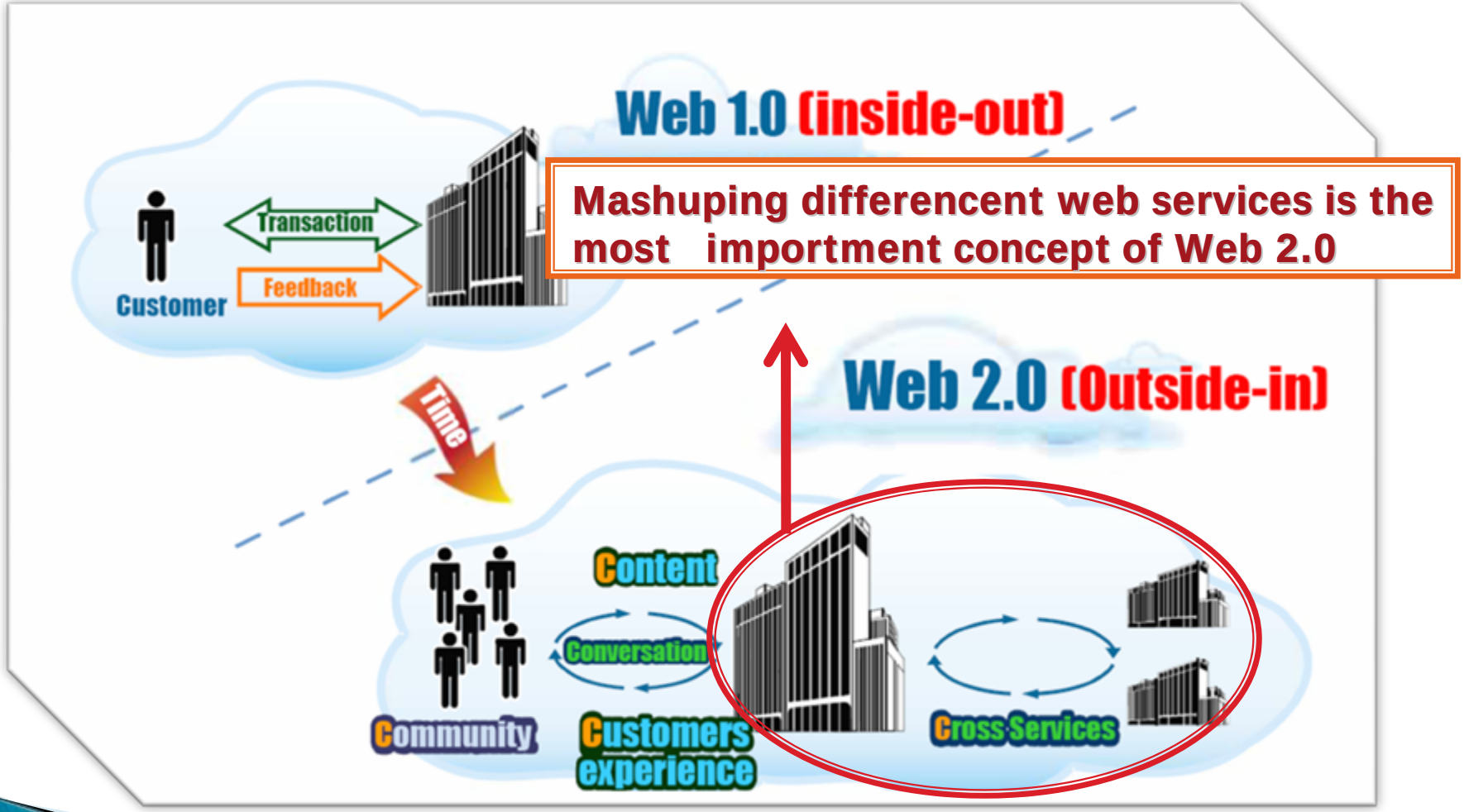
Background

- Example :



Craigslist + GoogleMaps = Housing Map

Concept of Web 2.0



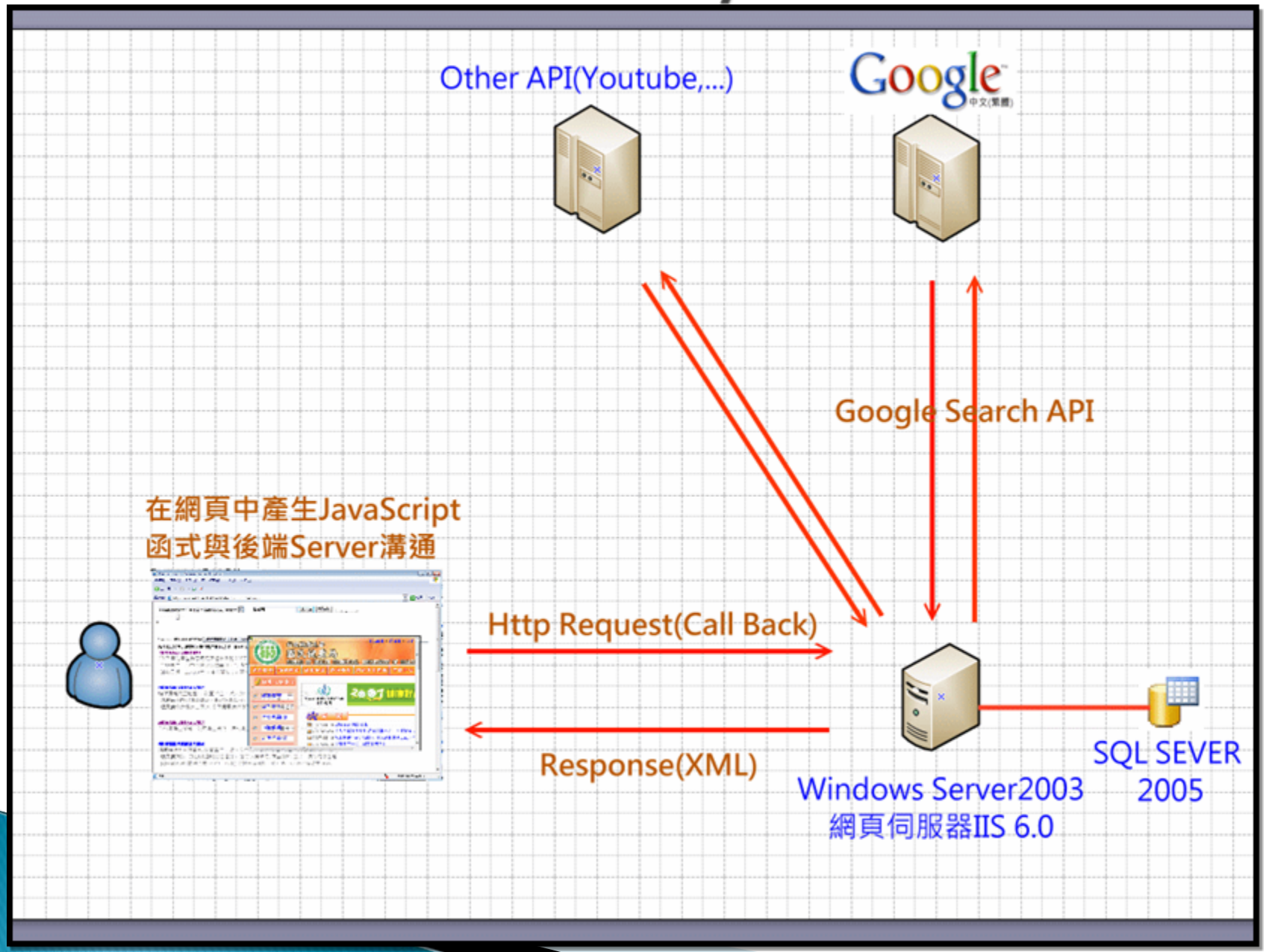
Introduction

By using the concept of Mash up of the Web 2.0, we integrated search engines ,and show the results by tabs in the same page, our purpose lies in leading users to find out the desirous information ,and to provide some searching guideline for people who without professional health knowledge, and finally we reach the goal to perform the satisfying information web-pages with tabs.

Tools

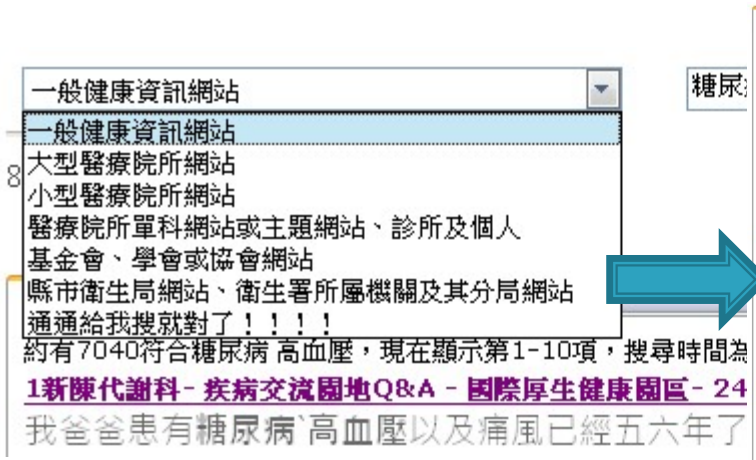
- ASP.NET 2.0 AJAX技術 與Google Search API、YouTube API。
- SQL SERVER 2005
- MicroSoftVisual Studio 2005

Architecture of System



- DEMO

demo1


一般健康資訊網站
一般健康資訊網站
大型醫療院所網站
小型醫療院所網站
醫療院所單科網站或主題網站、診所及個人
基金會、學會或協會網站
縣市衛生局網站、衛生署所屬機關及其分局網站
通通給我搜就對了！！！！
糖尿
約有7040符合糖尿病 高血壓，現在顯示第1-10項，搜尋時間為
1新陳代謝科 - 疾病交流園地Q&A - 國際厚生健康園區 - 24
我爸爸患有糖尿病`高血壓以及痛風已經五六年了


Search in 優良健康資訊網站
其他相關網站
影音
Search 4
News
MAP
約有7040符合糖尿病 高血壓，現在顯示第1-10項，搜尋時間為0.137788秒
1新陳代謝科 - 疾病交流園地Q&A - 國際厚生健康園區 - 24Drs.com
我爸爸患有糖尿病`高血壓以及痛風已經五六年了因為都在大陸工作很忙的關係導致經常性腹瀉而且容易發燒感冒及高血壓每天都吃降壓 ... 糖尿病若飲食不控制，使用藥物也是枉然。高血壓則需要將血壓控制在正常值。關於痛風，病情穩定時並不需要使用止痛劑。 ...
2向冠狀動脈疾病說拜拜 - 我有話要說 - 專題評論報導 - 國際厚生健康園區 ...
桃園敏盛醫院連續接獲兩急性心肌梗塞病患案例，患者都是在運動的時候病發的，該院心臟中心心臟內科主治醫師邱定宇發現，這兩病例都存有高血壓或糖尿病的病史，而且都沒有接受完整的治療，因此呼籲有糖尿病、高血壓、高血脂、強烈家族心臟病史及老煙槍的 ...
3國際厚生健康園區
目前這個研究的目的在探索腎臟病風險較高的病患其BMI和死亡風險間的關係：也就是KEEP族群；KEEP是一個篩檢計畫，納入的對象是18歲以上的糖尿病或高血壓病患，或有家族腎臟病、糖尿病、高血壓病史；目前的研究包括33473 位有完整資料的KEEP 參與者；CKD的 ...
4國際厚生健康園區
目前這個研究的目的在探索腎臟病風險較高的病患其BMI和死亡風險間的關係：也就是KEEP族群；KEEP是一個篩檢計畫，納入的對象是18歲以上的糖尿病或高血壓病患，或有家族腎臟病、糖尿病、高血壓病史；目前的研究包括33473 位有完整資料的KEEP 參與者；CKD的 ...
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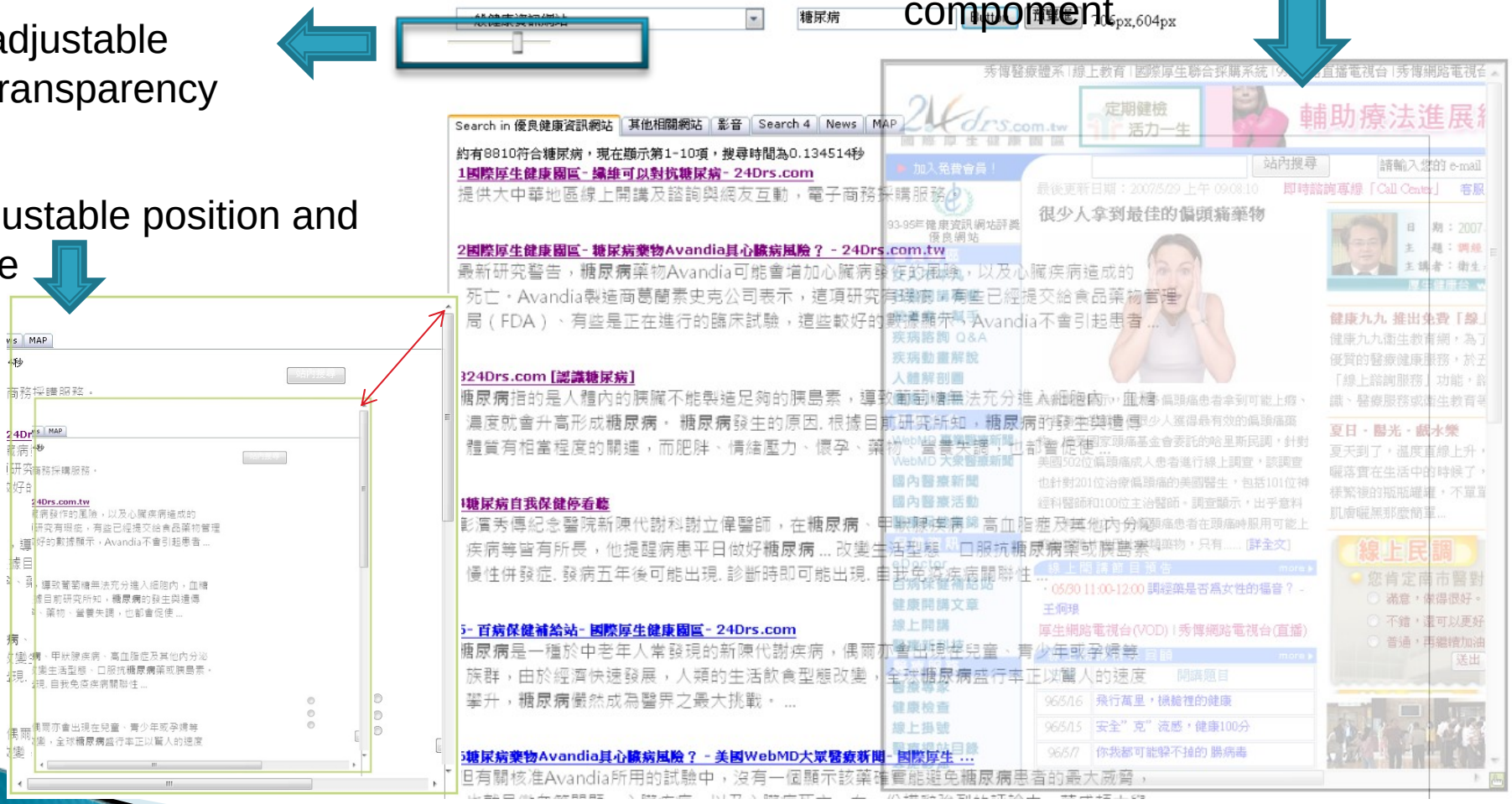
demo2

adjustable transparency

Open page in the transparency compoment

adjustable position and size

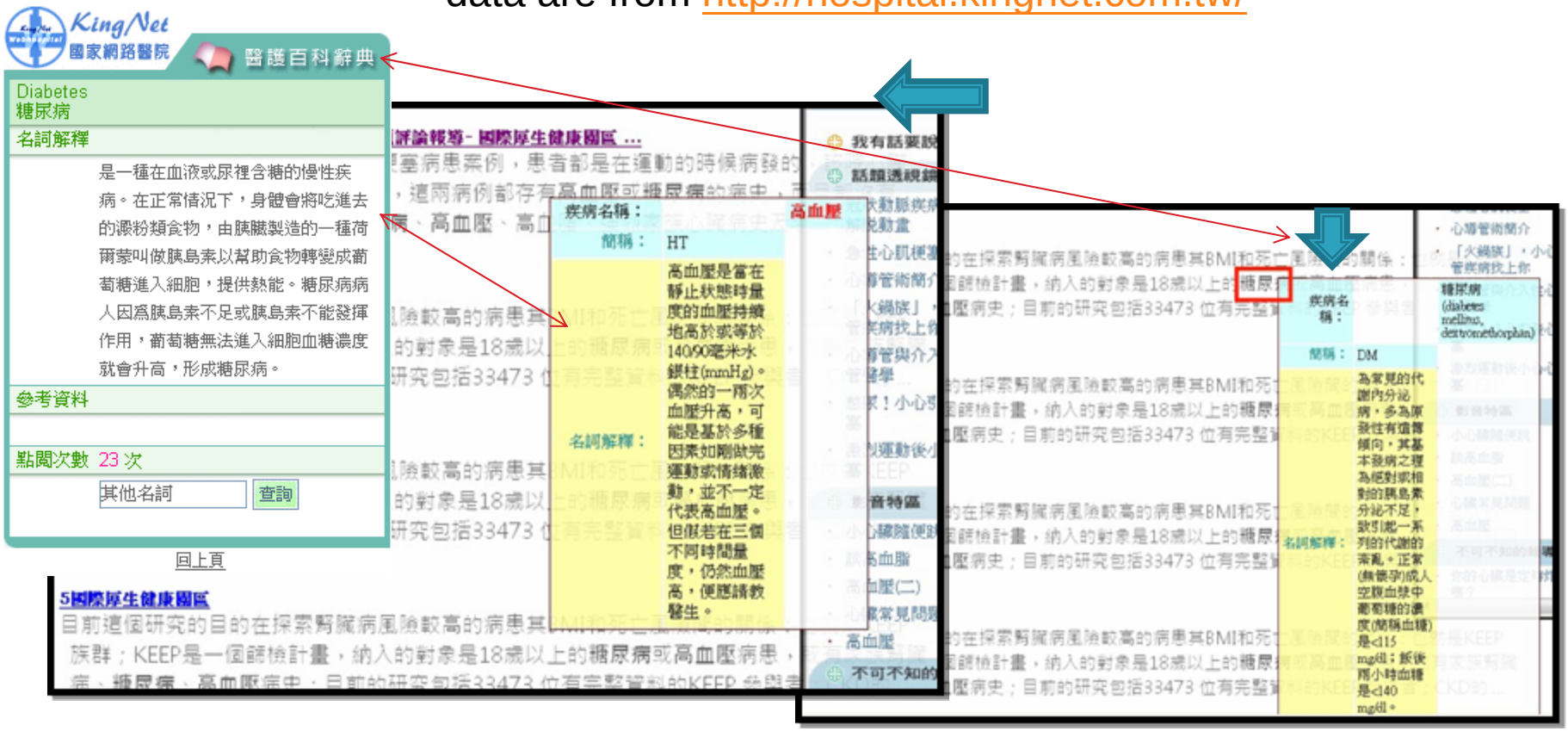


demo3

When the user want to compare with the browsing time of all webpages, the system would present these webpages with different transparency.

demo4

When the mouse move over the keyword of searched abstract, the system would present related keyword information with a frame. This information provide a reference of definition for users, and the source of these data are from http://hospital.kingnet.com.tw/



Thank You For Your Attention！

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Primary Health Care Information System for the Epidemiologic Study of Farmers

Dimitris Zikos, Marianna Diomidous, John Mantas

Health Informatics, Faculty of Nursing, National and Kapodistrian University of Athens

Abstract

The agricultural work is associated with a series of adverse health effects. Health informatics could potentially contribute to the organization and development of the health data, therefore the need for an organized electronic file regarding farmers' health is crucial. The current project aims to develop an Information System which shall gather and store information not only about farmers' health, but also about the level of exposure to hazardous substances, the extend of use of Personal Protective Equipment (PPE) by farmers and the type of agricultural work. The above structure is expected to allow the use of the collected data in epidemiologic studies on farmers' health in order to associate exposure with the development of various diseases. A questionnaire was used as a methodological tool in order to set the appropriate fields that would finally be included to the Information System. The evaluation is being performed by assessing the effectiveness of the application as an epidemiologic tool as well as the various characteristics of the Information System itself.

Keywords:

agricultural workers, diseases, information systems, epidemiologic studies,
computerized medical records system

Introduction

Epidemiology of farmers' health

The agricultural work is associated with a series of adverse health effects, which are mainly caused by exposure to pesticides, allergenic agents, bad posture and weight lifting. According to the literature, the exposure to pesticides can cause several types of cancer, whereas allergenic inorganic and organic dusts are associated with the development of asthma, rhinitis and chronic bronchitis. As far as the ergonomic factors are concerned, inappropriate body posture, vibrations and heavy weight lifting may cause osteoarthritis and other musculoskeletal adverse effects. Accidents also consist an important hazard for the safety of farmers.

The use of Electronic Health Record in Primary Health Care

Most Primary Health Care Units in Greece do not use any kind of Electronic Health Record for the organization of the patient data at all. The health centers of the countryside routinely collect data into hand-written health records, but the data is not easily utilizable for the efficient surveillance of the patient health. In many countryside regions, the majority of people who visit the Primary Health Care facilities are occupied as farmers and stock breeders. Due to their occupation, they are are exposed to various hazardous agents, thus the need for an organized Patient Health Record is crucial. An effectively organized health record could be efficiently used for the improvement of the surveillance of farmers' health.

The use of an Electronic Health Record as a tool for epidemiological studies

A carefully designed Health Information System which includes various fields related with occupational health of farmers could be used as a tool for epidemiological studies. The use of information systems for this purpose is a practice that is being studied recently. The 2004 Utrecht study combined the traditional epidemiological studies with the strength of the Electronic Health Record that is being kept in Primary Health Care Facilities. Another study was carried out in 2004 by Majeed, which concludes that the data files stored in electronic form are potentially available for process and analysis. Manson et al. studied the applicability of data extraction from an Electronic Health Record and concluded that the collection of data is feasible.

The utilization of a reformed Information System for Primary Health Care Units to improve organization of health data of farmers is expected to assist Primary Health Care workers in their everyday practice. In addition, such a reformed Information System could be based not only on health data fields, but also on data of exposure to harmful factors, data regarding the extend of use of Personal Protective Equipment (PPE) and data on the type of production. Thus it can be used as a tool for the research of farmers' health and the fulfillment of epidemiological studies.

Materials and methods

The aim of the current project is to develop an Information System which can effectively be used in Primary Health Care facilities. The Information System shall be used as a tool for the surveillance and epidemiological study of farmers' health.

In order to build the fields of the Information System, a literature research was carried out regarding farmers' health, habits and factors related with the various hazardous exposures. Specifically, studies regarding farmers' health problems were studied and the results were summarized by type of risk and type of production. Also, literature research was carried out regarding the appropriate Personal Protective Equipment that should be used for each agricultural work.

Based on the above data, a questionnaire was built which was used as a tool to test the applicability and feasibility of the selected fields, before the actual development of the Information System. The questionnaire includes sections that resemble the actual structure of the Information System.

Once the specification and selection of the fields to be included in the Information System was completed, a careful design of the database schema was performed and the data fields were organized in normalized tables, connected with the appropriate relationships. The Information System is going to be installed in Primary Health Care Units and the extracted data shall be used by healthcare institutes and organizations for the surveillance of farmers' health as well as for the efficient utilization in epidemiological studies. The evaluation of the Information System is being performed in two levels.

The Questionnaire

After the completion of the literature research regarding farmers' health, habits and exposure factors, a questionnaire based on the results was created. The questionnaire is an important tool towards the development of the Information System, due to the fact that the fields selected are the ones that would be included in the e-health application.

The questionnaire has 4 sections. The first section includes questions about the demographic characteristics of farmers and their occupational history. The second section includes questions regarding the health record of farmers and their families. The third section refers to the type of production and the hours/days of work for each type of agricultural production type. Finally, the last section is about the exposure to hazardous substances, accidents related to the agricultural work, and questions about the use of various Personal Protective Equipment. The selected questions were based on a literature research aiming to recapitulate the main findings of studies on the appropriate PPE the farmers should use. The main sources of information are relevant organizations and Universities conducting research on farmers' health.

The Application

The Information System is being developed with Microsoft SQL Server 2005 in conjunction with Microsoft .net platform. The tables of the database include fields that were applied in the questionnaire. The application is being installed in Primary Health Care facilities and the data collected shall be used by any relative healthcare institute/ organization interested in conducting epidemiological research on farmers' health.

The Information System itself includes statistical calculations based on the data collected and further analysis can be performed once the extraction of the e-health record is done. The careful selection of the fields included in the information System and the way the data is being stored into the database, allows for easy extraction and direct use of the data in statistical packages such as SPSS.

Correlation of data

The data collected in the Electronic Health Record can be used in various correlation studies regarding farmers' health. The selection of the fields that were included in the Information System as well as the way the data is being stored makes it possible to directly extract data for statistical analysis and use it in order to carry out epidemiological studies.

Correlation of personal characteristics of farmers with the development of specific diseases, correlation of personal characteristics of farmers with the extend of use of Personal Protective Equipment, correlation of the level of use of PPE with the development of certain symptoms and diseases, correlation of type of production/hours-days of work per sector with the development of diseases/ symptoms and correlation of exposure to pesticides, noise from tractors and other hazards with the development of diseases/symptoms.

Evaluation

The evaluation of the Information System will be performed once the development of the application is complete. The evaluation is going to be carried out in two levels. The first level includes the evaluation of its use as an epidemiologic tool. A correlation study will be carried out on a well known health issue in order to assess the efficiency of the Information System as a tool for epidemiologic research. The second level of evaluation includes the assessment of the application in terms of content quality, usability, responsiveness and appearance.

Discussion

The use of the Electronic Health Record will contribute in the everyday work of healthcare professionals in terms of time, accuracy and operational costs. The use of the International Classification of Diseases (ICD) in all fields referring to diseases and symptoms will help towards the accuracy and fidelity of the health data. Every piece of health information will only be recorded once in the Electronic Health Record, without the existence of any kind of data redundancy. The Health Record of farmers is

expected to be easily distributed across granted interested parties. Finally, the backup system developed for the security needs of the Information system is expected to ascertain the security of the health data.

Primary Health Care Information System for the Epidemiologic Study of Farmers

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INTRODUCTION

- Greece is a country with significant agricultural production
- 11% of the population are occupied as farmers.
- The agricultural work is associated with a series of adverse health effects, which are related with a series of characteristics of the specific sector.

Risk factors

- Physical (ie. exposure to sun)
- Chemical (ie. pesticides)
- Biological (ie. viruses)
- Ergonomical (ie. musculoskeletal problems)

MAIN OBJECTIVES

Development of an Information System

- For the epidemiological study of farmers health
- For the surveillance of heath and other health and safety parameters concerning farmers health
- For the improvement of farmers health

FIELDS OF THE INFORMATION SYSTEM

- Demographic data
- Health data
- Data concerning type of production and duration of farming work
- Exposure to risk factors
- Data on the use of Personal Protective Equipment
- Knowledge of farmers on health and safety issues

CORRELATIONS

- Correlation of personal characteristics of farmers with the development of specific diseases.
- Correlation of personal characteristics of farmers with the extend of use of Personal Protective Equipment.
- Correlation of the level of use of PPE with the development of certain symptoms and diseases.
- Correlation of type of production/hours-days of work per sector with the development of diseases/symptoms.
- Correlation of exposure to pesticides, noise from tractors and other hazards with the development of diseases/symptoms.

SELECTION OF FIELDS

- Research on farmers habits.
- Research on farmers health problems.
- Research on the Personal Protective Equipment that should be used.
- Research for the appropriate scales for each selected field
- Development of Questionnaire for the simulation of the Information System to check possible problems concerning the selected fields and feedback

THE QUESTIONNAIRE

The questionnaire is an important tool towards the development of the Information System, due to the fact that the fields selected are the ones that would be included in the e-health application.

- SECTION A: Demographic information, years of work, education
- SECTION B: Health record, current diseases, family health record, gynecologic record, accidents, smoking and alcohol consumption, inoculations.
- SECTION C: Type of production, hours /days of work by type of production, land use.
- SECTION D:Exposure to hazardous agents (noise, pesticides), description of occupational accidents, use of Personal Protective Equipment, Self-assessment of knowledge about hazards related to the agricultural work.

DEVELOPMENT OF THE INFORMATION SYSTEM

- MS Access ,SQL Server and .NET platform are being used
- Direct connection of Information System with Statistical Packages
- The Information System itself includes statistical calculations based on the data collected and further analysis can be performed once the extraction of the e-health record is done.
- The application is being installed in Primary Health Care facilities and the data collected shall be used by any relative healthcare institute interested in conducting epidemiological research on farmers' health.

EVALUATION

Assessment of the application in terms of

- Content quality
- Usability
- Responsiveness
- Appearance

- The evaluation of these parameters will be performed by healthcare professionals and healthcare students.

- A questionnaire will be used for this step.

EPIDEMIOLOGICAL STUDY

PURPOSE

- To detect the habits/level of knowledge in Health and Safety issues of farmers in Greece
- To detect correlation between exposure to hazards and development of diseases/symptoms

DISCUSSION

- The use of the Electronic Health Record will contribute in the everyday work of healthcare professionals in terms of time, accuracy and operational costs.
- The use of the International Classification of Diseases (ICD) in all fields referring to diseases and symptoms will help towards the accuracy and fidelity of the health data.
- The Health Record of farmers is expected to be easily distributed across granted interested parties.
- The backup system developed for the security needs of the Information system is expected to ascertain the security of the health data.

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Projects Integrating Information Systems are Going Regional – A Systematic Review

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Abstract and objective

Integrating Information Systems (IS) is essential to support shared care. Many different integration approaches have been implementation through the years. This paper summarises studies examining approaches to integrate patient data from different IS. The literature was systematically reviewed in the last decade (1995-2005) to identify articles that mention patient records, computers and data integration or sharing. Of 3124 articles, 84 were included describing 58 distinct projects. Most of the recent projects were regional. More recently significantly more IS are integrating referral letters and extending to primary care. We conclude that patient information is becoming more accessible as there are more integrated IS which are more likely to involve primary care and a wider range of patient level data.

Keywords:

computerized medical records systems,
systems integration

Introduction

A patient record is a set of documents containing clinical and administrative information regarding one particular patient, supporting communication and decision making in daily practice, and having different users and purposes. Today more data on patients is recorded than ever before [1]. In hospitals, information technologies tend to combine different modules or subsystems, resulting in a best-of-breed approach. Integration of healthcare Information Systems (IS) is essential to support shared care in hospitals, to provide proper care to mobile individuals and to make regional healthcare systems more efficient. However, to integrate clinical IS in a way that will improve communication and data use for healthcare delivery, research and management, many different issues must be addressed [2-4].

Consistently combining data from heterogeneous sources takes a great deal of effort because the individual feeder systems usually differ in several aspects, such as functionality, presentation, terminology, data representation and semantics [5]. Over the years different solutions to these problems have been proposed and some applied. Many of these solutions coexist in today's healthcare settings and are influenced by technology innovation and changes in healthcare delivery.

This review appraises studies examining the different approaches to integrating patient data from heterogeneous IS. Special attention is given to the type of integration engine and the type of integrated data. Articles published in the English literature with abstracts available were reviewed between 1995 and 2005. We aimed to specifically review the integration of patient data, and how systems are evolving in practice to meet patient, professional and organisational needs.

Methods

Only studies describing or evaluating IS implementation for integrating patient data from heterogeneous IS were selected.

The review team was composed of three Computer Scientists, namely Ana Margarida, Pedro Marques, and Ricardo Correia, one medical doctor Filipa Almeida advised by health informaticians experienced in systematic reviewing, Jeremy Wyatt and Altamiro Costa Pereira.

Studies were identified in the bibliographic databases from September to October 2005. Since there is no specific standardised MeSH term, we developed a search string that includes the concepts of patient record, computers and data integration or sharing. Only articles with an abstract in English were considered. Given the significant evolution in ICT in the last decade, only studies published after 1994 (the last ten years) were included.

Three distinct bibliographic databases were searched: Medline (via Pubmed - www.ncbi.nlm.nih.gov/entrez), IEEE (IEEE Xplore - ieeexplore.ieee.org) and ISI (ISI Web of Knowledge - isiknowledge.com). The query search string used in each database was ((medical or clinical or patient) and record*) and (comput* or digital or electronic*) and (integrat* or link* or sharing or share or shared).

This search method found 2443 articles in Pubmed, 961 in ISI and 414 in IEEE Xplore, a total of 3818 articles. After eliminating duplicate articles 3124 were selected.

All four reviewers from the review team were involved in study selection. Six combinations of reviewer pairs were defined, due to the large number of articles found. The first selection was based on the study title. Each pair of reviewers read 512 titles.

A total of 923 of 3124 articles were selected in this first selection on title alone.

The second phase of the study selection was based on abstracts. Again, six combinations of reviewer pairs were defined. Each pair of reviewers read 154 abstracts.

To maximize specificity, only selection by both reviewers was considered adequate. In cases of disagreement (n=215) a third reviewer was called to decide. A total of 159 out of 923 articles were selected.

The variables examined in this paper are related to these stages and intend to describe the context where the integration takes place (country, date, area covered, institutions involved, type of final users).

To analyse time trends, we divided the total period up into three shorter periods because of the small overall number of projects identified. The first period includes projects with their last publication 1994-1999, the second period last publication 2000-2002 and the last period 2003-2005.

The statistical analysis was performed with SPSS® version 14. P values were calculated using linear-by-linear association chi-square test with significance level of 0.05.

Results

Countries with the most published projects were the USA (15), Germany (8), Greece (6), Denmark (5) and China (4). 60% of the IS covered only a region, while 28% covered a hospital, 9% a department and 4% a whole country. There was a downward trend in publications related to projects that cover a hospital from 57% until 1999, 35% in 2000-02 and 17% in 2003-05 (p=0.022). The number of projects covering a region has increased over the years, and currently represents 73% (p=0,005).

Most of the integrated information comes from hospital IS (68%), with departmental (40%) and primary care (34%) IS representing the next two most frequent institution types. Four projects (9%) integrated information from health portals; all were published in the most recent period, 2003-05.

As expected, all information systems provided access to health professionals. Two recent projects were the first to claim giving data access to patients.

Currently there are more projects carrying out regional integration, especially between hospitals and primary care. Referral letters are mentioned in 8 of the 31 projects described in articles published 2003-05. It is also clear that patients are also becoming active participants because they appear for the first time as a user group in more recent projects.

Conclusion

Our results show an increasing number of publications describing projects which integrate data from multiple IS. This is in agreement with our initial assumption about the interest in improving the communication of health related data to support person-centred healthcare. As the number of heterogeneous health IS grows, their integration becomes a priority. Moreover, we may be witnessing an increasing interest in regional integration between heterogeneous healthcare information systems across different institutions, to help communication between the different stake holders (primary and secondary care doctors, nurses and patients). This is also supported by the increasing communication of referral letters.

Currently people have more mobility, longer lives and health care is more shared than ever before. It is clear that Information Systems are evolving to meet people's needs by implementing regional networks, allowing patient access and integration of ever more items of patient data.

One key omission from the literature reviewed is that most of the project publications failed to mention any type of error detection. We feel that is mandatory to verify the quality of integrated data, so that instead of propagating data errors, alerts regarding data quality can be triggered and correction processes can take place [6].

Note: Due to the lack of space it was not included in this article the references of the studies considered in this review. A full description can be asked to the first author. A full paper of this review is expected to be published in the near future.

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Integration of Specialist and Ancillary Services System into HIS: Development and Implementation of a Generic Report System

Gustavo Sosa, Hernán Navas, Alfredo Cancio, Fernando Plazzotta, Paula Otero, Daniel Luna, Enrique Soriano, Fernán González Bernaldo de Quirós

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Abstract

A common characteristic of medical specialties within hospitals is the generation of reports of complementary studies carried out. Considering the importance of the primary capture of data, the easiest alternative is the generation of specific reports for each study or a single system for all of these reports in a free text fashion. The great disadvantage is the impossibility of terminological control, analysis, or systematic use of this information. Using a Clinical Data Repository makes possible to use data-driven systems that satisfy present and future necessities. By these means the Hospital Italiano of Buenos Aires toke a development initiative and the Generic Report System was created. It was successfully implemented in the following Areas: Endoscopy, Fonoaudiology, Imaging Diagnosis, Pathology, Cardiology and Telemedicine.

Keywords:

point of care systems, forms and records control, user-computer interface

Introduction

The complementary studies ordered by primary care or specialist physicians are carried out, in some cases, by providers or other professionals of the healthcare team. In other cases they are performed by complex equipment, with or without human intervention. Independently of the way in which they make these complementary tests, these ancillary services or medical specialties are so called Effectors Services. This services shape the obtained results of the test that generates the reports; and each effector has its own way to do this, according to the particular needs of each specialty. Further more, one effector can make several tests, each requiring different reports. Thus, we can find long narrative texts without structure, tables with measurements, graphics, waves, images, etc.; and all the possible combinations. In contrast, in a hospital information system (HIS) setting, involving every patient's healthcare aspect, the primary capture of data in the instances it's created is a key issue.

Systematic incorporation of reports with such dissimilar characteristics raises a considerable challenge. A possible alternative is to generate computerized reports, each one dedicated to the particularities of each specialty. It arises then what medical literature denominates SPIS (Specialties Information systems), which includes the LIS (Laboratory Information Systems), RIS (Radiology Information Systems), CIS (Cardiology Information Systems), etc. Another possible option is a more simple approach, which involves a single reports system that allow the creation of different reports in free text, having as a disadvantage, the impossibility of terminological control[1], analysis, or systematic use of this information. In addition to the limitations of each alternative, any modification, adaptation to new necessities, or incorporation of new technologies, in both, requires modifications on the software that supports them.

Due to this reality, we arrived to the conclusion that the true solution was to create an integrated and unique system, adaptable to each effectors service's needs.

Materials and methods

Scenario

The Italian Hospital of Buenos Aires (HIBA) is a tertiary care, teaching and research hospital with a 150 year old history. Since 1998 a full scale HIS has been gradually implemented, including ambulatory Electronic Health Record (EHR)[2]., inpatient discharge summary, administrative systems, scheduling systems, inpatient tracking systems, pharmacy systems and complementary studies report and visualization. Several health informatics standards had been implemented, including HL7, CDA Version 2, ICD-9CM, DRG, ICD10, and ICPC.

Considering our scope and thinking about a generic system of reports, we developed unique software capable of been used by the different specialties of the Hospital, adaptable to the very different requirements for different information types, not requiring new developments each time new needs appear, regarding different structured forms of representing data, able to use controlled vocabularies and standard codifications, integrated with the administrative processes as with the EHR, offering a user friendly and versatile interface, able to generate an electronic but printable report, and having the capacity of to gaining functionality

Therefore come into sight the conception of a completely data-driven system. This system was called RptGen, as abbreviation for Generic System of Reports. Its fundamental concept is indeed to be generic; a way of being able to cover the most varied reporting needs.

Operational model

Creation of the report

The RptGen system allows defining groups for input forms and visualization of information generated and presented to the user in real time; and storage and data recovery of these groups; tabular representation for queries, the way in which these are stored or modified; the flow through these forms as well as their accessibility according to different roles for security purposes, as the generation of printable reports, export of queries, use of Web Services, etc; the use of different APIs (Application Programming Interface) to interface with hardware devices or integrate with other applications; the presentation format, as well as the actions and answers to events that are required while being with the client.

Like this, diverse types of fields can be included, from simple data type: text, numerical, dates, etc. (for which validation ranks can be defined); to complex data type: multiple lists (for which its domain of origin can be defined). They can also contain images, with DICOM format; or electronic documents. The amount and combination of these fields are defined according to the needs and they can be grouped in labels, helping its presentation and functionality.

Operation

It can work like an independent application, offering all the functionality that is defined, or offering presentation services or some specific functionality to other applications, that can invoke it by Web. In our case, it is fully integrated with the EHR in every scope, which allows physicians to access the complete information in real time.

Data flow

When an application performs an administrative act, an event within it sends an HL7 message with the patient's identification data and the detail of the ordered test. An interface disaggregates the message and enters the request to the Rptgen for its later processing. At the moment in which the request begins to be processed, the RptGen sends a message HL7 indicating the state has changed (from "Solicited" to "In process") to the administrative application as to the EHR. When the request is completed, a message is sent indicating the change of state to Fulfilled. Another message is also sent to the EHR with the results and/or the report (CDA).

Architecture and technological model

The RptGen was developed in a Web architecture [3], Java (IAS- Oracle) and Oracle database. MQSeries (IBM) as messaging engine, HL7 V2.X standard for transactions and CDA for the clinical document exchange[4].

Implementation

With the objective of initiating a process that would include most of the Effectors, in July of 2004 the first implementation of RptGen began for Gastroenterology. With this implementation the system was tested and adjusted, and we began to confirm the versatility of its data-driven concept, that enormously simplified modifications and updates.

Few months later, before the end of 2004, it was implemented in the Audiology area. A great challenge aroused that had not specifically been planned when designing the system: the upload of the test had to display a previsualization of audiometric graphics as data was loaded. The printed report had to contain graphics with the curves and symbols (in colors) of the study, preserving the corresponding standards. It was then confirmed that the approach and the architecture of the system were the correct ones, since no modification or internal aggregate to the system were required to satisfy these requirements.

It was also implemented giving workflow support to the test processing in Cardiology, Pathology and Radiology.

Conclusion

Designing and developing this system allowed us to create an application able to adapt to the needs of the Effectors and each professional, according to the way in which they prefer to upload data. It is possible to choose a completely structured interface, as it is the case of audiometry; an intermediate model with structuration of diagnosis and tests, like in G.I. Endoscopy, or free text, as in radiology reports.

This, as many other applications, can be supported with no need for internal modifications to the system, thanks to the great potentiality of its data-driven design. Within a more ambitious project, it will be integrated with the PACS that will be implemented during 2007.

Finally, as the implementations advance we are identifying improvements that can be incorporated to offer new characteristics as to simplify present solutions. RptGen is in a continuous process of improvement.

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Integration of specialist and ancillary services system into HIS: Development and implementation of a Generic Report System

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Introduction

- Complementary studies are
  - →carried out by providers or other professionals of the healthcare team
  - →performed by complex equipment, with or without human intervention
  - →these ancillary services or medical specialties are so called Effectors Services
- This services shape the obtained results of the test that generates the reports
  - →each effector has its own way to do this
  - →and each one can make several tests, each requiring different reports.
- We can find long narrative texts without structure, tables with measurements, graphics, waves, images, etc.; and all the possible combinations.
- In a hospital information system (HIS) setting, involving every patient's healthcare aspect, the primary capture of data in the instances created is a key issue.

Introduction (cont.)

- Systematic incorporation of reports with such dissimilar characteristics raises a considerable challenge.
  - →A possible alternative is to generate computerized reports, each one dedicated to the particularities of each specialty
    - SPIS (Specialties Information systems), which includes the LIS (Laboratory Information Systems), RIS (Radiology Information Systems), CIS (Cardiology Information Systems), etc.
  - →Another possible option is a more simple approach, a single reports system
    - Allowing the creation of different reports in free text
    - Disadvantage: impossibility of terminological control, analysis, or systematic use of this information.
  - →Any modification, adaptation to new necessities, or incorporation of new technologies, in both, requires modifications on the software that supports them.
- Our true solution was to create an integrated and unique system, adaptable to each effectors service's needs.

Scenario

- Hospital Italiano de Buenos Aires (HIBA)
  - →Tertiary care, teaching and research hospital with a 150 year old history.
- Since 1998 a full scale HIS has been gradually implemented
  - →Including ambulatory Electronic Health Record (EHR), inpatient discharge summary, administrative systems, scheduling systems, inpatient tracking systems, pharmacy systems and complementary studies report and visualization.
  - →Several health informatics standards had been implemented, including HL7, CDA Version 2, ICD-9CM, DRG, ICD10, and ICPC.

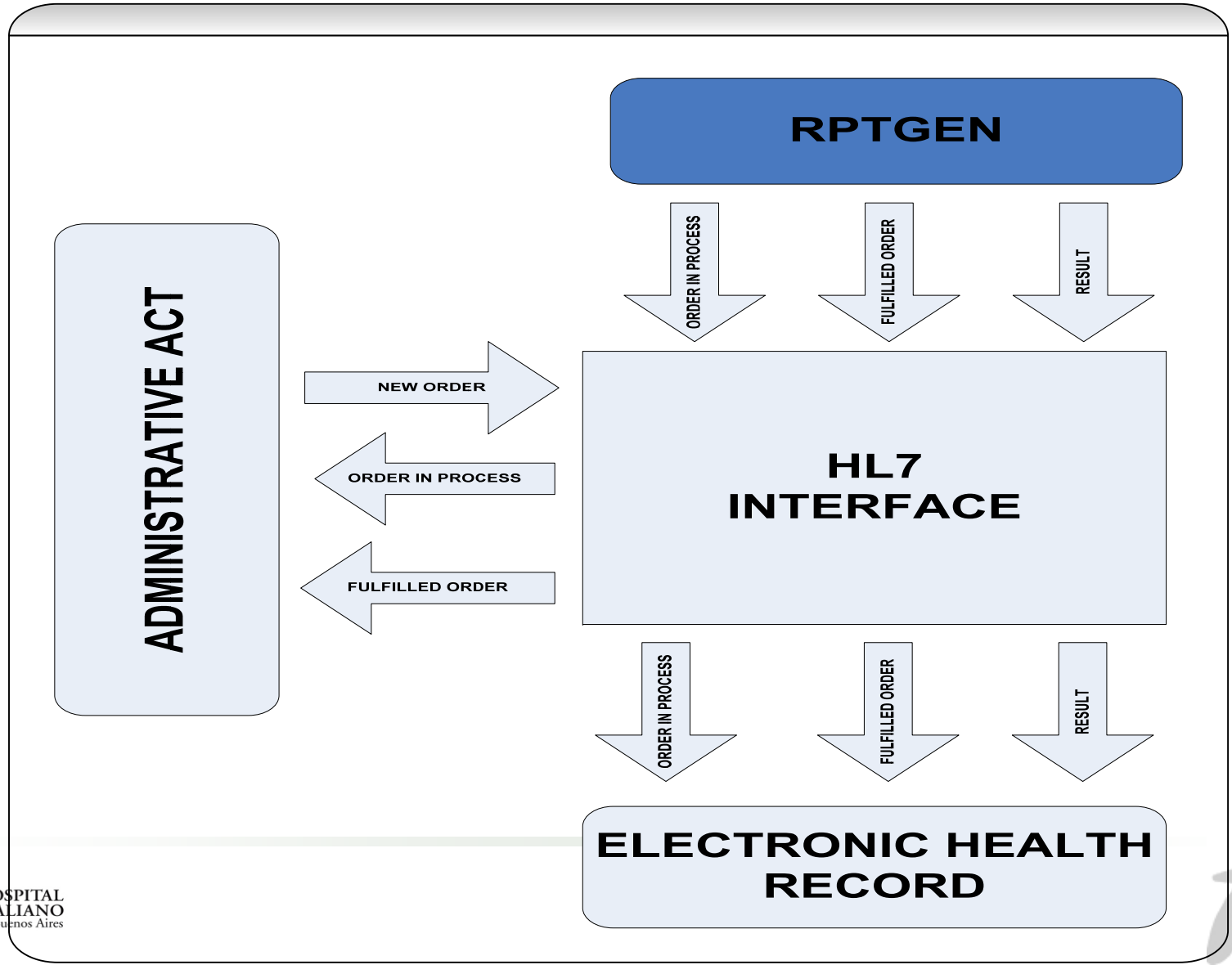
Operational Model – *Creation of the report*

- RptGen system allows to:
  - → define groups for input forms and visualization of generated information
  - → storage and data recovery of these groups
  - → tabular representation for queries
  - → accessibility according to different roles for security purposes
  - → generation of printable reports, export of queries, use of Web Services, etc;
  - → use of different APIs (Application Programming Interface) to interface with hardware devices or integrate with other applications
- Diverse types of fields can be included
  - → simple data type: text, numerical, dates, etc. (for which validation ranks can be defined)
  - → to complex data type: multiple lists (for which its domain of origin can be defined)
  - → images, with DICOM format
  - → electronic documents
- The amount and combination of these fields are defined according to the needs

Operation

- It can work like an independent application
  - →offering all the functionality that is defined
  - →offering presentation services
- Be functional to other applications through Web
- In our case it is fully integrated with the EHR in every scope
  - →allowing physicians to access the information in real time.

Data flow


RPTGEN
ORDER IN PROCESS
FULFILLED ORDER
RESULT
ADMINISTRATIVE ACT
NEW ORDER
ORDER IN PROCESS
FULFILLED ORDER
HL7
INTERFACE
ORDER IN PROCESS
FULFILLED ORDER
RESULT
ELECTRONIC HEALTH
RECORD

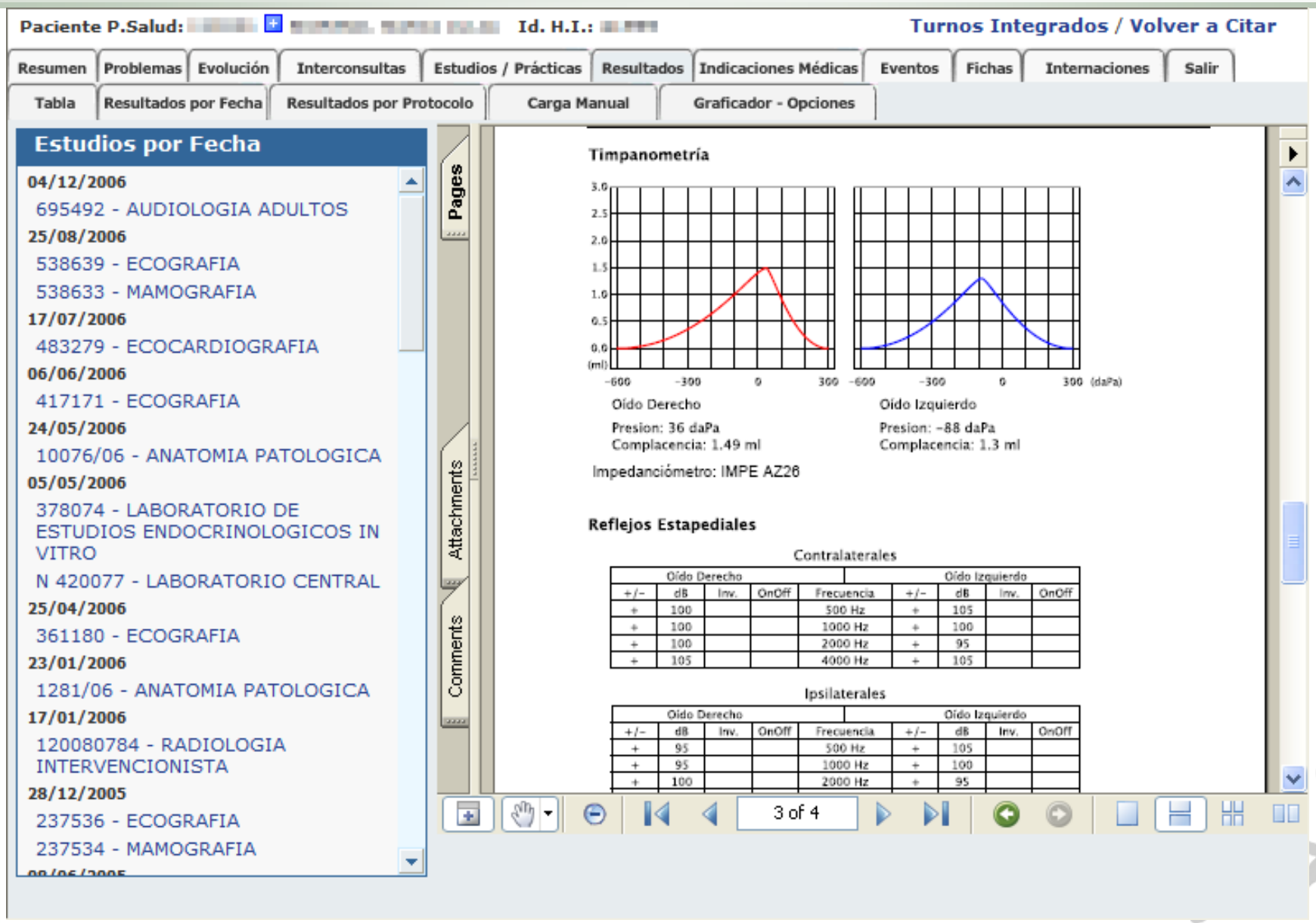
Architecture and Technological Model

- The RptGen was developed in
  - ⟶Web architecture
  - ⟶Java (IAS - Oracle)
  - ⟶Oracle database
  - ⟶MQSeries (IBM) as messaging engine
  - ⟶HL7 V2.X standard for transactions
  - ⟶CDA for the clinical document exchange

Implementation

- In July of 2004 the first implementation of RptGen began for Gastroenterology
- Few months later it was implemented in the Audiology area
  - →A great challenge aroused that had not specifically been planned when designing the system: the upload of the test had to display a previsualization of audiometric graphics as data was loaded.
  - →The printed report had to contain graphics with the curves and symbols (in colors) of the study, preserving the corresponding standards.
- It was also implemented giving workflow support to the test processing in Cardiology, Pathology and Radiology.

Visualization from the Web Based EHR



Conclusion

- This system allowed us to create an application able to adapt to the needs of the Effectors and each professional
  - →according to the way in which they prefer to upload data
    - it is possible to choose a completely structured interface, as it is the case of audiometry
    - an intermediate model with structuration of diagnosis and tests, like in G.I. Endoscopy
    - or free text, as in radiology reports.
- Data-driven design
  - →This, as many other applications, can be supported with no need for internal modifications to the system
- Within a more ambitious project, it will be integrated with the PACS that will be implemented during 2007.

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How Should Interfaces Specify Application Behaviors?

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Keywords:

behavior, conformance, DICOM, HL7, IHE, imaging, interface, interoperability, messaging, PACS, semantic

Introduction

A distinguishing feature of healthcare informatics in the 21st century has been the recognition that a patient-centric multi-enterprise health record is not only desirable but essential to the provision of safe, appropriate care.

Systems exchange information both to document healthcare activities in comprehensive records, and to share information necessary for current patient care, either locally or remotely. A local inpatient care system may accumulate test information from a remote laboratory system for the purpose of integrating it with local information in a flowsheet that is part of the patient health record. Based on the information received, a clinician using the same local system may immediately request further testing from the remote laboratory system, or may use the flowsheet information to inform a medication decision that will result in the placement of one or more orders to a local or remote pharmacy system.

However, it is not enough for patient care systems to agree on what they *know*: they must also agree on what they *do*. Interface specifications must address the expectations and responsibilities of both senders and receivers. Such requirements necessitate a quantum leap from legacy interface specifications through the middle 1990s, which typically confined themselves to the behavior of their own applications in providing data to other systems with which they might happen to be interfaced. Present-day interoperability architectures, both within and across enterprises, need to be able to constrain application behavior as well as interface contents.

Methods and results

Standards and the interoperable clinical record

The development of the concept of the interoperable health record is in part a logical extension of the application of such interface standards as LIS05-A (formerly ASTM E1238) [1] for transmission of clinical observations, Health Level Seven (HL7) [2] for dissemination of patient administrative and clinical information across single-enterprise systems, and DICOM [3] for the transmission of imaging information. It also owes its existence to the efforts of researchers such as Hammond [4] in distinguishing the *flow* of information from the information *stores* (both intra-enterprise and inter-enterprise).

However, there are a number of specific legal, ethical, policy, and operational requirements that have been developed by healthcare systems and that are not fully addressed by existing standards. These requirements apply both to manual operations and to information systems in the institution. Therefore, they must be supported by commercial systems that are interfaced to the institution's internal systems. For example:

- Privacy issues
- Patient safety issues (including patient identification issues, synchronization of systems, correction of errors, acknowledgement of messages from other systems)
- Health information management rules
- Data custody requirements and the role of "system(s) of record"

Early commercial interfaces

A typical method of interfacing clinical systems from the 1970s into the 1990s was for a system to advertise that it would make certain information available, such as testing results or billing transactions, to other systems that might happen to be interested in the data. The sending system (generator) could include the interface as part of its general data production requirements. This approach was successfully adopted both by vendors of systems using proprietary interfaces, as well as by some early commercial adopters of the ASTM E1238 standard.

HL7-based and DICOM-based interfaces

Early HL7 messaging definitions – those developed for Versions 2.0 through 2.4 of the HL7 Standard between 1987 and the late 1990s – standardized the elements communicated in interfaces, while continuing to apply minimal constraints to application behavior. Such minimal constraint has been axiomatic even into the 21st century.

HL7 added a conformance mechanism in Version 2.5 [5] that provides a template for interface specification. This template includes a dynamic definition that incorporates an interaction model as well as acknowledgment responsi-

bilities. While the template does not explicitly provide for the specification of application behaviors, these could conceivably be enumerated as an extension of the dynamic definition. This approach has been followed by the U.S. Veterans Health Administration's VistA Imaging Team to specify interfaces from its in-house-developed, open-source VistA software to commercial Picture Archiving and Communication Systems (PACS).

DICOM Conformance Statements (DCS) [6] are required documents (by the DICOM standard) that are designed to unambiguously define a product's specific DICOM features. VA uses the DCS as a primary communications tool in understanding a vendor's product. The DCS is used to compare system integration possibilities and, most importantly from the point of view of the current discussion, to perform validation conformance testing before use in the VA.

Each DCS includes a sequence of real-world activities to define interactions between its vendor and others. For example, the Storage Commitment transaction, as defined by the DICOM standard, allows a local system to request that a remote system commit to the safekeeping of one or more images, thus releasing the responsibility for storage from the local system. Each vendor states in its DCS how this functionality is implemented on its product.

IHE-based interfaces

The Integrating the Healthcare Enterprise (IHE) Initiative and the IHE Technical Frameworks, besides providing contexts for the constraint of messages using standards such as HL7 and DICOM, can assist in determining system behavior.

An IHE radiology transaction definition typically incorporates one or more DICOM or HL7 messages and defines the trigger events, message semantics and expected actions. The "expected actions" section generally includes the behavior that is expected of the receiver of the message. [7]

Specifying and testing behaviors of applications in VistA Imaging interfaces

The next step toward interoperability using IHE-based profiles is to incorporate context-specific requirements into interface specifications. "Context" in this case may refer to a single department or to a nationwide medical enterprise such as VA.

VA has requirements that apply to all of their systems, whether internally developed or commercially procured. These include specific requirements for patient identification, privacy, records custody, and patient safety. Commercial system interface specifications published by VistA Imaging incorporate these requirements as extensions to the behavioral conditions imposed by standards and by IHE.

Testing and lessons learned

Having developed interface profiles based on user input, organizational policies, and regulatory requirements, VA published its interface specifications and a testing summary on a public web page [8]. PACS vendors access this page to find what is required of their systems in communicating with the VistA Radiology and VistA Imaging PACS modules. As vendors develop new products, they contact the VistA Imaging Team to schedule testing of their interfaces.

Our experience over 18 months of testing has been that commercial products are not always prepared to meet the behavioral requirements as stated in our specifications. Evaluation of interface test results, feedback from vendors, and internal reviews have resulted in clarifications to the interface specification, such as the enumeration of table values for error acknowledgment codes.

Discussion and conclusion

It is not only desirable and possible, but also essential, to specify application behaviors as part of interoperability requirements. Such requirements, although presented here in the context of the VistA Imaging software, are not specific to the VA. All interoperating medical institutions will share many of the same needs. Some institutions may have more well-defined application requirements, perhaps due to more experience with clinical information systems. Thus, every vendor will need to meet the needs of a variety of healthcare systems. These needs can be met by enumerating behavioral constraints in addition to what is provided for in the HL7 and DICOM Standards and the IHE Technical Frameworks.

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Introduction

- Standard of care for 21st century health record
  - Patient-centric
  - Multi-enterprise
  - Both longitudinal and real-time orientations
  - Patient safety considerations
- Interface specification requirements
  - Static (what is known)
  - Dynamic (what is to be done)

Introduction

- Progress from last-generation interface specifications
  - Must work across enterprises
  - Must constrain interface contents
  - Must constrain application behavior
  - Quality of integration must be designed in, not retrofitted

Standards and the interoperable clinical record

- EHR models derived in part from early interface standards
  - LIS05-A (aka ASTM 1238)
  - HL7
  - DICOM
  - Vocabulary standards (SNOMED, etc.)
- Business requirements not generally addressed

Standards and the interoperable clinical record

- Privacy and trust issues
- Patient safety issues
  - Patient identification
  - Synchronization of systems
  - Correction of errors
  - Acknowledgment of messages received from other systems
- Health information management rules
- Custody requirements and the role of “system(s) of record”

Early commercial interfaces were minimally constraining

Characteristic	Description
Elements	Usually well-understood, sometimes proprietary
Transaction(s)	Few reporting-type ("generator") transactions
Controlled vocabularies	Frequently proprietary, some standard (*e.g.*, CPT4 for billing codes)
Acceptable identifier domains	Implementation-specific
Acknowledgment responsibilities	Often undefined for either sender or receiver
Receiver behavioral responsibilities	Storage: often minimally defined Application behavior: often undefined

IHE-based interfaces provide for greater and more explicit constraint...

Characteristic	Description
Elements	Always standardized
Transaction(s)	Both reporting-type ("generator") and order-type ("placer/filler" transactions
Controlled vocabularies	Can be proprietary or standard depending on element
Acceptable identifier domains	Depends on the standard being used
Acknowledgment responsibilities	Can be rigorously constrained
Receiver behavioral responsibilities	Can be rigorously constrained

... but behavioral requirements are needed too

- Example: Data storage requirement

ADT Message Received – ICN Not Found

When PACS receives an ADT registration message for a patient for which it does not find an Integration Control Number in its system, PACS will create a new patient record. It will extract the Basic Patient Data Set and the Basic Visit Data Set from the HL7 message, and will store this information in its system.

Requirements issuance process at USDVA

- Need orders and ADT interface between integrated in-house system
- Compiled and reviewed a set of fully constrained requirements, including behavioral specifications, based on:
  - normative HL7 conformance template
  - IHE Radiology Scheduled Workflow (SWF) profile
- Published requirements on web
- Developed and reviewed test suite
- Mutually agreed-on results

Testing and lessons learned

- Scheduled validation testing between any requesting PACS vendor and ex-firewall USDVA validation system
- Commercial products don't always meet requirements
  - Common issues: Error reporting, patient sensitivity
- Revisions and clarifications to interface requirements document

Conclusions

- Interface requirements must include behavioral constraints for standard of care
- Standards and IHE are essential bases
- Cross-enterprise behavioral requirements are in our sights
  - *e.g.,* to facilitate XDS-based implementations of wide-area repositories and registries

Literature and contact

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Computerized System of Regulation and Evaluation of Emergency Attending Mobile Unit Service – SAMU in the State of Santa Catarina Brazil

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Abstract

This study, which is characterized by a technological production and a methodological research presents the report of the development and the evaluation of a Computerized System of Regulation and Evaluation of the quality of SAMU in SC. The system was structured in 03 modules consisting of regulation, Web evaluation and mobile unit evaluation. The analyzed data revealed that the system has ergonomic criteria, usability and adequate content to work in emergency situations and it is multiplatform due to using open source language. Further, by including in its reports the SAMU quality evaluation indicators stablished by the Health Department , the system contributes to the continuous and systematic control of service quality.

Keywords:

information systems, emergency, regulation, evaluation

Introduction

The QualiSus program, result of a research applied by the Health State Secretaries National Council - Conselho Nacional de Secretários de Estado da Saúde (CONASS) and the Health Department, revealed that the lines in hospital emergency room, the long period of waiting to examinations and surgeries, as well as the inability of health units to receive patients, were frequent complaints among SUS usurers. The study data, concluded in the end of 2003, revealed that more than 90% of the Brazilian population is somehow Health System usurer [1], [2], [3], [4].

Facing this situation the Health Department elaborated the QualiSUS, which aims establishing a group of changes to offer more comfort to the usurer, encourage care according to the risk level, provide effective attention by the health professionals and decrease the period of permanence in hospitals. [1], [2], [3], [4].

As integrating part of QualiSUS it is noticeable the Emergency Attending Mobile Unit Service (SAMU/192). The service enables the organization and rationalization in the public sector. In the SAMU/192 regulation center, the doctor answering to an emergency call has autonomy to sort by triage and decide about the allocation of the patient according to information about emergency room availability in hospitals. With SAMU/192 there will be organization to the access to emergency rooms.

Historically , we know that the level of response to the critical life situation of victims of accidents, traumas and violence has been not enough, causing and perpetuating spontaneous patient demands in urgency situation and real or presumptuous emergency, in direction to hospital emergency rooms causing them not being able to offer a more qualified assistance[5].

SAMU was implemented in Sc in 2005 including seven (7) urgency regulation centrals, with 18 UTI Mobile Units and 56 Basic Life Support Units of SAMU.

In this way, the systematization of na integral attention network to the assistance of urgencies, organizing the flow of patients of basic needs until high complexity and giving a quality assistance is one of the priorities of the Health Department and State.

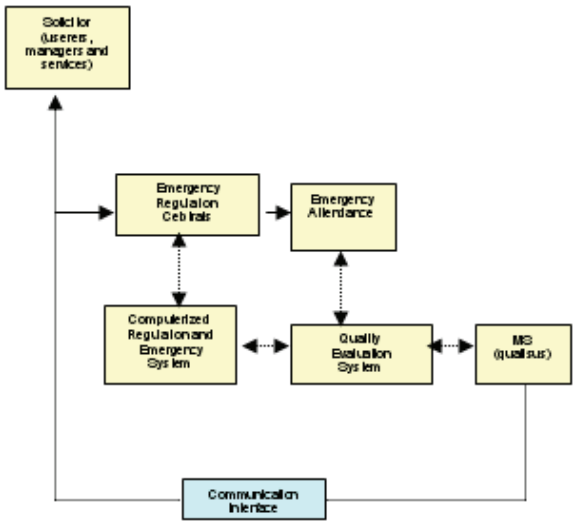
Following, in order to SAMU work properly , it is fundamental, through regulation centrals, the continuous and systemic accompaniment of urgency/emergency situations. This is possible by means of the development of a computerized systems of regulation and urgency assistance, with an ordinary language which can evaluate the suitability of this service in terms of controlling the indexes of demand and quality established by the Health Department. [1], [3],[4], [6].

Facing this ponorama, this study aimed developing and implementing a computerized system of urgency regulation of SAMU in the state of Santa Catarina as well as establishing the data which should integrate the information system of urgency regulation to evaluate the quality of SAMU in the State of Santa Catarina, form the indexes established by the Health Department.

Methodology

Technological Production and methodological research [7] which involved the participation through intentional or criteria choice of 06 people specified as follows: 01 regulator doctor, 01 nurse from intensive care unit, 03 systems analysts, 01 IT state manager and 01 Nursing student. The study followed ethical principles determined by the 196/96

Decree which determines the Regulating Rules and Norms of Research involving Human Beings and received the approval of the Research Ethics Committee of UFSC according to Protocol number 212/2005. The developing of SAMU system was based in the following flow structure:



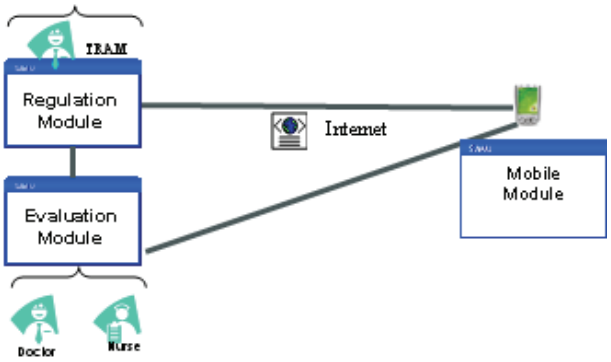
Picture 1 - Flow diagram

To the data collection the computerized regulation and evaluation of urgencies was used taking into account the following indexes: the number of attendance in emergency mobile units; the percentage of regulated emergency attendance, according to residential area; the percentage of emergency attendances regulated according to period of time; the percentage of attendances regulated according to demand; SAMU demand index according to neighborhood; time of response of emergency teams; time in local occurrence; time of total response; emergency mortality tax and main doctor diagnose. These items can be observed when implementing the system in the state of SC. However, they can already be obtained from the reports previously programmed. Still, a specific systems evaluation tool was used regarding the content criteria, usability and ergonomics [8]. The data were analyzed through descriptive statistics and qualitative description.

Results

In the development of the SAMU regulation and evaluation system the following phases were followed [8]:

1) Requirement Collection: problems of the emergency service and limitations to the development like time, place and economic. The system consists of 3 modules: regulation, Web evaluation and mobile unit according the following structure:

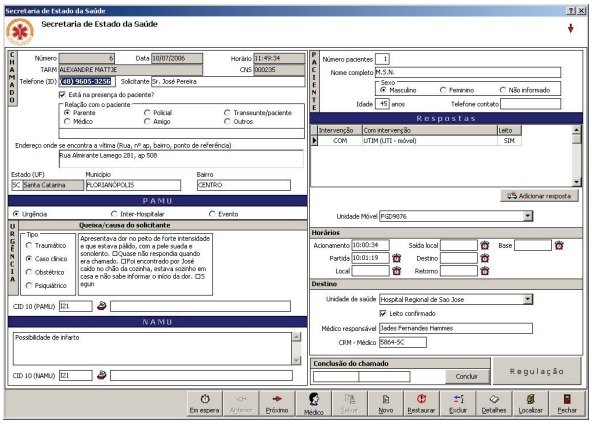


Picture 2 - SAMU Modules Structure

2) Analyses: choosing of the informatics tools to be used in and the design of the system. It was chosen that the Medical Regulation Module would be developed in Object Pascal language (Delphi environment) and JAVA to the File of Attendance of Web and Mobile patient, with database MY-SQL-SERVER. Delphi was chosen to the Medical Regulation Module due to the experience in the development of this language, made available by SES-SC and due to the facility of communication of other equipments. In the Web Evaluation Module JAVA was used, because it is an open code language, the framework available by SES-SC and its security. The database used was chosen because it is the pattern used at SES-SC in both Delphi and JAVA. It was also decided that the mobile system would be developed with Java technology (J2ME) because of, among other characteristics, its portability among different types of existing mobile devices in the market.

3) Project: definition, modeling of data and implementation in the computerized platform. The database of Regulation and Patient Evaluation via Web Modules was designed using IDEF1X patterns (definition of entity, relationship and characteristics) and, as a design tool of data, the ER-WIN was used. The Patient Mobile Evaluation system was conceived and implemented using the Objective Oriented Programming approach, in a way each distinctive group of evaluation was treated independently; however, keeping integration among all the groups in the general evaluation context. In this way, the system enables a progressive interaction and not necessarily sequential among the information universe which consists all the evaluation.

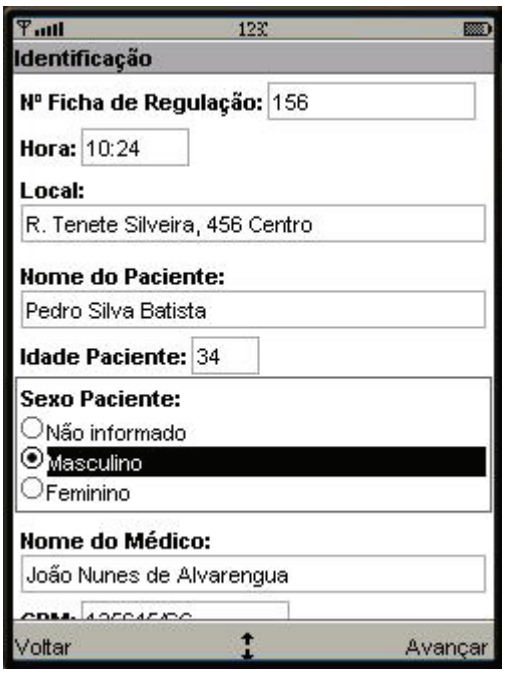
4) Implementation: development of the system in the reality of emergencies and test: pilot test of the system implementing and analysis of ergonometric and usability functions. In this phase, the system was structured in the computerized platform established this way:



Picture 3 - Example of Medical Regulation Module Screen

Picture 4 - Example of WebEvaluation of Patient Module Screen

The form of Medical Evaluation consists by items which identify the patient's situation in many areas. This evaluation comprehends in: Place Identification, Patient, Doctors Team. Initial State, Vital signals control and basic examinations, Breathing Evaluation, Cardiovascular, Neurological, Abdominal, Gynecological, Trauma, Burn, Hypotheses Diagnostics, Actual State and Doctor's Prescription. It also includes Glasgow scale, burn scale and progressive evaluation of trauma. The forms to emergency evaluation were also developed and organized according to CIPE – Classificação Internacional da Prática de Enfermagem - Nursing Practice International Classification - version 1.0



Picture 5 - Example of Mobile Evaluation Module Screen

The minimum necessary to the Mobile System work basically consists in a mobile device (PDA), which presents some type of implementation of the Java Virtual Machine (JVM) and has GPRS access through the qualified telephony operator. The readings carried through the patient's evaluation can be, when needed, typed and in other cases, selected by the usurer. The system presents synchronized menus to send and receive data and to browse among the evaluation modules. All access to the system is obligatory notarized through a login and password previously registered in the Web system.

From the structuring of the system, progressive evaluations were applied with the developing team discussing and reformulating the data in the system according to the needs and problems found. After that, a pilot test was organized simulating two real emergency attendance situations: one meningea syndrome and a hypovolemic chock due to displayed breaking.

04 appraisers from the informatics and health areas participated in this test, they evaluated the items: ergonometric and usability. The item ergonomics evaluated the criteria of organization, interface, content and technical. To each item scores were established from 1 to 5, being (5) excellent, (4) very good, (3) good, (2) regular, (1) bad. The data are presented in a statistics descriptive way. In the usability criterium 24 items were evaluated determined by scores from 1 to 5, being (5) totally agree, (4), agree, (3) disagree, (2), totally disagree and (1) not applicable according to qualitative analyses.

Table 1 - Ergonomics Evaluation

Score		Regulation Module						Evaluation Module						Móbile Module					
Critery		f1	f2	f3	MÉD	M.G.	D.M.	f1	f2	f3	MÉD	M.G.	D.M.	f1	f2	f3	MÉD	M.G.	D.M.
Organization	A	4	4	4	4,0	4,5	0,50	4	4	4	4,0	4,4	0,42	4	4	4	4,0	4,3	0,25
	B	5	5	5	5,0			5	5	5	5,0			5	4	4	4,3		
	C	4	4	4	4,0	4,3	0,17	4	4	4	4,0	4,7	0,33	4	4	4	4,0	4,2	
	D	5	5	5	5,0			5	5	4	4,7			5	5	4	4,7		
Interface	A	5	4	4	4,3			5	4	5	4,7			5	5	4	4,7		0,50
	B	5	4	4	4,3			5	5	5	5,0			5	5	4	4,7		
	C	4	4	4	4,0	5,0	0,0	4	4	4	4,0	4,8	0,2	4	3	3	3,3	4,3	
	D	5	4	5	4,7			5	5	5	5,0			5	4	3	4,0		
Content	A	5	5	5	5,0			5	5	4	4,7			5	4	4	4,3		0,0
	B	5	5	5	5,0			5	5	5	5,0			5	4	4	4,3		
Tecnic	A	4	5	4	4,3	3,8	0,29	3	4	4	3,7	4,0	0,33	3	4	3	3,3	3,3	0,17
	B	3	4	4	3,7			4	5	5	4,7			4	4	3	3,7		
	C	4	3	4	3,7			3	4	4	3,7			3	3	3	3,0		
	D	4	3	3	3,3			3	4	5	4,0			2	4	4	3,3		
					MG	4,4	0,4				MG	4,5	0,3				MG	4,0	0,3

Legend: Excelent (EX) 5; Very good (MB) 4: Good (B) 3; Regular (2); Bad (1). General Average (MG), Average shunting line (DM)

It was observed in the ergonomics evaluation according to table above in the evaluators perspective that the system is Very Good with an average variation of 4,0 to 4,4. The items content and interface received the best evaluations inside the ergonomics criterion with an average variation from 4,3 to 5,0. The technical item inside ergonomics criterion received a minor score, with average score variation from 3,3 to 4,0, specially because the system is under construction and the connection and communication among the modules (especially from mobile to fixed) are not finished. The average deviation among variables of ergonomics evaluation was around 0,4 to the Regulation Module and 0,3 to the Evaluation Module of patient form fixed and mobile.

Evaluation of usability

The main items approached by the evaluators to the usability criterion evaluation with scores (5) and (4) corresponding to totally agree and respectively agree were: the system easily runs on fixed and mobile platforms with no interferences, the system screens are clear, easy to read and interpret, the usurer is able to access the system easily, the menus are viable and easy to use, the system is modular and shows the structuring in the programming, the system has a limit of growing appropriate to the use demands, the memory requirements do not hinder the program running on the platforms, the system has automatic saving, the connection and communication among the Regulation and Fixed and Mobile Evaluation modules are appropriate, the system enables the recovery of data in the various modules, the hardware requirements are compatible to the reality, the system holds attendance network, the system has data locking.

Amongst items which received evaluation do not agree, with score (3), and that were marked only in the evaluation Regulation Module, are distinguished: does not run in different platforms; does not accept inexistent data and the system allows recovery of data in the various modules.

Positive aspects of the system are also distinguished: the agility, the neatness, the system is complete, it is easy to use it, friendly and it accomplishes the objectives. Another positive aspect is that it enables the emission of reports which contribute to the control and accompaniment of the quality of the attendance in SAMU from the indexes established by the Health Department. As negative aspects we have: the absence of the item help top the usurer in the menu of the Regulation and Web Evaluation Module, little functionality of tables of vital signals, scale of coma of Glasgow and progressive evaluation of trauma in the Mobile Evaluation module, as well as the lack of a complete database of streets and avenues of the State.

Discussion and conclusions

Although the system is not completely developed, it was perceived through the data collected during the pilot test that it has appropriate ergonomic criterion, content and usability to the emergency situations enabling the feeding of the system directly from the place of the accident. It is a pioneer and innovator system in Brazil due to including a complete structure of Regulation, Web and Mobile Evaluation of emergency embracing the doctor and nurse attendance.

The study also enables emphasizing that the information is a key element in the decision making and an essential requisite in the support and efficient management of health care, once it enables a systematic way of evaluating and comparing. It is recognized, though, as it is scored in OMS/OPAS[9],[10][11], that the access to information is an essential ingredient of the health services and planning, of supervising and health programs control, because it is a vital tool to evaluate the clinical interventions and management of health promoting activities.

In this way, the development of a computerized system of emergency regulation and attendance quality evaluation, from the establishment of definite indexes of quality which serve as ordinary and homogeneous measurement pattern, which constitutes in a permanent strategy of improvement of quality, at the same time it serves as a tool to the generation of new study fields.

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Computerized System of Regulation and Evaluation of Emergency Attending Mobile Unit Service – SAMU in the State of Santa Catarina Brazil

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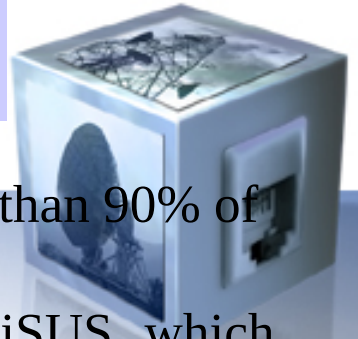
Fernanda Paese, Nursing Student, Nursing Department, Federal University of Santa Catarina, Brasil

Introduction



- The study data, concluded in the end of 2003, revealed that more than 90% of the Brazilian population is somehow Health System usurer.
- Facing this situation the Health Department elaborated the QualiSUS, which aims establishing a group of changes to offer more comfort to the usurer, encourage care according to the risk level, provide effective attention by the health professionals and decrease the period of permanence in hospitals .
- As integrating part of QualiSUS it is noticeable the Emergency Attending Mobile Unit Service (SAMU/192). The service enables the organization and rationalization in the public sector.
- Following, in order to SAMU work properly , it is fundamental, through regulation centrals, the continuous and systemic accompaniment of urgency/emergency situations.
- **Objective: Facing this ponorama, this study aimed developing and implementing a computerized system of urgency regulation of SAMU in the state of Santa Catarina as well as establishing the data which should integrate the information system of urgency regulation to evaluate the quality of SAMU in the State of Santa Catarina, form the indexes established by the Health Department.**

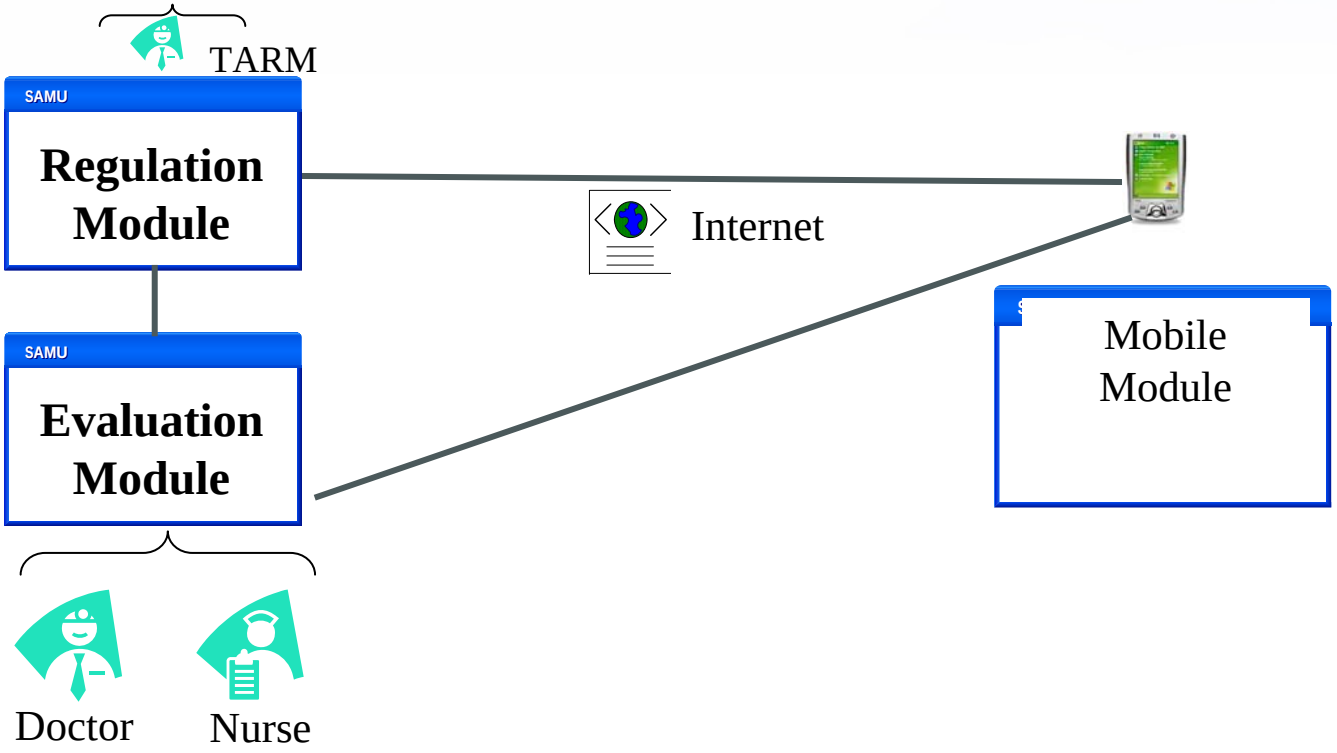
Methodology

- Technological Production and methodological research.
- Involved the participation through intentional or criteria choice of **06 people** specified as follows: 01 regulator doctor, 01 nurse from intensive care unit, 03 systems analysts, 01 IT state manager and 01 Nursing student.
- The study followed ethical principles determined by the 196/96 Decree which determines the Regulating Rules and Norms of Research involving Human Beings and received the approval of the Research Ethics Committee of UFSC according to Protocol number 212/2005.
- A specific systems evaluation tool was used regarding the content criteria, usability and ergonomics.
- The data were analyzed through descriptive statistics and qualitative description.

Results

- In the development of the SAMU regulation and evaluation system the following phases were followed:

  1) **Requirement Collection:** problems of the emergency service and limitations to the development like time, place and economic. The system consists of 3 modules: regulation, Web evaluation and mobile unit according the following structure:



Results

2) Analyses: choosing of the informatics tools to be used in and the design of the system.

- It was chosen that the Medical Regulation Module would be developed in Object Pascal language (Delphi environment) and JAVA to the File of Attendance of Web and Mobile patient, with database MY-SQL-SERVER.

- Delphi was chosen to the Medical Regulation Module due to the experience in the development of this language, made available by SES-SC and due to the facility of communication of other equipments. In the Web Evaluation Module JAVA was used, because it is an open code language, the framework available by SES-SC and its security. The database used was chosen because it is the pattern used at SES-SC in both Delphi and JAVA.

- It was also decided that the mobile system would be developed with Java technology (J2ME) because of, among other characteristics, its portability among different types of existing mobile devices in the market. :

Results

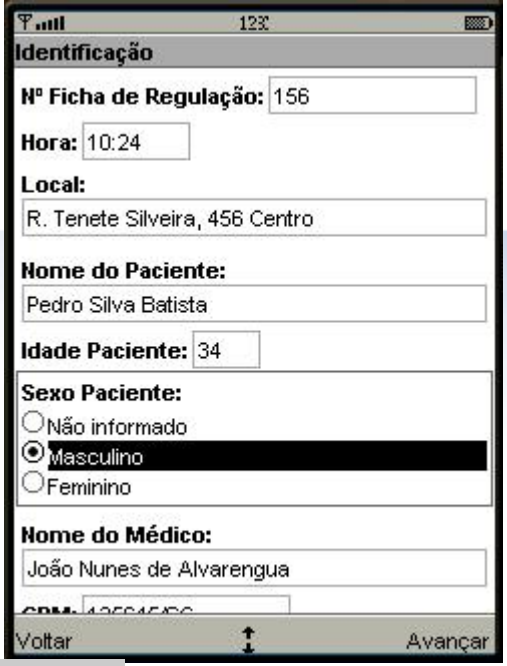
3) Project: definition, modeling of data and implementation in the computerized platform. The database of Regulation and Patient Evaluation via Web Modules was designed using IDEF1X patterns (definition of entity, relationship and characteristics) and, as a design tool of data, the ER-WIN was used.

- The Patient Mobile Evaluation system was conceived and implemented using the Objective Oriented Programming approach, in a way each distinctive group of evaluation was treated independently; however, keeping integration among all the groups in the general evaluation context. In this way, the system enables a progressive interaction and not necessarily sequential among the information universe which consists all the evaluation.

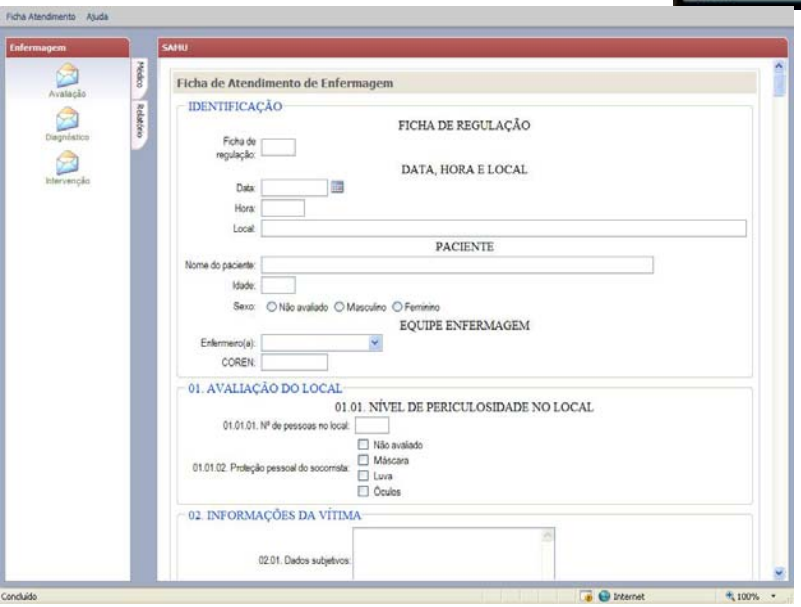
4) **Implementation**: development of the system in the reality of emergencies and test: pilot test of the system implementing and analysis of ergonometric and usability functions.

In this phase, the system was structured in the computerized platform established this way:

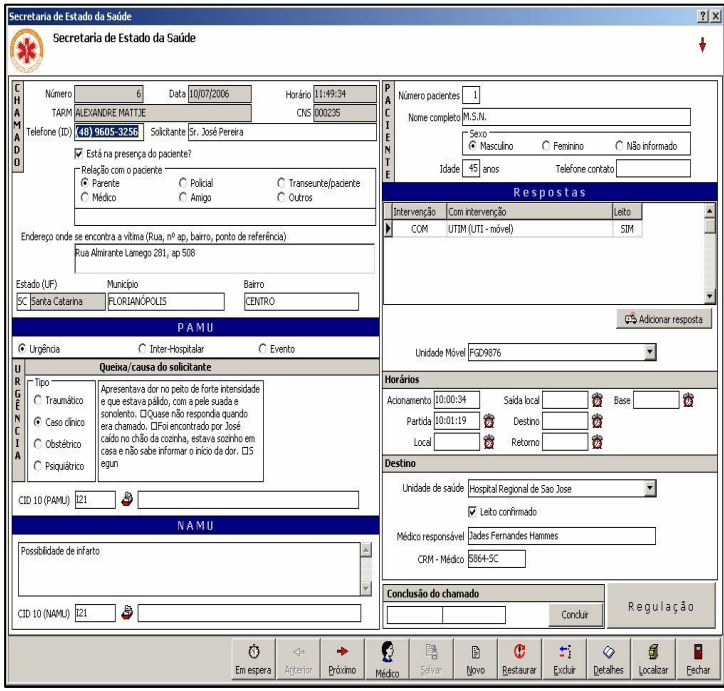
Exemples



Example of Mobile Evaluation Module Screen



Example of WebEvaluation of Patient Module Screen



Example of Medical Regulation Module Screen

Results

- The form of Medical Evaluation consists by items which identify the patient's situation in many areas. The forms to emergency evaluation were also developed and organized according to ICNP version 1.0.
- The minimum necessary to the Mobile System work basically consists in a mobile device (PDA), which presents some type of implementation of the Java Virtual Machine (JVM) and has GPRS access through the qualified telephony operator. All access to the system is obligatory notarized through a login and password previously registered in the Web system.
- From the structuring of the system, progressive evaluations were applied with the developing team discussing and reformulating the data in the system according to the needs and problems found. After that, a pilot test was organized simulating two real emergency attendance situations: one meningea syndrome and a hypovolemic chock due to displayed breaking.
- 04 appraisers from the informatics and health areas participated in this test, they evaluated the items: ergonometric and usability. The item ergonomics evaluated the criteria of organization, interface, content and technical. To each item scores were established from 1 to 5, being (5) excellent, (4) very good, (3) good, (2) regular, (1) bad.
- The data are presented in a statistics descriptive way. In the usability criterium 24 items were evaluated determined by scores from 1 to 5, being (5) totally agree, (4), agree, (3) disagree, (2), totally disagree and (1) not applicable according to qualitative analyses.

Results – Ergonomics Evaluation

- It was observed in the ergonomics evaluation that the evaluators perspective the system is Very Good with an average variation of 4,0 to 4,4. The items content and interface received the best evaluations inside the ergonomics criterion with an average variation from 4,3 to 5,0.
- The technical item inside ergonomics criterion received a minor score, with average score variation from 3,3 to 4,0, specially because the system is under construction and the connection and communication among the modules (especially from mobile to fixed) are not finished.
- The average deviation among variables of ergonomics evaluation was around 0,4 to the Regulation Module and 0,3 to the Evaluation Module of patient form fixed and mobile. The main items approached by the evaluators to the usability criterion evaluation with scores (5) and (4) corresponding to totally agree and respectively agree were:
  - the system easily runs on fixed and mobile platforms with no interferences, the system screens are clear, easy to read and interpret, the usurer is able to access the system easily, the menus are viable and easy to use, the system is modular and shows the structuring in the programming, the system has a limit of growing appropriate to the use demands, the memory requirements do not hinder the program running on the platforms, the system has automatic saving, the connection and communication among the Regulation and Fixed and Mobile Evaluation modules are appropriate, the system enables the recovery of data in the various modules, the hardware requirements are compatible to the reality, the system holds attendance network, the system has data locking.

Results – Usability Evaluation

- Amongst items which received evaluation do not agree, with score **(3),** and that were marked only in the evaluation Regulation Module, are distinguished: does not run in different platforms; does not accept inexistent data and the system allows recovery of data in the various modules.

- Positive aspects of the system are also distinguished: the agility, the neatness, the system is complete, it is easy to use it, friendly and it accomplishes the objectives. Another positive aspect is that it enables the emission of reports which contribute to the control and accompaniment of the quality of the attendance in SAMU from the indexes established by the Health Department. As negative aspects we have: the absence of the item help top the usurer in the menu of the Regulation and Web Evaluation Module, little functionality of tables of vital signals, scale of coma of Glasgow and progressive evaluation of trauma in the Mobile Evaluation module, as well as the lack of a complete database of streets and avenues of the State.

Discussions and Conclusions

- Although the system is not completely developed, it was perceived through the data collected during the pilot test that it has appropriate ergonomic criterion, content and usability to the emergency situations enabling the feeding of the system directly from the place of the accident. It is a pioneer and innovator system in Brazil due to including a complete structure of Regulation, Web and Mobile Evaluation of emergency embracing the doctor and nurse attendance.
- The study also enables emphasizing that the information is a key element in the decision making and an essential requisite in the support and efficient management of health care, once it enables a systematic way of evaluating and comparing.

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MEDINFO 2007
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Web Portal for Health Disclosure: A Promising Future

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Abstract

This poster presents the idea of developing web portal for health disclosure in the future. Some preliminary data on disclosure behaviors by patients give some promising hope for the use of Information and Communication Technologies (ICT) specifically for health disclosure in the coming future. A concept of web portal is also introduced in this poster.

Keywords:

Web Portal, disclosure, privacy, health information

Web Portal for health disclosure

A qualitative research [1] was conducted by the author to understand the disclosure and privacy behaviors displayed by medical patients when facing illness. One portion of the qualitative interview asked about the use of ICT for purposed of disclosure.

The data indicated that a large number of the respondents used ICT to inform their relatives, to contact someone who has similar medical history, to start a friendship with another patient, to get information on alternative treatments and to update their health status (see Table 1). The telephone was the most common technology used while electronic mail and the Internet were used by the respondents. However, there is no doubt that the medium of communication may change to other ICTs in the future. Recent market research reports have shown that the usage of Internet, text messaging and instant messaging are increasing all over the world [2]

One suggestion is to create a web-based portal for access to health information. The purpose of a portal is to provide a one-stop center for patients, where the medical team, with patient consent, can provide health information to patient's network . A portal may be useful when patients are admitted to hospital and going through treatments. One research idea would be to develop a portal prototype and recruit a patient sample to get feedback on the usefulness of a portal system. Specific aspect of disclosure like the content of information, depth of information, the timing of information and the recipient of health information will be a question when designing a portal for this purpose. With careful planning in research design and by combining mixed methodology research (think aloud and experiment), I believe that there is a great potential for a health web portal whose design takes into consideration both disclosure and privacy aspects.

Respondent	Type of ICT	Purpose
Patient	*Email* *Phone*	*Update mom*
Patient	*Internet* *Email*	*To communicate with support group* *To disseminate information*
Patient	*Email* *Phone*	*Contacted medically literate member DC* *Informed all family members about diagnosis*
Patient	*Phone*	*Update best friend about health* *Update employers about treatment status*
Patient	*Phone*	*Update relatives out of state*
Patient	*Phone*	*Check status of family member*
Patient	*Phone*	*Update sisters about health*
Patient	*Phone*	*Update spiritual community about treatment status*
Patient's family	*Phone*	*Call church members to get update*
Patient's family	*Phone*	*Inform siblings who live out of state*
Patient's family	*Internet*	*Check out alternative treatment*
Patient's family	*Email*	*Used email to update friends when sister in law already in critical stage.*
Patient's family	*Phone*	*Called mom's friends to tell about dying stage*
Patient's family	*Phone*	*Update spiritual community* *Called patients to see their status*
Patient's family	*Phone*	*Call mom's friend to update mom status*
Patient's family	*Email*	*Communicated with brother in Europe about mom's health status*

9 medical workers	*Phone*	*Consult patients* *Receive calls from family members to ask about medical decision* *Receive calls from patients' family members to access patient information*

Table 1 - List of respondents who use ICT for health disclosure

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Construction of Simple Mobile PACS system Using Wireless Internet

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Departments of Nuclear Medicine and Internal Medicine, Gachon Medical Center, Incheon, Korea; CAD Impact, Inc. *, Seoul Korea**

Background

Wireless mobile internet has advanced and been widely applied to a variety of social systems. We constructed a simple mobile PACS system, using this wireless mobile internet to improve the medical imaging service.

Method

The mobile PACS system consisted of intranet wired main PACS system, mobile PACS server (connected to main PACS system) and mobile notebook. KT Netspot system was used for wireless internet system. Medical images were compressed and downloaded to the mobile PACS server and displayed on the reader's mobile notebook via KT Netspot. Approach to the mobile PACS was limited to the readers with ID and password.

Results

The mobile PACS system was effectively operated and the quality of the transferred images was acceptable after file compression. However, the mobile PACS was available only in areas of wireless internet zone.

Conclusion

The simple mobile PACS system was constructed using wireless internet system and may improve the quality and speed of medical service. Further studies using more high speed wireless system and more compact mobile notebook are needed.

Automatic Appraisal System

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Abstract

In Taiwan, we have systematically evaluated health web sites due to our national Health Web Award since 2002. Through appraisal of the field masters, recognized websites will be awarded by Label of Excellent. It's also the way to provide identified credit for general public. This study intends to further digger the possibility of automating the process mentioned above.

Keywords*：*text mining

Introduction

People in Taiwan are getting used to read health and medical related information on line, but they may not be capable to judge the accountability of gotten information. To lift up the quality involved in health information for people, and to encourage providers to enhance qualitative content, the government initiated annual contest for Health Information Website. Through appraisal of the field masters, recognized websites will be awarded by Label of Excellent. It's also the way to provide credit to be identified by general public. This study intends to further digger the possibility to automate the process mentioned above.

Methods

First, to collect web pages, which are to provide trained and tested function, and to utilize cutting words system, provided by Academia Sinica (http://ckipsvr.iis.sinica.edu.tw/), to cutting words on the web pages in order to calculate the weighting of feature.

Second, term selection and Extraction.

Third, design a categorizing tool by SVM, support vector machines, and by means of result, produced by first step, to classify whether health information web pages are related.

Fourth, creating a crawler to catch those web pages, which cover 'tw' in the last two words of their web addresses, automatically.

Fifth, using the categorizing tool to subgroup those web pages, filtered by the crawler, in order to get health information websites.

Sixth, initiating a phase pool system to give points to those health information websites according to scoring standard of annual contest, such as whether footnotes, creator and posting time included, are provided in the article.

Finally, comparison of grading difference between manual and the system.

Program is coded by VB 6.0, database by SQL2000.

Results

Steps one to three are almost accomplished, and steps four to six are incomplete.

Fig.1 the cutting words system to calculate the weighting of feature.

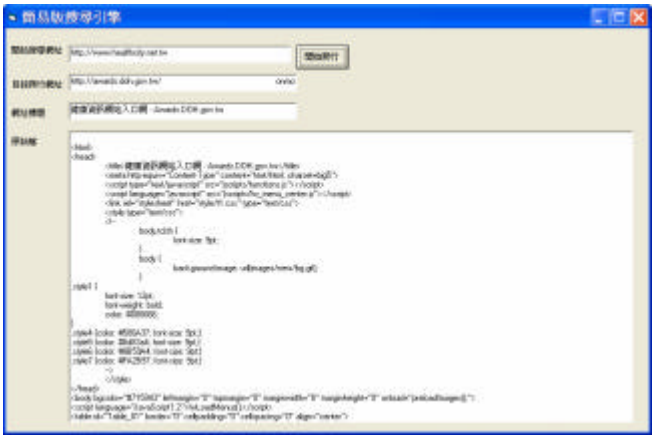

Fig.2 the crawler to catch web pages.

Discussion

Once the result of the system is accountable, it may be established broadly in public health institutions. Keep on searching and apprizing health information websites on the internet, and to be reference for people to select high profile websites. If evaluation being poor, public health institutions may review the content of web pages voluntarily and find out inappropriateness to fix it.

Sustainability of computerised Health Information System Implementation in Developing Countries: a Meta Analysis of Evidence

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Abstract

A Systematic review of studies of computerized HIS in developing countries was carried out. A realist review method was chosen to refine the questions, develop pa framework and synthesize the findings.Complexity and context of internal and external environment are key to sustainability of computerized HIS in DC. HIS system that are aligned to the technical environment of the context(country) and those that can be localized (through adaptation) will be sustainable, as long as their product has currency to the users.

Keywords: Sustainability, health information system, developing countries\, frameworks

Introduction

Information technology (IT) failure has been documented in the literature in Industrialized Countries (IC) for some time. It has been estimated that one to three fifth of IT projects do not attain major goals or have undesirable outcomes (termed partial failure) and one fifths to a quarter where it was never implemented or immediately abandoned (termed total failure), leaving only a few with success[1]. (Heeks, 2002). In the health sector few major disasters attract attention, many are not publicly discussed due to their political nature.

Such disasters also take place in developing countries (DC), in some cases in some of the poorest countries in the world. The impact can be large in economic terms. The failed hospital information system in South Africa cost the province, a total of 20.2 million pounds, accounting for about 3.8 % of the total health and welfare budget[2] . It also brings into stark contrast the opportunity cost, when these countries, cannot afford, proven , highly effective public health intervention such as immunizations. These countries, need to even resist such investments till there is clear evidence of its effectiveness, or at least build in good evaluations into the contract[2].

The identification of an IT failure, is not very clear, as it is a subjective judgment. One of the key dimensions is the timing, as today's success can be tomorrow's failure and vice versa[1]. Of particular interest, therefore is the category called " sus tainability failure" where the implemented HIS results in a successful handover, which is then abandoned later, by the organization. In most ICs, the resources and know how exists to resurrect or modify the problems and such failures do not result in publicity. However in the case of DCs, design and actuality gaps are wider and immediate " cover up" does not occur, leading to a "strech" , with provides the opportunity for a better understanding of the characteristics and factors that take place[1].

The motivation for the paper is the emergence of commercial interests in computerized HIS in DC. Most of the poorer countries, depend on development partners to provide such investments, which is eventually supplied on a commercial basis[3]. In addition, relative to the mid and late 1990's there is more literature in the public domain, of this phenomenon.

The paper is organized as follows. First the conceptual and theoretical understanding of sustainable HIS will be discussed in relation to other similar concepts. A review of theory from the will be used to develop a framework for conducting a meta analysis. A method based on systematic review will use a purposive sample of case studies, both from the published and "grey" literature. The studies will be analyzed to understand the temporal effects and seek a better understanding of sustainability of HIS in DC.

Theoretical concepts of sustainability and HIS sustainability.

Early work in development aid literature identified sustainability to relate to the capacity of recipients' (countries and institutions) need to be self reliant as a consequence of donor aid [4]. The sustainable solutions have been identified as investments that continue to provide a return. The term return is defined in a broader sense , to include social, educational ,[and health] returns[5].

In the field of HIS, many of the definitions for the term , sustainability come from public health[6] and has been used in HIS [3] .

" Sustainability implies user organizations ability to identify and manage risks that threaten long term viability of HIS following the withdrawal of external support "[3]

An important feature of these definitions is the recognition that HIS (and the institutions that install HIS) face risks of change. If one could separate the technology from the organization, the former is more prone to change than the latter. In most cases public institutions that install HIS, produce benefits by the nature of their product, that is health care services. Therefore it can be argued that HIS sustainability also needs to consider the viability and long term benefit of the technology towards health care.

A closely related concept to sustainability in the development literature is " capacity building" . The following statement illustrates the connection lucidly

" we would go further to state that it [capacity building] should enable programme execution independent of change of personalities, technologies, social structures and resource crises…it implies developing sustainable and robust systems" [7]

In the literature, the concept of capacity building seems to be used interchangeably with institution building, institution strengthening and development management. Institutional capacity, has been identified as a vital ingredient in providing effective service[7].

Methods

Realist reviews are relatively a new strategy for synthesizing research findings that are qualitative. Instead of seeking representation and generalizability, sought in positivist research, realist reviews seek to unpack the mechanisms of "how" complex programs work or why they fail in particular contexts and settings[8]. It answers the question of " what works for whom in what circumstances and what respects" [8]. Therefore this method is appropriate to address the aims set out in the introduction. As it is a relatively new method, the methods for data gathering and analyses are described , relative to the steps of the method (table 1).

Table 1. Methods of realist review

Realist review methodology steps	Description of Methods followed
Step 1. Clarifying Scope a)identify the review question (nature /context) b) refine purpose of review c) articulate key theory	Scope of the review was limited to HIS in DC. The nature of the study is a systematic qualitative meta analysis, using a realist review method. Initial purpose was identified as a comparison: how does computerized HIS work (or fail) in different settings? This was refined after initial synthesis(see below) A literature search on " sustainability" was conducted. Three theories were identified that have relevance to the purpose.
Step 2. Search for Evidence a) exploratory search to get a feel. b) progressive focusing to identify key theory and refine inclusion criteria c) purposive sampling and "snowball" sampling	Literature on HIS in DC over the last two decades was known by author. Progressive focusing occurred by reading key articles, and the concept of " sustainability failure" used as inclusion criteria. Based on framework for review (Figure 1) purposive sampling was used to search to populate it . Grey literature was included.
Step 3. Appraise primary studies and extract data a) use judgment: relevance and rigour b) develop data extraction forms and notation devices. c) Extract different data from different studies to populate framework.	Judgments made to access and use studies were based on peer reviewed publications. Grey literature was included when the author had firsthand assurance of authenticity. Data extraction from documents were used to develop case studies and comparative tables (see results)
Step 4: Synthesize evidence and draw conclusions. a) allow purpose to drive synthesis. b) use contradictory evidence. c) present conclusions	Initial synthesis from key articles, was used to refine the purpose to " How does long term sustainability of computerized HIS in DC unfold? What are the key characteristics that affect failure and success?" Contradictions were sought in the studies. Conclusions are presented as a set of principles that guide, not rules that govern the phenomenon.

Results

As a realist review is an iterative process, the results will be presented in the sequence of evidence gathering, synthesis, further extraction of evidence from studies and synthesis.

<u>Evidence on theory</u>

The literature review identified three theories of relevance to the purpose of the review.

1. IS sustainability as a design-actuality gap[1].
2. Systemic capacity building framework[7]; and
3. Framework for strategy in sustainable development of institutions[4].

The key ideas, concepts from these theories were extracted to build the framework for the study and search for evidence (step 2b).

Building a theoretical framework

Complexity is the key issue, and it is inversely related to sustainability[4]. It can be decomposed to internal and external dimensions, based on concepts for strategic planning, that identify complexity of internal processes and environmental hostility[4]. Pettigrew and Ferlie[9] has argued that useful research on change should involve the constant interplay between ideas about the context of change, the process of change and the content of change. Analysis of the context of the system, can be differentiated to an 'inner' context and an 'outer' context. The former refers to the ongoing strategy, structure, culture, management and political process of the organisation itself (eg. the Department of Health and/or Ministry of Health) and the latter includes the national economic, political and social context which is the wider public sector and the political milieu of health systems (eg. the National and/or Provincial Governments) in these countries.

Heeks[1] reviewed IS failure in DC and identified a number of dimensions by which one could understand the reasons. He proposed , using the Leavitt framework, that a design – actuality gap exists with tools, process, people and structure, is implementing IS in DC. Using the example of project implementation in India, Potter & Brough [7] proposed that within a systemic capacity building framework there exists four key components , a) tools; b) skills; c) staff and facilities; and d) structure, systems and roles. They state that it is easier (and requires less time) to build capacity in the first two, than the latter two components. A framework for evaluating sustainability of HIS in DC needs to include the concept of time. Our initial definitions of sustainability emphasized the viability over time.

Based on the above theories, a framework for sustainability analysis of HIS in DC was developed (Table 2). Studies were searched to populate the framework (step 3c).

Framework for evidence review.

Table 2: framework and studies

	Content and Process	Context (environment)
Internal Complexity hi	Northern Province HIS [2]	Northern Province HIS
low	New Hope HIS[12]	Samoa HIS
External complexity hi	FHSIS[11]	FHSIS
low	Tanzania HISP[3]	India[15]

Exemplar of a case study for longitudinal analysis

In 1989, the Department of Health in the Philippines embarked on to provide a single comprehensive system of information for all health preventive programs. The FHSIS design called for provision of one or more computers at each Provincial health office (PHO, a total of 67) and City Health Office (CHO). The viability of the FHSIS depended very heavily upon the computer processing scheme developed for the system[10] .

It was agreed that data processing using computers was necessary to enable, reduction of staff time in aggregating data, reduce time lag of reports from the field to the centre, and to have a database for further analysis[10]. A decision was taken that the lowest level of computerisation was to be at the Province and that an Information Distribution center would be established at Central level with a database that could be accessed by all relevant units in the DOH [10]. By 1993, there were numerous projects(both national and donor funded) and a number of stakeholders addressing issues of information systems. At this point, three different sections had different responsibilities for HIS, there was resultant ambiguity even among the DOH hierarchy as to the responsibilities for HIS in the DOH. Many had elements that were components of the original FHSIS or overlapped with the system[11].

A major re-organisation in Health services occurred in October 1991 with decentralisation of power, authority, responsibility and resources of certain agencies to the local government units, provinces, cities , municipalities and barangays. This resulted in the Provincial Offices, which were the key nodes for the computerized FHSIS, being under a different authority, the provincial governor. Their allegiance, with the DOH was severed.

Implementation of FHSIS had been planned to be completed by 1990, but by the end of 1993 though the computers were in place in all the provinces, many of the users in the DOH were disillusioned with the system [11]. Over the time that had been taken for the system to be implemented the needs of information of these units had changed. Since it was perceived that the system did not provide the information they required in a reliable and timely manner program managers in the DOH began to once again develop their own vertical systems of reporting to suit their requirements.

Through the period 1994-2002, a number of donor projects assisted, in strengthening the HIS in the country. The long time frame also resulted in availability of more sophisticated database environments for the DOH and the ability to develop technical skills at the central level. While the technical capacity now exists, there was no impetus for the provinces to improve the system. In 2005, the FHSIS still functioned as the official system , but with reports that were submitted as hard copies from province to DOH, with delays of transmission and with little utilization by users at local level.

Exemplar of comparative analysis of two case studies

These two case studies were selected, to look at similarities and contrasts within the framework. In both cases, the designs of the HIS was based on experience in IC. As the environment within a hospital, was expected (by the designers) to be very similar in terms of functions and processes in DC.

Table 3. Comparative analysis of Hospital Information Systems

	CIS system in Samoa	Hospital System in Northern Province South Africa
Purpose and context	A computerized Hospital information system, designed to improve clinical care and hospital management. Two main hospitals in country.	Computerization of Hospital Information in all 42 hospital in one province. To improve patient management and revenue collection
Project duration and period	1999-2001 (project still ongoing)	1998 - 2003
Design and development	Contractors for the donor driven project design on a specifications of an IC hospital	IBM contract terminated and subsequent contract given to another contractor
Internal environment (System implementation issues)	A number of promised sub – systems not delivered. No capacity in house. Trained staff leaves country. Synchronization and back up not functional. Reports not generated. Some basic core functions enabled (eg PMI). Long period of system not in use	Most application programs not completed . however, some benefits seem by staff of the system. Others resist due to lack of training. System malfunctioning, due to poor infrastructure (power supply etc). Periods of shut down creates additional work for staff. Some increase in revenue collection, but overall management of
	as no local technical support contract. Not used in hospital management	hospitals not improved. Not used in hospital management
External environment (Project management and institutionalization)	DOH not in a position to carry out technical negotiations with contractors. Change of senior staff responsible. Insufficient resources to have maintenance contracts.	Different expectation of managers, contractors and users. Change of "champions and key staff at the province. Insufficient technical know how to institutionalize systems.
Long term developments	Donor support provided from 2003- onwards to resurrect system. Decision to replace with more suitable software.	Reluctance to give up project leads to second contract which is also a failure.

A number of other case studies were also chosen for the review. Reference these are made in the discussion .

Discussion

The purpose of the review was to understand how implementation of Computerized HIS in DC , can be successful. This aim was then revised in the process of the realist method used to how does long term sustainability of computerized HIS in DC unfold? What are the key characteristics that affect failure and success?

Theory inform us that factors such as complexity (both internal and external) , content, process and context influence long term sustainability. We looked at the evidence from actual case studies to further understand the phenomenon .

HIS in DC, and specifically computerized HIS (where the technology is key tool) is vulnerable to both internal complexity and external changes in the environment. Internal complexity was analyzed using two complex Hospital Information systems, that were designed with IC environments (of both users and infra structure in mind) in Samoa and Northern Province in South Africa (see table 3). This was contrasted to the New Hope HIS in a small rural hospital in South Africa [12]. In the latter case, success of implementation was linked the ability to local adapt the system. The technology used (ie software) was a universally available database, without the need for high level design skills. In addition, this project was backed up by a consortium that had long term experience in introducing the same tools in similar poor DC environments. The key points (principles) that were revealed were:

- Technology to be introduced to green field sites need to be comparable to the environment (in the country). Ambitious plans to "leap frog" development is not sustainable till the environment comes to

that level of development (as in case of FHSIS in 2005).

- Previous experience in introducing technology (HIS) and the ability to be flexible allows sustainability of HIS in DC [13].

Complexity is also created in HIS by the variety of health programs that have different motives and "rationalities" [14]. two longitudinal case studies , illustrate the issues. The FHSIS faced the pressure from different program managers , when it failed to provide the information they required. In the case of HISP in India, over the longer term the developers were able to negotiate their " niche" within other systems [15].

Key factors that influence such long term viability of projects especially in the area of primary health care and disease prevention HIS are:

The constant change of "sponsors" and "champions" for the system, due to the high turn over of senior staff in DC situations. This was well illustrated in the Andhra Pradesh case [15].

Most HIS systems designed to produce management information, to a higher level , have an inherent deficiency, in terms of sustainability as they do not have immediate or explicit health returns. This is compounded by the fact that, in most DC situations management decisions are not based on information. There is need for a long term investment in training and changing the processes in such situations for HIS to be used.
In summary, both complexity and context of internal and external environment are key to sustainability of computerized HIS in DC. HIS system that are aligned to the technical environment of the context(country) and those that can be localized (through adaptation) will be sustainable, as long as their product has currency to the users.

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A Study of Clinicians' Information Systems Usage in Patient-Centered Situations – Preliminary Results

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Abstract

This paper presents preliminary results from an observational study performed at a Norwegian university hospital. The purpose of the study was to identify and capture clinicians' information and communication behaviour and also to further develop a method for performing structured observation of clinicians' patient-centered work. One fifth-year medical student spent 20 days in two different hospital wards, following 7 physicians from one to seven days each. The observer recorded data from several ward situations such as pre-rounds meetings, ward rounds, and discharge situations. The data was recorded by means of an observation form consisting of a mixture of codes and free-text fields.

Keywords:

observational study, structured observations,
mobile health information systems,
requirements engineering

Introduction

This paper presents an extensive observational study performed during a three-month period in two hospital wards. The aim of the study was to identify and capture information and communication behaviour among healthcare workers in hospital wards, based on the further development of a framework for performing focused and structured observations. The framework has been developed iteratively during several previous observational studies[1]. The underlying purpose for the study and for the framework development has been to be able to elicit and produce comprehensive requirements for the user interface of mobile clinical information systems.

Methods

The study was carried out at a large Norwegian university hospital during the period July – September 2005. The observations were conducted by one fifth-year medical student. The student performed non-participatory observations of physicians in two hospital wards (Division of Gastroenterology and Department of Cardiology). During the study, the medical student followed one physician at a time, observing the physicians' daily patient-centered work. The participants included one chief physician with many years of experience in the ward, medium experienced senior residents, assistant residents, and one young intern. Both male and female physicians were among the participants.

The data was recorded by means of an observation form and processed in Microsoft Excel. The observer recorded data regarding the physicians' use of various information sources for retrieving and storing patient-related information in several common ward situations (e.g. pre-round meetings, ward rounds, and discharge). One *situation* is here defined as a time-limited process or sequence of actions/tasks (for an individual patient) in which the cast (actors filling roles) does not change, and which has an identifiable start, preconditions, end, and result. The recorded information consisted of sequences of acts with associated activity, trigger, location, main actor and role, co-actor(s) and role(s), patient ID, situation start and end time, information source, information type, purpose, and result. No sensitive or personal identifying data was recorded. Most of the recorded information was coded on-site by means of pre-defined values, while for instance 'Purpose' and 'Result' consisted of short free-text notes.

After four days of observation at Division of Gastroenterology, the recorded data was evaluated. This resulted in an expansion of the observation form of four new free-text columns; 'Illness history', 'Reason for admission', 'Previous knowledge', and 'Patient category'. The purpose of the extension was to enable more qualitative analysis of the data.

Results

During the study, 11 days of observation were conducted at Division of Gastroenterology and 9 days at Department of Cardiology. One chief physician, 5 residents, and 1 intern were followed. The co-actors of the situations consisted of other physicians, nurses, patients, and relatives. The recorded activities concerned approximately 70 different patients. One hundred and thirty-five situations consisting of a total of 525 acts were recorded at Div. of Gastroenterology, while 190 situations/1032 acts were recorded at Dept. of Cardiology. The numbers of each observed situation type are summarized in Table 1.

More than 200 of the 325 observed situations were recorded during pre-rounds meetings and ward rounds, which are the most predefined and regular, daily activities concerning all patients in the two wards. In the preliminary analysis of the data we have focused on the communication and information behaviour during these situations for *Resident1* (R1), *Resident9* (R9), and *ChiefPhysician9* (CP9). We have manually categorized the observed events into 12 different predefined communicative acts (i.e. navigate into common understanding, assess, answer inquiry, inform, evaluate, request information, prescribe, order, refer, delegate responsibility, remind, sign) and created communicative acts profiles for the physicians [2]. The profiles have been plotted as radar graphs, in order to visualize how the different information sources (categorized as paper-based, electronic, or human) have been used when performing the various communicative acts during the pre-rounds meetings and the ward rounds. Among the interesting results of our analysis were: Experienced clinicians cooperate without explicit communication, in contrast to interns who are much more explicit. Younger clinicians tend to use information systems more systematically and broadly. See elsewhere [2] for a more detailed analysis.

Discussion

Table 1 – Summary of observed situations. The table shows the number of observed situation types per main actor; Residents 'R1' and 'R2' and intern 'I1' from Div. of Gastroenterology (Gastro) and residents'R7', 'R9', and 'R14', and chief physician 'CP9' from Dept. of Cardiology

Situation type	*Gastro*			*Cardiology*				*Sum*
	R1	*R2*	*I1*	*R7*	*R9*	*R14*	*CP9*	
Morning meeting	5	-	6	-	-	-	-	11
Pre-pre-rounds	-	-	-	5	-	-	-	5
Pre-rounds meeting	37	6	20	7	22	11	24	127
Ward-rounds	15	7	-	7	21	11	24	85
Examinations	-	-	-	-	8	2	6	16
Office work	16	7	-	-	8	9	13	53
Discharge prep.	1	4	-	-	-	2	4	11
Disch. Meeting	-	-	-	-	-	-	4	4
Heart meeting	-	-	-	-	1	-	1	2
Other meetings	5	1	5	-	-	-	-	11
Total	79	25	31	19	60	35	76	325

The communicative acts profiles created so far have been for individual physicians, but it is also interesting to create role profiles (i.e. interns, senior residents etc.) in order to study differences between communicative behaviour of various groups of healthcare workers. Another approach is to profile specific activities (e.g. drug related events), as a means for eliciting and analyzing requirements for new information systems.

The recorded data are based on the observations and subjective interpretation by one medical student. In future studies, the method should be improved by using two or more observers in order to ensure consistency.

The study was mainly performed during summer time, and thus the ward staff was reduced and the remaining physicians had more responsibilities than they normally do (e.g. chief physicians performing ward rounds). However, the intention of the study was not to capture 'normality', but rather to verify a method for observation and recording of clinicians' information and communication behaviour, regardless of working conditions.

The physicians in the hospital wards work on a rotation scheme, and the observer followed various physicians on call, from one (*R2* and *R7*) to seven days (*R1*) each. So far, mainly the data of the 3 most observed physicians have been analyzed, but the remaining data can be used in qualitative analysis and to illustrate variations in the observed situations. Only physicians were followed in this study, but future studies should also include other actors/roles (e.g. nurses).

Conclusion

The observational study presented in this paper was mainly performed in order to validate and improve a method for conducting structured observation of clinicians. The results of the study confirm our previous findings:

- Structured observation by means of pre-defined forms enables efficient recording of clinicians' information and communication practice in hospital wards
- Using apprentices (medical students) as observers is beneficial due to their domain knowledge and natural, non-intrusive presence in the hospital wards
- The data recorded via observation differs from e.g. survey data, and the detailed context information of the various situations is valuable when eliciting and analyzing requirements for new mobile clinical information systems

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A Study of Clinicians' Information Systems Usage in Patient-Centered Situations – Preliminary Results

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NTNU
Innovation and Creativity

Aims and motivation

- Aim of the study:
  - to identify and capture information and communication behaviour among healthcare workers in hospital wards
  - validation and further development of a previously iteratively developed framework for focused and structured observations of clinicians during patient-centred work

- Underlying motivation:
  - for the study and for the framework development has been to be able to elicit and produce comprehensive requirements for the user interface of mobile clinical information systems

Methods

- Non-participatory, structured observations of physicians' patient-centered work (e.g. pre-rounds, ward rounds, discharge etc.) in 2 different hospital wards
- Observer: Medical student (fifth year)
- Observation period: July – September 2005
- Field data recorded by means of a previously developed form based on pre-defined codes and free-text fields [1]
- Recorded data consist of sequences of information and communi-cation acts of one main actor, and focus on *information sources* and *information categories* (e.g. diagnosis and procedure, medication, findings and examination results, biographical data, assessment etc.)
- Additional information include situation trigger, patient ID, start and end time, and various context information like location, co-actors and roles, and patient category

Ref: Sørby & Nytrø, 2007a

Information Sources

Patient-specific:

- Patient record (paper)
- Patient chart (paper)
- Patient list (paper)
- Personal notes (paper)
- EPR (electronic patient record)
- PAS (patient administrative system)
- X-rays/CT/MRI reports/pictures
- Patient
- Nurses
- Physicians

Other information sources:

- Physicians' Desk Reference (PDR); paper-based and electronic
- ICD-10 codes overview; paper-based, electronic and personal lists

Observation form and example data

Activity	Trigger	Location	Main actor	Role	Co-actors	Role(s)	Patient-ID	Reason for admission (RfA)	Time	Informaiton Source	I/O	Information	Purpose	Patient category
Pre-rounds	Continue after interruption	OFF4	Res9	PR	Nur9	GR	P57	Admitted due to unstable angina. Must be carefully watched when considering further treatment.	10:50	PATLIST	I	NAME	Name of the patient	New patient for the pysician. Under investigation
										NUR	I	NEW	Changes since admission	
										EPR	I	ALL	Overview of patient	
										NUR	O	FINDEX	Info. about examination	
										PC	I	MED	Review med.	
									11:05	PC	O	MED	Sign	
Examin.	The physician is under specialization and is obliged to perform a certain number of US examinations. Will receive a pager call if such an examin. is to be performed	OFF4	Res9	PR	CP13 on phone (Nur9GR)	Ex			11:10				The physician is paged from the ultrasound lab. Both the patient and the ultrasound machine are ready	
		LAB2	Res9	PR	CP13	Ex			11:45				Perform US examination	
Suppl. work	Quest. arose after pre-rounds. Asks before patient rounds in order to be able to give the answer to the patient during rounds	LAB3	Res9	PR	CP12	Ex	P55	As previously described	11:50				Discuss with colleague if the patient can delay aniography until tomorrow or if the pat. should start on K-vit. and wait for INR level to decrease until tomorrow.	New patient for the pysician. Particular examination
Rounds	After pre-rounds	PR10	Res9	PR	Nur9	GR	P41	Like Day 12	12:02	PATLIST	I	NAMEROOM	Overview of name of patient and where patient is placed	Under investigation
										PAT	O	MED	Inform about cease of med	
										PAT	O	FINDEX	Info about result of examination	
									12:08	PAT	I	NEW	Changes since yesterday	

Figure 1 – Excerpt from observational data (Dept. of Cardiology). The example shows data from one pre-rounds situation, one examination, one supplementary work situation, and one ward rounds situation. The main actor in all the situations is resident 'R9', and his role is 'patient responsible' (PR). The co-actors are one nurse ('Nur9'), who's role is the team leader ('GR'), and two different chief physicians ('CP12' and 'CP13'). Patients 'P41', 'P55', 'P57', and 'P67' are in focus and the locations vary from Office 4 via Lab2 and Lab3 to Patient room 10. The resident uses four different information sources/systems; the patient list (PATLIST) for retrieval of the name of the patient, the nurse (NUR) for retrieving changes since patient admission (information code 'NEW'), the electronic patient record (EPR) for getting an overview of the patient (information code 'ALL'), and the patient chart (PC) for information about the patient's medications. Information is given to the nurse (about examination), and the medication form in the patient chart is signed. During the ward round situation, the physician informs the patient (PAT) about ceasing a drug and the result of an examination, and the patient tells the physician about any changes since the previous day.

Results (Dept. of Cardiology)

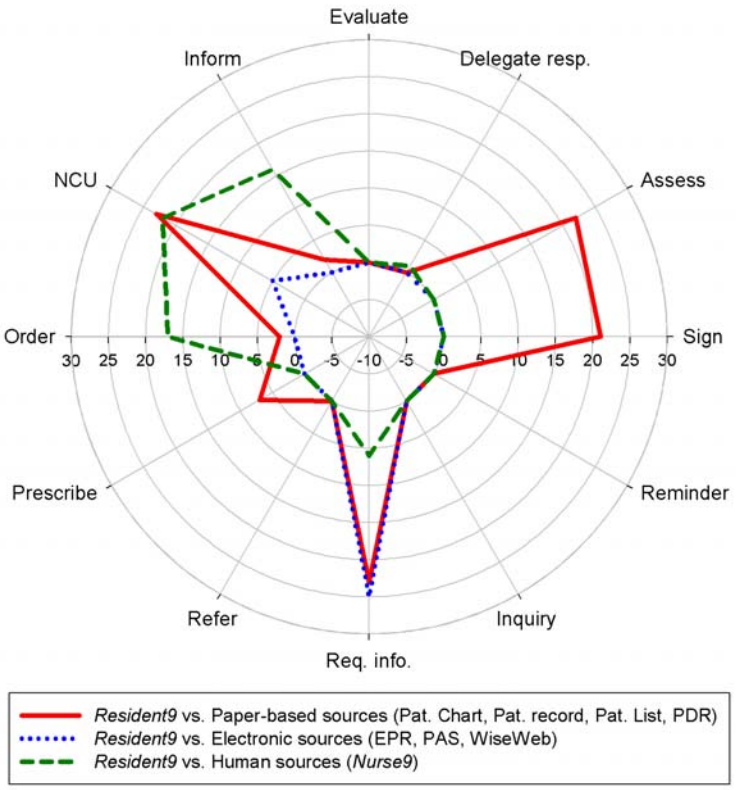
Situation type	*Main actor*				**Sum**	*# drug rel. situations*	*Sources for drug information*	#events per situation	
	R7	*R9*	*R14*	*CP9*				*Min.*	*Max.*
Pre-pre-ward-rounds	5	-	-	-	5	1	COL, NOTE	2	2
Pre-ward-rounds	7	22	11	24	64	62	PC, NUR, PDR, EPR	1	16
Ward-rounds	7	21	11	24	63	23	PAT, PC, NUR	2	11
Examinations	-	8	2	6	16	-	-	-	-
Office work	-	8	9	13	30	4	PC, NUR, PDR	1	9
Discharge prep.	-	-	2	4	6	6	PC, PATINFO	8	15
Discharge meeting	-	-	-	4	4	3	PATINFO, RES, PAT	2	10
Heart meeting	-	1	-	1	2	-	-	-	-
Total	19	60	35	76	190	99	-	-	-

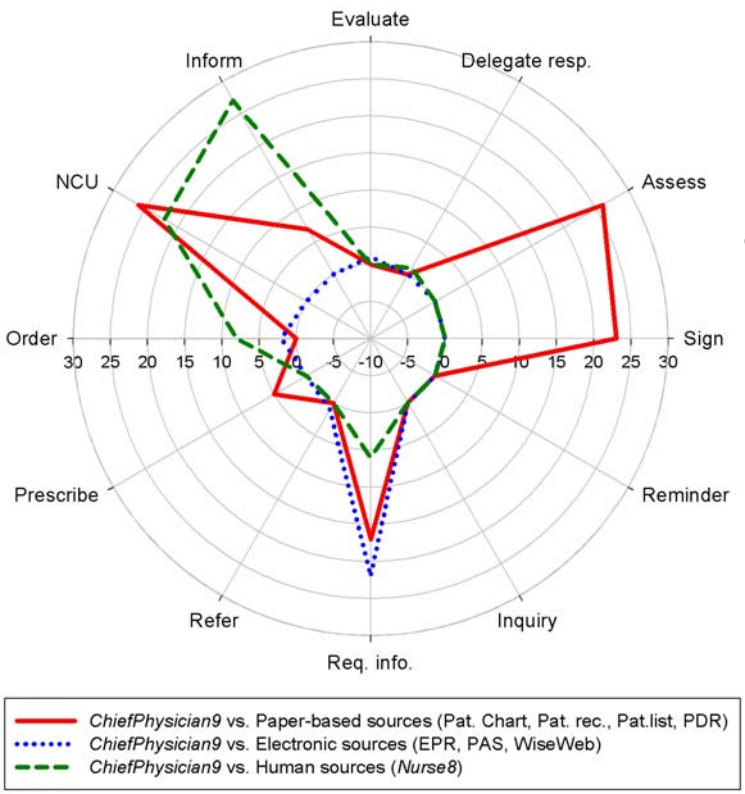
Table 1 – Summary of observations from Dept. of Cardiology. The first part summarizes the number of different observed situation types per main actor (residents"R7", "R9", and "R14", and chief physician "CP9"). The next column shows the number of situations related to drugs (prescription, administering or assessment) and the associated information sources used for gathering or recording drug information. The two last columns denote minimum and maximum number of events or communicative acts in the various situation types.

Analysis of communicative behaviour: Profiling roles and activities

- The observed events have been categorized into 12 different predefined communicative acts (i.e. navigate into common understanding, assess, answer inquiry, inform, evaluate, request information, prescribe, order, refer, delegate responsibility, remind, sign) [2]
- Resulting profiles are plotted as radar graphs that show distribution of communicative acts for several actors during various situations.
- The angular axes of the plots show the 12 communicative acts that have been identified in the observational data
- Radial axes indicate the number of each act found in the various selected observational data sets.

Example profiles, pre-rounds situations



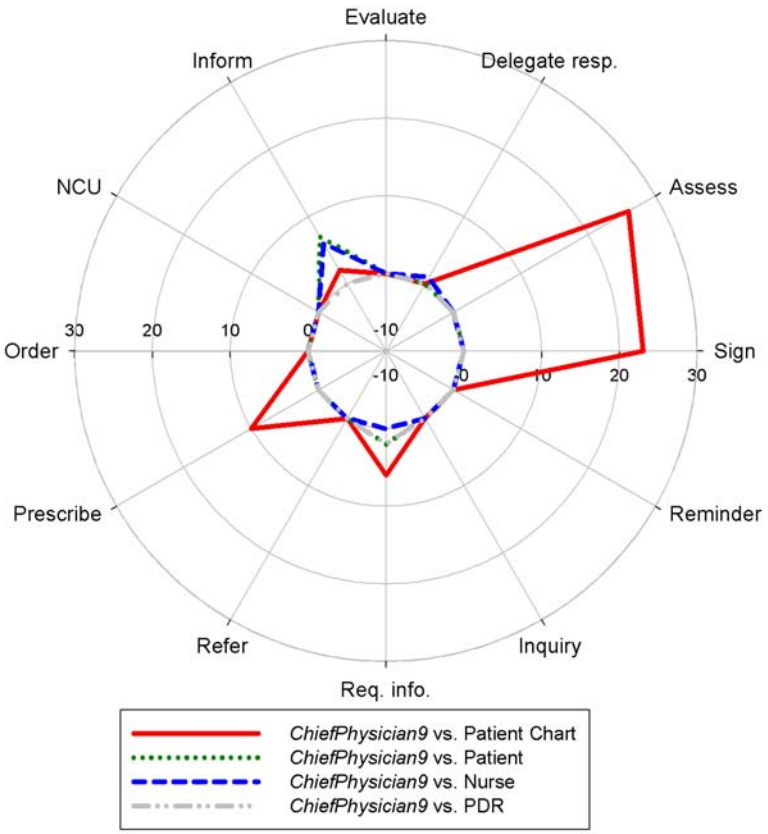


Communicative acts profile, *Resident9 (Dept. of Cardiology). 22 pre-rounds situations, #comm. acts: 214*

Communicative acts profile, *ChiefPhysician9 (Dept. of Cardiology). 24 pre-rounds situations, #comm. acts: 220*

Ref: Sørby & Nytrø, 2007b

Example profile, drug related events



Communicative acts profile, *ChiefPhysician9 (Dept. of Cardiology). Pre-rounds and ward rounds situations, drug-related events. #comm. acts: 108*

Communicative acts profiles

- give a good visual presentation of the information and communication behaviour of individual clinicians, roles, or larger groups of healthcare workers during various clinical activities
- can serve as a basis for generating use cases and scenarios
- can serve as input for systems requirements specifications (e.g. regarding medication activities)

- So far: Merely counting number of different communicative acts
- Next step: Statistical analysis and profiling of other roles and actors (e.g. nurses)

Ref: Sørby & Nytrø, 2007b

Conclusions

The results of this study confirm our previous findings:

- Structured observation by means of pre-defined forms enables efficient recording of field data during observation of clinicians' information and communication practice

- Apprentices (medical students) as observers is beneficial due to their domain knowledge and natural, non-intrusive presence in the hospital wards

- The data recorded via observational studies differs from e.g. survey data, and the combination of coded values and detailed context information of the various situations is valuable when eliciting and specifying requirements for new clinical information systems

Further Work

- Method Validation and Triangulation:
  - To improve the validation of the method, future observational studies will include an initial phase where field data recorded by two or more concurrent observers will be compared and analyzed in order to ensure consistency.
  - Data/results from an observational study carried out during summer 2007 will be compared to survey data and data from laboratory experiments

- Focus on Actors and Patient Trajectories
  - Future studies will focus on following *actors* with different roles (chief physicians, residents, interns, nurses etc.)
  - We also plan to follow *patients* from admission to discharge to enable analysis of patient trajectories.

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*These publications contain more detailed presentations of our research, and include references on related work by Coiera et al., Schoop, Searle, Winograd & Flores, Dietz, and others

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Ubiquitous Healthcare Service in South Korea

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Abstract

The study presented here describes evaluation result designed to deliver the ubiquitous healthcare service in Korea. Based on the well -developed IT infrastructure, Korea has trying to find business opportunities in health-care sectors and has initiated several pilot healthcare services for last few years. The characteristics of those services are providing personal healthcare services at home to the help of portable monitoring devices and communication network.

Introduction

Delivery of healthcare service by means of ubiquitous computing has arousing a great interest in Korea in order to reduce healthcare cost pressure and promote health maintenance of aging population. The ubiquitous healthcare (in short u-Health) enables anytime and anywhere healthcare service access. In pursuit of those goals, the efforts have tried in terms of u-Health pilot study to bridge the boundaries IT and medical industries despite the business attitudes and cultures of these two industries were different. IT industry has achieved success through rapid technological advance while medical industries have more value on ensuring rapport between care recipients and providers with face-to-face interaction.

To understand these emerging integrations better and which services groups of customers with needs really want, Korea conducted several u-Health pilot studies.

The u-Health service

The u-Health ecosystem includes a broad spectrum of capabilities; monitoring devices (vital sign, weight, glucose, ECG, physical activity, etc), communications (Zigbee, Bluetooth, Ethernet, Cellular network, etc), data aggregations (PDA, cell phone, PC, etc), and services (disease management service, diet or fitness service, personal health record service, etc).

The service delivery has done by acquisition of specific health-related data (glucose, ECG, blood pressure) with the use of portable monitoring devices, forwarding data to the hospital through wire or wireless communication using PDA, cell phone or Internet, and providing feedbacks such as data presentation via Internet and consulting with medical staffs by phone and Internet.

The participated organizations for these pilot services include three government departments (Ministry of Health and Welfare, Ministry of Information and Communication, Ministry of Commerce, Industry and Energy), hospitals (Seoul, Busan, Hanyang, Gachon, Severance University Hospital, etc) and local health centers, telecommunication operators (KT, SKT) and several equipment and solution providers.

Result

From the early 2000, there have initiated several kinds of u-Health studies but in this result only aggregates major 3 pilot studies which are relatively large in scale from 2005 and aim at disease managements for elderly. Average service period is 3 months and total subjects are 284 for glucose, ECG, blood pressure, and body mass monitoring. The evaluation result, care recipients expressed that they satisfied with quick and regular checkup of their health status, felt secure at all times, and said good to see their health records anytime but they went through a little difficulties to handle devices and doubted the confidentiality of data with the use of portable monitoring devices (service satisfaction point is around 70-80%, device satisfaction point is around 50-60%).

Conclusion

Government-driven u-Health pilot service seems like to succeed to gain interests of public as well as over several industries. But there are many reasons that make u-Health service difficult. Among them the following three need urgent addressing: (1) legal and standard issues (2) developing of profitable business models for both IT and medical industries, and (3) ensuring of accuracy and reliability of monitoring data. As a result of these pilot studies, the service providers found that the some of their services were of little value to customers and now they are preparing next pilot studies to meet customers' requirements.

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Clinical Decision Support to Improve Antibiotic Prescribing for Acute Respiratory Infections: Results of a Pilot Study

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Abstract

Acute Respiratory Infections (ARIs) are the number one reason for antibiotic prescribing in the United States, and much antibiotic prescribing for ARIs is inappropriate. We designed an electronic health record-integrated, documentation-based clinical decision support system for the care of patients with ARIs, the ARI Smart Form. To evaluate the ARI Smart Form and assess the feasibility of performing a larger trial, we conducted a pilot study with 10 clinicians who used the ARI Smart Form with 26 unique patients. Clinicians prescribed antibiotics to 6 of 6 patients with antibiotic-appropriate diagnoses and to 3 of 20 (15%) patients with antibiotic-inappropriate diagnoses (compared to 26% during the previous winter season). The average duration of use of the ARI Smart Form was 7.5 (SD±4.5) minutes. Nine of 10 survey respondents (90%) would recommend the ARI SF to colleagues unchanged or with minor modification. Eight of 10 respondents (80%) reported that the ARI Smart Form was either time-neutral or timesaving. The ARI Smart Form requires further evaluation but has the potential to improve workflow and reduce inappropriate antibiotic prescribing.

Keywords:

Decision Support Systems, clinical,
Respiratory Tract Infections, anti-bacterial agents

Introduction

Acute Respiratory Infections (ARIs) – including nonspecific upper respiratory infections, otitis media, sinusitis, pharyngitis, acute bronchitis, pneumonia, and influenza – are the most common symptomatic reason for seeking ambulatory care in the United States, accounting for approximately 7% of visits.[1] ARIs are also the number one reason for antibiotic prescribing in the United States, accounting for about 50% of antibiotic prescriptions to adults.[2] Much antibiotic prescribing for ARIs is inappropriate due to prescribing antibiotics for viral conditions or prescribing unnecessarily broad-spectrum antibiotics.[3] Inappropriate antibiotic prescribing increases medical costs, increases the prevalence of antibiotic-resistant bacteria, and exposes patients to adverse drug events.

Health information technology, including electronic health records (EHRs) with clinical decision support, has shown the potential for improving the quality of medical care, mainly through the use of prescribing alerts and preventive care reminders.[4] Improving care for acute problems, like ARIs, may be particularly challenging because of the brevity of ARI visits.[5] In addition, partially because ARI visits are so brief, research into ARIs is frequently hampered by inadequate and non-standard documentation.

We designed an electronic health record (EHR)-integrated, documentation-based clinical decision support system for the care of patients with ARIs, the ARI Smart Form (**Figure**). The ARI Smart Form has 3 objectives: 1) assist clinicians in reducing inappropriate antibiotic prescribing; 2) improve workflow for clinicians; and 3) improve and standardize documentation. We have previously reported results of usability testing of the ARI Smart Form.[6] To further evaluate the ARI Smart Form and assess the feasibility of performing a larger randomized controlled trial, we performed pilot testing in actual clinical practice.

Methods

Setting and EHR

Partners HealthCare System is an integrated regional health delivery network in eastern Massachusetts. Partners HealthCare includes 20 primary care clinics affiliated with Brigham and Women's Hospital or Massachusetts General Hospital. The main EHR used in Partners HealthCare ambulatory clinics is the Longitudinal Medical Record, or LMR. The LMR is an internally developed, full-featured EHR including typed and dictated notes from primary care and subspecialty clinics; problem lists; medication lists; coded allergies; and laboratory test and radiographic results.

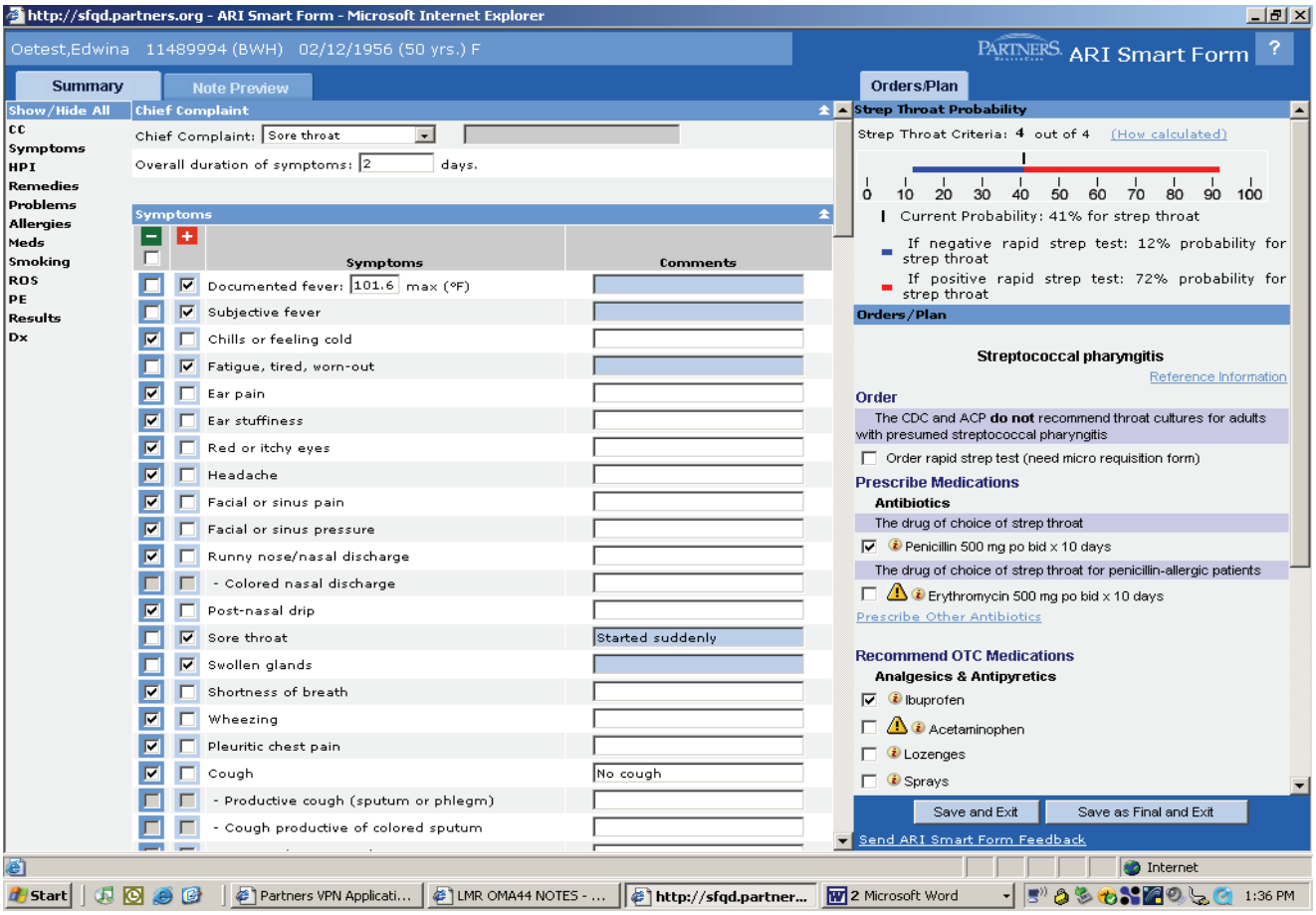

Figure – Screen Shot of the ARI Smart Form

The ARI Smart Form

The ARI Smart Form is launched from the Notes page of the EHR and is designed to be used while interviewing and evaluating patients. The ARI Smart Form integrates display of information, decision support, ordering and documentation and includes 6 components: entry of clinical information; patient data display; diagnosis selection; presentation of treatment options with integrated decision support; printing of patient handouts; and access to supporting medical literature. The ARI Smart Form imports patients' problem lists, allergies, medications, and vital signs into the visit note; speeds workflow using drop-down lists, radio buttons, and check boxes (especially "all normal" checkboxes); and provides "one-click" ordering of medicines, patient handouts, and excuse-from-work letters. The ARI Smart Form automatically generates a narrative visit note from all entered information, including orders and actions.

The ARI Smart Form provides decision support in several ways. First and foremost, clinicians' selection of a particular ARI diagnosis results in the generation of a diagnosis-appropriate order set. Antibiotic prescribing and antibiotic choices are based on the recommendations of the Centers for Disease Control and Prevention (CDC) and American College of Physicians (ACP).[7] At a basic level, the ARI Smart Form decision support strives to make the antibiotic treatment match the diagnosis (e.g., not prescribing antibiotics for patients with acute bronchitis; prescribing penicillin for patients with streptococcal pharyngitis). Second, the ARI Smart Form provides diagnostic decision support by calculating the probability of streptococcal pharyngitis based on signs and symptoms and how rapid streptococcal testing would change the probability of streptococcal pharyngitis (**Figure**).[8] Third, the ARI Smart Form has medication prescribing alerts to potential medication interactions or patient allergies to aid clinician decision-making. Fourth, the ARI Smart Form supports clinicians by providing easy access to diagnosis-appropriate patient handouts. The handouts contain information about the diagnosis and why or why not antibiotics may be indicated.

The ARI Smart Form should standardize documentation for several reasons. To obtain the workflow benefits of using the ARI Smart Form (i.e., facilitated orders and patient instructions), clinicians need to indicate a specific

diagnosis as opposed to using non-standard or vague diagnoses like "URI." In addition, clinicians use the ARI Smart Form to enter standard data elements that are stored and can be used in subsequent analyses.

Pilot clinicians

We recruited pilot clinicians by emailing 10 clinic directors and asking them to identify 2 volunteers each. Potential pilot clinicians were then contacted via email and invited to participate in using the pilot version of the ARI Smart Form. Those clinicians who accepted were instructed on how to use the ARI Smart Form through a series of emails detailing the layout, functionality, and technical issues associated with the ARI Smart Form. We encouraged clinicians to practice with the ARI Smart Form by using it with "test patients" (fictitious patients contained in the LMR) and then to start using it for all their ARI visits. On-line support for usability and technical issues was provided for the duration of the pilot via a link in the ARI Smart Form. The pilot period ran from August 29, 2005 to September 31, 2005. The Partners Human Research Committee approved the study.

Outcomes

Outcomes of interest for this pilot study included the proportion of all ARI visits for which the ARI Smart Form was used, the proportion of ARI visits at which antibiotics were prescribed, rates of antibiotic prescribing across different diagnoses, and the duration of ARI Smart Form use.

Post-pilot survey

At the end of the pilot period, we asked pilot clinicians to complete a survey by e-mail. The 5-minute survey asked questions about clinicians' satisfaction with the ARI Smart Form, focusing on areas needing improvement. In particular, the survey asked clinicians if they would recommend the ARI Smart Form to colleagues and if they felt using the ARI Smart Form saved time as compared to traditional visit note generation tools in LMR.

Data capture, extraction and analysis

We captured data about diagnosis and antibiotic prescribing from the ARI Smart Form itself. We also captured information about the prescription of non-antibiotic medications, recommendation of over-the-counter medications, and the printing of patient handouts and excuse-from-work notes. In addition, we recorded time stamps associated with starting and ending the ARI Smart Form session, which allowed us to calculate the duration of use of the ARI Smart Form. The duration of use is only a proxy for the visit duration as clinicians could choose to use the ARI Smart Form throughout a visit or use the ARI Smart Form at the end of a visit.

After the pilot was complete, we assessed our ability to compare antibiotic prescribing between visits at which the ARI Smart Form was used to visits at which the ARI Smart Form was not used. We extracted 2 groups for comparison. The first comparison group was all contemporaneous ARI visits at which the pilot clinicians did not use the ARI Smart Form. The second comparison group was all ARI visits from the previous winter season (from October 1, 2004 to May 31, 2005) made to the pilot clinicians.

We identified comparison visits using administrative data coded as International Classification of Diseases, Ninth Edition, Clinical Modification (ICD-9-CM). We identified visits with diagnoses of non-specific upper respiratory infections (ICD-9-CM 460, 464, and 465), otitis media (ICD-9-CM 381 and 382), sinusitis (ICD-9-CM 461 and 473), pharyngitis (ICD-9-CM 034.0, 462, and 463), acute bronchitis (ICD-9-CM 466 and 490), and pneumonia (ICD-9-CM 481-486). There were no diagnoses of influenza made by participating clinicians during the pilot period. We considered otitis media, sinusitis, streptococcal pharyngitis, and pneumonia to be antibiotic-appropriate diagnoses. We considered non-specific upper respiratory tract infections, non-streptococcal pharyngitis, acute bronchitis, viral syndrome, and other diagnoses to be non-antibiotic-appropriate diagnoses.

We report results as simple proportions and means with standard deviations (SD). We did not perform statistical testing because of the small sample size of this pilot study.

Results

Clinician participation and characteristics

We identified and invited 17 clinicians to use the ARI Smart Form. Sixteen of 17 used the ARI Smart Form on either test or real patients. A total of 58 notes were generated via the ARI Smart Form for test and real patients for an average of 3.6 notes per clinician (a single ARI Smart Form is used for each patient). During the pilot period, 10 clinicians used the ARI Smart Form 26 times with real patients, including 15 of 57 actual patient visits (26%) with an ICD-9-CM code of an ARI and an additional 11 visits that did not have an ARI ICD-9-CM.

This group of 10 Partners-affiliated physicians represented 9 different practices in the Partners network. Although nurse practitioners were among those invited to participate in the pilot, all 10 participants who used the ARI Smart Form with real patients were physicians. These clinicians included 5 women, had a mean age of 42 (SD±6.7) years old, and, on average, graduated from medical school 15 years previously. The pilot clinicians averaged 41 clinic visits per week. In terms of the practice site, 4 pilot clinicians worked in hospital-based clinics, 4 worked in community-based clinics, and 2 worked in community health centers. Nine of the pilot clinicians had primary care practices and 1 saw only urgent care patients.

Patient characteristics

The mean age of the 26 patients for whom the ARI Smart Form was used was 44 (SD±15) years old and included 15 (60%) women. Of these patients, 17 (65%) were white, 2 (8%) were Latino, and 7 (27%) had unknown race and ethnicity. Twenty-four patients (92%) spoke English as their primary language.

Antibiotic prescribing

Overall, during the pilot period, clinicians prescribed antibiotics to 35% (9 of 26) of patients when using the ARI Smart Form and 38% (15 of 39) of patients when not using the ARI Smart Form for ARI visits (**Table 1**). During the previous influenza season, these same clinicians prescribed antibiotics in 30% of ARI visits. For antibiotic-appropriate diagnoses, clinicians prescribed antibiotics in 6 of 6 visits (100%) when using the ARI Smart Form, 9 of 10 visits (90%) when not using the ARI Smart Form and in 154 of 367 visits (42%) during the previous cold and influenza season. For antibiotic-inappropriate diagnoses, clinicians prescribed antibiotics in 3 of 20 visits (15%) when using the ARI Smart Form, 6 of 29 visits (21%) when not using the ARI Smart Form, and 269 of 1027 visits (26%) during the previous cold and influenza season.

Use of other ARI Smart Form features

Clinicians prescribed non-antibiotic medications in 4 visits and recommended over the counter medications in 17 visits. Clinicians printed patient handouts in 3 visits and an excuse from work note in 1 visit.

Visit duration

The mean duration of ARI Smart Form use (calculated from the time the Smart Form was opened to the time the Smart Form was completed) was 7.5 minutes (SD±4.5), ranging from 2.0 minutes to 18.7 minutes (**Table 2**). The duration of use appeared to generally decrease with the number of uses by clinicians though there was notable variability within and between clinicians and 3 clinicians only used the ARI Smart Form one time.

Survey results

The 10 pilot clinicians responded to the post-pilot survey. Three clinicians felt the ARI Smart Form was marginally timesaving, 5 felt it was time-neutral, 1 felt it marginally increased work, and 1 felt it significantly increased work. Six clinicians would recommend that other clinicians use the ARI Smart Form unmodified and 3 would recommend it with some minor modification, such as increasing flexibility with more "freelance choices" and the feeling that the final note did not "flow naturally."

Table 1 – Antibiotic Prescribing by Diagnosis

	Pilot Period				Previous Season	
	Smart Form		Non-Smart Form			
	Visits, N	Antibiotic, N (%)	Visits, N	Antibiotic, N (%)	Visits, N	Antibiotic, N (%)
Antibiotic Appropriate Diagnoses						
Otitis media	0	NA*	1	1 (100)	54	29 (54)
Sinusitis	3	3 (100)	7	7 (100)	188	96 (51)
Streptococcal pharyngitis	3	3 (100)	1	1 (100)	4	4 (100)
Pneumonia	0	NA	1	0 (0)	121	25 (21)
Sub-Total	6	6 (100)	10	9 (90)	367	154 (42)
Non-Antibiotic Appropriate Diagnoses						
Non-specific upper respiratory infection	8	2 (25)	15	4 (27)	578	130 (22)
Non-streptococcal pharyngitis	2	0 (0)	2	1(50)	260	72 (28)
Acute bronchitis	7	1 (14)	1	1(100)	167	65 (39)
Viral syndrome	2	0 (0)	4	0 (0)	22	2 (9)
Other	1	0 (0)	7	0 (0)	NA	NA
Sub-Total	20	3 (15)	29	6 (21)	1027	269 (26)
Total	26	9 (35)	39	15 (38)	1394	423 (30)

*NA is not applicable

Discussion

In this pilot, we demonstrated the feasibility of conducting a larger study to evaluate the ARI Smart Form. We found that the ARI Smart Form has the potential to decrease inappropriate antibiotic prescribing for ARIs and improve workflow. The antibiotic prescribing rate for all ARIs did not change, but clinicians appeared to increase antibiotic prescribing for antibiotic-appropriate diagnoses and decrease antibiotic prescribing for non-antibiotic-appropriate diagnoses. This is in line with a major objective of the ARI Smart Form decision support: to get the antibiotic treatment of ARIs to match the diagnosis. Achieving such a goal could have a major impact on

reducing overall antibiotic prescribing in the United States.[2]

Table 2 – ARI Smart Form Use Duration by Clinician and Number of Uses

Clinician	Uses of the ARI Smart Form					
	1st	2nd	3rd	4th	5th	6th
	Time (minutes)					
1	10.2					
2	14.8	7.0	4.9	8.7	5.0	
3	4.1	10.5				
4	6.3	7.9	8.5	14.5		
5	4.1	3.6				
6	8.3	7.6				
7	13.2					
8	7.0					
9	8.6	18.7				
10	3.5	3.8	4.4	3.3	2.0	3.8
Mean	8.0	8.4	5.9	8.8	3.5	3.8

A major barrier to the adoption of EHRs is the perception that they interfere with workflow. Encouragingly, pilot clinicians generally felt that the ARI Smart Form was time-neutral or timesaving. This perception is in agreement with the measured results of local time-motion studies.[9] It is especially promising that 9 of 10 pilot users who used the ARI Smart Form with actual patients would recommend the ARI Smart Form to their colleagues.

The ARI Smart Form should provide additional benefits by standardizing documentation for ARIs. Some structured data elements are required for ARI Smart Form decision support at the time of use, like the signs and symptoms for calculating the probability of streptococcal pharyngitis. In addition, structured information can be used for quality reporting and quality improvement initiatives. Indeed, we are implementing an ARI "Quality Dashboard," with which clinicians review their antibiotic prescribing rates for ARIs compared to colleagues and national averages.

Limitations

This pilot study has several limitations that should be considered. First, and most obviously, this study was small with few participating clinicians using the ARI Smart Form with actual patients. This limited our ability to perform more meaningful comparisons between groups and statistical testing. Second, apparent improvements in appropriate antibiotic prescribing may simply reflect learning by clinicians to better match diagnosis codes with prescribed treatments. Third, not all of the invited clinicians used the ARI Smart From. Clinicians who are more inclined towards applications like the ARI Smart Form might assess it more favorably, leading to response bias in our satisfaction measures. Fourth, though we have previously found that administrative diagnoses have good positive predictive value for identifying ARI visits,[10] in this pilot, there was not a 1:1 relationship between the administrative diagnosis and the diagnosis from the ARI Smart Form. Fifth, participating clinicians did not use the ARI Smart Form for all of their ARI patients. There could be systematic differences between patients and visits at which clinicians do and do not chose to use the ARI Smart Form. The fact the pilot users did not use the ARI Smart Form in all patients with ARI suggests potential limitations in its design (e.g., difficulty using it with patients who have other active medical problems).

Future directions

The ARI Smart Form requires further evaluation with a larger sample of clinicians and patients in a randomized controlled trial. Such a trial could include a broader range of outcomes, such as re-visit rates, antibiotic costs, use of broader-spectrum antibiotics, and quality of documentation. In assessing the appropriateness of antibiotic prescribing in a larger study, we need to be aware of the potential for increasing the use of antibiotic-appropriate diagnoses and inadvertently increasing antibiotic prescribing for ARIs. For this reason, the primary outcome should be the overall antibiotic prescribing rate for all ARIs combined. Within this primary outcome, one can detect "diagnosis-shifting" from non-antibiotic-appropriate diagnoses to antibiotic-appropriate diagnoses.

Further changes to the application are also planned, including better integration of the ARI Smart Form into a visit in which multiple medical problems are addressed, increasing the flexibility of the form, and improving the readability of the generated note.

Conclusion

In this pilot study, we found that the ARI Smart Form did not appear to change the overall antibiotic prescribing rate. We did find the ARI Smart Form has the potential to decrease the antibiotic prescribing rate for non-antibiotic-appropriate diagnoses. We also found that pilot clinicians felt that the ARI Smart Form was time-neutral or timesaving and would generally recommend it to colleagues. Decision support applications for acute problems must provide clinicians with self-evident benefits at the time of the visit (e.g., saving time, improving patient education) or they will go unused. The ARI Smart Form requires further evaluation, but has the potential to improve workflow, reduce inappropriate antibiotic prescribing, and standardize documentation.

Acknowledgments

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A National Healthcare Data Network for India

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Abstract

The Indian healthcare sector is going through a period of significant transformation; moving from paper-based systems to electronic solutions. In order to be accessible to the current population and be able to cope with societal and technological advances, the new system has to be guided by present well-established medical practices in India and be designed and engineered to adapt and interoperate with other systems, both local and international. At the core of such a system has to be a well-designed data network. In this paper, we present our work on building such a network. We also highlight our design imperatives, which include the ability to address the issues of interoperability, scalability, privacy, security and extensibility in a very large data system.

Keywords:

India, Healthcare Systems, Healthcare Delivery, Healthcare Reform

Introduction

A safe and scalable information system is the essential backbone for building a nation-wide healthcare system to improve the quality of care, maximize operational efficiency, enhance planning & research and introduce cost-effective channels for delivering healthcare. The system needs to be able to evolve incrementally, build on the current traditions of medical practice and being able to explore new opportunities to eliminate inefficiency and reduce operational costs. In this paper, we describe the design of such an information system for the healthcare industry in India. We start off by discussing the current state of Healthcare in India and by presenting the factors driving the adoption of the National Health Data Network.

Method: The National Health Data Network

Most of the healthcare records in India are on paper and the health transactions are managed manually, with the exception of a few private hospitals. Manual data management invites error, inefficiency and significantly reduces the possibility of timely analysis of data to detect health-related emergencies such as an outbreak of a communicable disease in a particular city or state. The manual practice for exchanging the health data outside the enterprise introduces errors and inefficiencies into the system. The IT infrastructure in the private-sector hospitals cannot be utilized effectively for information exchange with the agencies having limited or no IT support.

The lack of data standards for integration and communication under-utilize the investments; as the health data will lie un-leveraged and fragmented across the primary, secondary and tertiary health institutions. The fragmented data continues to add to errors and duplication and will in the future demand higher technology investments to integrate diverse systems hosting data. Thus, it became clear that it is crucial to establish a standards-based, safe and secure IT backbone that can naturally enable the collaboration of health institutions nationwide and could virtually tie together a network of providers so that operational, clinical, and financial synergies can be realized.

Keeping the unique attributes of the Indian health industry in mind, IBM submitted a report in early 2005 entitled "Improving India's Healthcare System through Information Technology" to the President of India. This report made three principal recommendations:

- Adoption of electronic storage of data at all stages (including health records)
- Adoption of standards for communication and storage
- The construction of a nationwide health data network for sharing health information

These recommendations were expected to benefit the Indian society in the following areas:

- Operational efficiency (insurance, drug supply chain processing improvements, etc)
- Planning and management (disease surveillance, resource mapping etc)
- Education and research
- Cost effective and improved healthcare delivery

Our work takes an initial step towards addressing the recommendations in the IBM report to the president of India. The IT backbone infrastructure that we have designed facilitates sharing of information among heterogeneous data sources. The health institutions can use the infrastructure as an underlying network to collaborate in a safe, secure, scalable and fault-tolerant environment.

Discussion

Deployed over the Internet, NHDN is a special-purpose network to facilitate collaboration among health enterprises in a safe, secure, scalable and extensible environment based on the healthcare industry standards. The healthcare application service providers (HASP) can deploy their applications and services over this *virtual private health network* in the same way ASPs deploy their e-commerce applications on the Internet. In the healthcare sector, examples of such applications include Hospital Information System, Electronic Health Record and Claim Processing applications.

Applications deployed over the health data network, naturally gain the ability to establish collaboration among healthcare enterprises and their IT infrastructure. The collaboration is based on *hub-and-spoke* architecture that is better than point-to-point communication that lacks scalability and extensibility. The hub-and-spoke model is organic in design and deployment and allows enterprises to adapt to business transformations, new partnerships, vendors and business expansion.

The following are the key design considerations for NHDN:

- The network should be ***safe and secure***
  - Only authorized entities should connect to the network
  - All communication on the network should be encrypted
  - All communication on the network should be delivered to the targeted entity and should not be accessible to other entities. Effectively, network should prevent any sniffing.
  - The network should allow data privacy policies and enforce them
- The network should be ***standards-based***
  - Industry standards should be used to write and read information from the network.
  - The network should be specific to the healthcare industry and should use industry standards to represent information packets on the network.
- The network should integrate with legacy systems and should provide data ***integration and federation*** from disparate systems
- The network should be ***scalable and fault-tolerant*** for a nation-wide deployment

A **NHDN Access Point** is designed and developed to include all the above considerations and enable the healthcare enterprises and application service providers to connect to the NHDN. The technical details of NHDN access point for each of the above considerations are described below:

- **Security**
  - The health data network is deployed over Virtual Private Network technology that offers authentication and data encryption over the network.
  - Authentication technology prevents any unauthenticated access and retrieval of information
  - Hippocratic Database technology is used to specify fine-grained disclosure policies based upon the role of the user, purpose of access, intended recipient.
- **Standards**
  - Structured Query Language (SQL) is adopted to read and write information on the network.
  - Clinical Document Architecture (CDA) is adopted to represent health information on the network.
- **Integration and Federation**
  - IBM WebSphere Information Integrator (WS-II) is deployed to perform data integration and federation and enable the network to integrate with the legacy and disparate information systems.
- **Scalable and Fault-tolerant**
  - Grid technology is used in the design and development of Health Data Network that offers scalability and discovery to integrate disparate health data repositories available on the network.

Healthcare software vendors can package and deploy applications (ex: claim processing application) on NHDN access point and leverage the safe, secure and scalable collaboration among healthcare enterprises on the health data network. The generic data federation and integration capability of NHDN access point offloads the applications from the need to integrate data from disparate systems. The grid capability of the data network transparently enables the healthcare applications to adapt the business transformations of a healthcare enterprise as new customers, vendors join the network or the existing ones drop off the network. The applications coded for and deployed over NHDN, can naturally adapt to the entities connected on NHDN without the need of redeployment.

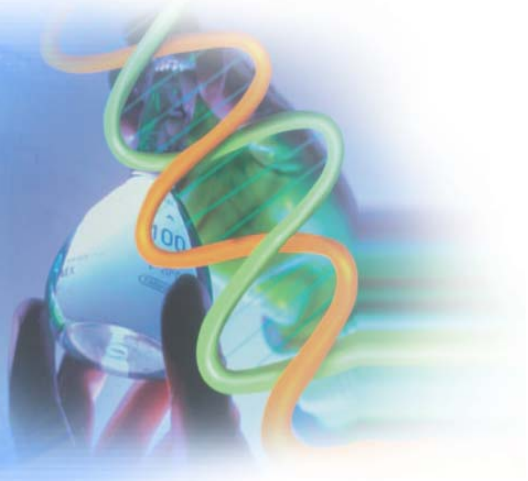
Conclusion

India is undergoing massive change in the healthcare market. There is a push towards transforming all the paper-based system to their electronic equivalents. Obviously, there are obstacles in the way of this renovation. One of the biggest hurdles is to ensure that all these electronic systems can collaborate seamlessly and securely in an effort to reduce transaction cost, increase quality of care, increase efficiency and lower administration overhead. To enable this, a safe and

scaleable data network is critical. In this paper, we present the National Healthcare Data Network (NHDN), which enables secure and privacy-preserving collaboration, while being scaleable and fault-tolerant. NHDN is standards-based, extensible and is able to evolve as the healthcare landscape changes.

IBM Healthcare & Life Sciences

A National Healthcare Data Network for India



IBM
Vishal Batra,Tyrone Grandison ,Sumit Negi, Ashwin Srinivasan

India's Healthcare System: Positive Things

- Eradication of diseases like small-pox
- Increased life expectancy (about 65 in 2000)
- About 5× more hospitals and 10× more doctors now than in 1951
- World-class pharmaceutical industry
  - About 20% of all (legal) drugs entering the US are from Indian pharmaceutical companies
  - Other than the US, Indian pharmaceutical companies have the highest number of drug filings with the FDA
- Some very good high-end hospitals

India's Healthcare System: Issues

- Money
  - Stagnant public spending (bottom 20% of countries)
  - 75% - 90% of government spending is made by state governments, which in turn consists largely of salaries
  - Large variance between states – Kerala spends twice as much as Bihar per capita
- Almost 80% of all health spending is private (largely unregulated)
- Number of hospital beds per 1000 population: 0.7
  - Comparable number is 1.4 for low income countries and 7.4 for high income countries
- India accounts for 17% of world population and 20% of disease burden

India's Healthcare System: Issues

- Nearly all private spending is "out-of-pocket"
  - About 25% of hospitalized individuals fall below poverty line as a result
  - Less than 15% of the population is covered through some form of pre-payment
- Poor still depend on public services for majority of major healthcare services
- Significant inefficiency and fraud in the distribution of drugs and supplies

Background: The Presidential Report

In early 2005, an IRL-led team submitted a report entitled "*Improving India's Healthcare System through Information Technology*" to the President of India

This report made 3 principal recommendations:

1. The construction of a nationwide health data network for sharing health information
2. The adoption of electronic storage of data at all stages (including health records)
3. The adoption of standards for communication and storage

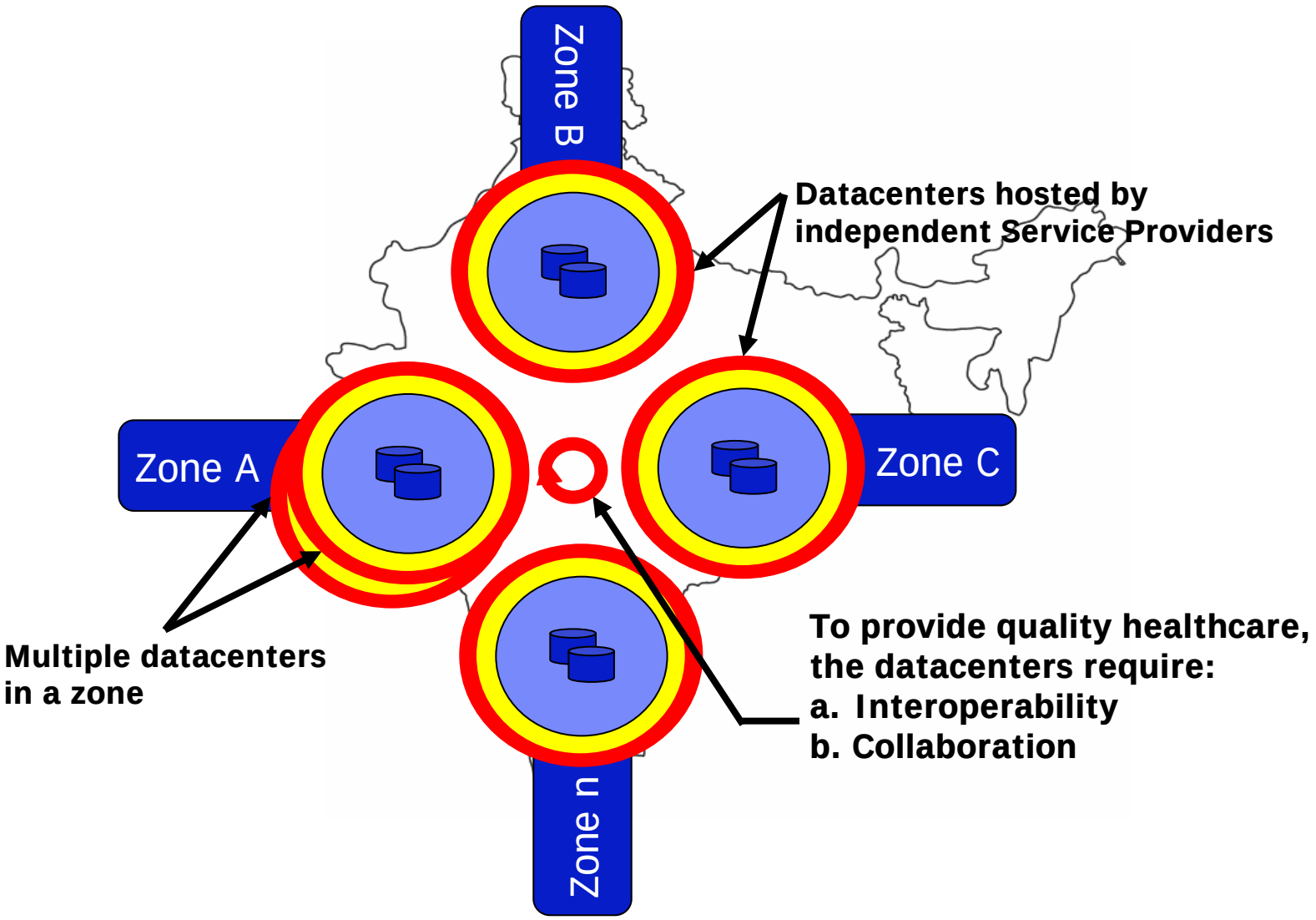
4 areas were expected to benefit

1. Operational efficiency
2. Planning and management
3. Education and research
4. New models of health delivery

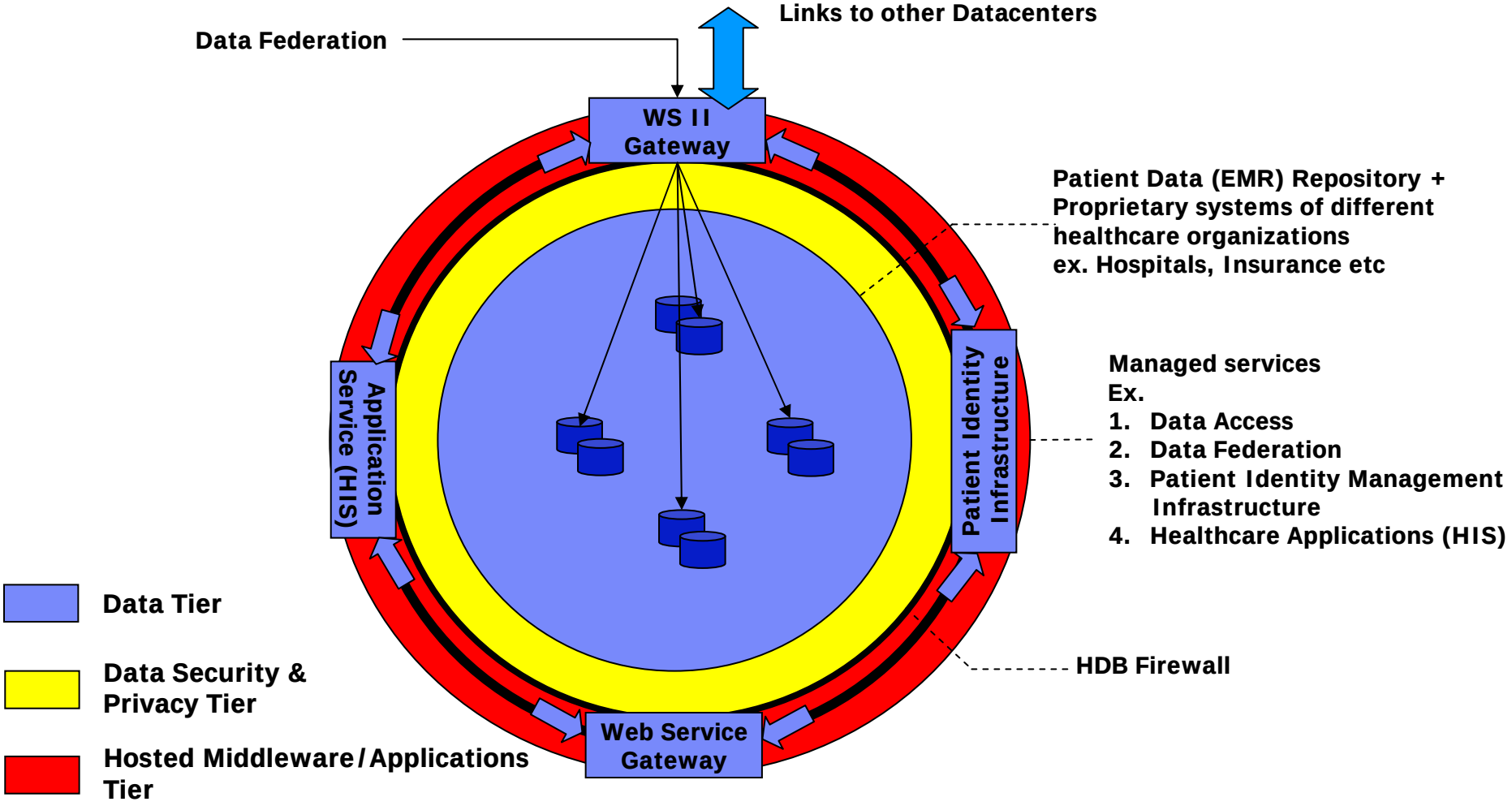
Background: India Healthcare Hyper-growth plan

- The Executive Summary in a hyper-growth plan for Healthcare in India makes the following points (from a draft document dated February 2005)
  - Health insurance is on the rise, and is creating incentives for driving efficiency and quality improvements in hospitals
  - Professionally managed private hospital chains have emerged, and are growing
  - Innovative high-volume business models are emerging around specialty care
  - Healthcare is high on the National agenda
  - Success in healthcare in India will have global implications for IBM
    - Medical BTO, pharma clinical BTO, and medical tourism to India are on the rise
    - There is strong demand for proven global solutions, e.g., clinical ISV applications, standards-based healthcare middleware, data warehousing, *etc*.
    - Successful models for hospitals and insurance will provide strong references for other developing markets
  - Suggests three market experiments with key customers early in 2005-2006:
    1. Insurance claims connectivity pilot with one or more insurance companies and TPAs
    2. EMR pilot with Apollo and other hospitals
    3. Hospital BPTS offering pilot with a hospital partner

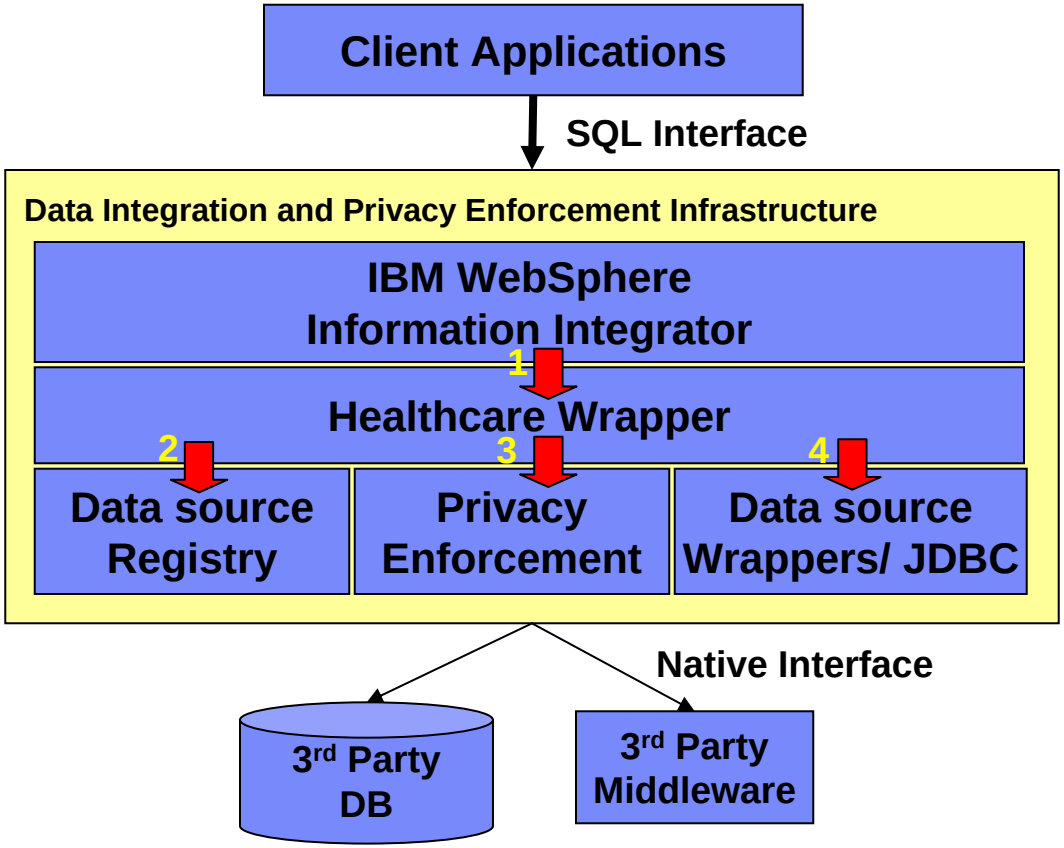
Distributed Healthcare DataCenter Overview



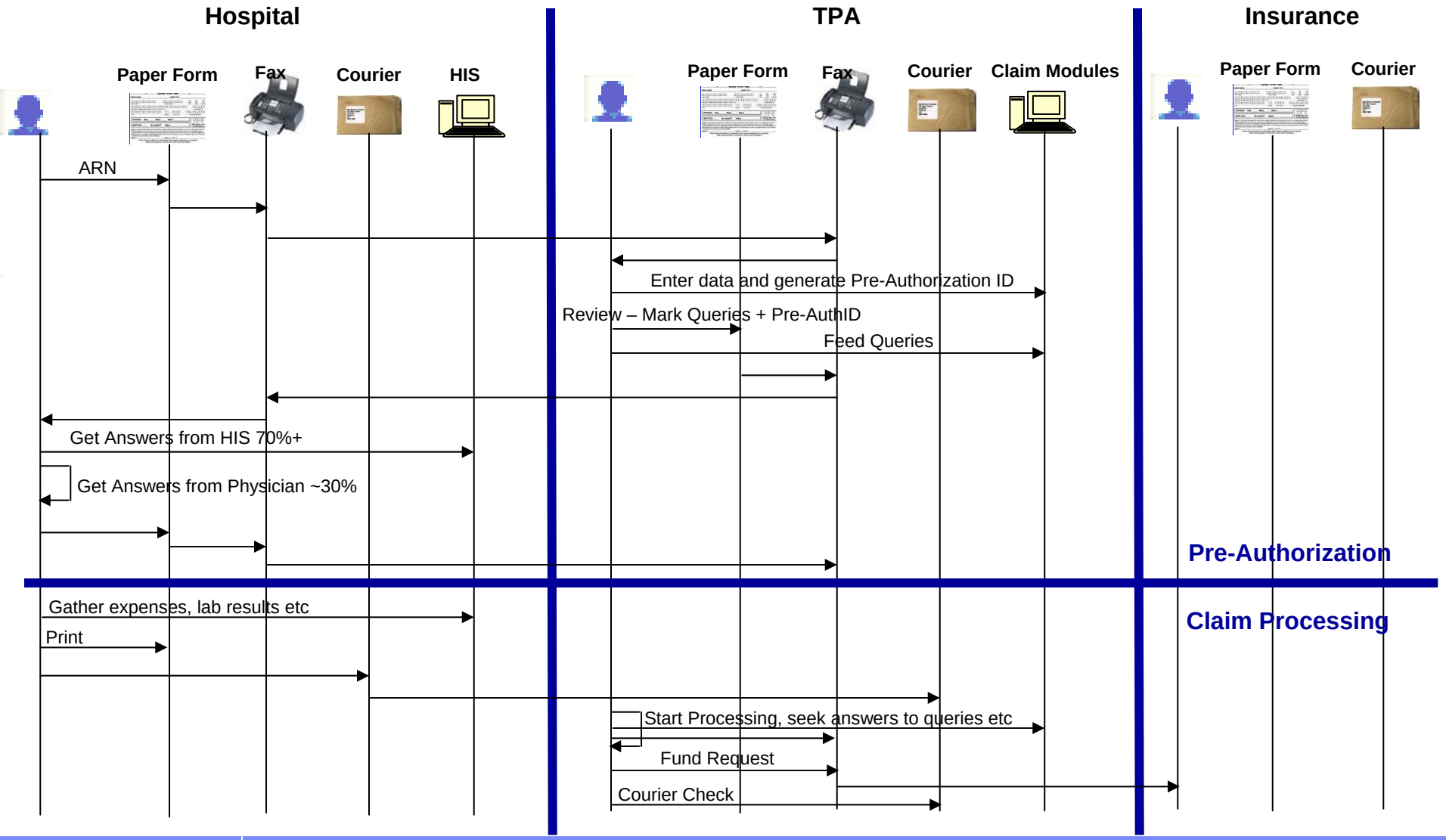
Healthcare Datacenter Stack



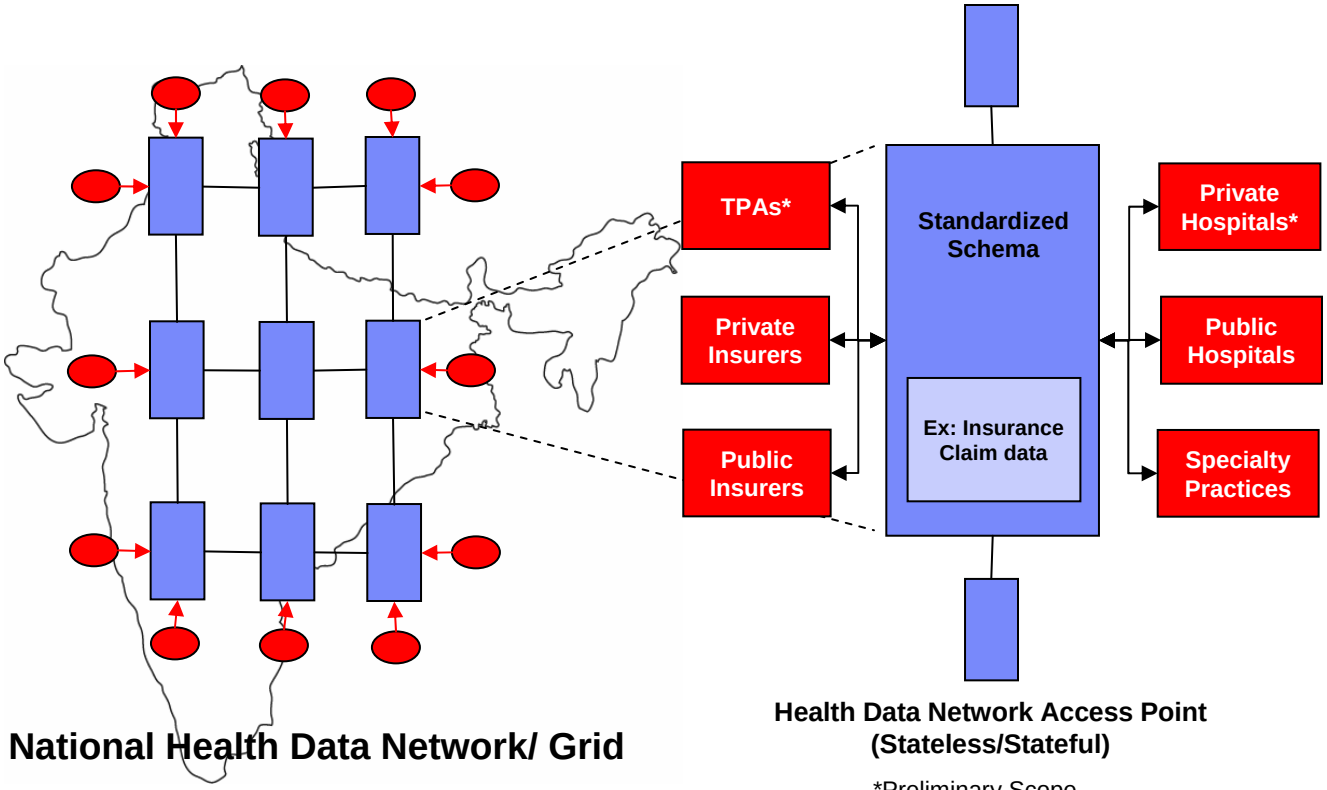
Data Integration & Privacy Enforcement Architecture



Claim Processing Sequence Diagram



Repository Based Architecture



Health Data Network Access Point (Stateless/Stateful)

*Preliminary Scope

Health Data Network Offers:

1. Standard data model over relational Schema.
2. SQL interface and query capability to aggregate data across desperate data sources allowing easy & rapid EAI.
3. Flexible (persistent/non-persistent) communication channel among multiple health care entities.

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Strategic Information Management in Integrated Care – a Systematic Approach

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Abstract

Integrated care is an important element in achieving more efficient and effective health care. Information technology plays a vital role in implementing integrated care. In this paper, specific challenges of strategic information management in integrated care are approached.

Methods: Based on literature, two opposite organizational forms of integrated care are described: integrated care networks and hierarchies. A literature analysis concerning information management in integrated care was performed. The publications were indexed with regards to discussed scope of information management. Publications, that were assigned to strategic information management were analyzed with respect to their perspective (national/ regional or integrated care organization). In closing, specific conditions of strategic information management in integrated care are discussed.

Results: 56 of 88 publications could be assigned to strategic and/ or tactical information management. Information strategies were mainly formulated from a regional or national perspective. 3 publications described strategies for hierarchical forms of integrated care. It is concluded, that the absence of centralized authority in integrated care networks requires specific methods of strategic information management.

Keywords:

information management, integrated care,
medical informatics

Introduction

Improved coordination of health care is seen as a key issue in enhancing efficiency and effectiveness [1]. Given the degree of differentiation in health care regarding professionals, units and organizations which leads not only to complex coordination problems, but is also a great strength of the system, integration should be increased [2, 3]. The term “Integrated care” characterizes an organizational status, in which shared care, continuity of care and seamless care are achieved, tailored to individual needs [4-6].

Information technology is often regarded as a prerequisite for integrated care [6-9]. Equivalent to institutional information systems, transinstitutional information systems that support integrated care should be managed systematically. In this paper, we focus on strategic information management, which aims at translating strategic goals into information strategies [10]. While strategic information management is well described for institutional settings, e.g. [10, 11], it is not clear, how it can be implemented in transinstitutional situations [12], such as integrated care.

To approach this problem systematically, the following research questions are addressed in this paper:

Q1 Which organizational forms of integrated care are currently observable?

Q2 Which scopes (strategic or tactical) of information management in integrated care are discussed in current publications?

Q3 What can be concluded by the results of Q1-Q2 regarding strategic information management in integrated care?

Methods

Q1 is answered by applying a framework for systematizing organizational relations in general, e.g. [13, 14] and in health care, e.g. [15-17] with regards to the arrangement of institutions and management within integrated care.

To answer Q2, a literature research was conducted. The study design was designed as retrospective and prolective [18]. Using the pubmed database, we searched for publications with the following limitations: only journal articles were allowed that were published between 2001/10/01 and 2006/10/01, an abstract had to be available and the language had to be English. The queries were conducted on 2006/11/06.

Our goal was to identify publications that deal with the role of medical informatics, information systems or information management in integrated care. In order to generate comprehensive results, we combined each of the MeSH terms “Medical Informatics”, “Information Systems” and “Information Management” with each the following terms related to integrated care: "Delivery of Health Care, Integrated" (MeSH), "Continuity of Patient Care" (MeSH), “integrated care”, “seamless care”, “shared care” and “health networks”. Thus, 18 queries were performed. The relevant publications were indexed with respect to their scope, i.e. assigned to strategic and / or tactical information management [10]. Publications assigned to strategic information management were classified regarding their perspective (national/ regional or integrated care organiza-

tion). The indexation was performed based on the abstracts. If the information contained in an abstract was regarded as not sufficient for indexing, the full article was analyzed. Q3 is answered in the Discussion section by arguing with respect to results of Q1 and Q2.

Results

Q1 Organizational Forms of Integrated Care: hierarchies and networks

Organizational aspects of integrated care can be analyzed at an external level, management level, institutional or patient level [16, 19, 20]. In this paper, we focus on the management and institutional level. Integrated care means division of labour across professionals, units and institutions. This requires coordination [2, 21].

Two basic coordination mechanisms define the boundaries of a range with different organizational forms [13, 21, 22]. One approach is to establish hierarchical organizations, i.e. integrating health care providers of the same level in the value chain (horizontal integration) and of different levels (vertical integration) under unified ownership. Here, division of labor is coordinated through authority [21]. This approach has been pursued in the United States, where large Health Maintenance Organizations (HMOs) have been founded. As summarized by Wijngaarden et al [2], HMOs have been criticized for integrating structures without improving the alignment of care processes to patient needs.

In opposite to hierarchies, another coordination mechanism is to coordinate division of labor through formalized cooperation and exchange relationships between legally independent institutions [16, 17]. We refer to these forms of collaboration as integrated care networks (ICNs). It has been shown in different countries, that ICNs can be successful in providing integrated care across professions, functions, sites and over time [1, 2, 23].

Between the two basic forms hierarchy and ICNs, many different organizational arrangements can occur which possess characteristics of both hierarchies and ICNs. These intermediate forms can therefore be termed “hybrids” [24]. Regarding management, hybrids can be organized from completely independent and decentralized management units to centralized management units with high level of authority, [24], as illustrated in Figure 1.

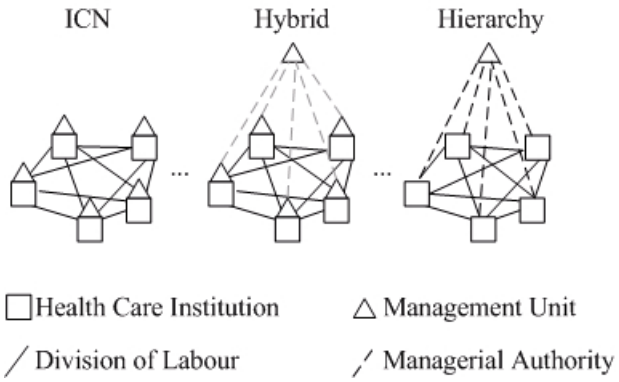

Figure 1 – The organizational continuum of management in integrated care

Q2 Current scopes of Information Management in integrated care

Our pubmed queries returned 269 different publications. 181 publications were excluded, because they discussed either ICN OR issues of medical Informatics/ information systems/ information management, but not both. Of the remaining 88 publications, 56 publications could be assigned to strategic and/ or tactical information management.

Table 1 – Assigned scopes of information management

Scope of Information Management	
Strategic	15
Tactical	48

Most of the publications were assigned to tactical information management. Hence, the focus was on specific technological issues of transinstitutional information transfer. Some publications presented concepts, in which transinstitutional information systems were seen as enablers for integrated care or related concepts, e.g. [25-28]. Another group of publications specified their concepts by describing technological approaches. Here, interoperability and security were the predominant subjects. With regards to interoperability standards such as HL7 respectively CDA were discussed in order to support transinstitutional information exchange, e.g. [29-31]. Security was discussed mainly from the view of access control and authorisation, e.g. [38-41], as well as information transfer, e.g. [32, 42, 43].

Beside the conceptual papers, pilot projects of electronic transinstitutional information transfer were described, e.g. [32-37]. Some publications presented evaluations, e.g. [45-47].

15 publications engaged information strategies or at least approached the topic. As Table 2 summarizes, 12 of these publications formulate strategies to enhance transinstitutional information sharing on regional or national level. Three publications could be identified, that present information strategies for organizational forms that aim to provide integrated care. These three publications refer to hierarchical health care organizations in the United States such as the Veterans Health Administration and PeaceHealth, e.g. [56, 58] [57].

Table 2 – Perspectives of Information Strategies

Author, Title	Perspective
Asp et al (2003): A conceptual model for documentation of clinical information in the EHR [48]	national
Burton et al (2004): Using electronic health records to help coordinate care[26]	national
Dietzel (2003): The electronic health card as a tool for seamless care. German activities to implement telematics [49]	national
Dimond (2005): Electronic health record and electronic patient record [50]	national
Halamka et al (2005): Health care IT collaboration in Massachusetts: the experience of creating regional connectivity [51]	regional
Harno (2004): Integrated regional services: are working process changes desirable and achievable? [52]	regional
Itkonen (2003): North Karelia regional chain of care: Finnish experiences [53]	regional
Malmqvist et al (2004): Sjunet--the national IT infrastructure for healthcare in Sweden	national
Mann (2005): From "silos" to seamless healthcare: bringing hospitals and GPs back together again [28]	national
Mohan et al (2004): The Malaysian Telehealth Flagship Application: a national approach to health data protection and utilisation and consumer rights [54]	national
Orphanoudakis (2004): HYGEIAnet: the integrated regional health information network of Crete [55]	regional
Schabetsberger et al (2006): From a paper-based transmission of discharge summaries to electronic communication in health care regions [44]	regional
Memel et al (2001): Development and implementation of an information management and information technology strategy for improving healthcare services: a case study [56]	Hierarchy
Nolan et al (2005): Using a framework for spread: The case of patient access in the Veterans Health Administration [57]	Hierarchy
Malone et al (2005): Developing and implementing a patient-centered IT strategy [58]	Hierarchy

Discussion

As presented, integrated care can be achieved through different organizational arrangements. In many countries a trend towards the ICNs is observable [2, 21].

The conducted literature analysis revealed that information technology plays a central role in implementing integrated care. However, it also revealed, that strategic information management is an unsolved issue in non-hierarchical organizational forms of integrated care. Most research focuses on technological challenges, such as security and standardization. Without denying the complexity and relevance of this research, we see a research gap with regards to how align transinstitutional information systems to organizational settings in integrated care. Information strategies are formulated exceptionally on regional/ national levels or with respect to hierarchical organizations.

The specific feature of ICN with regards to strategic information management is, that an ICN on the one hand is a conglomerate of different institutions, whose strategic goal systems overlap only in a limited scope and that on the other hand possesses no centralized management that could implement an information strategy by authority. In hybrid organizations it is also unclear, how a centralized information management is related to institutional information management.

For future research, we aim at constructing a framework for describing organizational forms of integrated care more precisely. Furthermore, we want to systematize specific requirements on information management in integrated care in order to develop adequate methods. Here, a key issue will be the balancing of different strategies within ICNs or hybrid forms in order to develop comprehensive information strategies.

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Shortage of Beds: A Local Solution for a Global Concern. A Traffic Light System

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Abstract

Bed shortage is a growing world problem and affects health care endangering patient safety, increasing length of stay, costs and morbimortality rates. The objective of this paper is describe a local solution centered on nurses and clerks work on intrahospital patients' transfer. Hospital Italiano of Buenos Aires gives on line support to the hospital census of 650 beds. There are 3000 inpatients admissions per month, with approximately 9500 transfers. This is possible due to an integrated Electronic Medical Record and ADT System (Admission, Discharge, and Transfer). In spite of transferring patients on line , with low beds availability setting, nurses depend and rely on telephone calls, wasting time on arranging a transfer in extreme situations, occupy beds without checking the Admitting Coordinator causing problems to others actors whom were waiting for that bed. As a solution to this problem the ADT System will be improved with a traffic light system with a bed waiting list, in which bed ordering from ICU and operating rooms are prioritized, with a bed differentiated display on the Nurse Control Chart establishing an asynchronic but effective communication.

Keywords:

bed occupancy, admitting department, hospital, patient transfer, inpatients

Introduction

Shortage of beds is a problem that affects all hospital system decreasing productivity and efficiency. This situation is a direct consequence of patient-flow problems[1]: in a hospital environment, a patient is admitted to the hospital, transferred and discharged when leaving the hospital.[2]

Trustworthy and on time updated the information where inpatients are as knowing availability of non occupied beds, is a critical aspect in daily hospital resources management. Since bed occupation information is not always well documented on information systems , the lack of correlation results in several complications such as cancellation of the admission of patients due to not having an accurate number of vacant beds[3] or employ human resources in nonessential functions like nurses calling to different hospital areas looking for non occupied beds [4]

Low availability of beds occurs during seasonal peaks, in this case reliable information of hospital census becomes critical [5], as well as to avoid bottle necks on passage of patients from one ward to another, commonly observed in the intensive care unit (ICU) and anesthetic recovery rooms

The objective of this paper is to propose a solution to this point being centered on nurses and clerks working on inpatients transfer.

Materials and methods

Setting

Hospital Italiano of Buenos Aires is a Hospital with 650 beds allocated in levels such as, general in-patients areas, intermediate and intensive care units. There are 3000 inpatient monthly admissions, with approximately 9500 transfers.

Hospital Italiano has been integrating several informatics systems in clinical layer with an Electronic Medical Record (EMR) that runs on web platform. The nurses work on a Nurse Control Chart (NCC) in which they organize human resources for each inpatient area and follow their assigned patients. In the field of Admission and Discharges patients, a software for their management was developed and called ADT system (Admission, Discharge, Transfer) This application made it possible to health care providers (nurses, doctors), stretcher-bearers (orderlies) and Admitting Department staff to make maintenance of Hospital census on line. But with the Online Census, bed occupancy information management was ameliorated but we realized that although all of the transfers were done through the system, disagreements with real bed occupation continued. A description of the issue is explained below and different situations will be described.

Two settings are related to intrahospital patient transfer:

- Appropriate beds availability: meaning there is an appropriate obtainable amount of beds.
- Low beds availability: means that there is not an appropriate obtainable amount of beds.

When the nurse needs to transfer a patient with appropriate beds availability, she chooses and allocates a vacant bed on

the EMR for this patient. If the transfer of the patient requires a stretcher bearer she asks for him through the system. When the patient leaves the bed, a housemaid prepares this room for the next patient. ***With low beds availability*** she **has to telephone** the Admitting Coordinator asking for a non occupied bed. When it is accomplished, a **Synchronic Communication between Nurse-Coordinator** occurs. If there are not "ready for use" beds, the Admitting Coordinator reserves ones.

These activities have these disadvantages: dependency on telephone call that not always can be achieved, causing delays, in extreme situations, nurses occupy beds without the Coordinators reply causing problems to others actors whom were waiting for that bed; in addition, it must consider wasted time on the arrangement of this transfer.

Considering these situations, and for **optimizing resources,** improvements are developed. The changes include : reorganization of the inpatients section on the system and introduction of "traffic light" concept with a Bed waiting list so as to increase the availability of beds.

Results

Modification developed on the ADT System, EMR and Nurse Control Chart (NCC)

The improvements on ADT system will be: inclusion of *Bed Manager* for the Admitting Manager, addition of *Stretcher Bearer Manager* for Stretcher Bearer Coordinator and inclusion of *Housemaid Manager* for Housemaids.

Hospital map will be redefined on ADT system as *Non Centralized Units* (ICU and operating rooms) and *Centralized Units* (Adult, Pediatric and Geriatric Areas) Inpatient areas from our Hospital were reorganized and combined in Sectors Admitting Units (SAU), and each of one is coordinated by an Admitting Manager using a *Bed Manager*. Admitting Manager with Bed Manager can have a quick view of inpatient episodes with discharges in progress, save beds for scheduled admissions for the following days is enlisted and the reservation can be done in accordance with each patient, administrate non-scheduled Admission (emergencies) and save beds for intrahospital transfer. Depending on number of occupied beds (higher than 85%) SAU Admitting Manager sets up on Red or Green for each SAU on the system.

When nurses need to transfer a patient to a SAU "in Red" (low availability) asks for a bed through the EMR. The solicitation is automatically enlisted in the Admitting Manager waiting list while the nurse continues working on their activities establishing an **Asynchronic communication between Nurse-Admitting Managers.** The system prioritizes ICU and operating rooms. When a bed is granted by the Admitting Manager, the system indicates an active reservation on the Nurse Control Chart: color bed changes *and* shows patients beds in four different colors. Depending on this color nurses can quickly identify who of their assigned patients have a pending transfer or is being discharged. Nurse continues with the transfer, with a reserved bed. A reserved bed has an expiration time, it has to be accepted within 3 hours by the nurse or the reservation is lost.

Discussion

Bed shortage is a growing world problem and affects health care endangering patient safety, increasing length of stay, costs and morbimortality rates. [1] As a solution to this problem a traffic light system with waiting list and asynchronic communication is presented. This work was merely descriptive and we consider it as limitation of this paper. This is an only an approach and our intention is compare how long every actor involved on Patient Flow spends on his work and how long every actor, mainly nurses, would save with changes introduced, as to show the efficacy of our implementation. We estimate that allocate beds and transfer patient task would be performed faster, and on the other hand , with a low beds availability setting, the improvements applied would give an opportunity for better bed management.

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A local solution for a global concern
Shortage of beds: A traffic light system

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Introduction

- Shortage of beds affects all hospital system decreasing productivity and efficiency
  - ⟶Factors that contribute to this situation
    - inappropriate nurse-patient ratio
    - delay in rooms cleaning after discharge patients
  - ⟶Direct consequence of patient-flow problems

- Bed shortage affects health care
  - ⟶Endangers patient safety
  - ⟶Increases length of stay, costs and morbimortality rates.

Introduction (cont.)

- Bed occupation information not well documented on information systems produces
  - ⟶cancellation of the admission of patients
  - ⟶employ human resources in nonessential functions
- Low availability of beds occurs during seasonal peaks
- Bottle necks exist on passage of patients from one ward to another

This work

- Describes a possible solution centered on nurses and clerks working on inpatients transfer.

- Approach to a plan of two parts.

  →compare how long every actor involved on Patient Flow spends on his work and how long every actor would save with changes introduced, as to show the efficacy of our implementation.

Materials and Methods: Setting

- **Hospital Italiano de Buenos Aires**
  - ⟶Academic Medical Hospital with 650 beds
  - ⟶3000 inpatient admissions monthly, with 9500 transfers
  - ⟶Electronic Medical Record (EMR) that runs on web platform.
  - ⟶The nurses work on a Nurse Control Chart (NCC)
  - ⟶ADT system (Admission, Discharge, Transfer) made possible to make maintenance of Hospital census on line.
  - ⟶Hospital census had a 14% error on information before implementation Census on line. Two cross-sectional studies demonstrated a 5% decrease on global error
  - ⟶Bed occupation information was better documented on the system due to online support.

Materials and Methods: Necessity

- When the nurse needs to transfer a patient:
  - ⟶With low beds availability
    - She **has to telephone** the Admitting Coordinator asking for a non occupied bed.
      - **Synchronic Communication between Nurse-Coordinator**

- Disadvantages:
  - ⟶Dependency on telephone call
  - ⟶Nurses occupy beds without the Coordinators reply.
  - ⟶wasted time on the arrangement of this transfer.

- For **optimizing resources,** improvements were developed on ADT system, EMR and Nurse Control Chart.

Results: Modifications

- Inpatient areas reorganized in Sectors Admitting Units (SAU) on ADT
- ADT System: Inclusion of Bed Manager for the Admitting Manager

  →when his SAU has bed occupancy higher than 85% can define it as “in Red”.

Color	Condition : bed occupancy
Green	lower than 85%
Red	higher than 85%

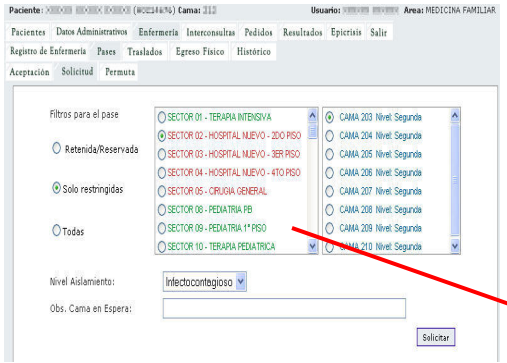
- EMR :Bed ordering System
  - bed ordering is enlisted in the Admitting Manager waiting list.
  - This solicitation is done on the EMR where nurses can visualize the SAU in Red or Green.
- Nurse Control Chart (NCC): Nurse Bed differentiated display

Results: Change on Nurse Workflow

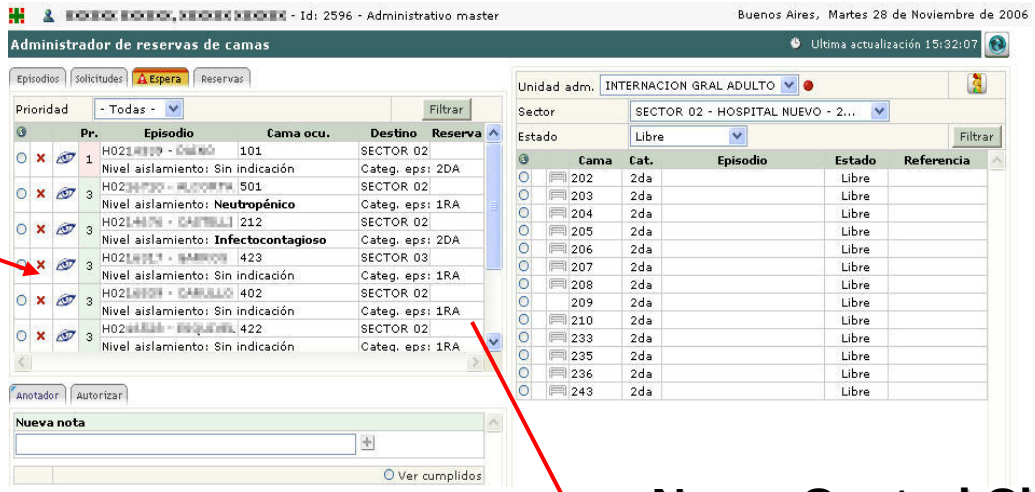
- When the nurses need to transfer a patient to a SAU “in Red” (low availability)
  - ⟶Asks for a bed through the EMR
  - ⟶The solicitation is automatically enlisted in the Admitting Manager waiting list (ADT) establishing an **Asynchronic communication between Nurse-Admitting Manager.**
  - ⟶When a bed is granted by the Admitting Manager, the system indicates an active reservation on the Nurse Control Chart (color bed changes) nurse continues with the transfer, with a reserved bed which has an expiration time

Results (cont.)

EMR



ADT System: Bed Manager



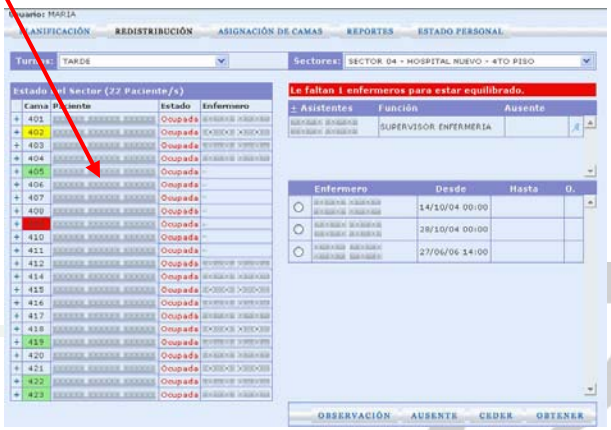
Waiting List

Bed Solicitation

color bed changes

Green	Patient, who occupies this bed, is being discharged from the hospital.
Yellow	Patient, who occupies this bed, has another one already reserved for him. Transfer can be done ***without delay*** due to be a vacant reserved bed.
Red	Patient who occupies this bed has another one already reserved for him. Transfer can be done ***with delay*** because is an occupied reserved bed.

Nurse Control Chart



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Building Care Delivery Systems for Patient Value: Adding Nursing to Evidence-Based Practice

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Abstract

Healthcare organizations in every country are exploring how to develop clinical best practices to guide delivery of safe, effective and appropriate health care as rapidly as possible. This paper reports on the innovative work of a major collaborative evidence-based practice (EBP) research initiative that adds nursing knowledge into team care protocols for the full life cycle of specific health conditions, e.g. congestive heart failure and nurses' clinical adoption of these new tools and practices.

Keywords:

nursing knowledge, best practices, evidence-based practices, nursing standard terminology; nursing data sets, data infrastructure, patient value

Introduction

Numerous efforts have been made to fill the quality chasm stemming from wide variations in practice patterns and access to healthcare providers. There have been intense efforts to develop and apply the best possible science to inform healthcare delivery [1-3]. Surprisingly, even though nurses are considered "knowledge workers," much of what nurses contribute to the care process and outcomes of care is not visible. This invisibility also extends to the data captured and stored in local, regional and national EHR systems [4]. In 2002, Aurora Health Care, Inc., a large Wisconsin-based integrated health system, prepared to implement plan of care clinical documentation across its delivery system. Aurora encountered a near total absence of evidence-based nursing content available to use within its clinical information systems (CIS). The research project reported here emerged from discussions on how best to address that void [5]. The scope included the redesign of care protocols to cross the full care continuum using evidence-based content for the care team. The decision was made to adopt a rigorous research methodology to generate best practice content in view of the many barriers that impede healthcare professionals in obtaining and applying best evidence. These barriers include a lack of clinician competency for literature searches, study evaluation and implementation, unfavorable attitudes toward EBP, and less supportive external environments [6].

Methods

The methodology used addresses the following three research aims:

1. to discover and generate the evidence-based nursing knowledge related to major clinical conditions
2. to define a framework for representing that knowledge to clinicians to use in clinical practice
3. to provide structured data using standard nursing terminologies for quality measurement, outcomes and research

The team started the knowledge generation process by working with clinical nurse experts to "name" and rank the "phenomenon of concern" that most commonly occurred in the care of their patients with major health conditions. Once identified, the research team used a systematic search and critical appraisal process to discover, synthesize, and organize the knowledge content to align with the nursing process. The second step in this process is the translation of the synthesized content into nursing knowledge for clinician application at the point of care into the work flow, decision support rules engine. The nursing knowledge is embedded in the assessment documentation content, decision support rules engine and into pre-built plans of care.

The EBP content was divided into two types of nursing knowledge for representation within the CIS - referential and actionable knowledge. Referential knowledge can be accessed as a point of information by any team member through a reference knowledge database that provides descriptions of the given problem, interventions Actionable knowledge refers to the actions that are programmed into the clinical rules engine for the system in response to the given documented value or result. Thus, the actionable knowledge is available at a screen level linked to a given procedure, topic or data element.

Concept representation

Since the ability to communicate, transfer and compare nursing data is essential to meeting the aims of this collaborative project, a dedicated terminology task group was built into project activities from inception. This team has focused specially on concept representation and the application of terminology standards to the nursing data embedded under the categories of assessment, diagnosis, interventions and outcomes. The terminology task group used international standards to guide the concept representation work, including (a) International Organization for Standardization ISO 18104:2003 Health Informatics – Integration of a reference terminology model for nursing [7], (b) International Classification for Nursing Practice (ICNP®) [8], and (c) Systematized Nomenclature of Medicine Clinical Terms (SNOMED-CT) [9].

Results and findings

To date 15 nursing "phenomenon of concern" have been developed into EBP recommendations for assessments, problem identification, plans of care, and outcomes evaluation. An initial pilot test was conducted at a 72-bed acute care site and focused on one phenomenon - Activity Tolerance. The pilot evaluation aimed to assess the extent to which the embedded knowledge pertaining to Activity Tolerance was utilized by nurses at the point of care. The sample of 773 adult patients (age 18) admitted from July 1 to October 31 2006 was used for this preliminary analysis. All the subjects projected for the analysis were medical patients and admitted for emergent services (72%) with a mean length of stay of 5 days (SD =4.6). The majority of patients were female (57%). Mean age of subjects was 59.3 years (SD = 19).

Table 1 - Summary of Nurse-Sensitive Outcomes

- **Activity level tolerated appropriate to level required in discharged setting (85.3%)**
  - **Met: 61.3%, Not Met: 24%, Missing: 14.7%**
- **Functional status maintained or improved relative to baseline ADL Index score (84.7%)**
  - **Met: 64.2%, Not Met: 20.5%, Missing: 15.3%**

Basic Descriptive Correlations: Activity Intolerance

Medical Patients (*n* = 773)	Mean Age	Mean Functional Score	Mean LOS	Readmission (Mean days)
Patients w/o Activity Intolerance (n = 494)	53.7 ± 18	11.17 ± 1.7 (*n* = 29)	3.8 ± 2.4	10.1% (*n* = 50) (34.8 ± 30.8)
Patients with Activity Intolerance (n = 279)	69.2 ± 16.8	6.1 ± 3.6 (*n* = 133)	6.0 ± 3.6	19.4% (*n* = 54) (27.7 ± 24)

Table 1 shows the significant differences in age, functional activity score, length of stay and readmission rates for those medical patients without activity intolerance (n=494) and those medical patients assessed as having activity intolerance (n=279). Nurses' documentation indicated that functional goals were documented as "met" in a little over 60 percent of the time with missing documented values for about 20 percent of discharged patients. The poorer health indicators for the patient group assessed as having activity intolerance also shows almost double the readmission rate as compared to the patient group without activity intolerance. We will continue to track these outcomes as our analyses evolve and we expand our integration of evidence based nursing in all aspects of nursing operations and culture.

Table 2 presents our approach to the descriptive analyses for nurses' compliance to the evidence-based recommendations within the ACW conceptual framework: general assessment,

focused assessment, nursing intervention, and outcome measurement. Focused assessments were to be performed if further assessments were necessary for a patient based on the findings of the initial general assessment. For example, if a nurse identifies that a patient needed "assistance" for Activity of Daily Living (ADL) prior to the admission, a decision support rule is triggered by the system. Additional assessment factors are then presented for the nurse to examine the level of functional status of the patient.

Table 2 - Nurses' compliance to the evidence-based recommendations related to activity tolerance

Care Component	Percentage of Compliance
Patient Assessment (General)	(*n* = 773)
• ADL's prior to admission	86%
• ADL activity	99%
Functional Assessment (Focused)	(*n* = 279)
• ADL Bathing	48%
• ADL Continence	48%
• ADL Dressing	48%
• ADL Feeding	48%
• ADL Toileting	48%
• ADL Transferring	48%
• ADL Index Score	48%
Plan of Interventions Established	(*n* = 773) 89%
Outcome Measurement	(*n* = 773)
• Activity level tolerated appropriate to level required in discharged setting	85%
• Functional status maintained or improved relative to baseline ADL Index score	85%

These findings show that the nurses were doing initial assessments at nearly 100 percent but completed follow-up assessments at only 48 percent of the time. In addition, while nurses took the next step of activating interventions and documenting against outcome measures at a rate of 85 percent compliance, they predominantly choose to work from a common universal plan of care rather than the specific problem plan of care. Use of the universal plan of care reflected the care approach prior to implementing the EBN plans of care. Thus, we view these behaviors as indications of incomplete clinical adoption by nurses. In summary, lessons learned regarding nurses' clinical adoption indicate a need to reengage with the next rollout phase and give a more concentrated focus on the people and processes portion of the implementation over the technology.

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Web-service based Healthcare Information Presentation using Portable Device over wireless and wired network.

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Introduction

- In an ubiquitous healthcare domain, mobile computing system using mobile devices such as mobile phones, personal digital assistants (PDA) are carried nearly everywhere by excellent mobility and ease of accessibility.
- Web services now support a single uniform method for application integration through the Internet at distributed computing environments.
- In this paper, we suggest a healthcare information system that provides medical information on both wired and wireless networks with the following functions.
- First, the system provides medical information used for desktops on wired networks. Second, the system has a mobile context server that reconfigures web contents according to the mobile device.
- The mobile context server applies context to the contents by using styles, an attribute override, and templates according to the resources of a given mobile device.
- In this manner the system support reconfigured web contents to the mobile device.

Materials and Methods

- When a user requests medical information through a wired network, the web server serves the information by connecting to the databases of the web server.
- The mobile context server optimizes web contents according to the type of mobile device. The mobile context server was developed by Micro-soft and is called the Mobile Internet Toolkit. The Mobile Internet Toolkit filters mobile devices and creates “Device Specific/Choice” structure.
- The Device Specific/Choice filter can describe a style according to the browser type by using style sheets. In this system, a page is divided and made up of the select/result structure.

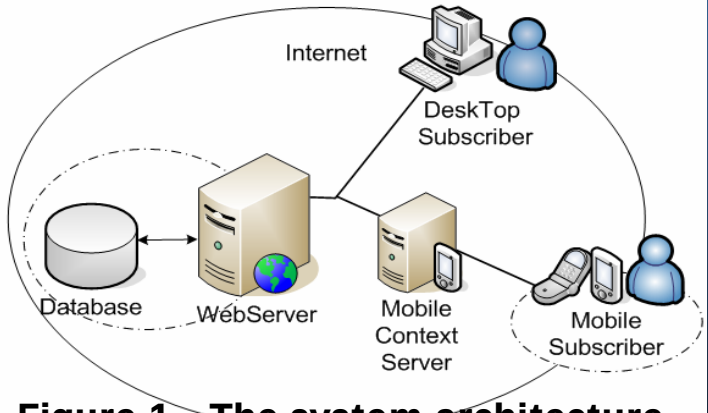

Figure 1 - The system architecture

- The system is conceptually composed of five main components: the web server, medical information database, mobile context server, mobile user, and desktop user.

Materials and Methods

- Using a tightly coupled application development approach provides certain safeguards from quality-of-service, security, privacy, data integrity, and complex transaction processing perspectives as compared to the Web Services architecture .

- After the system evaluates a mobile device's computing capacity, the system serves the web contents based on the context chosen by the mobile context server.

- When a user requests medical information through a wireless network, the mobile context server divides the con-tent pages according to the screen size of the mobile device. It also filters the pages according to mobile devices and then browses the adopted contents from the context server to the mobile web browser.

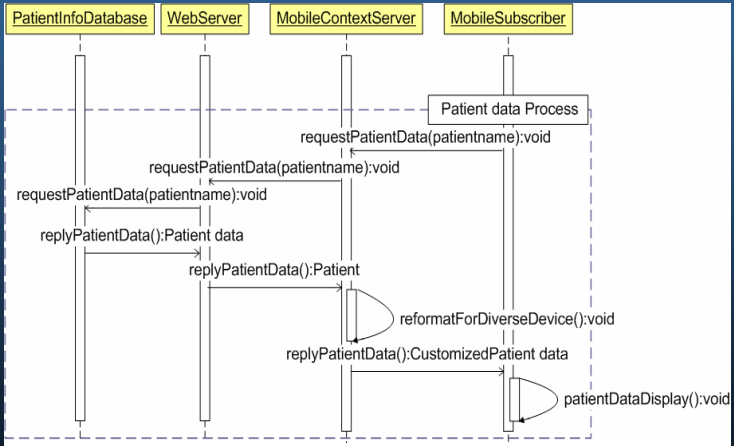

Figure 2 - Web service sequence diagram of a mobile device

- Figure 2 shows web service sequence diagrams of a mobile device.

- The mobile context server reconfigures contents offered by the web sever.

Results

- The web server was served using Microsoft IIS 5.1 and Microsoft Windows XP Professional. Server application was developed by Microsoft ASP.NET based on C# .
- The medical information database was served by Microsoft SQL-SERVER 2000. The context server connected to the web server acted as the web server. The user system served on the wired network was browsed by Microsoft Internet Explorer 6.0.
- The mobile web browsers used in the wireless network were a Microsoft MME 3.0 emulator, Microsoft Pocket PC 2003 PDA, HP i-PAQ H2200, or LG SC8000.

Results

- Figure 3 shows the contents that are displayed on the web browser using a wired network.

- The desktops shown have an adequate screen size, so web contents can be displayed on one screen. In this case, the content consists of the date, patient list, diagnosis, patient information, symptoms, and patient images.

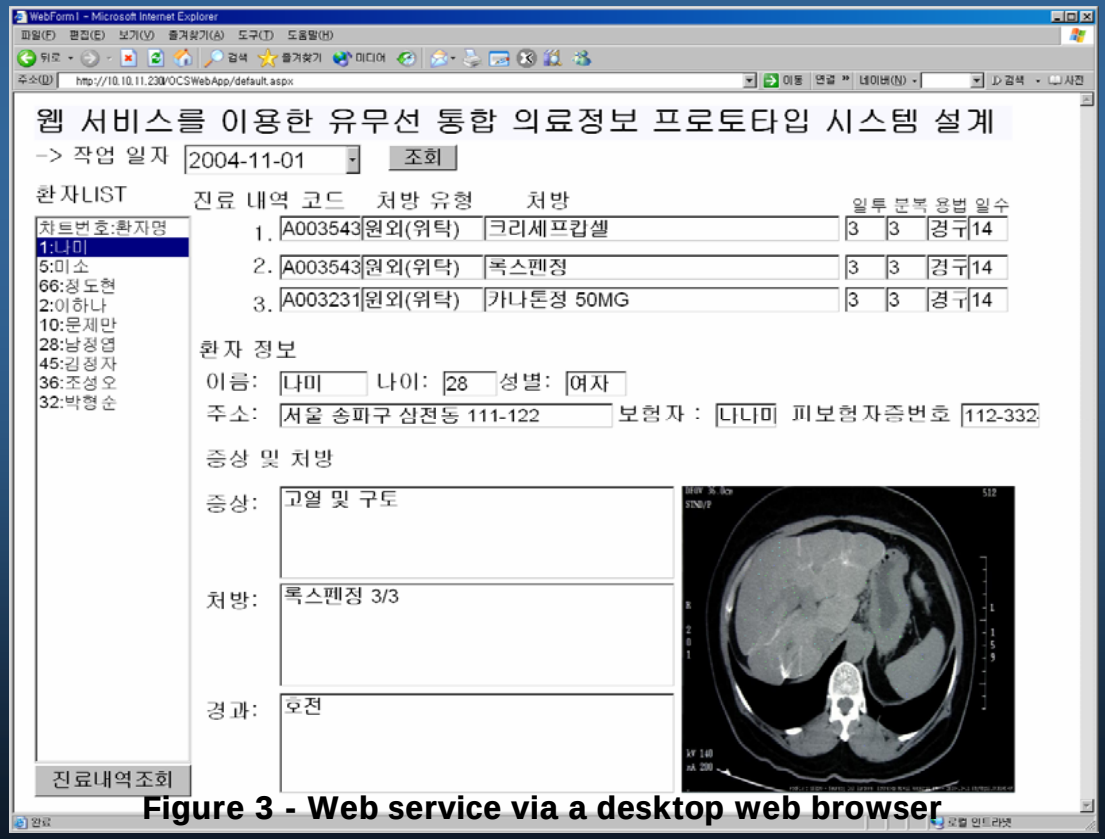

Figure 3 - Web service via a desktop web browser

Results-Experiment I

- This system is suggested to aid in faster diagnosis using medical information on both wired and wireless networks. It displays optimized web contents according to the user's browser resources.

- Figure 4 show the results displayed on a MME 3.0 emulator and HP i-PAQ H2200. This system can display optimized contents on mobile devices determined by the context server.

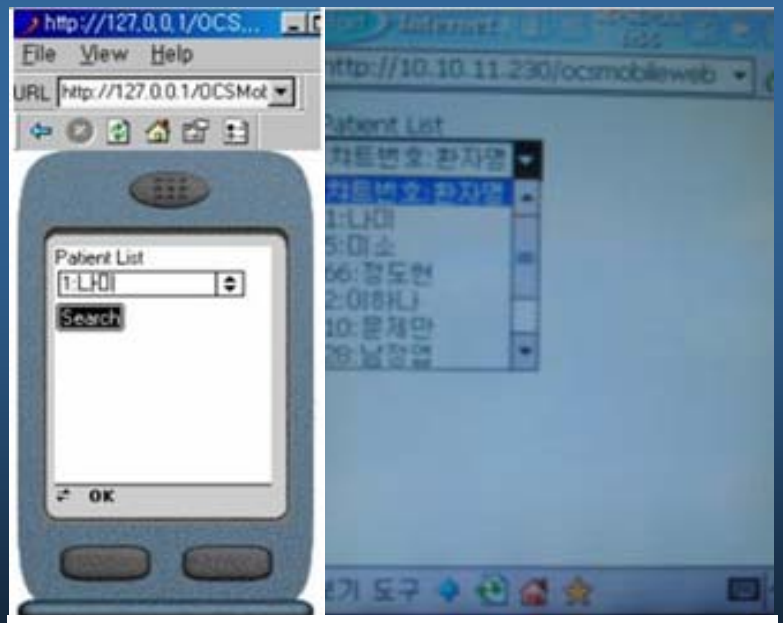

Figure 4 - Patient list page of various mobile browsers

Results-Experiment I

- Figure 5 shows the patient image. This application can enumerated the patient names using combo box control. Because each mobile device has its own screen size, the amount of information that can be displayed differs in each model.

Figure 5 - Patient image information

Results-Experiment II

- Figure 6 shows a divided web page for a mobile web browser. Our system divides the discharged web page into one “choose” page and eight “result” pages with considering the user friendly interface,

- C1 is a choose page of date and patient number. R1 is a result page of diagnosis confirmation. R2 is a result page of past history and present illness. R3 is a result page of physical exam. R4 is a result page of laboratory findings. R5 is a result page of result and plan. R6 is a result page of drug discharged. Finally, R7 is a result page of an MRI image

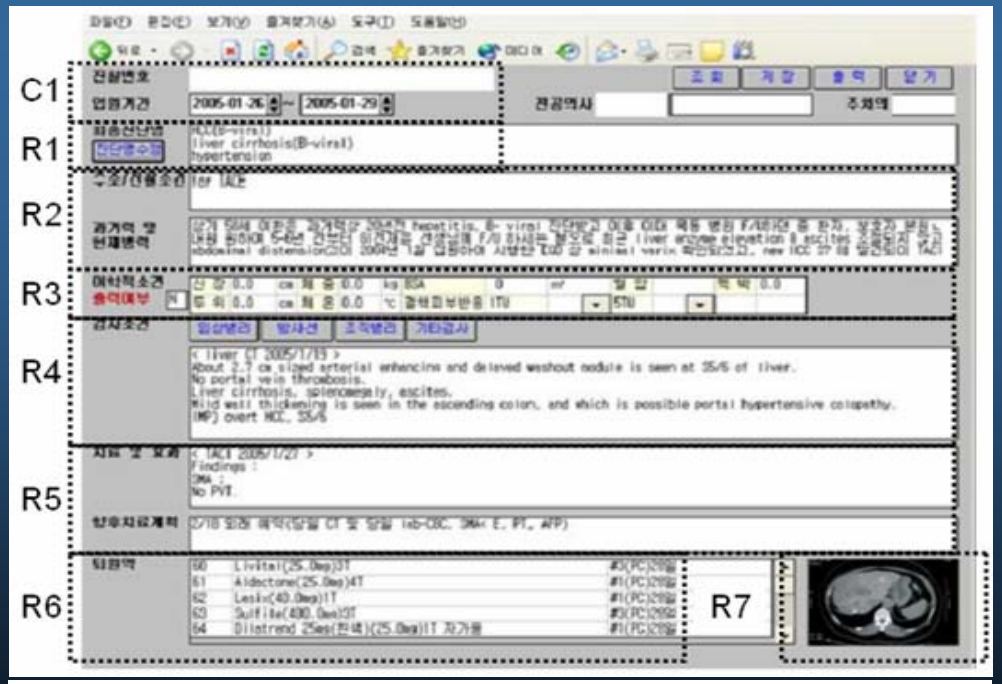

Figure 6- Discharge web page on the Order Communication System

Results-Experiment II

- As a result, the web service is considered an important technology to the healthcare system.
- Our proposed system solves some limits of mobile web services by using a mobile context server that applies context and serves information based on the type of mobile device.
- To develop this system from a prototype to a total healthcare system, additional patient information and research is needed, and a greater compatibility with divisions in dynamic web pages.

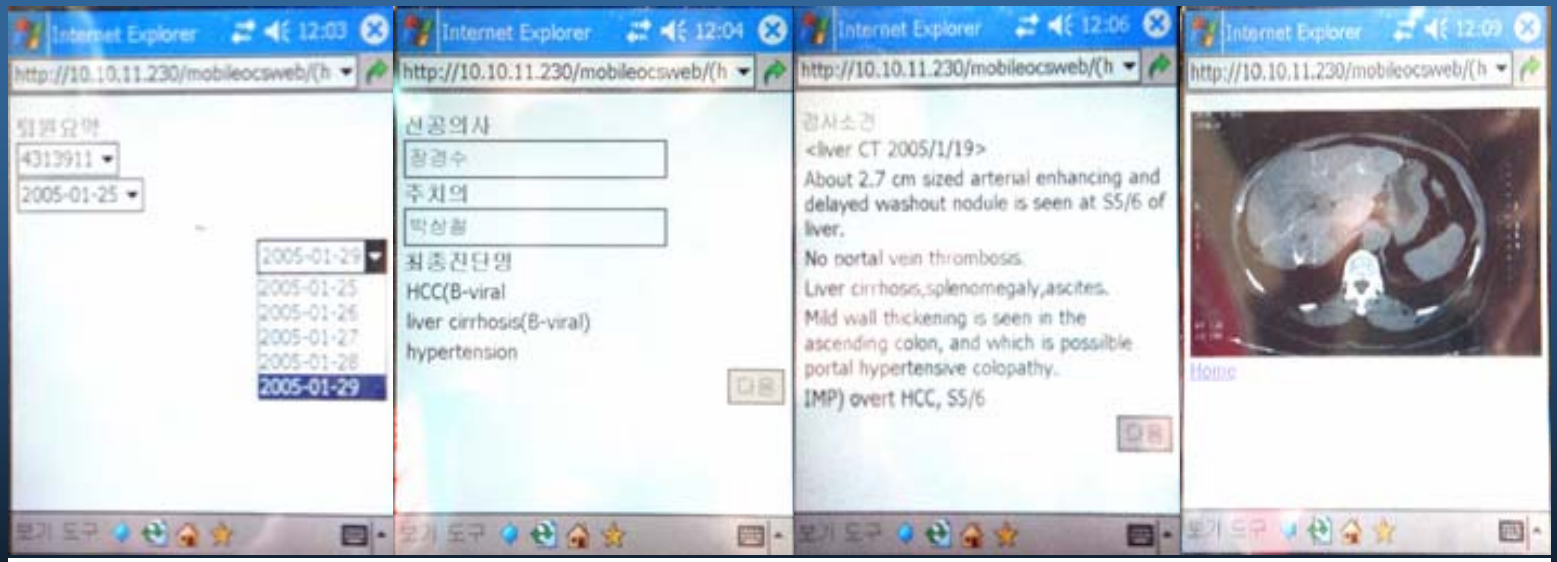

Figure 7. a) Date and patient number, b) Confirmation of diagnosis, c) Laboratory finding, d) MRI image

Discussion

- At present, there are not enough content applications to meet user requirements. Available existing web contents are mainly used for desktops on wired networks, but are not yet compatible with mobile web services.
- This paper suggested a healthcare information support system using Web services for wired/wireless integrated services according to the resources of a given device.
- This system solved some limits of mobile web services by using context server that applies context, and served information based on the type of device. So these results will help to implement effective web based healthcare information system at wired and wireless network environments.
- However, further complement research will be necessary. When regarding particularity of medical information system, enhanced security methods and healthcare information standard have to considered. Maybe HL7 can be one of alternative plan.

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Acknowledgments

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Web-service Based Healthcare Information Presentation using Portable Device Over Wireless and Wired Network

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Abstract

In an ubiquitous healthcare domain, mobile computing system using mobile devices such as mobile phones, personal digital assistants (PDA) are carried nearly everywhere by excellent mobility and ease of accessibility. This paper suggests a Web Services based healthcare information support system using portable device over wireless and wired network according to the resources of a given device. When a mobile device requires web services, a mobile context server reconfigures and offers the equivalent contents provided by the web server to suit the required device's resources.

Keywords:

healthcare, wireless, mobile, web service

Introduction

Web services now support a single uniform method for application integration through the Internet at distributed computing environments. In particular, they provide a model for accessing software systems over the web by pointing to their web address (URI), while their public interfaces and bindings are defined and described using an XML standard format. Mobile web services have the following features: interoperability of web services for desktop, internet compatibility, convenient use with small mobile devices, and mobility.

Materials and methods

We presented an overview of the system architecture and the healthcare web service processes at Figure 1. The system is conceptually composed of five main components: the web server, medical information database, mobile context server, mobile user, and desktop user. The web server served medical information for mobile devices on both wired and wireless networks using WSDL (Web Service Description Language) to describe functions and protocols. Figure 2 shows web service sequence diagrams of a mobile device. The mobile context server reconfigures contents offered by the web sever.

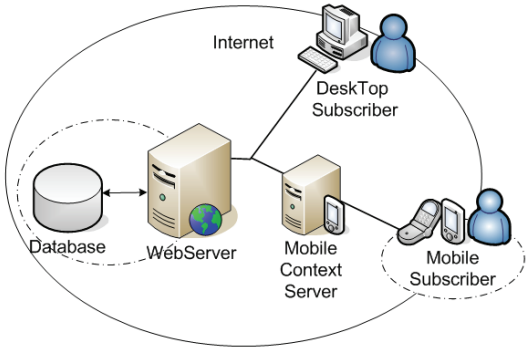


Figure 1 - The system architecture

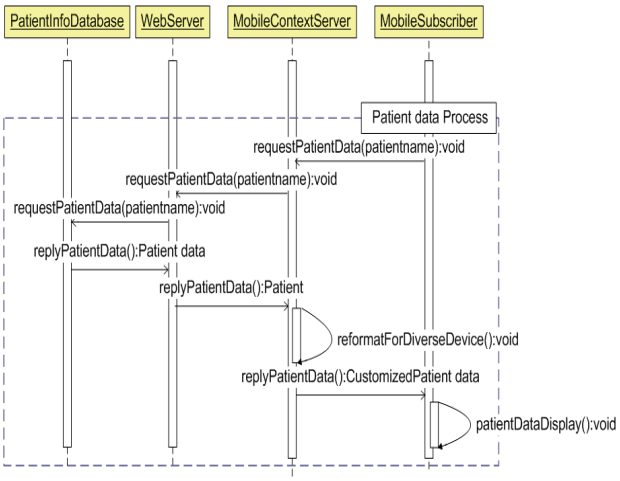


Figure 2 - Web service sequence diagram of a mobile device

The proposed system is not based on loose coupling that is open to UDDI (Universal Description Discovery and Integration) sending and receiving SOAP messages, but rather a tight coupling of a client and server. Using a tightly coupled application development approach provides certain safeguards from quality-of-service, security, privacy, data integrity, and complex transaction processing perspectives as compared to the Web Services architecture. After the system evaluates a mobile device's computing capacity,

the system serves the web contents based on the context chosen by the mobile context server. When a user requests medical information through a wireless network, the mobile context server divides the content pages according to the screen size of the mobile device. It also filters the pages according to mobile devices and then browses the adopted contents from the context server to the mobile web browser.

Results

This system is suggested to aid in faster diagnosis using medical information on both wired and wireless networks. It displays optimized web contents according to the user's browser resources. Figure 3 shows the contents that are displayed on the web browser using a wired network. The desktops shown have an adequate screen size, so web contents can be displayed on one screen.

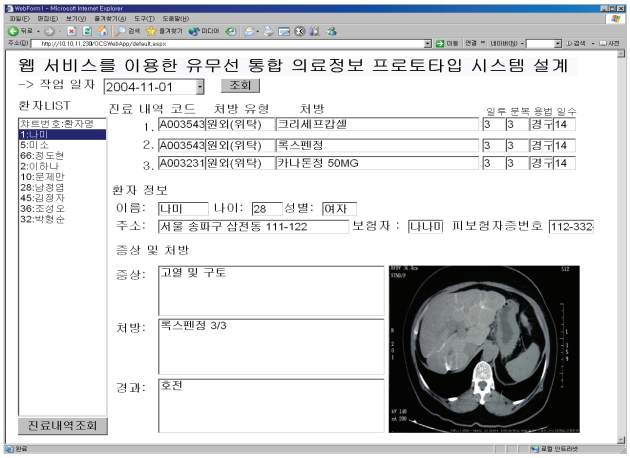
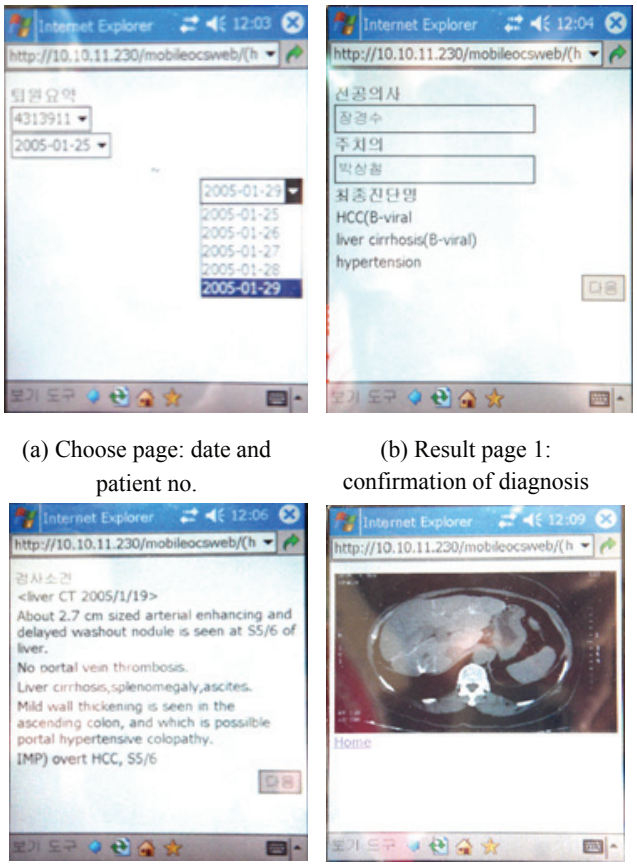


Figure 3 - Web service via a desktop web browser

The web server was served using Microsoft IIS 5.1 and Microsoft Windows XP Professional. Server application was developed by Microsoft ASP.NET based on C#. The medical information database was served by Microsoft SQL-SERVER 2000. The context server connected to the web server acted as the web server. The user system served on the wired network was browsed by Microsoft Internet Explorer 6.0. The mobile web browsers used in the wireless network were a Microsoft MME 3.0 emulator, Microsoft Pocket PC 2003 PDA, HP iPAQ H2200, or LG SC8000.

Figure 4 shows the discharge mobile web pages displayed on a HP iPAQ H2200. This paper suggests an healthcare information support system using Web services for wired/wireless integrated services according to the resources of a given device. The web service is internet friendly, interoperational, and compatible with fire walls. As a result, the web service is considered an important technology to the healthcare system. Our proposed system solves some limits of mobile web services by using a mobile context server that applies context and serves information based on the type of mobile device. Our proposed system is a prototype based on a wired/wireless network. To develop this system from a prototype to a total healthcare system, additional patient information and research is needed, and a greater compatibility with divisions in dynamic web pages.



(a) Choose page: date and patient no.

(b) Result page 1: confirmation of diagnosis

(c) Result page 4: Laboratory finding

(d) Result page 7: MRI image

Figure 4 - Discharge mobile web pages on a mobile device

Discussion

This system solves some limits of mobile web services by using context server that applies context and serves information based on the type of device. So these results will help to implement effective web based mobile health care system. But we think that further research will be necessary.

When regarding particularity of medical information system, security and information standard problem is very important things. Therefore, point of further research must be medical information standard and security. HL7 could

be one of alternative plan. Although security problem was considered in this research, we think that web security must be intensified. Because patient's personal information and other medical data's secrecy is very important. So we will perform aggressive research about web security problem.

To develop this system from a prototype to a total medical care information and research is needed. The system requires greater compatibility with divisions in dynamic web pages.

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The Mobile Phone and Health – Results from a Literature Survey

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Abstract

Due to its ubiquitous availability and rapid technological advancement the mobile phone (MP) has been considered and evaluated for many applications beneficial to health. On the other hand, MP use has raised concerns related to possible adverse health effects like interference with and exposure to electromagnetic fields or distraction during driving. The aim of the present study has been to elucidate and quantify the relationship between research on potentially beneficial and adverse effects of MPs on health by means of a literature survey. Results show that relevant publications increased steadily since the 1990's, initially dealing mostly with potentially adverse effects. Publications on beneficial effects started to increase since the late 1990's and amount to approximately 20% of all publications since 2004. Upcoming technologies and still rapidly increasing numbers of MP users are likely to further increase research within the full spectrum of supposedly beneficial and adverse health effects of MP use.

Keywords:

mobile phone, eHealth, telemedicine, health risk

Introduction

Patient empowerment is one of the top priorities among the many hopes and chances the eHealth era is expected to bring for future healthcare [1]. Placing patients in the center of the healthcare system and providing them with tools and knowledge to manage their health and health related data is considered to be essential in facilitating prevention and improving the outcome of treatment.

Due to its ubiquitous availability and rapid technological advancement the MP is poised to be the universal information and communication toolbox for a steadily increasing portion of the worlds population, both in the developed and the developing parts of the world. MPs have, therefore, the potential to serve as a universal eHealth terminal.

As a consequence, MPs have been used and evaluated for health applications by numerous authors. Likewise, we demonstrated the benefits of MP use for the management of patients with chronic diseases [2] and cardiological teleconsultations [3] together with clinical partners.

On the other hand, MP technologies have also raised concerns related to possible adverse health effects. Initial research occurring during the early 1990's assessed health risks in the following categories:

1. distraction during using and handling MPs, e.g. traffic accidents,
2. the impact of electromagnetic fields on medical devices, i.e. electromagnetic interference (EMI),
3. exposure of humans to electromagnetic fields associated with MPs.

A systematic comparison of both, adverse and beneficial effects of MP technology, however, is lacking. The aim of the present study has been to elucidate and quantify the relationship between research on potentially beneficial and potentially adverse effects of MPs on health by means of a literature survey.

Methods

The impact of MPs with respect to health related issues was assessed by querying the PubMed database [4] with the following search phrase:

"(mobile [ti] OR cellular [ti] OR cell [ti]) AND (phone [ti] OR phones [ti] OR telephone [ti] OR telephones [ti])"

so as to find any citation containing at least one of the various expressions for "mobile phone" in the title string.

The received citations were classified based on the title and - if necessary and available - the abstract as belonging to one of the following main categories:

1. **Adverse**: article clearly deals with potentially adverse effects of MPs on health
2. **Beneficial**: article clearly deals with potentially beneficial applications of MPs to improve health
3. **Other:** Undefined (title and abstract are inconclusive), Irrelevant (article not specifically associated with health), and Duplicate (article relates to a preceding article which had already been classified)

Results

A total of 814 citations have been obtained and examined (last PubMed access update on Nov. 28th, 2006).

The evolutions of the frequencies of articles over time are depicted as histograms for citations on adverse and beneficial effects in Figure 1.

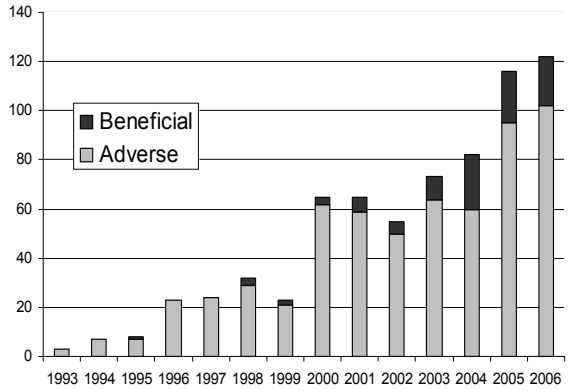

Figure 1 - Annual numbers of citations dealing with adverse (lower and light part of the bars) and beneficial effects (upper and dark part of the bars) of MPs on health

Discussion

Figure 1 indicates that Publications on the health impact of MPs actually started in the early 1990's and increased in a more or less linear way during the subsequent years. Initially, there were mostly publications on potentially adverse effects. Consistent publication activities on beneficial effects started in the late 1990's, increased until 2003 moderately and leaped to higher levels beginning with 2004. In recent years such publications amount to approximately 20% of all publications considered by this survey.

The presented survey includes only articles listed on PubMed. There are – of course – additional articles dealing with this issue, e.g. articles being associated with the author [3], including articles that would actually have satisfied the search phrase but are not listed on PubMed [5]. Hence, the list is far from being complete and no conclusions can be drawn in terms of absolute numbers.

Since the survey was concluded at the end of November 2006, the numbers for the year 2006 do not yet include December and are therefore underrepresented.

It has to be emphasized that this survey did not attempt to assess details of the outcome of the many articles, neither with respect to adverse nor beneficial effects. Other than a review, this survey did not intend to answer questions like "what is the odds ratio of using MPs with respect to a certain cancer?" or "does MP based home monitoring reduce the frequency of hospital admissions in heart failure patients?". Since for many – in particular older – articles only the title is available on PubMed, a detailed analysis with respect to the outcome would require an additional (probably enormous) effort.

This survey specifically aimed at assessing the interest of the scientific community in all health related effects of MP usage, not only in a particular class or sub-class of effects. To the author's best knowledge such a survey has not yet been performed. This notion is supported by the fact, that in the present sample, no article has been found which covered both, adverse and beneficial aspects of MP use.

Conclusions

Today's MPs provide a large portion of the world's population with an ever more powerful communication tool. With respect to health, MPs were already shown to have both adverse and beneficial aspects – as can be expected from any kind of effective technology. After initial research focused mainly on the risk aspects of MP use, during the last years an increasing number of investigations concentrated on potential benefits.

Upcoming technologies and capabilities and a still rapidly increasing number of MP users will warrant continued and new research within the full spectrum of possible risks and benefits of MP use with respect to health.

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Identifying Visually Lossless Image Compression Levels For A Regional Scale Digital Radiological Image Distribution

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Abstract

This experimental study determined visually lossless image compression levels for 3 common digital radiological image modalities: Xrays, computerized tomography (CT) and magnetic resonance imaging (MRI). Compressed images of 17 different radiological pictures using JPEG lossy compression algorithm at different compression quality factors were rated by 160 clinicians from various clinical specialties using original-revealed side-by-side comparison method. Image quality of each testing image was rated as compared with the original image. The visually lossless compression level of each testing image was identified by the threshold of visible image quality deterioration. This study demonstrated that most radiological images could be moderately compressed with image quality well preserved. Visually lossless image compression levels for different image modalities were: Xray: Q10 (1:34-1:89); MRI: Q50-40 (1:6-1:14); CT: Q80-50 (1:8-1:13). The knowledge of visually lossless compression helps to reduce the data volume and network loading, which were critical for effective enterprise-wide radiological image distribution.

Keywords:

compression ratio, visually lossless,
image compression, JPEG, PACS

Introduction

Image compression has been advocated for effective large scale PACS implementation [1-2]. This study aimed at identifying the visually lossless image compression levels of three common radiological image modalities using JPEG compression.

Methods

This study evaluated the image quality of 17 radiological images including 6 Xrays (2 PA Chest Xray; 2 Lateral lumbosacral spine Xray; 2 AP abdominal Xray), 7 computerized tomography (CT) (2 Horizontal slice CT brain; 2 Horizontal slice CT thorax, 3 Horizontal slice CT abdomen) and 4 magnetic resonance imaging (MRI), 3 Horizontal slice MRI brain; 1 Saggital slice MRI spinal cord) at different JPEG (12-bit) compression ratios in a clinical environment by 160 clinicians from different specialties. Image quality of each compressed image was evaluated by original-revealed side-by-side comparison method [3]. Relative image quality of each testing image as compared to the "original" image was rated on a 4 point scale (3=no visible difference; 2= slightly poor; 1=moderately poor; 0=significantly poor). The image evaluation interface is shown in Figure 1. The mean image quality score of each was calculated. Any difference in the image quality between the original and testing image was identified by ANOVA post hoc analysis. Visually lossless image compression levels of various image modalities were identified by comparing the relative image quality of images compressed at different compression levels and identifying the thresholds of visible image quality deterioration.

Results

Relative image quality of different image at different compression levels are presented in Figures 2 to 4**.**

For Xrays, the difference of image quality was not statistically significant even up to maximum compression of Q10 quality factor (p=0.35-1.0) with a corresponding compression ratio of 1:32-1:89. For MRI, the image quality of images was maintained until reaching Q10-Q20 quality factor with compression ratio 1:7-1:18 ($p<0.001$). The image quality of all CT images dropped significantly past compression Q30-Q70 ($p<0.001$-0.02) with compression ratio 1:9-1:14.

Visually lossless image compression level thresholds for different image modalities were: Xray: Q10 (1:32-1:89); MRI: Q30(1:6-1:12); CT: Q80 (1:7)

Discussion

Clinically acceptable compression levels have been the focus of many studies worldwide. It has been shown that image quality deterioration can be tolerated without affecting diagnostic accuracy [4]. Similar studies using receiver

operating characteristic analysis have shown that diagnostic performance can be well preserved despite noticeable compression artifacts [5-8]. Although high level of compression could allow substantial cost savings, it has seldom been applied in real clinically situations and the presence of perceivable artifact reduces acceptance amongst skeptical clinicians and radiologists. In this study, another approach was adopted to determine more conservative thresholds - "visually lossless" compression levels. Although the identified visually lossless compression ratios were dependent on the images selected and the image viewing condition, monitor grade and size, they provide practical information for applying image compression in clinical settings.

Conclusion

Most radiological images could be moderately compressed with image quality well preserved. The knowledge of the visually lossless image compression of various images allows a great reduction in data volume and network loading to an affordable level for effective image distribution on a regional based network

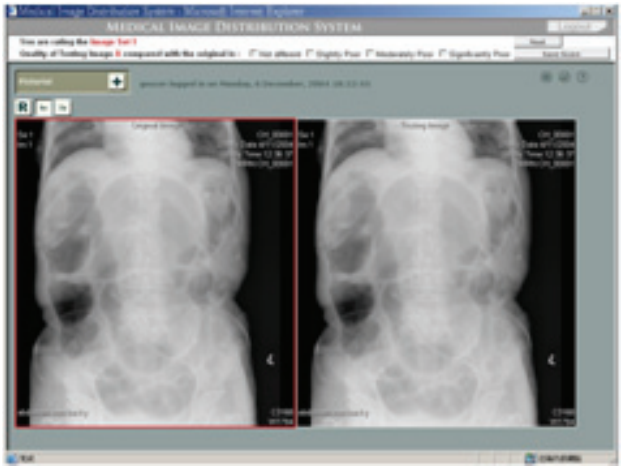

Figure 1 - Showed the image web browser for image quality evaluation. Original uncompressed image was shown on the left while testing image on the right

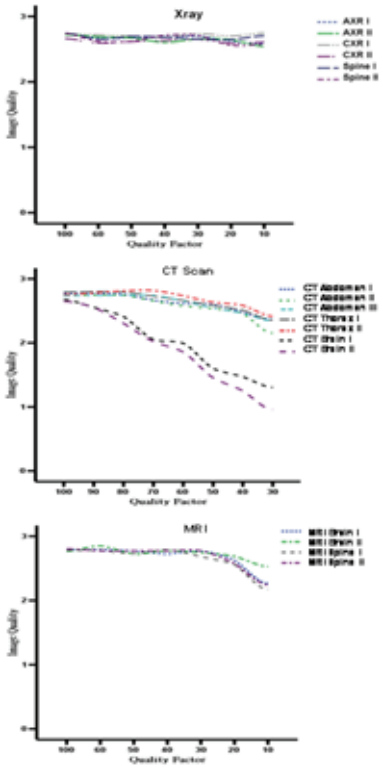

Figure 2 - Showed the image quality of Xrays, CT scans and MRI scans at different quality factor compressions. Image quality of different testing images compressed at different quality factors was evaluated on 4 points scale (3=not different, 2=slightly poor, 1=moderately poor and 0=significantly poor)

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Extraction of White Matter Connectivity in the Human Brain Using the Projected Diffusion-Tensor Distance

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Abstract

Diffusion tensor imaging (DTI) has become a powerful tool for analyzing the structure of white matter. We have already developed a novel method to assess white matter connectivity using diffusion tensor distance between neighborhood voxels. Diffusion tensor distance is defined as the length from the center to the surface of the diffusion tensor. In the proposed method, we use directional diffusion measurements to infer regional white matter connectivity. To assess the connectivity, we investigate the method using the iterative algorithm. By the algorithm, we can segment typical white matter trajectories such as Corpus Callosum. Compared with other algorithms using eigenvalues of the diffusion tensor, our approach has flexibility in selecting connected regions by using basic characteristics of the diffusion tensor shape.

Keywords:

diffusion tensor, MRI, anisotropy, white matter, connectivity

Introduction

Recently, the study of brain function has received much attention and in vivo detection of the structure of deep brain white matter has become more important. Conventional Magnetic Resonance Imaging (MRI) methods, however, cannot detect them. With the development of the devices and techniques of MRI, we can measure the diffusion of water molecules. This technique is called Diffusion Weighted Imaging (DWI). In DWI, the area where the degree of diffusion is large shows as dark and where the degree of diffusion is small shows as bright. Using such images, we can obtain MR diffusion tensor maps. Particularly in white matter, the diffusion varies very much. The value and orientation of the diffusion are directly related to the interaction between nerve bundles and magnetic gradients. This is known as the diffusion anisotropy. Namely if the nerve bundles are perpendicular to the magnetic gradient, we can obtain the minor diffusion coefficient. Conversely if the nerve bundles are parallel to it, we can obtain the major one.

In this study, directional diffusion measurements are used to infer regional white matter connectivity. The connectivity is determined as a function of distance between the origin of the tensor and the surface for each voxel. With the iterative algorithm, we can segment typical white matter trajectories such as Corpus Callosum and Internal Capsules. This approach is different from other methods that use the principal eigenvector or full tensor. Here, a novel method for labeling and segmenting white matter connectivity using DT-MRI is described.

Methods

Diffusion tensor images are acquired on a 1.5 T Signa MRI system (GE). Echo planar images are acquired on a subject in the axial plane at 36 slice locations. The six dimension weighting was done and the maximum b value was 1014 sec/mm2. Other parameters were Echo Time (TE) =78 msec, Repetition Time (TR) =7000 msec, slice thickness=3 mm, image matrix=256x256 pixels (zero filling), in plane resolution=1 mm.

First, the algorithm is started from a specified point in a slice. Second, an iteration method is used to select multiple neighborhoods

We consider the normalized distance potential by multiplying the in-coming and out-going distance divided by trace (D),

$$\varphi_i = \vec{x}_i^{\,t} \boldsymbol{D}_i \vec{x}_i FA_i \vec{x}_j^{\,t} \boldsymbol{D}_j \vec{x}_j FA_j \Big/ TRACE(\boldsymbol{D}_i) TRACE(\boldsymbol{D}_j) \quad (1)$$

where i indicates the reference, j indicates the neighborhood.

In Fig. 1, the searching algorithm is performed for all eight 2-D neighborhoods (26 neighborhoods in 3D). In this case, we start from the center as a reference. Left-up, up, down, right-down voxels are the subsequent references. We continue searching until visiting the previous reference.

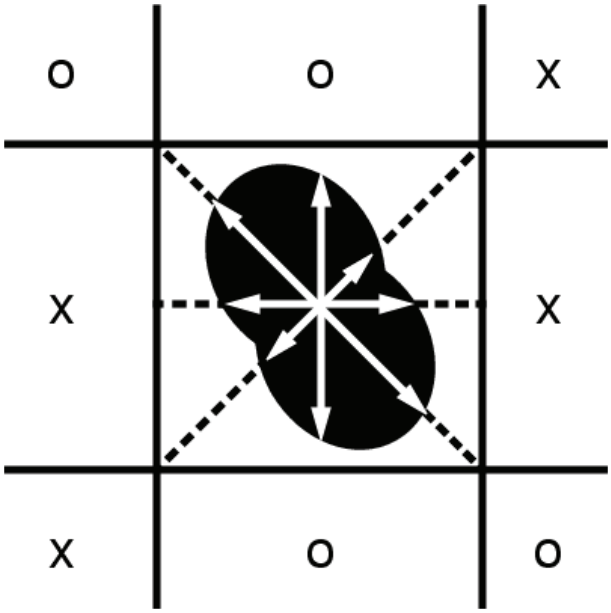

Figure 1 - Concept of threshold distance and iterative searching (o are candidates of next step (to be references) and x are discarded)

Results

In Fig. 2, we show the result of iterative algorithm superimposed on corresponding FA images for a single subject. The starting point is on major fiber trajectories such as Corpus Callosum and Internal Capsule.

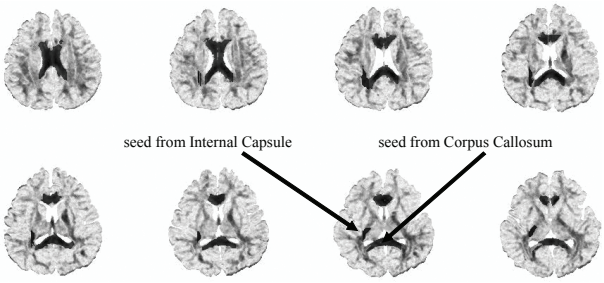

Figure 2 - Result of an iterative algorithm superimposed on corresponding FA images (8 contiguous slices: dark regions are seeding from Corpus Callosum and Internal Capsule)

Discussion

The result of the algorithm depends on the threshold value. For example, we used threshold 2.1 in Fig. 2. It is important to determine the value statistically and automatically. And the anisotropy of voxel size should also be improved. We are now investigating the effect of interpolation on the accuracy of the results.

We also have a plan to verify the feasibility of our method by way of adding noise simulation. The estimation of the effect of noise will be important before using the method in clinical studies.

These results are promising for connecting and segmenting specific white matter regions. The segmented volume may be used to constrain white matter tracking algorithms. The results here are preliminary and will require more work. We show that the iterative algorithm is refined further considering the interaction between the outgoing and incoming directions.

Conclusion

In this study, we propose methods to assess the white matter connectivity using projected diffusion tensor distance. This algorithm is different from other tracking methods and has potential to be used in combination with traditional tracking algorithm. The algorithm is iterative and consists of two steps. We can also use the result to analyze the connectivity quantitatively and statistically. Information derived from the result is important and necessary to obtain the structure of the white matter and it will enhance the study of human brain function.

Acknowledgments

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Extraction of White Matter Connectivity in the Human Brain Using the Projected Diffusion Tensor Distance

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Introduction

- MRI is important modality for imaging human brain function and structure
- With the development of devices, we can measure diffusion of water molecules (Bihan et al. 1986)
- Using diffusion tensor maps, we can obtain structural information of nerve bundles in white matter (Moseley et al. 1990)

Aim

- Obtain structural information of white matter trajectories
- Enhance and detect nerve bundles

Qualitative analysis of white matter trajectories

Apply the result to the statistical test of human brain function

Diffusion Coefficients

- Diffusion coefficients calculated from diffusion weighted images are reflecting the relative direction between diffusion gradient and fiber trajectories
  - Parallel measurements along a trajectory
    - High coefficient
  - Perpendicular measurements along a trajectory
    - Low coefficient

Diffusion Tensor

$$\begin{pmatrix} D_{xx} & D_{xy} & D_{xz} \\ D_{xy} & D_{yy} & D_{yz} \\ D_{xz} & D_{yz} & D_{zz} \end{pmatrix} \rightarrow \begin{pmatrix} e_1 & 0 & 0 \\ 0 & e_2 & 0 \\ 0 & 0 & e_3 \end{pmatrix}$$

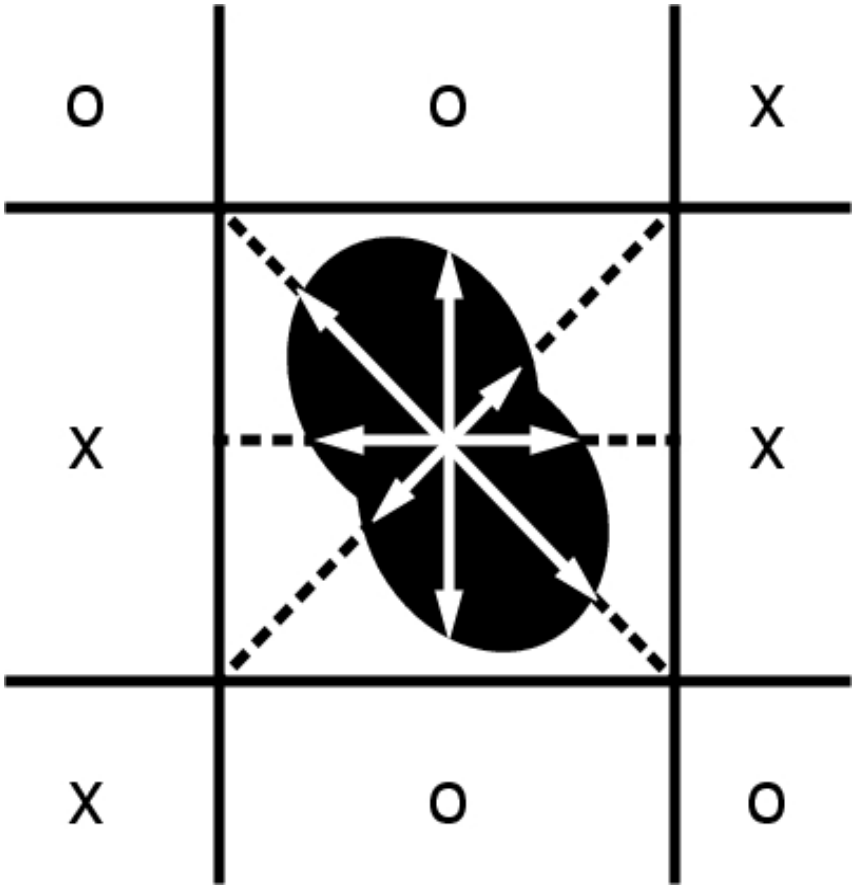
Diffusion tensor whose components are from diffusion coefficients

- Eigenvalues
  - Principal（e_1）, second（e_2）, third（e_3）
- Principal eigenvector
  - X, Y, Z components
- Fractional anisotropy（FA）

Diffusion Distance Analysis

- The connectivity is determined as a function of distance between the origin of the tensor and the surface for each voxel
- This approach is different from other methods that use the principal eigenvector or full tensor

Iterative Algorithm



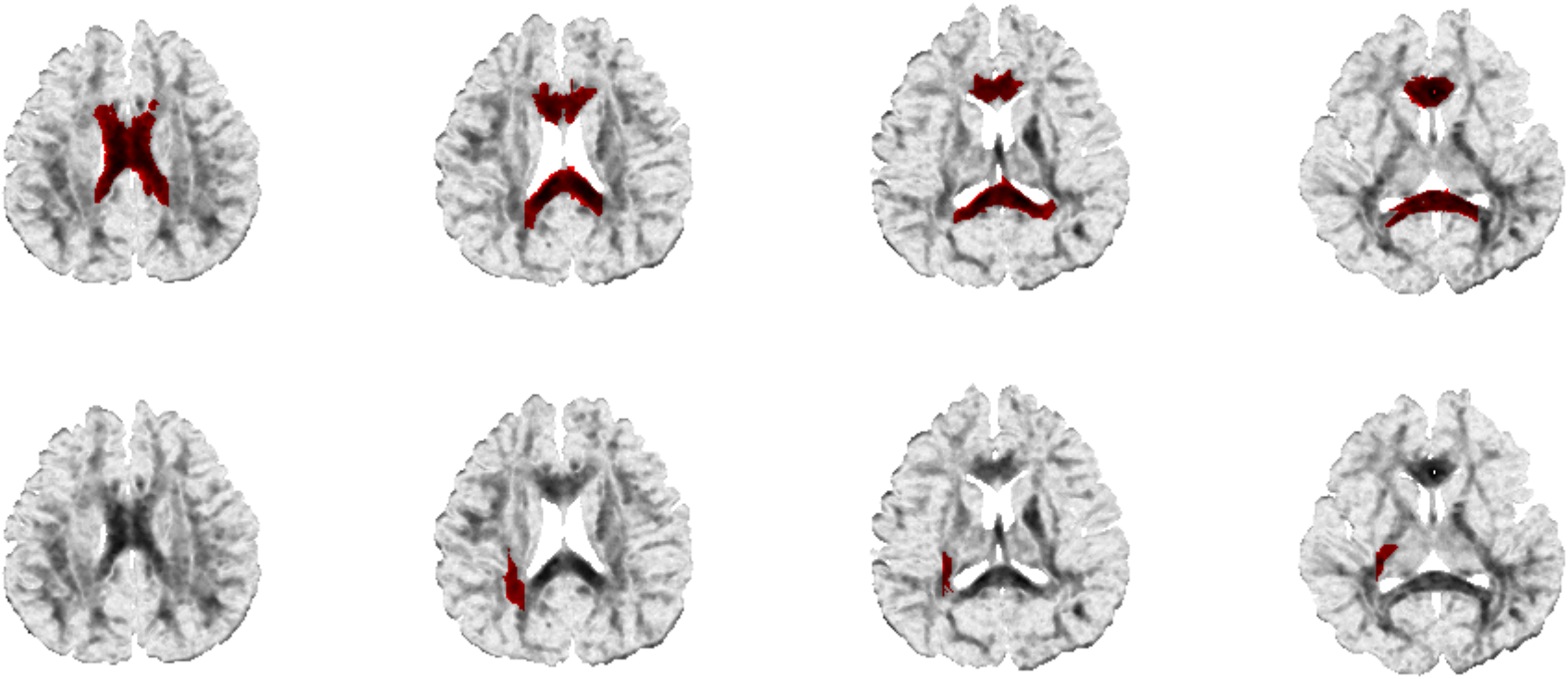
- Start from the center in the left, next check right-up, up, left-up, right-down, down, left-down iteratively
- Continue searching until visiting the already tracked voxel again

Distance Potential

$$\varphi_i = \{\vec{x}_i{}^t D\vec{x}_i / Trace(D_i)\}\{\vec{x}_j{}^t D\vec{x}_j / Trace(D_j)\}$$

- Consider the normalized distance potential combining by the in-coming distance and the out-going distance divided by its trace (D)
- Where i indicates the reference, j indicates the neighborhood

Result



Result of an iterative algorithm superimposed on cor-responding FA images

(8 contiguous slices: dark regions are seeding from Corpus Callosum and Internal Capsule)

Discussion

- The result of the algorithm depends on the threshold value
- To determine the value statistically and automatically is important
- To verify the feasibility of our methods by way of adding noise simulation will be important before using the method in clinical studies

Conclusion

- In this study, we propose a method to assess the white matter connectivity using projected diffusion tensor distance
- Proposed algorithm is different from other tracking methods and has potential to be used in combination with conventional tracking algorithm

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Automatic Volumetry for Surgical Reconstruction of the Orbit

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Abstract

Fractures of the orbital floor are within the most frequent in craniomaxillofacial surgery. For surgical reconstruction, the orbital volume must be restored exactly to maintain the vision abilities of the subject. In this paper, we present an automatic segmentation and volume determination of human orbit based on a general discrete contour model applied to CT volumes of the skull. The coefficient of variation for manually placed start points is below 2%. The system is evaluated based on six subjects, where the difference between left and right eye- assumed to be zero – is determined experimentally. Here, the mean variation is 1.52%. Therefore, our method is sufficiently robust and applicable for surgery planning and follow-up studies.

Keywords:

surgery planning, orbit reconstruction,
image processing, active shapes, segmentation,
quantitative measurements

Introduction

Just after fractures of the mandible and the zygomatic bone the fracture of the orbital floor is the most frequent one in craniomaxillofacial surgery [1]. It is often diagnosed as an isolated blow-out-fracture or in combination with a fracture of the zygomatic bone. As much as 40% of all midface fractures are associated with defects of the orbital floor. This leads to a descent of the orbital soft tissues and a consecutive increased orbital volume [2]. Moreover the bulb of the affected eye moves towards a more inferior and posterior position which leads to double vision or diplopia, which causes visual impairment and thus a high economic deficit [3]. According to our investigations, 58% – 86% of all blow-out-fractures and 13% – 20 % of all midface fractures seem to be associated with diplopia.

In most cases, the smallest fragments are not subject to a reposition via osteosynthesis. The medial wall of the orbit and the transition to the orbital floor are frequently affected. The current standard procedure comprises an insertion of an alloplastic foil or a titan mesh via a transconjunctival approach [4,5]. Regarding defects smaller than 2cm², the use of a resorbable alloplastic membrane is recommended [6].

The treatment of fractures of the orbital floor and the medial wall of the orbit is still a big issue in craniomaxillofacial surgery [7]. However, there is still no solution for an exact determination of the orbital volume in case of fractures of different orbital walls.

Automated segmentation of osseous structures of the midface from acquired CT data sets is yet unsatisfying, because typical partial volume effects according to the CT data lead to discontinuities in the virtual reconstruction. Further difficulties result from the distinct recalculation of an anterior and posterior border of the orbit, which is unavailable up to now. Only distinct borders can describe a self-contained volume which can be compared to the unaffected side or with standard values. The lack of reliable segmentation procedures becomes crucial if individual preformed titanium meshes are used for reconstruction of orbital fractures [8].

Unsupervised image segmentation is one of the major challenges in medical image processing [9,10]. In this paper, we apply an general discrete contour model [11] for automatic segmentation and measurement of orbit volumes. The method is evaluated based on six healthy subjects.

Materials and methods

Subjects and image data

Based on the image data obtained at the Department of Craniomaxillofacial Surgery, University Freiburg, Germany, six subjects without orbit fractures were selected and included in this study. Computed tomography was performed using a Siemens sensation 64 scanner (Siemens Medical Solutions, Forchheim, Germany), with 120 kV at 82 mA. Anisotropic volumes were obtained with 1 mm slice thickness and a spatial resolution of 512 x 512 voxel in $x - y$ direction. The number z of slices varied between 139 and 261 (Table 1).

The discrete contour model

For the segmentation of the orbit, a general contour model was applied to the three-dimensional (3D) data [11]. In two dimensions, the contour is represented by a simplex mesh, i.e. by vertices and edges. The segmentation proceeds iteratively, taking into account different powers to calculate the configuration of the next step. In each step, vertices

may be deleted, because they are located too close to each other, and others maybe inserted to reduce the distance between two vertices. In contrast to other active contour approaches, the vertices are not limited to positions within the slices.

The effecting powers are pressure, deformation and external influences. When these three powers reach an equilibrium a vertex is fixed.

- *Pressure* stays constant during the entire segmentation process and therefore constantly moves the vertices towards the searched edges. The start configuration of a contour can be a minimal sphere around a given starting point or a mesh along the outside border of the image space. In the first case, pressure is a positive power pressing vertices towards the outside, and in the second case, the pressure pulls vertices towards the inside.
- *Deformation* prevents the contour from accepting too sharp bends. It is calculated modeling the properties of biological membranes.
- *External influences* are derived from the individual CT data. In contrast to other active contour approaches, external influences regionally depend on the Hounsfield Units of the neighborhood of the considered vertex and the edges between the vertices.

This 3D model can be compared to a balloon, which is slowly blown up inside an image. For further details to this model, which was generally developed for two, three and four dimensions, see [1].

Segmentation of the orbit

When adapting the general model to the orbit, several difficulties occur. To facilitate further processing, images are smoothed (Fig. 1a) and binarized (Fig. 1b) such that only bone structures receive gray value 255 (white) and everything else gray value 0 (black). Resulting from the normilazed nature of CT Hounsfield Units, the perfect threshold varies only little between different image series and is regarded as constant.

The main problem is that the orbit is not cohesive. The front is completely open and it is not obvious where the segmentation should end. The images do not clearly display a limit between orbit and the surface of the face. Two methods have been applied to artificially insert a limit. Both work on the two dimensional slice images.

First, the orbit is closed by a straight line connecting the nasal bone with the cranial bone bordering the orbit (Fig. 1c). The nasal bone is identified as the first white pixel in the image when testing row by row from front to back. Then a straight line is tilted left and right from this point, until it touches another white pixel. The entire area above these lines is filled white to mark the new limit.

A second strategy applies two dimensional segmentation of cranial bones with the same active contour model as later used for the segmentation of the orbit. Here, however, the segmentation starts with a mesh on the outside image border and slowly encloses the cranium (Fig. 1d). The deformation power is high to prevent the contour from entering the orbit. The maximal distance between two vertices in the contour is small to assure that the thin bone structures around the orbit are recognized and cannot slip through between two vertices. The external influences are highly weighted, because in the binarized image a white pixel stands where bone was with high certainty and vertices near bone should be fixed immediately. Once the segmentation identified an area as the cranium, everything outside this area is filled white in the original binarized image.

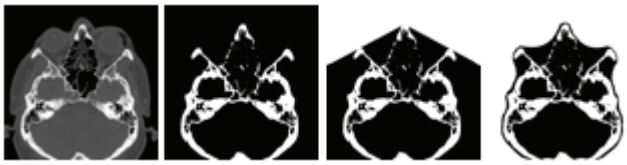

Figure 1 - Noise reduction, binarization, linear,and contour-based outer boundary of the orbit

The opening at the front of the orbit is not the only one, but there are several canals in the back of the orbit. Furthermore, the ethmoid bone between both orbits is extremely thin, and is not always visible cohesively. These difficulties must be overcome by suitable parameterization. Deformation cannot be chosen too high because the orbit becomes narrow to the back. The external influences must be set rather high to identify bone structures accurately. Pressure comes from the inside, but is of no relevance here. Far more important is the manual choice of a starting point, which is placed manually in the center of the orbit. However, this step can easily be easily performed automatically using the a-priori knowledge of the general geometry of the human skull.

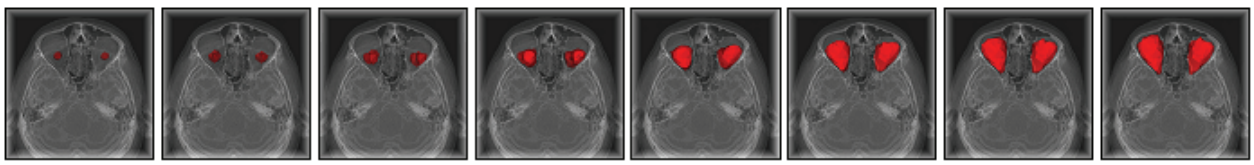

Figure 2 - Iterative orbit segmentation using a 3D balloon model

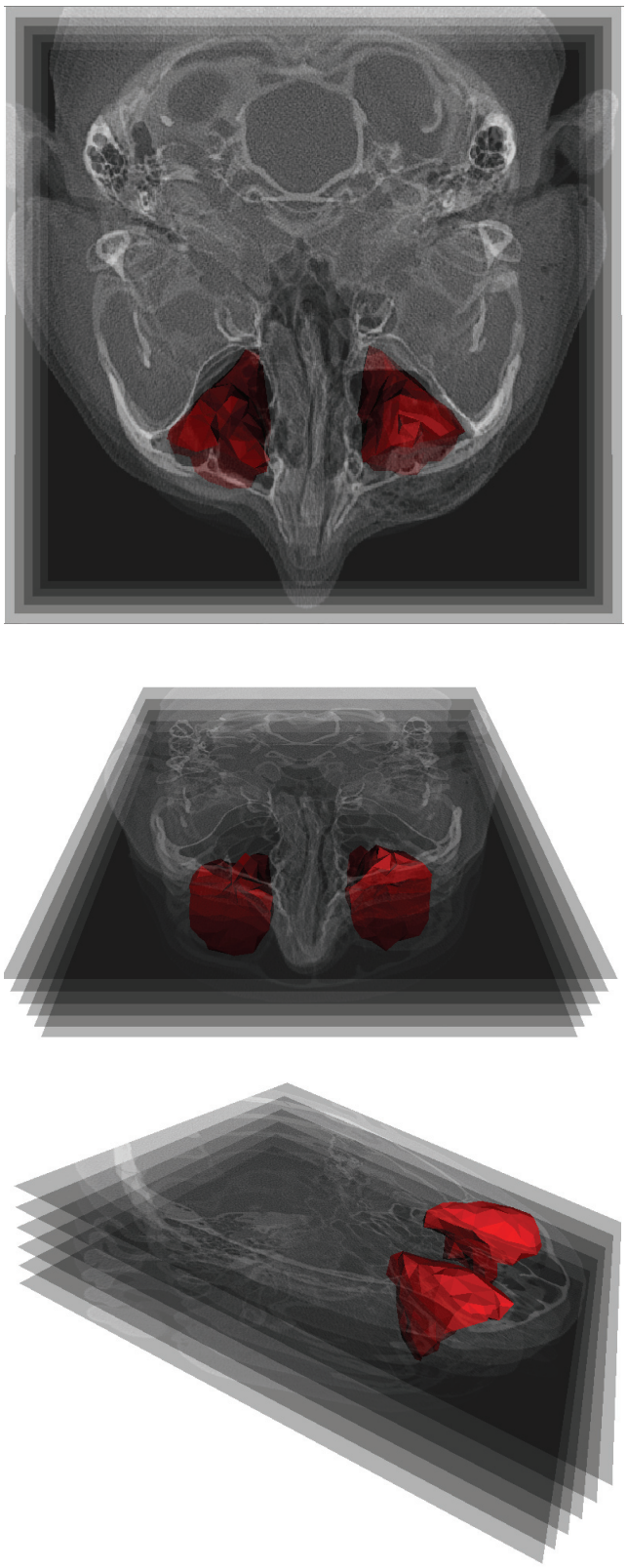

Figure 3 - Results on Subject 1

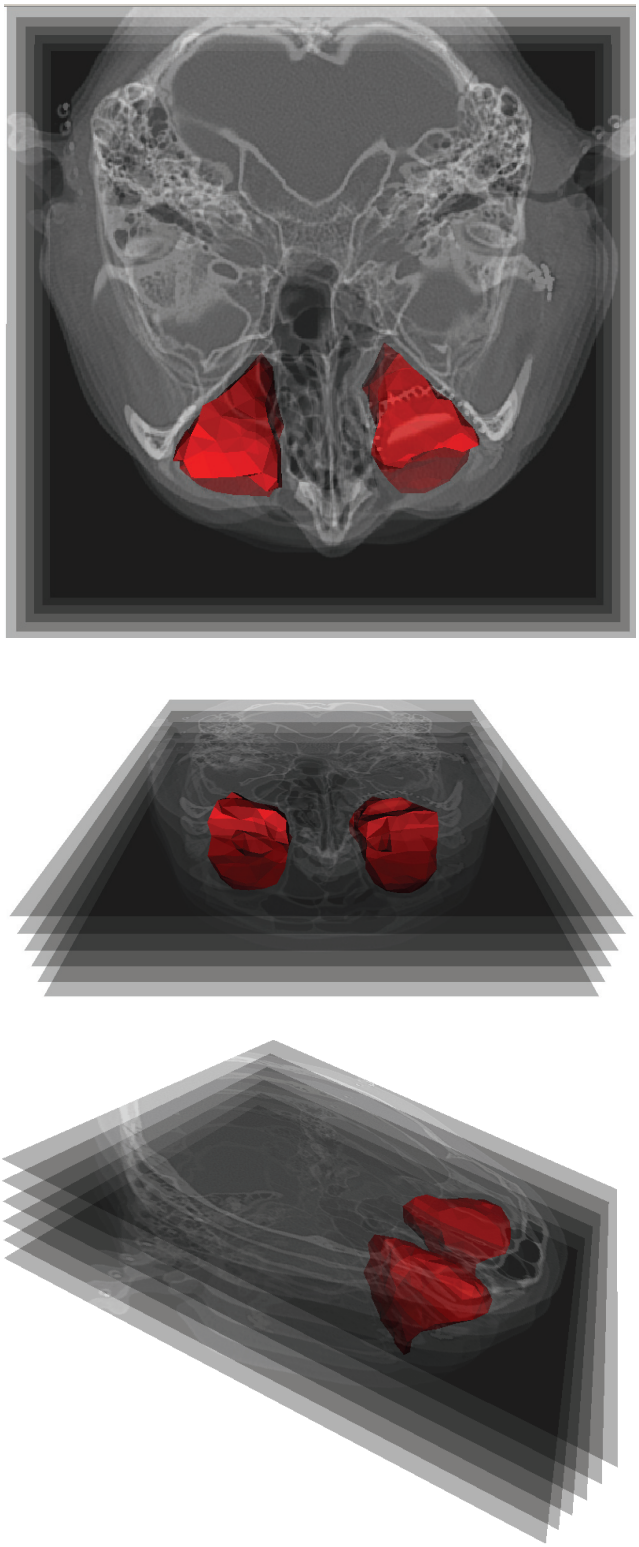

Figure 4 - Results on Subject 2

Results

A fixed set of parameters for the 3D active contour model was determined manually and applied to segment the six data sets selected arbitrarily from the clinical day-today routine.

Based on five segmentations on Subject 1 that were initiated with different starting points, the variation coefficients (standard deviation divided by the mean) of the volumes of left and right orbits were 0.98% and 1.28%, respectively. Since these coefficients are much smaller than 5 %, the method is considered as sufficiently stable.

The results of automatic orbit segmentation is visualized in Figures 3 and 4. For qualitative evaluation, the segmentation was confirmed by a skilled radiologist. The quantitative results obtained on the six patients are summarized in Table 1. The volume of left and right orbits are given by the number of segmented voxels. For all subjects, the relative differences

$$d = 100\frac{|l-r|}{l+r}$$

is below 5%, and the mean relative differences is $d_m = 1.52\%$.

Table 1 - Image data and results

Patient No	No of slices	Volume left *l*	Volume right *r*	Relative difference *d*
1	139	339819	350085	1.49 %
2	181	485792	491097	0.54 %
3	136	541376	521174	1.90 %
4	204	358029	365773	1.07 %
5	261	207250	221110	3.23 %
6	188	260264	255632	0.90 %

Discussion and conclusion

The general active contour model is applicable for automatic segmentation of orbits in CT data. The model consists of a membrane-like structure which is blown up from the interior of the orbit. Discontinuous surfaces caused by insufficient CT data are bridged with a defined surface tension of the membrane. The anterior border is defined as a vertical plane travelling along the infra-orbital rim. The posterior border is to be defined as a cone-like top of a pyramid.

The application of this virtual model to a real 3D model allows the exact pre-bending of a titan mesh for the surgical reconstruction of the orbital floor. First interventions with navigation guidance have shown that this mesh can be adapted with a geometric accuracy smaller than 1mm. Finally, in case of severe midface asymmetry, a preoperative transition of a virtual volume from an unaffected orbit to the affected side and consecutive integrative fusion with the mirrored orbital floor (morphing) can lead to an exact prediction of the reconstructed orbit. This will be evaluated in further studies.

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Automatic Volumetry for Surgical Reconstruction of the Orbit

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Relevance

- Fracture of orbital floor is frequent in cranio-maxillofacial surgery
- Double vision or diplopia results from
  - 58% – 86% of all blow-out fractures
  - 13% – 20% of all midface fractures
- Surgical treatment [1]
  - Preformed titanium mesh
  - Exact reconstruction of orbital volume (same volume on each side)

Goal

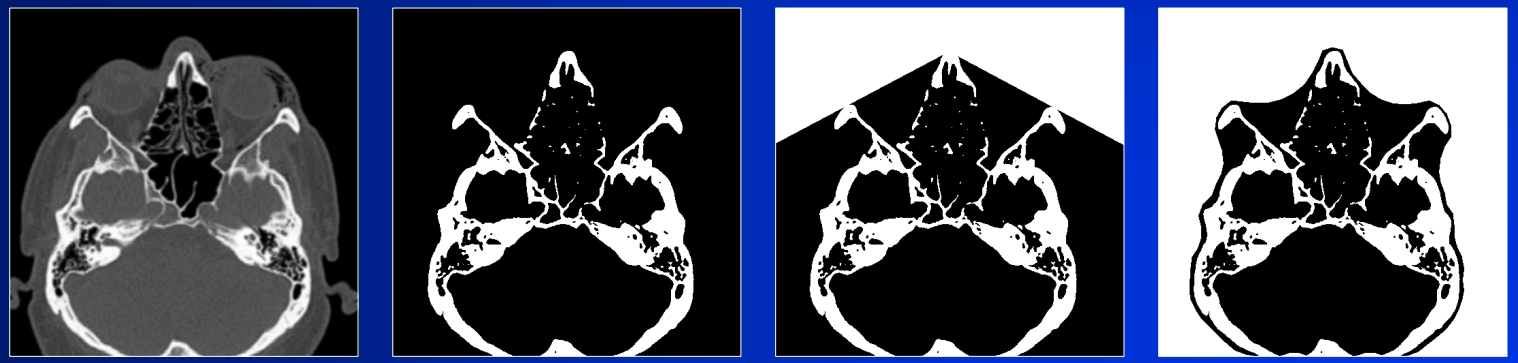
- Support of treatment planning
  - Automatic orbit segmentation in CT volumes
  - Orbital volume measurement
- Robust and reliable image processing scheme
  - Find suitable algorithm
  - Find robust parameterization
  - Evaluate on real data

Materials & Methods

- Selected subjects
  - A: 2 normal cases
  - B: 3 with fracture before treatment
  - C: 6 after mesh-based reconstruction
- Siemens Sensation 64 CT scanner
  - 120 kV at 82 mA
  - 512 x 512, 1mm slice thickness
- General discrete contour model [2]
  - Constant pressure moves towards edges
  - Biological membrane behavior avoids sharp bends
  - External influences regionally based on HU

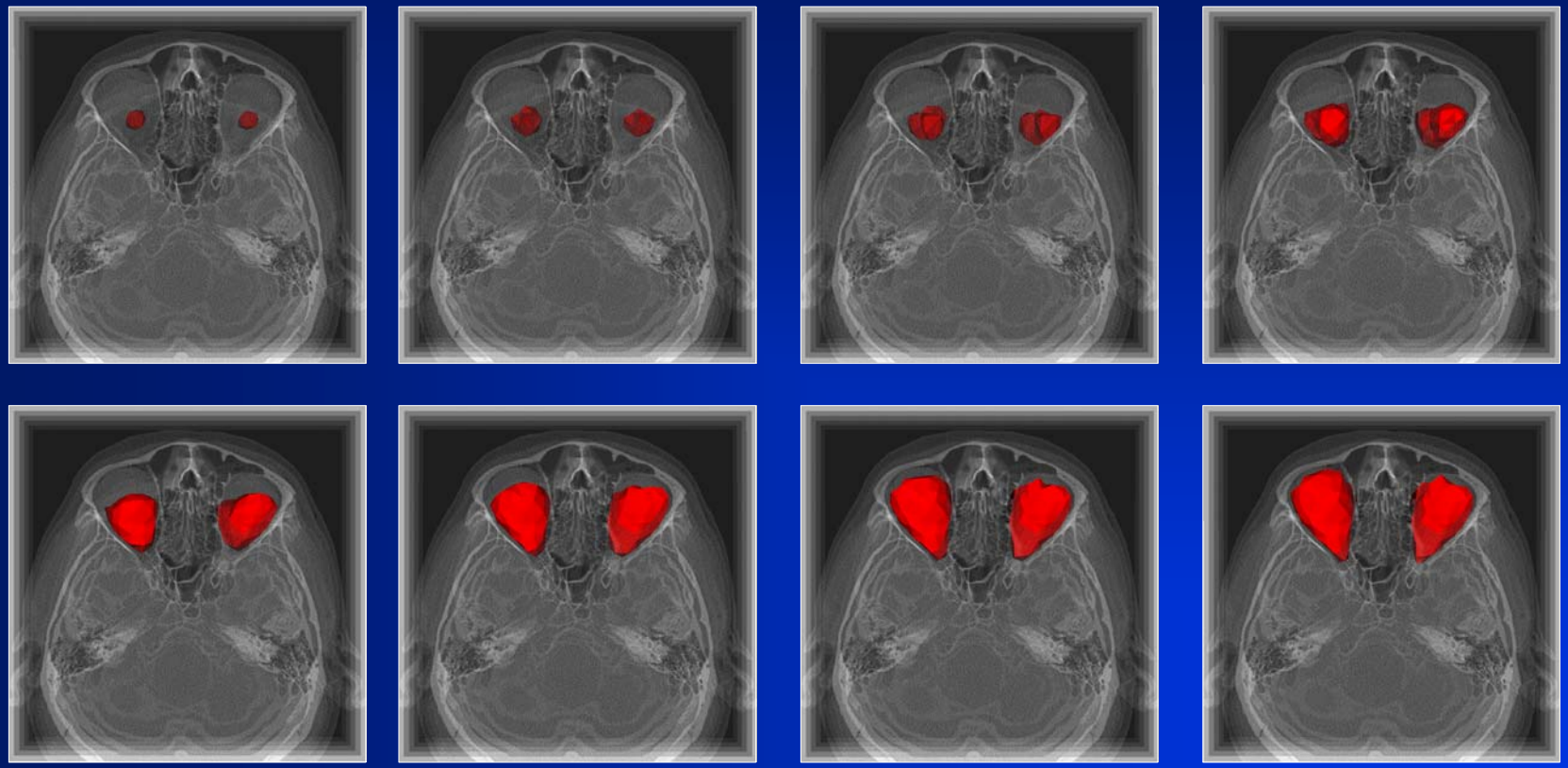
Preprocessing

- Problem: open orbit
- Solution
  - Noise reduction
  - Binarization
  - Linear boundary
  - Contour-based boundary using same balloon model



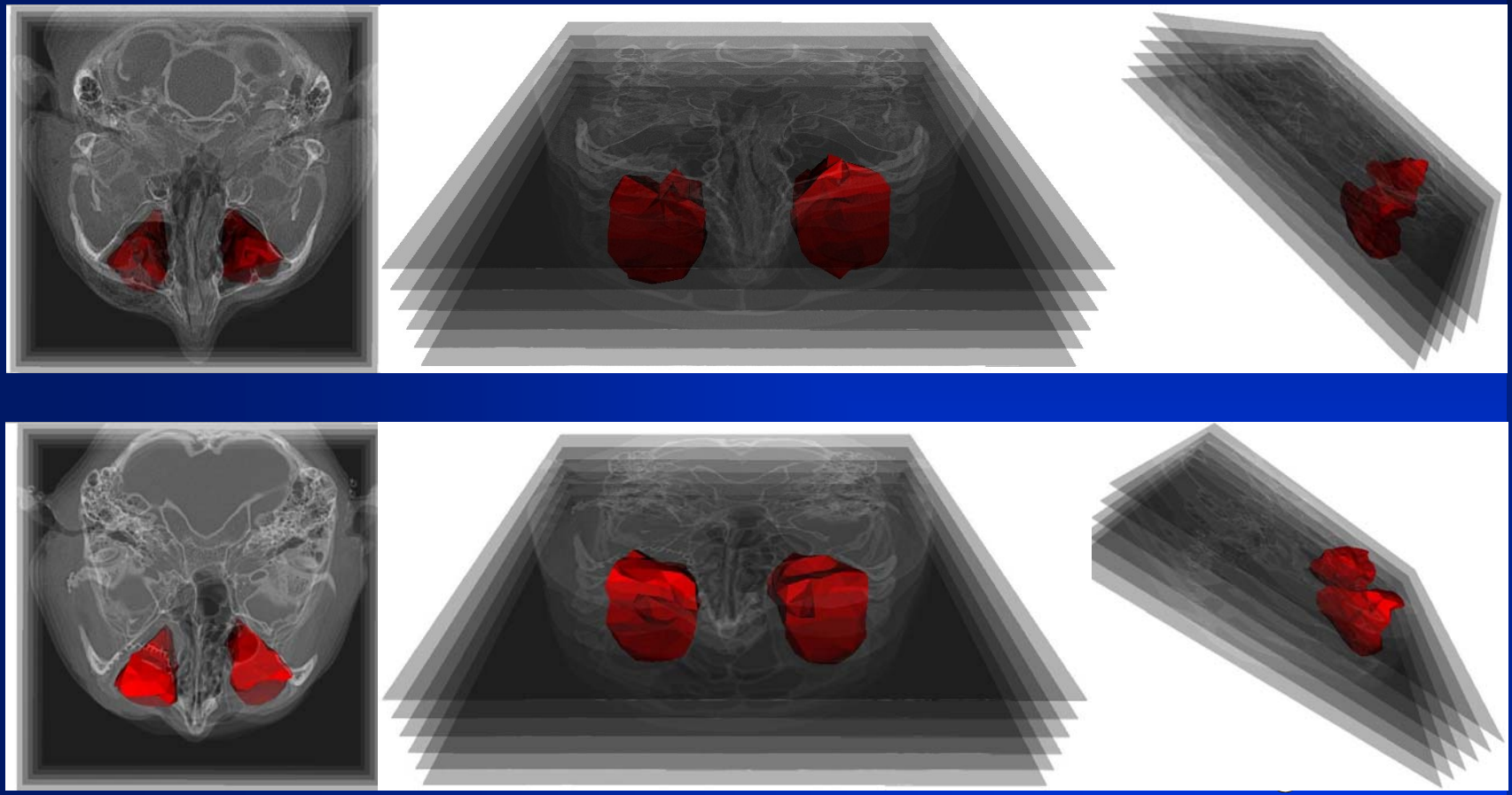
Example

- Iteration



Example

- Orbit segmentation



Evaluation

- Healthy patients
  - Left side equals right side
- Measurements
  - Volume of left orbit: l
  - Volume of right orbit: r
- Relative difference: d
  - Assumed to be zero

$$d = 100 \frac{|l - r|}{l + r}$$

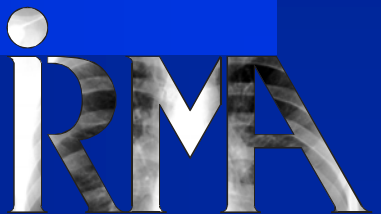
IRMA

Results

Group	ID	No of slices	V_l	V_r	d
A	3a	136	541376	521174	1,90%
A	6	226	89395	87841	0,88%
					1.39%
B	1	139	339819	350085	1,49%
B	4	261	207250	221110	3,24%
B	10	191	506487	544712	3,65%
					2.79%
C	2	181	396430	390265	0,78%
C	3b	204	358029	365773	1,07%
C	5	244	469642	527664	5,82%
C	8	188	260264	255632	0,90%
C	9	216	151774	153774	0,65%
C	14	192	381866	320753	8,70%
					3.58%

Discussion & Conclusion

- New method for CT orbita segmentation
  - Membrane-like balloon structure
  - Shrunk from image border to close orbit
  - Blown from the orbit center for volume measurements
- Robustness
  - Mean variation below 5% for
    (A) healthy, (B) fractured, (C) reconstructed subjects
- Applications
  - Surgery planning
  - Follow-up studies



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Clinical Trial of a CAD System for Microcalcification Detection and Classification

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Abstract

According to the World Health Organisation, breast cancer is the second leading cause of cancer deaths in women today and is the most common cancer among women, excluding nonmelanoma skin cancers. Several studies have proved that the early detection of breast cancer can reduce mortality rates and improve the chances that the patient is diagnosed at an early stage and treated successfully. Mammography is widely used as the primary method for breast cancer detection.

Breast microcalcifications usually appear in the form of clusters and sometimes can be easily detected on mammografic films due to their high clustering density. An approach in the classification of microcalcifications has been presented by Ligomenides et al. and it is based on detailed analysis and evaluation of seven features of individual microcalcifications and of formed clusters. The proposed system is now in clinical trial in an Athens University Hospital's Breast Unit. The results from the first 51 cases (all biopsy tested) that were processed are presented in this paper and indicate that all malignant cases were classified correctly.

Keywords:

computer aided diagnosis, mammogram,
microcalcifications, breast cancer, clinical trial

Introduction

Breast cancer is the second leading cause of cancer deaths in women and is the most common cancer among women, excluding nonmelanoma skin cancers. According to the World Health Organization, more than 1.2 million people will be diagnosed with breast cancer every year worldwide. The chance of developing invasive breast cancer during a woman's lifetime is approximately 1 in 7 (13.4%). The death rates from breast cancer also declined significantly during the last years, with the largest decreases among younger women. This is attributed to earlier detection and more effective treatments.

Breast microcalcifications are considered a very useful index of malignancy, which helps in the early detection of breast cancer. Malignant calcifications may occur with or without the presence of a tumor mass and are typically clustered, varying in size and shape. Mammography is accepted as the most effective method to detect breast cancer. However, interpreting a mammogram is not easy for not experienced radiologists. The aim of computer aided detection techniques in breast cancer is to improve the chance that a malignant region is detected and appropriately evaluated. It is very important for the success of the treatment that any malignant area is detected as early as possible. Furthermore, the ability to discriminate benign cases (specificity) is a major issue in computer-aided diagnosis.

Breast microcalcifications are viewed as bright spots with diameter varying from 0.1 to 0.3 mm and usually appear in the form of clusters that can be detected on mammographic films due to their high clustering density. Nevertheless, the existence of microcalcifications in breast tissue is not always a clear evidence of malignancy. Many research efforts have been made to segment medical image findings and specifically to classify breast microcalcifications as benign or malignant, based on computer-aided analysis of their structural and photometric characteristics as those appear in mammographic images.

A computer aided diagnosis (CAD) system, called Hippocrates-mst, has been developed and is based on detailed analysis and evaluation of related features of individual microcalcifications and of formed clusters. The output of the system is considered to be very useful to the radiologists, giving them extra input before reviewing each case.

After an initial evaluation that was done in the laboratory with a set of 200 mammograms, the system is now been tested in a Breast Unit of an Athens University Hospital. The system's integration and ease of use within the unit's workflow as well as the results are examined closely as they may indicate future developments.

Methods

Microcalcification detection and analysis is carried out with the use of an algorithm based on the processing of

three image data sets: a) the application of a high pass filter b) the variance normalization c) the application of an adaptive filter. Similar techniques have been successfully used to process medical and astronomical images.

The proposed methodology for microcalcification classification uses a four-way projection method and examines each microcalcification cluster from four different viewing angles in order to process all possible variations of each view. Seven characteristics are extracted for each microcalcification including size, circularity, existence of sub dense center, brightness level, anomaly of shape, existence of apophyses and branches and existence of windings.

The workstation of the system comprises of a modern IBM compatible personal computer, a printer and a high quality film scanner unless a digital mammographic device exists.

Each case is processed as follows: each mammogram has to be digitized using certain parameters and then the doctor/user enters the patient's demographic data and medical history in the system's digital patient record. After those initial steps the doctor has the option to examine the mammogram(s) using the provided digital tools. These tools include modules as the 'digital lens', which helps users to zoom in an area of interest, or the brightness, contrast and -value adjustment tools that help the user reveal anomalies in a selected area of the mammogram. At the next step, the doctor can use the system's microcalcification detection algorithms and reveal the microcalcifications of a selected area. The microcalcifications of this area are counted and categorized using a color-based categorization.

The final results of the Hippocrates-mst system are presented in a risk percentage scale from 0 to 100. Percentage lesser than or equal to 35 means there are not enough evidence to support sending the patient for a biopsy test. Percentage from 35 to 55 declares benign state and a biopsy test is suggested, while percentage greater than 55 indicates malignancy and a biopsy test has to be made as soon as possible. It must be stated that the system only makes suggestions to the doctor and it is the doctor that makes the final decision whether a case has to be sent for a biopsy test or not.

As from February 2006 the Hippocrates-mst system is used on a daily basis in the Hippocratio Hospital Breast Unit. The Breast Unit belongs to the 1st Propaedeutic Surgical Clinic of the University of Athens Medical School and is fully equipped with: Mammography system (Siemens Mammomat 3000 Nova), Ultrasound system (Siemens Sonoline), Fischer's Table, Vacuum assisted Breast Biopsy (Mammotome), and Ductal endoscopy.

Hippocrates-mst is used following a specific clinical evaluation protocol. Our goal, in this initial clinical trial phase that will last for 6 months, is to achieve integration within the Breast Unit's workflow and make sure every case that would be Mammotome examined would also be processed with the CAD system. During this initial phase of the clinical trial protocol, the system's results must be compared versus the corresponding biopsy results.

The clinical workflow of a typical case involving Hippocrates-mst is as follows: the woman/patient undergoes breast clinical examination along with a mammographic examination. Depending on the mammogram and the clinical examination results, there are a number of options. In case the mammogram shows signs of suspicious microcalcifications or in case there are findings suggesting malignancy, the patient undergoes a Mammotome examination.

When a case is processed with Hippocrates-mst CAD system, the doctor (usually one of the Unit's radiologists) selects the mammogram(s) that must be digitized and scans it/them using the system's scanner. Then adds the resulted image files to the patient's digital record and begins to process each mammogram using Hippocrates-mst's digital image tools and classification modules. At the final step of the computer-aided examination, the system provides the doctor with the overall risk estimation for the selected region of interest. After reviewing a case, the doctor has the option to save the results, along with any notes on the case, to the system's hard disk drive or to a cd. The whole process from the film digitization to the final results takes no more than 6 minutes.

The sample images set contained 51 mammograms, of both craniocaudal and mediolateral views, with microcalcifications collected in a period of five months, from March 2006 to mid July 2006. Each case was accompanied with the patient's demographic data and medical history as well. Indications for mammography could be routine check up, screening or follow-up.

The mammoraphic images obtained through digitization using UMAX 1000XL scanner, with a resolution of 300 dots per inch (DPI), 16 bit greyscale colour depth and .tiff unzipped as the image format. The image size for each image was 2048X2048 while the size in megabytes was approximately 10 MB for each image.

Results

So far 51 cases have been reviewed and biopsy tested, following the clinical trial workflow mentioned earlier.

It must be stated that all these cases would have gone either to surgery or biopsy using Mammotome so every successful indication of a benign case from the CAD system would save this woman from an unnecessary surgery or biopsy.

The initial results have shown that 17 out of 51 patients that underwent biopsy with Mammotome had an actual -

tissue biopsy proven- malignant finding. The system successfully identified all malignant cases showing no false negatives. Furthermore, regarding the benign cases, Hippocrates-mst was able to identify that eighteen of them were benign or possibly benign assigning them a percentage between 0 and 55.

Discussion

The clinical trial protocol worked flawlessly as there were no problems in the CAD system's integration in the Breast Unit's workflow. The doctors were tutored on how to use the system and were able to quickly review each case using Hippocrates-mst's digital image tools as well as the microcalcification detection and classification module.

The laboratory's as well as the first clinical evaluation test results of all malignant cases were encouraging, since no malignant cases were falsely classified as benign. It must be stated here that the correct categorisation of malignant cases was our primary goal during the proposed system's development.

Clinical Trial of a CAD System for microcalcification detection and classification.

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The Hippocrates-mst

Is a computer aided diagnosis system (CAD) that uses:

- Image processing techniques
- Artificial intelligence methods

In order to help in early breast cancer diagnosis

Methodology

- Image Processing
  For microcalcification detection
- Image Analysis
  To export and quantify the microcalcifications' characteristics
- Classification Algorithms
  For the microcalcifications' classification
- Diagnosis Model
  To evaluate the findings and to propose a diagnosis

Image Analysis for the export and quantification of characteristics

Microcalcifications' measured characteristics:

- Size
- Sub dense Center
- Circularity
- Brightness
- Anomalies in shape
- Branching
- Windings

Classification Algorithms

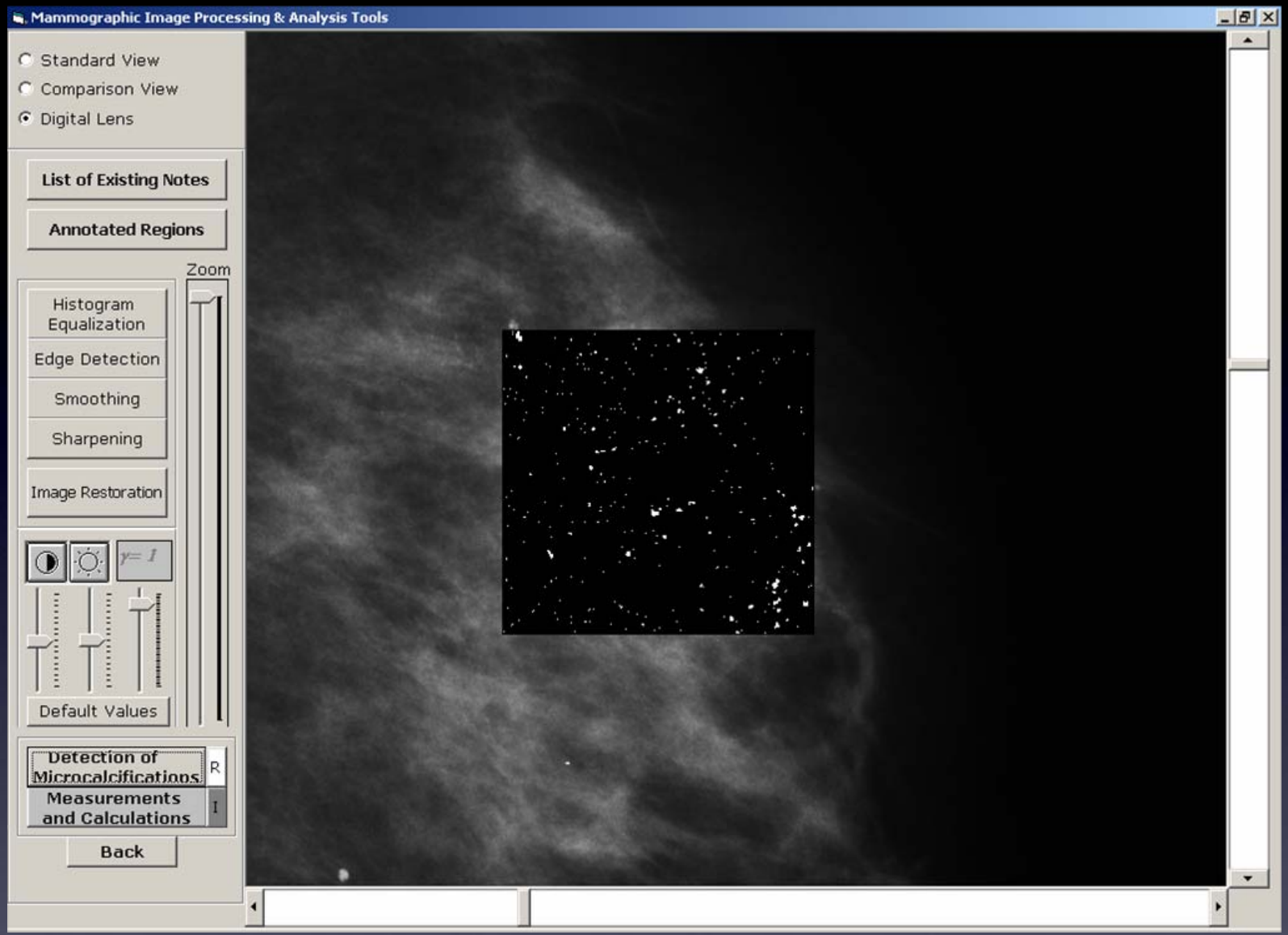
Consist of modeled empirical rules based on :

- Information given by specialized clinical doctors
- Relevant Medical Bibliography

Diagnosis Model

Mathematical model based on the following parameters :

- Risk from total number of microcalcifications
- Number of high risk microcalcifications
- Polymorphy of microcalcifications
- Position and direction of the microcalcification cluster
- Patient’s age and medical history



Microcalcification Detection

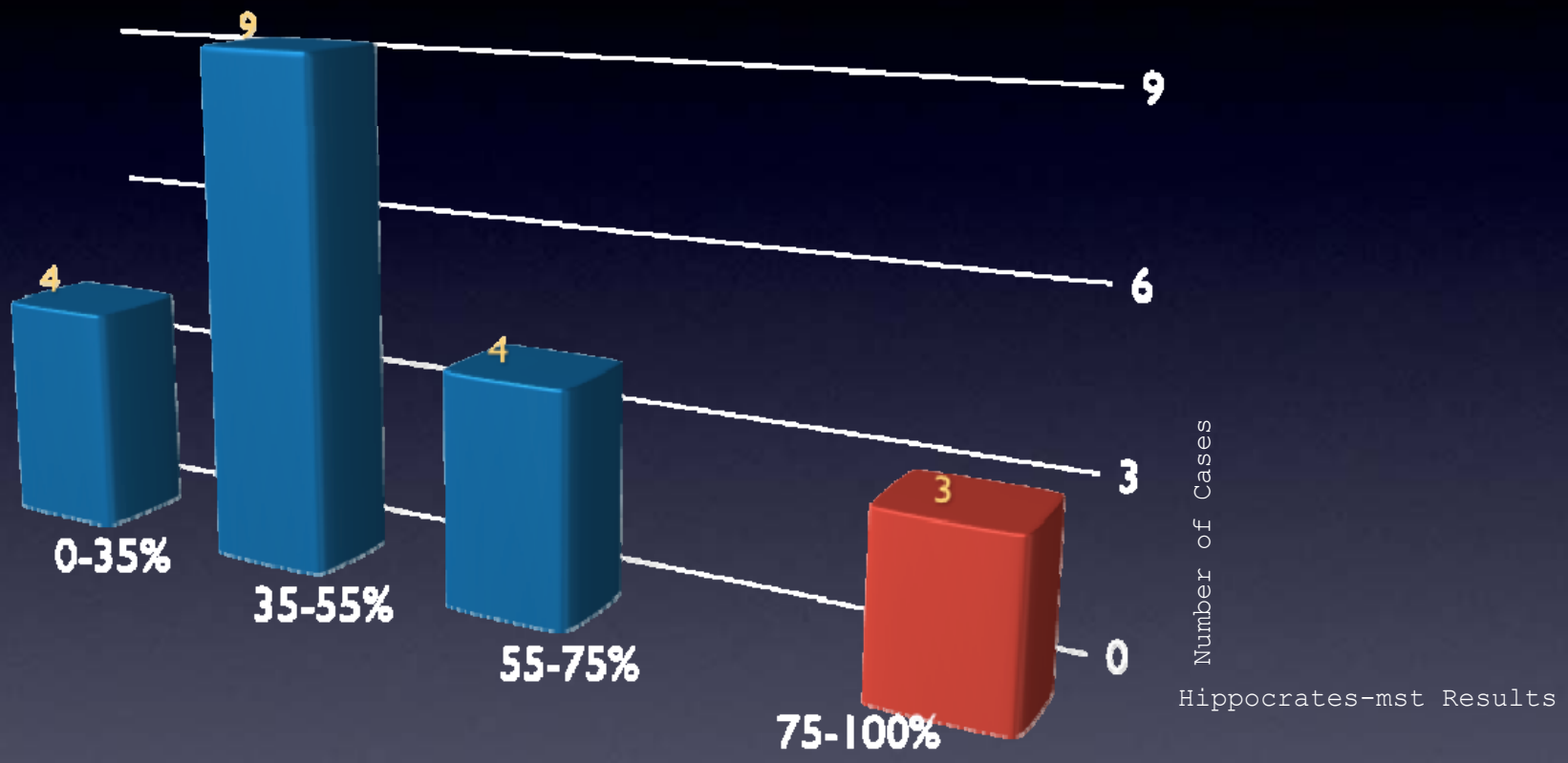
Results

- The sample images set contained 20 mammograms, of both craniocaudal and mediolateral views, with microcalcifications collected in a period of two months, from mid February 2006 to mid April 2006. Each case was accompanied with the patient's demographic data and medical
- 3 out of 20 patients that underwent biopsy with Mammotome had an actual -tissue biopsy proven- malignant finding. The system successfully identified all malignant cases showing no false negatives.

Results

- Hippocrates-mst was able to identify that eight of them were benign or possibly benign assigning them a percentage between 0 and 55.
- Every successful indication of a benign case from the CAD system could save this woman from an unnecessary surgery or biopsy.

Clinical Trial Results



Discussion

- The clinical trial protocol worked flawlessly as there were no problems in the CAD system's integration in the Breast Unit's workflow.
- The first week the doctors seemed unfamiliar with the system's interface but after a number of tutorials and some hours of hands-on experience they were able to quickly review each case using Hippocrates-mst's digital image tools as well as the microcalcification detection and classification module.

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Content Based Image Retrieval of Glioblastoma Multiforme

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UCLA Medical Imaging Informatics

Introduction

- Glioblastoma multiforme brain tumors have a variety of MR image presentations
- Mean time to survival of patients diagnosed with GBM who have undergone standard treatment protocols is 18 months
- Time to survival, within the GBM subgroup of malignant brain tumors, is highly variable

Background

- Several studies have been done to find relationship between imaging variables and prognosis
- Imaging variables that negatively correlated with survival were: presence of edema, necrosis, satellites, and multifocality
- Previous literature uses qualitative descriptors of imaging findings or simple quantitative indices, such as bi-linear measurements

Methodology

- **T1 post-contrast SPGR sequences, prior to surgery, from 40 patients diagnosed in GBM made up the data set.**
- **All patients underwent gross total resection and subsequent radiation and chemotherapy regimen.**
- **Quantitative features extracted from T1 post contrast study, but the T2 sequence was used to accurately delineate the edema region (Figure 1)**

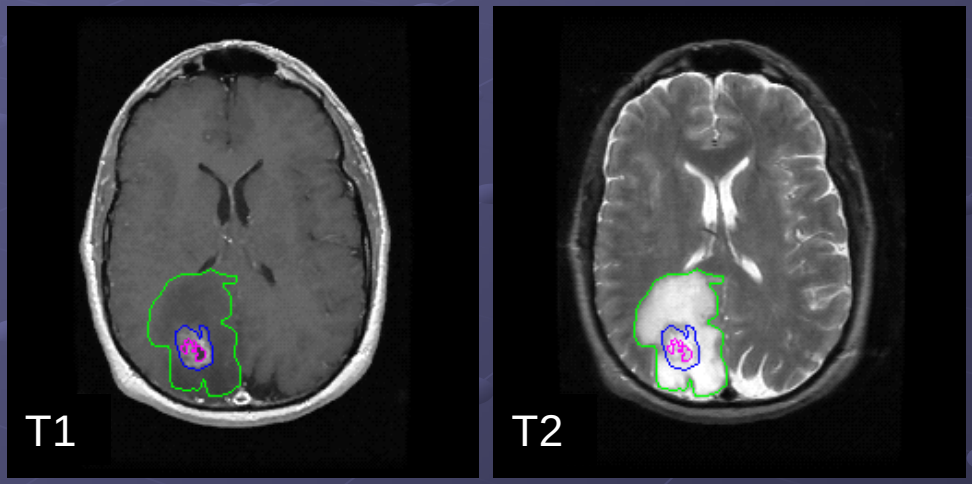


Figure 1. The left and right images are the T1 post contrast and respective T2 with the labeled regions that were segmented for quantitative analysis. The edema boundary is outlined by green, contrast enhancement by blue, and necrosis by magenta.

Image Conditioning

- Images were pre-processed to improve image quality
- The steps consisted of:
  1. Denoising (FSL)
  2. Brain Extraction (FSL)
  3. Image Alignment (FSL)
  4. Image Intensity Standardization via Normal Hemisphere Histogram Matching

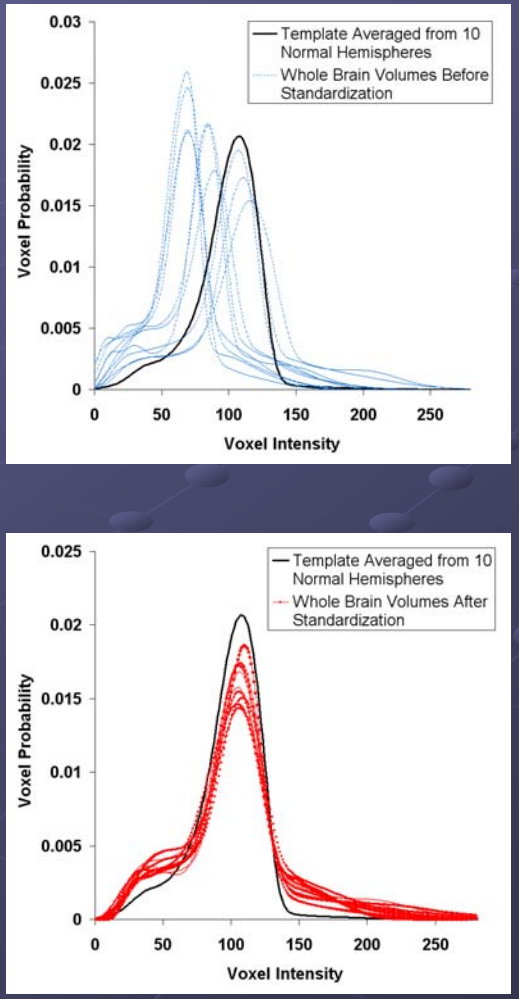


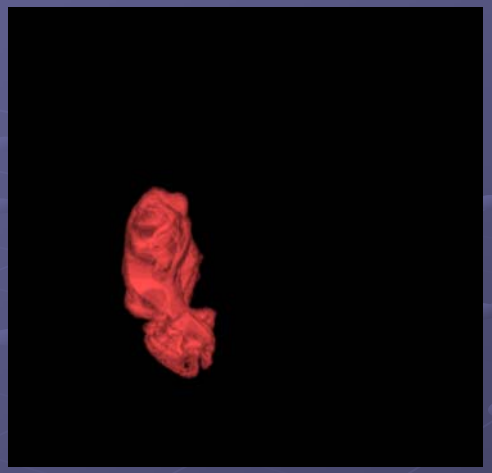
Figure 2. a) Histogram plots of $h_{template}$ and patient data before standardization b) Histogram plots of $h_{template}$ and patient data after standardization

Features

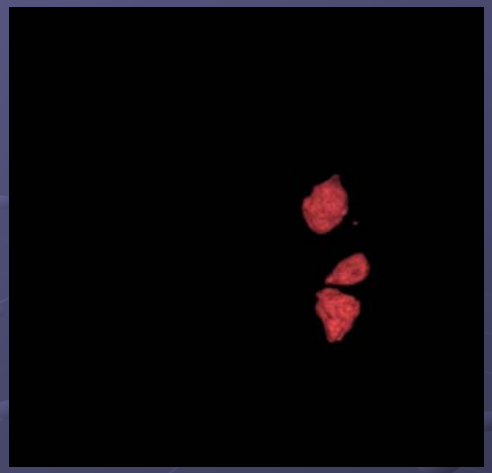
Category	Features
3D Texture via Co-occurrence Matrix	Correlation Contrast Homogeneity Energy
3D Shape Moments	Order 0 Invariant Moment (Volume) Order 1 Invariant Moments Order 2 Invariant Moments Order 3 Invariant Moments
Histogram	Mean Variance Skewness Kurtosis

Table 1: List of the different features extracted for each sub-region. The features consisted of texture parameters derived from 3D co-occurrence matrices, 3D shape moments, and histogram parameters.

Example 1 (Age = 68 years, TTS = 80 days)

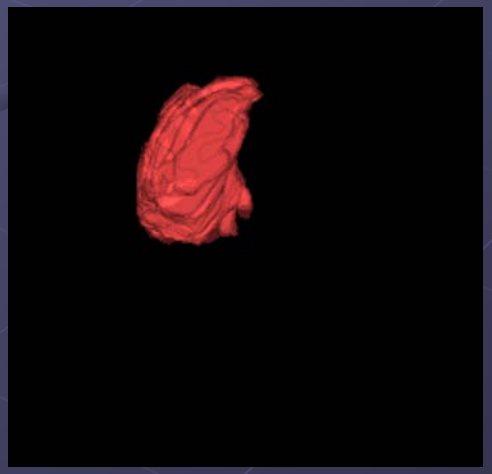


Edema Volume

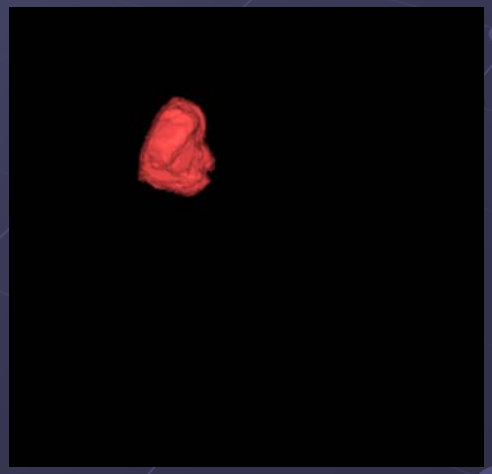


Contrast Enhancing Tumor Volume

Example 2 (Age = 64 years, TTS = 721 days)

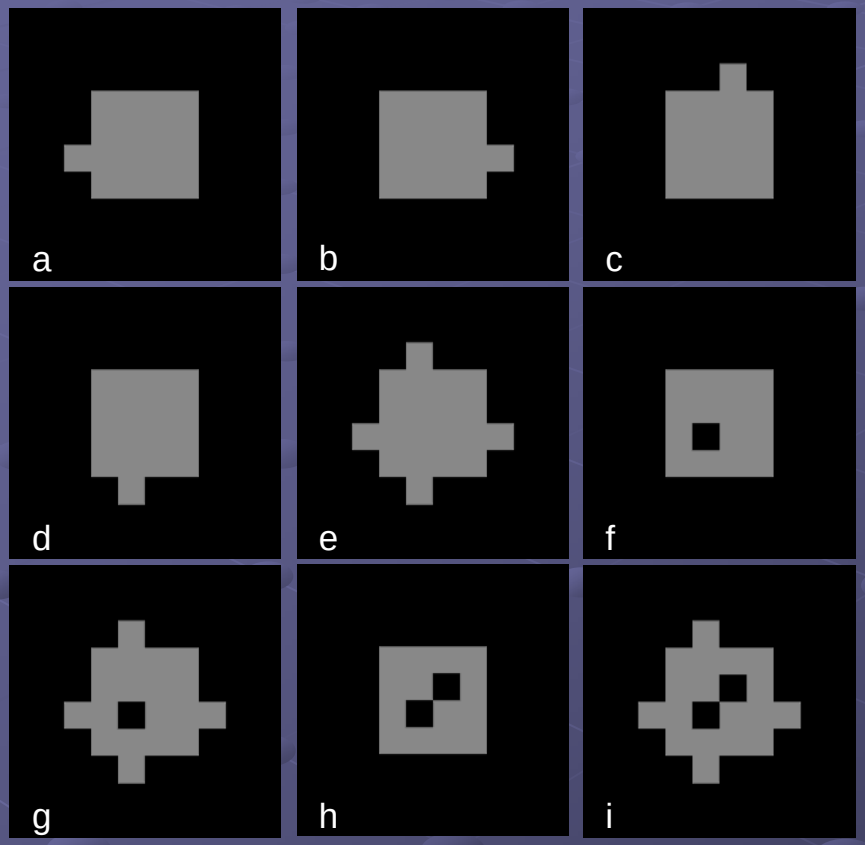


Edema Volume



Contrast Enhancing Tumor Volume

Invariant Shape Features

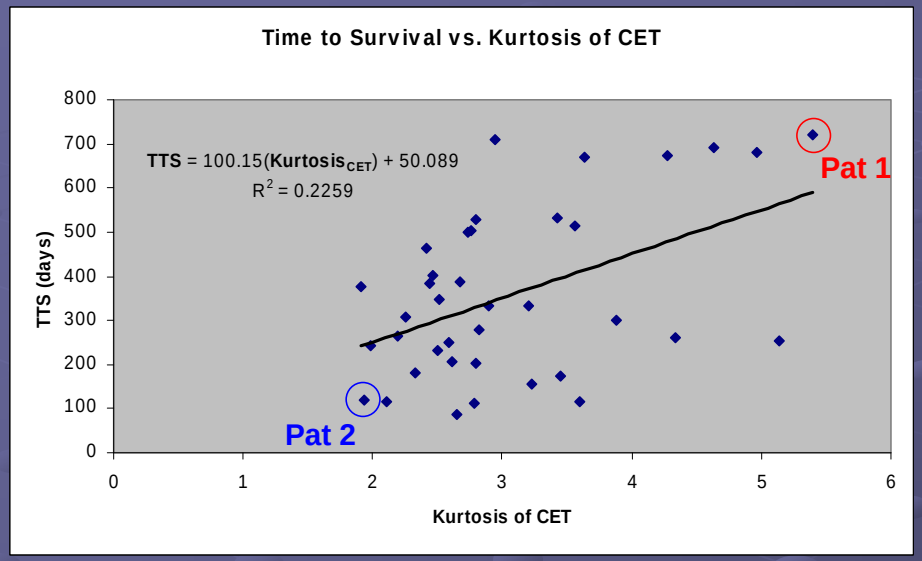


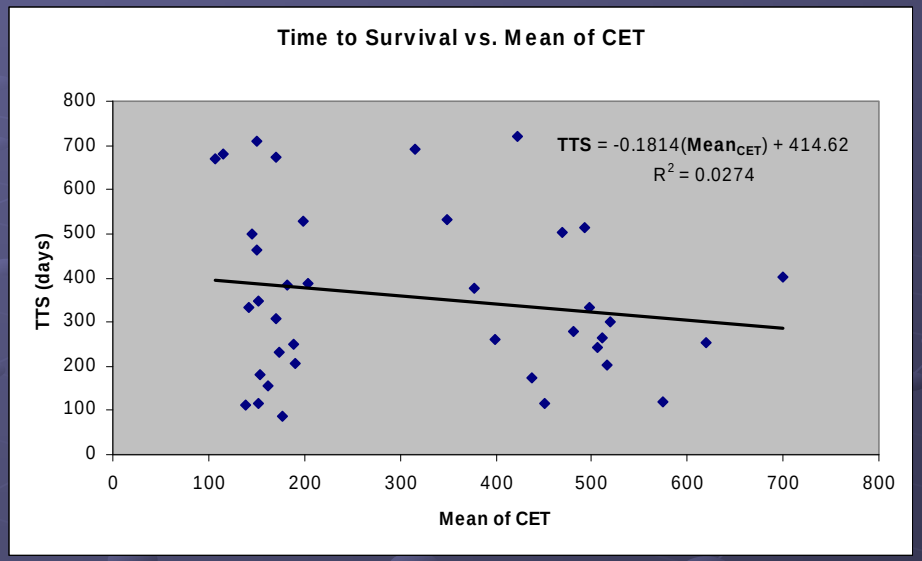
Synthetic shapes based on a cube

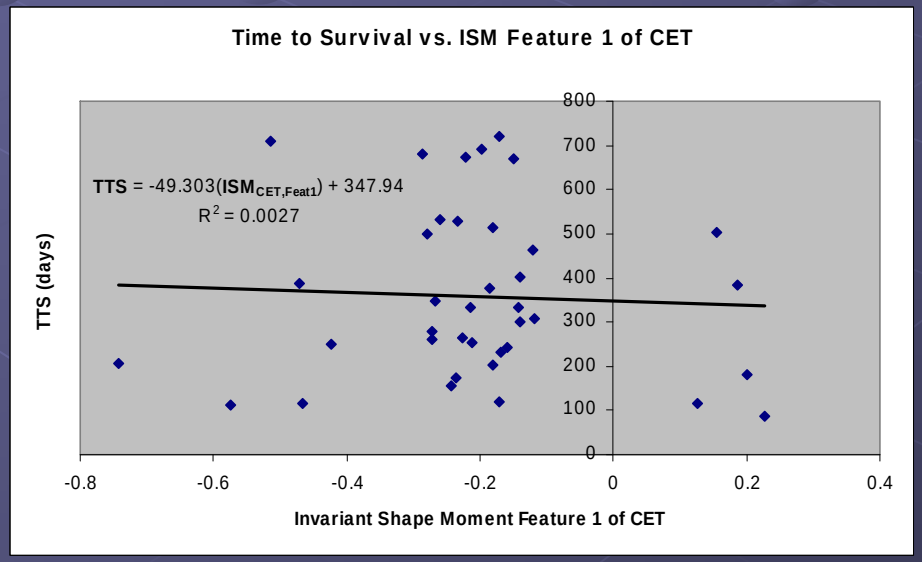
	Cube	A	B	C	D	E	F	G	H	I
I^2_00	**0.526**	**0.529**	**0.529**	**0.529**	**0.529**	**0.533**	**0.543**	**0.548**	**0.56**	**0.56**
I^2_22	**0**	**0.108**	**0.108**	**0.108**	**0.108**	**0.121**	**0.048**	**0.129**	**0.06**	**0.139**
I^2_222	0	-0.104	-0.104	-0.104	-0.104	0.117	0.044	0.124	-0.04	0.132
I^3_11	0	-0.1008	-0.1008	-0.1008	-0.1008	-0.124	-0.144	-0.155	-0.14	-0.16
I^3_33	0	-0.144	-0.144	-0.144	-0.144	-0.161	-0.077	-0.167	-0.08	-0.17
I^3_1113	0	-0.106	-0.106	-0.106	-0.106	0.124	0.1038	0.127	0.125	0.156
I^3_1133	0	0.118	0.118	0.118	0.118	0.126	0.102	0.149	0.11	0.152
I^3_1333	**0**	**-0.126**	**-0.126**	**-0.126**	**-0.126**	**-0.134**	**0.086**	**-0.145**	**0.08**	**-0.149**
I^3_3333	0	0.14	0.14	0.14	0.14	0.143	0.074	0.144	0.08	0.147
I^2,3_112	0	0.099	0.099	0.099	0.099	-0.123	-0.102	-0.134	-0.116	-0.156
I^2,3_123	**0**	**-0.115**	**-0.115**	**-0.115**	**-0.115**	**-0.124**	**-0.083**	**-0.139**	**-0.09**	**-0.148**
I^2,3_233	0	0.128	0.128	0.128	0.128	0.14	-0.066	0.139	-0.055	0.144

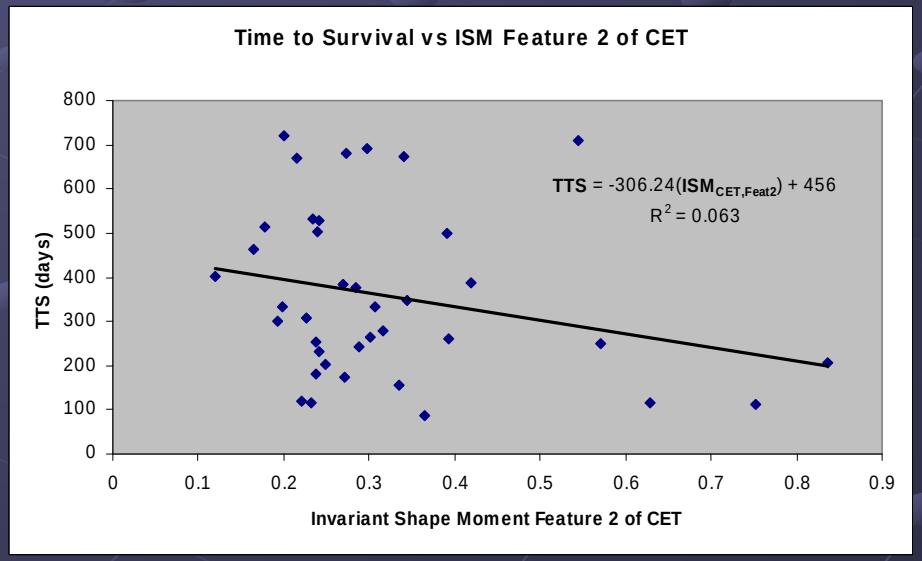
Invariant Shape Feature Values for Synthetic Shapes

Results

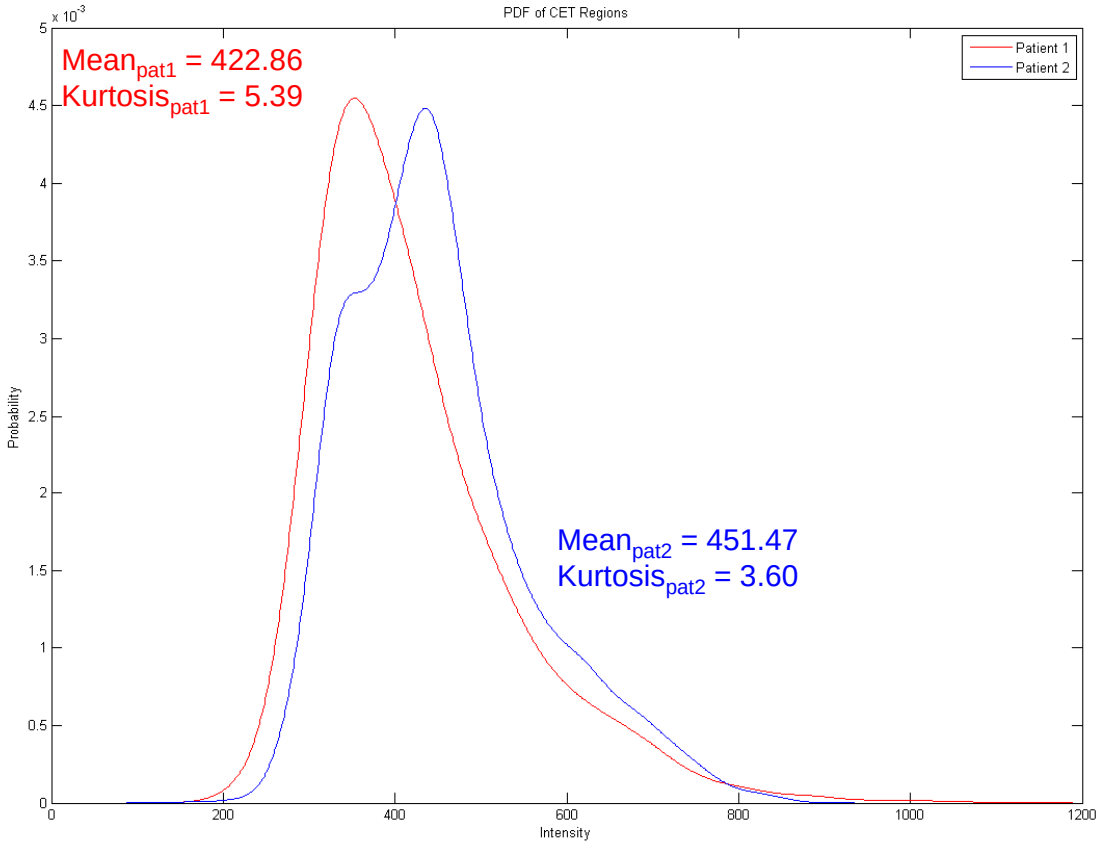

Time to Survival vs. Kurtosis of CET
TTS = 100.15(Kurtosis$_{CET}$) + 50.089
R^2 = 0.2259
Pat 1
Pat 2
TTS (days)
Kurtosis of CET


Time to Survival vs. Mean of CET
TTS = -0.1814(Mean$_{CET}$) + 414.62
R^2 = 0.0274
TTS (days)
Mean of CET

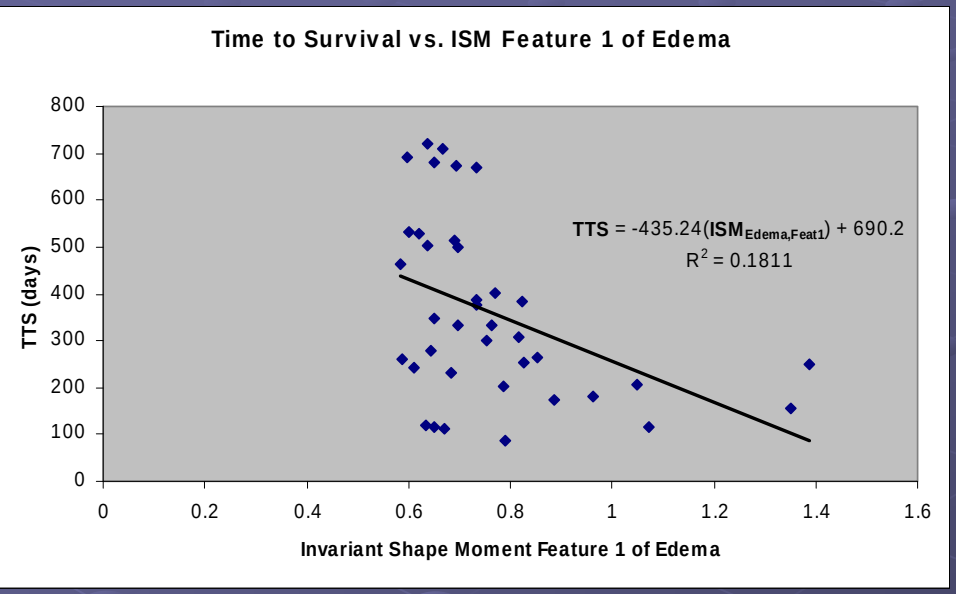

Time to Survival vs. ISM Feature 1 of CET
TTS = -49.303(ISM$_{CET,Feat1}$) + 347.94
R^2 = 0.0027
TTS (days)
Invariant Shape Moment Feature 1 of CET

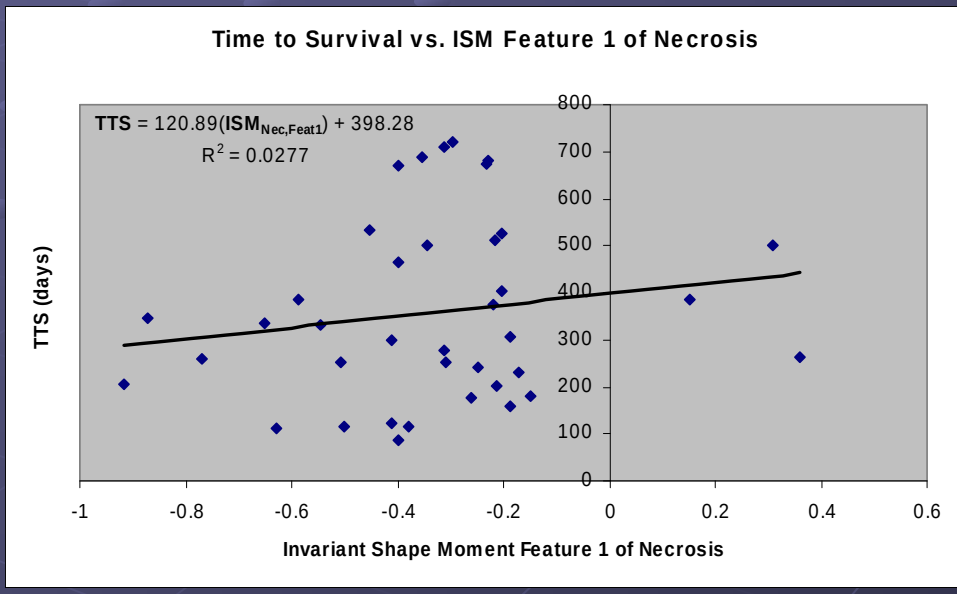

Time to Survival vs ISM Feature 2 of CET
TTS = -306.24(ISM$_{CET,Feat2}$) + 456
R^2 = 0.063
TTS (days)
Invariant Shape Moment Feature 2 of CET

Results


PDF of CET Regions
x 10^-3
Patient 1
Patient 2
Mean_pat1 = 422.86
Kurtosis_pat1 = 5.39
Mean_pat2 = 451.47
Kurtosis_pat2 = 3.60
Probability
Intensity
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
0
200
400
600
800
1000
1200

Results


Time to Survival vs. ISM Feature 1 of Edema
TTS = -435.24(ISM Edema,Feat1) + 690.2
R2 = 0.1811
TTS (days)
Invariant Shape Moment Feature 1 of Edema
0
100
200
300
400
500
600
700
800
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6


Time to Survival vs. ISM Feature 1 of Necrosis
TTS = 120.89(ISM Nec,Feat1) + 398.28
R2 = 0.0277
TTS (days)
Invariant Shape Moment Feature 1 of Necrosis
0
100
200
300
400
500
600
700
800
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6

Feature Correlation

Model	Variables	Coefficients	Adjusted R Squared
1	Constant	50.09	0.204
	Kurtosis of CET	100.15	
2	Constant	363.15	0.301
	Kurtosis of CET	85.46	
	2nd order ISM of Edema	-351.03	
3	Constant	501.80	0.374
	Kurtosis of CET	89.67	
	2nd order ISM of Edema	-414.70	
	Mean of CET	-0.33	
4	Constant	588.17	0.468
	Kurtosis of CET	100.76	
	2nd order ISM of Edema	-438.04	
	Mean of CET	-0.41	
	3rd order ISM of Necrosis	238.23	
5	Constant	613.02	0.539
	Kurtosis of CET	101.66	
	2nd order ISM of Edema	-510.09	
	Mean of CET	-0.39	
	3rd order ISM of Necrosis	365.13	
	2nd order ISM of CET	-315.30	
6	***Constant***	***713.84***	***0.585***
	Kurtosis of CET	***89.25***	
	2nd order ISM of Edema	***-428.44***	
	Mean of CET	***-0.48***	
	3rd order ISM of Necrosis	***325.91***	
	2nd order ISM of CET	***-518.02***	
	2nd order ISM of CET	***-469.59***	

Table 2: Results of the stepwise multivariate linear regression model applied to the quantitative imaging data. Each model shows the variables involved, their weighting coefficients, and the resulting correlation coefficient to describe how well the model fits the data.

Edema Features:

- **The value of the invariant shape descriptor chosen for edema has a trend to increase the more irregular a shape becomes and in the presence of holes (i.e. tumor/necrotic regions)**

Necrotic Features:

- **For the necrotic shape descriptor, higher irregularity also leads to an overall lower estimate of survival, indicating the malignant nature in the morphology of the necrotic region**

Contrast Enhancing Tumor Features:

- **Kurtosis of CET reflects the peakedness of the intensity histogram, which is narrower for CET regions that had high TTS**
- **Mean intensity of the CET regions corresponds to average voxel uptake of the tumor. Thus, a higher uptake could indicate a higher degree of infiltration**
- **The two invariant shape parameters indicate that CET regions with a higher irregular structure accompanied with larger presence of necrosis yield an overall lower survival time estimate**

Future Work

- Expansion to a larger patient population
- Inclusion of more quantitative and qualitative (i.e. age, multifocality presence) features
- Correlations to other outcomes (i.e. time to tumor progression)
- Glioma molecular subtype characterization
- Application of an AdaBoost cascade methodology

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Content Based Image Retrieval of Glioblastoma Multiforme

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Abstract

We propose a Content Based Image Retrieval system, for patients diagnosed with Glioblastoma Multiforme that will predict of time to survival and allow a neuroradiologist to modify treatment procedures based on quantified features explicitly extracted from segmented regions of the tumor. Our proposed system has two components: a preprocessing scheme to improve the image quality and provide consistency and a multivariate linear model. The multivariate linear model applied to the training data had a correlation coefficient of 0.848, which indicated a strong association of the selected features to time to survival. Future work will involve expanding the training set and incorporating additional features not explicitly extracted from the segmented tumor regions.

Keywords:

content based image retrieval, imaging informatics, image data mining, image processing, disease modeling

Introduction

Medical image databases have grown immensely in the past few years. Imaging studies, such as magnetic resonance (MR) and computed tomography (CT) result in a large volume of data. The ability to query large image databases can form the basis of a decision support system. However, a large number of existing image databases are indexed by text annotations that routinely contain patient demographic or study information. Manual methods to extend this with more comprehensive text annotation that capture image content are both tedious and time-consuming. We propose a CBIR system for GBM tumor cases for the purposes of visualizing the variety of different disease presentations that can exist given similar features as well as prediction of time to survival given a query volume (for the purposes of treatment modification). Our proposed CBIR system includes a fast and automated segmentation component with the ability to allow a radiologist to modify the pertinent regions segmented, as well as a multivariate linear regression model predicting time to survival based on particular features (extracted only from the T1 post contrast enhanced studies) of the tumor region.

Materials and methods

Two important components are required in order to have an accurate and efficient CBIR system of brain tumor images: I) preprocessing of images to reduce variability resulting from differing MR scanner conditions; II) an accurate model relating time to survival to extracted quantified features. Our proposed methods for the three areas are discussed below.

Preprocessing scheme

The following steps were performed to improve SNR, register the two image channels of a given subject, and to obtain consistent image intensities across all subjects for a given channel: Denoising –FSL nonlinear filter [3], Registration – For image alignment [3], Intensity Standardization – Performed via a histogram matching method (Figure 1) [4].

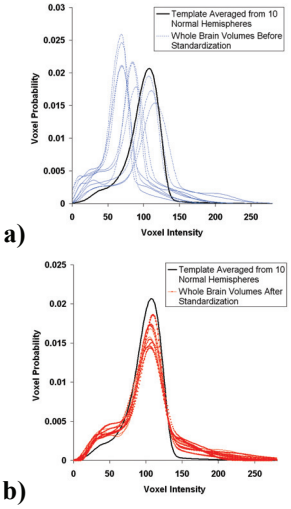

Figure 1 - a) Histogram plots of $h_{template}$ and patient data before standardization b) Histogram plots of $h_{template}$ and patient data after standardization

Quantitative feature modeling

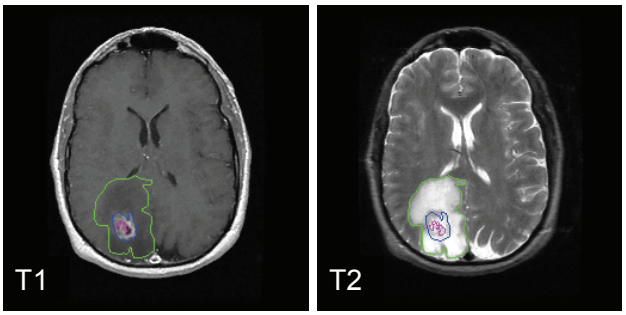

Figure 2 - The left and right images are the T1 post contrast and respective T2 with the labeled regions that were segmented for quantitative analysis. The edema boundary is outlined by green, contrast enhancement by blue, and necrosis by magenta

Imaging data from 34 subjects with GBM were included in the analysis for training purposes, and an additional 4 patients' images were kept aside for querying purposes. The quantitative features were extracted from only the T1 post-contrast study, but the T2 sequence was used to accurately delineate the edema region (Figure 2). Table 1 is a list of the shape, texture and intensity histogram features extracted for each tumor sub-region. A stepwise multivariate linear regression model was applied to the quantitative data to determine the quantitative variable (or combination of variables) that best predict time to survival.

Table 1 - List of the different features extracted for each sub-region. The features consisted of texture parameters derived from 3D co-occurrence matrices, 3D shape moments, and histogram parameters

Category	Features
3D Texture via Co-occurrence Matrix	Correlation Contrast Homogeneity Energy
3D Shape Moments	Order 0 Invariant Moment (Volume) Order 1 Invariant Moments Order 2 Invariant Moments Order 3 Invariant Moments
Histogram	Mean Variance Skewness Kurtosis

Results

Multivariate Linear Regression Model

Table 2 shows the results of the stepwise multivariate linear regression model.

Table 2 - Results of the stepwise multivariate linear regression model applied to the quantitative imaging data

Model	Variables	Coefficients	Adjusted R^2
1	Constant	329.54	0.648
	3rd order SM of CE	4.37E-06	
2	Constant	326.154	0.739
	3rd order SM of CE	4.27E-06	
	2nd order SM of Edema	-8.40E-06	
3	Constant	404.316	0.783
	3rd order SM of CE	4.51E-06	
	2nd order SM of Edema	-6.50E-06	
	Correlation of Edema	788.71	
4	Constant	406.22	0.814
	3rd order SM of CE	4.55E-06	
	2nd order SM of Edema	-5.50E-06	
	Correlation of Edema	771.308	
	3rd order SM of Edema	6.34E-07	
5	**Constant**	**214.446**	**0.848**
	3rd order SM of CE	**4.61E-06**	
	2nd order SM of Edema	**-3.80E-06**	
	Correlation of Edema	**747.286**	
	3rd order SM of Edema	**6.85E-07**	
	Kurtosis of CE	**64.09**	

Table 2 shows the results of the stepwise multivariate linear regression model. Each model corresponds to the number of variables used to predict survival and the respective correlation coefficient. For a given model n (where n represents the number of variables), the variables (along with their respective weighting coefficients) that gave the best correlation with time to survival are listed.

Discussion

As can be seen in Table 2, the shape and texture of edema show strong correlations to time to survival. Edema presumably follows the white matter tracts, and a higher infiltration of the tracts may be captured in the shape indices as structures of high morphological anisotropy. The correlation texture feature is related to the inhomogeneity of intensity in the edema sub-region. Infiltration of tumor cells into edema could potentially result in inhomogeneous intensities of the edema sub-regions. Greater infiltration into the surrounding peri-tumoral edema has a poor prognosis and this could be the basis for a correlation between the edema texture feature and time to survival. The correlation of the shape of contrast enhancing tumor region to survival time may also have its origin in the infiltrative nature of tumor. Kurtosis of the intensity histogram primarily reflects asymmetry and the presence of a long tail in the high intensity end of the histogram. This heterogeneous intensity profile may arise from some voxels

showing a high uptake of the contrast agent, which in turn may reflect tumor aggressiveness.

Future work will involve expanding the multivariate model training set to 100 patients and including features not derived explicitly from the segmented volumes (i.e. age, presence of multifocality) that have been shown to have some correlation with survival.

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On Classification of Otoneurological Cases Based on Vestibulo-ocular Reflex Signals

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Abstract

According to signal analysis and pattern recognition results earlier computed by us, we distinguished a set of patients from the healthy subjects. Classification was executed on the basis of machine learning methods to explore, which methods are the most efficient to identify the two classes from each other. We implemented programs for nearest neighbour searching, clustering, decision trees, Bayesian decision rule, multilayer perceptron networks and Kohonen networks. The last method was better than the others and obtained total accuracies as high as 94 %.

Keywords:

vestibulo-ocular reflex, eye movements, classification

Introduction

In otoneurology diseases entailing vertigo and other balance problems are investigated, among others, with signal analysis techniques applied to various measurements recorded from subjects. We began our research on this topic already in the 1980s by using syntactic pattern recognition methods for saccades, nystagmus, sinusoidal tracking eye movements and vestibulo-ocular reflex.

We constructed a computer program developed from our earlier research to recognize vestibulo-ocular reflex responses. In this research we continue the work by testing and surveying several classification methods to identify patients from healthy subjects along with the signal analysis results given by our syntactic pattern recognition technique.

Methods

In order to yield vestibulo-ocular reflex, head movements have to be made. We have developed a computer-controlled mechanical device to produce carefully guided horizontal head movements of a subject. For this purpose, a subject sat in a fixed chair and a boxer's helmet was tightly set on the subject's head. Two push rods controlled by an electronic DC motor and connected to the boxer's helmet moved the head from the centre to the left or right and back after an interval of 0.7-1.2 s.

During the measurement the subject was due to keep the gaze toward a fixed object. Each head movement stimulates a rather symmetric eye movement response in the opposite direction. Head movements were recorded with a potentiometer. Both signals were measured at the same time at 400 Hz and lowpass filtered to dampen noise above approximately 70 Hz. Signals of 22 healthy subjects and 22 patients were measured for 80 s.

We applied our syntactic method to recognize stimulation head movements and their eye movement response from each signal pair. Latency and gain values between stimulations and responses were computed. We computed three gain estimates. The first one, g_1, was computed according to linear regression. Second, we applied the ratio g_2 of the maximum velocity values of the response and stimulation and the ratio g_3 of their mean angular velocities. All three gains were computed on the basis of the 100 ms duration immediately after the beginning of a vestibulo-ocular reflex.

We computed average gain and latency values for the group of the 22 randomly selected healthy control subjects and similarly for the 22 patients, who suffered from unilateral otoneurological dysfunctions caused primarily by an operated acousticus neuroma. We separated their intact sides from those of the dysfunction since the intact side should be almost normal.

Results of machine learning methods

Our goal was to distinguish the healthy subjects from the patients by means of algorithms implemented in Matlab. They were run to compare their efficacy in the classification based on eye movements of vestibulo-reflex. We applied ten-fold crossvalidation by dividing the stimulation-response pairs of both subject groups (483 from the healthy and 371 from the patients) into ten subsets. If a method was such as neural networks that had some random initialization values, ten runs were still performed for each crossvalidation situation. Sensitivity, positive predictive value and total accuracy were computed for both classes.

Tests of *k*-nearest neighbour searching (Table 1) and *k*-means clustering in the Euclidean variable space (Table 2)

were run. We tested decision trees (Table 3), Bayesian decision rule (Table 4) and multilayer perceptron neural networks (Table 5).

Table 1 - Means and standard deviations [%] of classification results with k-nearest neighbour searching

k	Sensitivity		Positive predictive value		Total accuracy
	healthy	disordered	healthy	disordered	
1	86.9±7.2	80.5±12.7	85.9±8.3	82.7±8.0	84.2±7.5
3	93.8±5.6	76.2±13.4	84.3±7.6	90.7±6.7	86.2±6.4

Table 2 - Means and standard deviations [%] of classification results with k-means clustering

k	Sensitivity		Positive predictive value		Total accuracy
	healthy	disordered	healthy	disordered	
2	90.2±7.2	78.2±10.7	84.8±6.7	86.6±8.6	85.0±6.2
4	63.1±15.9	48.8±14.8	61.3±10.1	51.3±11.5	56.9±10.7

Table 3 - Means and standard deviations [%] of classification results with decision trees

Mean of leaves used	Sensitivity		Positive predictive value		Total accuracy
	healthy	disordered	healthy	disordered	
25.9	94.7±6.0	83.6±13.3	89.0±7.8	92.6±7.3	89.8±6.9

Table 4 - Means and standard deviations [%] of classification results with Bayesian decision rule

Sensitivity		Positive predictive value		Total accuracy
healthy	disordered	healthy	disordered	
92.5±7.0	82.7±11.3	87.9±7.3	89.8±8.8	88.3±7.1

Table 5 - Means and standard deviations [%] of classification results with multilayer perceptron neural networks

Hidden nodes	Sensitivity		Positive predictive value		Total accuracy
	healthy	disordered	healthy	disordered	
4	94.3±6.7	80.6±14.5	87.1±7.8	91.0±12.5	88.4±7.5
8	93.4±7.9	82.0±11.4	87.5±7.1	91.1±9.5	88.5±7.3
16	93.4±8.2	82.9±11.6	88.1±7.1	91.2±9.3	88.8±7.3

Kohonen networks were tested with ten runs with hexagonal neighbourhood pattern used with link distance (Table 6). Networks including 36 or more nodes reached 3-11 % higher outcomes than those in Tables 1-5.

Table 6 - Means and standard deviations [%] of classification results with Kohonen neural networks

Nodes	Sensitivity		Positive predictive value		Total accuracy
	healthy	disordered	healthy	disordered	
3 × 3	94.4±4.8	83.5±9.6	88.6±6.3	92.3±6.4	89.7±4.9
5 × 5	94.8±2.2	89.5±9.6	92.5±6.4	93.0±2.9	92.5±4.4
7 × 7	98.1±2.3	90.0±7.2	93.0±4.8	97.5±3.1	94.6±3.4

Using Wilcoxon matched-pairs signed-ranks test, the efficiency of the methods are compared to each other. Because the *k*-nearest neighbour searching method, Bayesian decision rule and Kohonen networks were tested with ten and the others with 100 test settings, we compare inside these two method groups. The results of Kohonen networks of size 7 × 7 significantly differed from those of the *k* nearest neighbour searching of k=3 at the significant level of 0.001 and from those of the Bayesian decision rule at 0.01. The results of the perceptron networks of size 16 hidden nodes highly significantly differed from those of the *k*-means clustering with k=2. Further, the results of the decision trees highly significantly differed from clustering results and perceptron networks at 0.001.

Discussion and conclusion

The methods of *k*-nearest neighbour searching and *k*-means clustering produced average total accuracies of 84-86 %, the Bayesian decision rule evolved 88 % and the decision trees gave as high as 90 % total accuracies. Per-

ceptron neural networks obtained 88 % total accuracies. Thus, the nearest neighbour searching and clustering were the weakest, the multilayer perceptron networks followed with the Bayesian decision rule, the decision tree method was the next best, and the Kohonen neural networks were the best. The running times (with the 3 GHz processor) expectedly favoured the first three simple methods. The approximate durations were 7 s for the 10 nearest neighbour searching tests, 3 s for the 100 k means clustering tests, 1 min 13 s for the 100 decision tree tests. The Bayesian decision rule was the fastest, with clearly less than 1 s. For the 100 tests of the multilayer perceptron networks they were approximately 4 min 25 s for two hidden nodes and 6 min 23 s for 16 hidden nodes. For the 10 tests of the Kohonen neural networks they were 2 h 15 min for 2×2 nodes and 2 h 21 min for 7×7 nodes. These durations show how more effective but also complicated methods require considerably more time. On the other hand, the training process of the networks only once run engulfed most of the running time.

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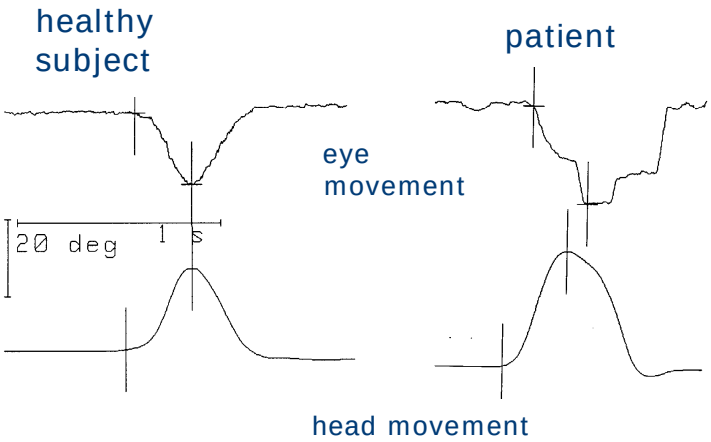
Methods

In order to stimulate vestibulo-ocular reflex [5-7] (upper fig.), head movements are made. We have developed a computer-controlled mechanical device [8] to produce horizontal head movements of a subject. A subject sat in a fixed chair (lower fig.) and a boxer's helmet was tightly set on her head. Two push rods controlled by an electronic DC motor and connected to the boxer's helmet moved the head from the centre to the left or right and back after an interval of 0.7-1.2 s.



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We computed average gain and latency values for the group of the 22 randomly selected healthy control subjects and similarly for the 22 patients, who suffered from unilateral otoneurological dysfunctions caused primarily by an operated acousticus neuroma. We separated their intact sides from those of the dysfunction since the intact side should be almost normal.

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Table 4 – Means and standard deviations [%] of classification results with Bayesian decision rule.

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92.5±7.0	82.7±11.3	87.9±7.3	89.8±8.8	88.3±7.1

Table 5 – Means and standard deviations [%] of classification results with multilayer perceptron neural networks.

Hidden nodes	Sensitivity		Positive predictive value		Total accuracy
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4	94.3±6.7	80.6±14.5	87.1±7.8	91.0±12.5	88.4±7.5
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16	93.4±8.2	82.9±11.6	88.1±7.1	91.2±9.3	88.8±7.3

Table 6 – Means and standard deviations [%] of classification results with Kohonen neural networks.

Nodes	Sensitivity		Positive predictive value		Total accuracy
	healthy	disordered	healthy	disordered	
3 × 3	94.4±4.8	83.5±9.6	88.6±6.3	92.3±6.4	89.7±4.9
5 × 5	94.8±2.2	89.5±9.6	92.5±6.4	93.0±2.9	92.5±4.4
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Photoplethysmographic Measurement of Pulse Shape

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Background

Photoplethysmography (PPG) is a noninvasive test that uses a light-emitting diode and a photoelectric cell to detect changes in skin blood volume. Blood volume of the skin can be changes, so too does the amount of light reflected back to the sensor.

We developed multi-channel PPG systems and tested the reproducibility of the system to measure the volume pulse from healthy subjects.

Method

Twenty healthy volunteers were studied (M:F = 6:14) The PPG sensor was applied to the 2nd finger tip of subjects Pulse acquisition was done for 3 min and repeated again with 3 min interval (Sampling rate of 400 Hz). Acquired pulses was synchronously averaged into one representative pulse (only including the pulses with pulse duration of average ± 1 SD)
Pulse averaging was performed using Visual C++ & Matlab on PC.

Results

In 11 subjects, pulse parameters were calculated and correlation coefficients were r=0.68 for PT1, 0.48 for PT2 and 0.58 for augmentation index

Conclusion

Parameters of digital PPG did not showed reasonable reproducibility. However, further studies including more subjects & advanced devices is warranted.

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Towards Computational Formulation of Complex Theories through Model Interchange and Integration

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Abstract

Traditionally the time it took researchers to collect high-quality data through experimentation was longer than the time it took to formulate theories that explain them. In recent years, high-throughput data gathering methods have reversed this. Advances in computer technology and a systems approach to biology has led to the adoption of computer models as a means to formulate and test theories in silico faster and more cheaply than previously possible. This has led to a proliferation of model representations and ontologies, creating a complexity that is unwieldy to its human authors. Based on these trends and state-of-the-art practices evidenced in the literature, a new trend of computer-generated, integrated models of high complexity is predicted. In this paper we explain the trend and the challenges that it is likely to raise.

Keywords:

computer aided knowledge discovery, multi-models, multi-scale models, multi-method models

Introduction

In recent years, changes have been emerging in the way life-scientists make novel discoveries. New high-throughput measurement technologies such as mass spectrography, flow cytometry, microarray chips and biobanks are so widespread that more data is gathered than can be analysed [1]. Computer models are nowadays well established as tools required for gaining profound insights from data. The amounts of data and complexity of models is becoming a research area [2-5].

Another emerging research area, in which models are used in scientific discovery, is called "hypothesis generation". Briefly, an algorithm generates models that don't contradict known data [6,7]. In this paper we explain and give examples of two integrated biomedical models. We then discuss the requirements for computer generated integrated biomedical models.

Materials and methods

Many distinct methods have been shown to be effective in modelling life science systems. Some of the more common methods are differential equations [8], numerical methods [9], system dynamics [10], Bayesian networks [11], -calculus [12] and petri-nets [13].

Computer aided knowledge discovery is a relatively new sub-discipline of Machine Learning that is concerned with supporting the discovery of scientific theories. In biomedicine, machine learning has only been used for about 15 years [6,7,14-18]. The on-line Journal of Biomedical Discovery and Collaboration, the first peer-reviewed journal dedicated to biomedical knowledge discovery, was launched in March, 2006 [19].

Multi-modelling

Model construction is a tedious manual task even when assisted by authoring software. Recently, automatic generation of models was shown to be a promising way of constructing hypotheses and suggesting experiments that can falsify them and thus lead to new discoveries [15,20]. These successes exemplify a potentially substantial change in the way we discover natural phenomena.

Complex models are generally limited by several factors. The following issues are of interest to this paper:

- *Two or more modelled interacting systems might not have a common representation suitable to all of them.*
- *The data available for different modelled systems or even different parts of a system are collected in a variety of experimental settings and can't easily be consolidated.*
- *Models' complexity is hindering their intelligibility.*

These limitations can usually be alleviated by modelling each system independently and then interchanging information between the models. We call this method **multi-modelling**.

We distinguish between two kinds of multi-models: multi-scale models, and multi-method models.

Multi-scale models

These are multi-models in which at least one pair of interacting systems operate in different spatio-temporal scales (*e.g.* a cell model integrated with a tissue model) or ontologies *(e.g.* a protein model integrated with a metabolic model). While the models need not be spatial themselves, the interaction crosses scales.

Multi-method models

These are multi-models in which at least one pair of interacting systems are simulated using different representations. Many representations are agnostic to scale. The representation method determines how modelled systems are simulated, visualised (or otherwise explained) and how the model interacts with- or is compared to other models.

Typically, multi-models are either multi-scale, multi-method or both. It is possible to construct multi-models that are neither, assembling components at the same scale and using the same representation. A model of the interactions between two separately developed metabolic pathway models that use the same representation is an example of a multi-model that is neither multi-method nor multi-scale.

Model integration through spatial representation

A representation that is to interchange data between models that vary in method and scale will need one or more mathematical entities to be present in both models. Since spatial relationships are very common in biomedical modelling across all scales, we created a spatio-temporal representation language called the Field Representation Language (FRL)[21] to facilitate interchange of spatial information between different models.

FRL is a representation of algebraic fields which are constructs that vary over a domain defined in space and/or time. The language uses analytic expressions in predefined spatio-temporal coordinates (*e.g.* X, Y, Z) to define fields analytically, represent new interpolation methods and define field domains. FRL supports fields that are composed of one or more other fields. The composition is defined by mathematical relationships given as analytic expressions.

To facilitate integration between different simulation environments we created the Abstract Field Layer (AFL) – a mathematical library that can read and manipulate FRL files and perform numeric interpolation, derivation and integration on them. AFL is released under the General Public Licence (GPL) and is available from http://visiome.sourceforge.net.

Results

Multi-method model example

The work presented in this section was previously published [22]. This section summarises the work for completeness. The emphasis here is on the interchange of information between models of different representations. The interchange is illustrated in Figure 1.

The multi-model described is for treatment planning of progressed liver cancer. Ferromagnetic microspheres are introduced locally and then lodge in tumour capillaries. When the patient is subjected to an alternating magnetic field the microspheres emit heat, preferentially heating and destroying tumour tissue.

We developed a three-dimensional fractal model of microvasculature within the peripheral shell of a tumour (Figure 2a). Our model construction starts with four initial cylindrical segments representing arterial vessels. These initial segments then branch into smaller daughter segments according to probabilities derived from the literature. The segments are further constrained to a spherical shell. In turn, each segment branches and the process is repeated until the segments are too thin to allow microspheres through. The resulting vasculature covers more than an octant of the tumour.

We constructed 21 different vasculature models using different random seeds. We simulated microsphere infusion into the four initial segments of each model and recorded the proportional size and location of each cluster of microspheres in the vasculature in a FRL field. One of these fields is shown in Figure 2b.

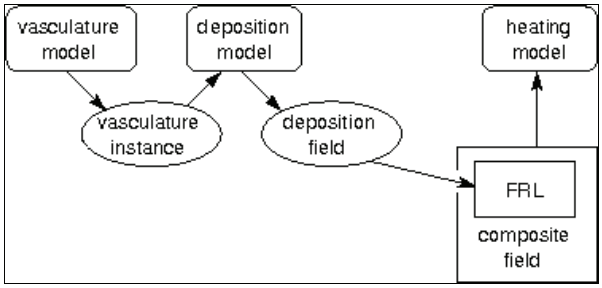

Figure 1 – Interchange between the three component models of the liver cancer treatment multi-model

Separately, we modelled an octant of the tumour with tetrahedral finite elements and assigned a volumetric heat generation rate (VHGR) to each element. The values for each element's VHGR are calculated based on the number of microspheres lodged in that element's space.

We used a composite field to scale and orientate the microsphere probabilities models so that the modelled regions were aligned. We then used AFL to compute the integral of the probabilities field over each tetrahedral element of the heating model. Listing 1 is a part of the FRL representation of the composite field that transforms the coordinate systems of the microsphere deposition field "depo5", the fifth instance of the 21 model instances generated.

The integral for each element of the composite field gives the proportion of microspheres lodged in the volume of the element and from that we computed the VHGR. The temperature field resulting from the heating simulation is shown in Figure 2c.

Listing 2 is a pseudo-code illustration of the algorithm that assigns the VHGR to each element. The integral of the field gives a number between 0 and 1 that represents the fraction of the microspheres in the entire tumour that are lodged in the volume of the current element. The VHGR is linearly proportional to that fraction.

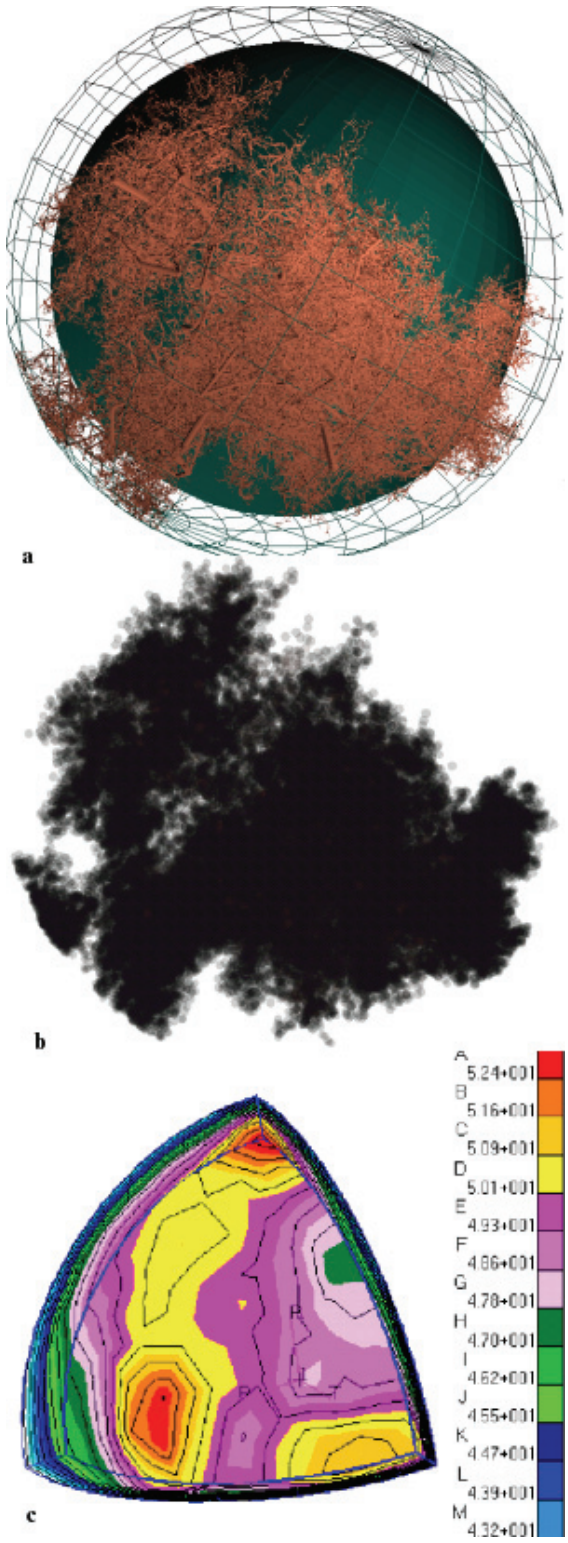

Figure 2 - Four arterial trees constrained to the spherical shell of the tumour periphery (a), their corresponding microsphere distribution field (b) and the resulting temperature field showing a heterogeneous heating pattern (c)

```
<composite name="depo5c">
  <fieldref uri="file:///depo5.xml"/>
  <function>
     depo5( -81.65*(X+Y) + 163.3*Z,
            -115.47*(X+Y+Z) + 11.25,
            -141.42*(X-Y) - 30)
  </function>
</composite>
```

Listing 1 – The composite FRL field that scales and reorientates the field "depo5" from the coordinates system of the deposition model, to that of the heating model. The coefficients were worked by hand

```
depo := load AFL field ("depo5c")
for each element e in mesh do:
    Tetrahedra t := e.getVertices()
    fraction f := depo.integral(t)
    e.assignVHGR(totalVHGR * f)
```

Listing 2 – a pseudo-code of the algorithm that assigns the VHGR to each element in the heating model based on information obtained from the composite field shown in Listing 1

Multi-scale model example

The work summarised in this section was previously presented in [23]. We created a 2D finite-difference model of activation propagation in a rabbit sinoatrial node (SAN). The model was composed of two models of specialised SAN myocytes and 231 spatio-temporal models of the extra-cellular environment (which can be thought of as the extra cellular fluid or ECF) of the tissue (*e.g.* a field of membrane potential). The myocyte models were developed separately [24] as a series of ODEs. The environment models were represented as FRL fields, of which 29 change over time as part of the interaction between individual myocytes. Individual cells interact with each other through a feedback mechanism embedded in their models. The feedback process is facilitated by changes to the ECF. For example, if one cell emits Ca^{2+} ions to the ECF, the Ca^{2+} concentration level around it goes up and this affects nearby cells.

Figure 3 illustrates the interaction between three myocytes and the environment. At each iteration T of the simulation, each myocyte reads the membrane potential's spatial derivative from the ECF at the end of T-1 (B) uses an ODE solver to compute the state of the cell at T, and updates the ECF (A). Listing 3 shows the algorithm that controls this process.

The result is a tissue model in which activation of individual myocytes was synchronised through the extra-cellular environment (Figure 4).

Discussion and conclusion

Coming up with new hypotheses is still normally done manually and is often called "model identification", "system identification" or the "inverse" problem. Existing hypothesis generation algorithms search through a space of unknown variables and identify points in the space that are consistent with the known data and first-principle rules.

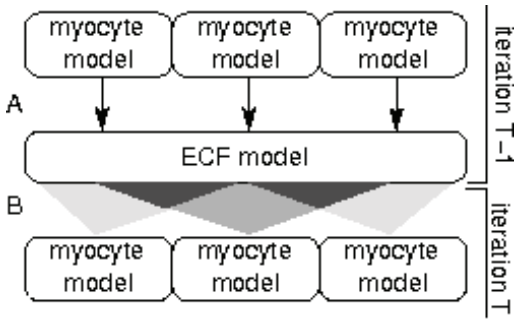

Figure 3 – Interactions in the SAN multi-model. The values set by each arrow in A is at a particular point in the ECF but affects larger regions (in grey) in B of the next iteration

```
ECF_T := set of AFL fields
ECF_T-1 := set of AFL fields
for each iteration T do:
    ECF_T-1 := ECF_T
    clear(ECF_T)
    for each myocyte m do:
        m.read(ECF_T-1)
        m.solveToNextIteration()
        m.update(ECF_T)
```

Listing 3 – Pseudo code of the algorithm that causes the cells to interact and thus drives the simulation

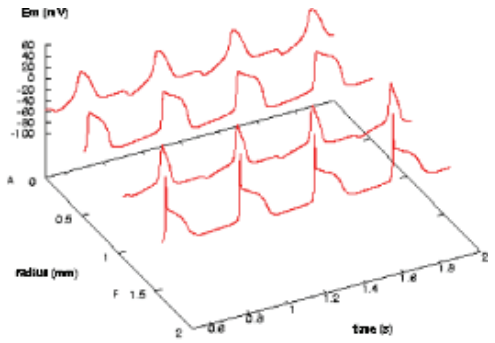

Figure 4 – A plot of membrane potential (Em) at 4 points along a radial slice of the membrane potential field in the SAN tissue model. The regular activation pattern indicates that the cells are interacting through their environment

To be able to search through knowledge spaces of multiple scales and using multiple methods, model-generating algorithms would need to be able to consider several representation languages, use a variety of modelling methods and present complex models in a human-readable fashion [25].

In addition to spatio-temporal interchange we argue for a **logical** setting for model integration in hypothesis generation and propose a machine learning approach based on inductive logic programming (ILP) [26]. Consider, a multi-model composed of three

for example, the problem of discovering metabolic networks in eukaryotic cells. Normally this process relies on quantitative methods such as flux analysis [27]. King *et al.* [17] demonstrated for the first time a successful ILP multi-model that integrated metabolic pathways from KEGG [28] with data from auxotrophic growth experiments in the budding yeast *S. cerevisiae.* Hypothesis generation in this case was the search for new experiments to maximize the refutation rate of potential genetic regulatory interactions in a multi-stage process, at the end of which a robot scientist had converged on a network to explain the data.

In a hypothetical model of pheromone response: the hypothesis space would contain a model of the cell membrane sensors, a protein interaction pathway, a transcriptional regulatory network and a set of metabolic pathways. These different types of models all have to be integrated to generate a hypothesis. ILP is the *only* machine learning approach that can integrate arbitrary background knowledge and hence different model types. A logical interface in AFL could facilitate this integration.

Standard representation languages are essential for interchange between models developed independently. However, machine learning algorithms that can reason in multiple scales and interact with other algorithms require a more profound solution, of which representation is only a part.

The current research in the area of multi-modelling is predominantly limited to standardisation of representation languages. Among those, quantitative languages seem to be leading the charge [21,29,30]. However, as of yet, there are no standard representation languages that are recognised by *any* international standards organisation.

In contrast with the current model identification algorithms which are constrained to a particular modelling method, multi-method hypothesis generation algorithms should be capable of choosing appropriate modelling methods. For this task, ontology of the available methods is required [4].

Given this ontology, a calculus of model interactions based on their model type would allow intelligent algorithms to decide which methods to use and how to construct the interactions between the modelled systems. Finally, with an ontology and a calculus, new machine learning techniques need to be formulated that are able to deduce knowledge in multiple representations, using multiple methods and support a variety of inter-model interaction models.

High-throughput biological methods necessitate high-throughput analysis methods. Computer aided knowledge discovery is an emerging field that shows promise in interpreting information from large volumes of complex data. Computational multi-modelling techniques are relatively new techniques that make complex models wieldy. As theories become more detailed, supported by more data and harder to formulate, an amalgamation of computer aided knowledge discovery and computational multi-modelling will become necessary.

In this paper we presented two examples of manually constructed multi-models and referred to several discoveries in the life-sciences that were directly aided by computer generated hypotheses. Finally, we identified several enabling areas of computer generated multi-models that are still deficient.

Acknowledgments

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Guideline-based Visualization of Medication in Chronic Disease

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Abstract

Chronic disease management at the General Practice level is a challenging task requiring synthesis of information across time and possibly several practitioners. Sparsity of data, lack of structure, lack of time are limiting factors of computer use in this domain. Authors are exploring the concept of visualization of individual patient's medication using a clinical guideline to provide some structure to the problem by creating a state-transition model. This approach was shown to be promising at the practice level in previous research [1,5] where an overall synthesis of practice decisions was created and alerts were generated on the basis of individual transactions or states - current focus is on individual patient and the sequence of states describing his/her medication history.

Keywords:

general practice, visualization, decision support, guideline

Introduction

In managing chronic diseases, the information on the past course of the disease can be important - but many practitioners see reviewing of past data as a (necessary) evil to be done as quickly as possible [2]. With more and more general practitioners (GPs) using a computer in their everyday practice [3] it is more than tempting to use the existing data to provide support for quality and continuity of care. Typically the data is rather unstructured, with highly variable quality in terms of completeness or adherence to some coding standards. In a comprehensive review it was shown, that prescription data is the one most complete and reliable [4]. Assuming, that medication reflects significant proportion of decision-making about a case a guideline-based state-transition model was created and used for analysis at the practice level, as well as for generation of patient-related alerts [1]. While this approach shows promising results, information on patients as drawn from the model does not take into account patient-specific sequences of states. In the current work we explore the visualization of these sequences as well as generating alerts based on sequential patterns for particular patients in line with the ideas of Aigner and Miksch [9].

Materials and methods

The backbone of the study was a state-transition model focusing on treatment of hypertension in diabetes mellitus based on an American Diabetes Association guideline [1]. The data used in the study were de-identified extracts from a general practice in rural Australia holding age, gender, visit dates, problem codes, blood pressure measurements and drug prescriptions. The extracts covered 6 years and contain more than 70000 prescriptions. Two sequences of events/states were generated for each patient: prescription path and treatment path.

Treatment path

According to methodology described in [1] medications were clustered into 6 groups (group B has 3 subgroups):

- Group A: Angiotensine converting enzyme inhibitors (ACEi) - ATC codes C09A and C09C
- Group B1: -blockers (BB) - ATC codes C07AA, C07AB
- Group B2: Diuretics - ATC codes C03AA, C03CA or C03D
- Group B3: Non-dihydropyridine Ca-channel blockers (NCCB) - ATC code C08D
- Group C: Dihydropyridine Ca-channel blockers (DCCB) - ATC code C08CA
- Group D: -blockers, hydralazines, clonidine - ATC codes C02CA, C02DB, C02AC

To simplify the model-building process we deviated slightly from standard ATC coding - combination drugs were coded as if a set of separate drugs was given.

Based on prescription data states were generated, using the amount and the daily dose of prescribed drug to calculate duration of treatment with a particular drug group. In this calculation we assumed, that patient starts the medication on the same day as it was prescribed, that the dosage is unchanged throughout the time covered by a particular prescription (and the patient adheres to the dosage).

All methods were implemented using Cache and Ensemble (Intersystems Inc.), graphs were generated using GraphViz software (www.graphviz.org).

Prescription path

A prescription is a sequence of prescription instances. A prescription instance is a drug, or combination of drugs as

prescribed on a particular day, disregarding dosage or quantities prescribed.

Results

A prescription path and a treatment path are shown simultaneously and provide different views on what was done. E.g. if a drug containing a BB and diuretic was prescribed and at the same time a potassium-sparing diuretic was prescribed the prescription instance is shown as B1+B2+B2; while the treatment path will show B1+B2 combination. (Figure 1).

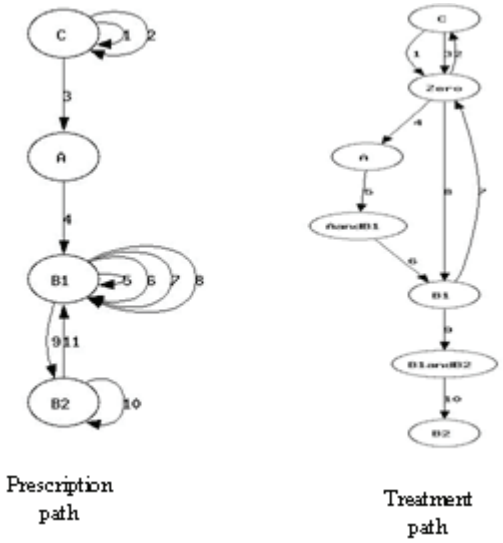

Figure 1 - Prescription path vs. Treatment path

Alerts

Visualisation of the paths should be in most cases enough for an experienced GP to see any unusual patterns. Analysing treatment paths allows to create an additional class of alerts, taking into account more than just one state or one transition Eventually the whole path can be taken into account in launching an alert - e.g. a cyclic repetition of transition tuple (A to B1 followed by B1 to A) for more than **n** (usually 2-4) times may be considered an unusual pattern and an alert should be launched.

Discussion

Guideline can be utilized at two levels in data analysis. First approach is to use the guideline to structure the problem space and then fit the data into the resulting of structure. Several authors applies such approach in hospital settings [6, 7, 8]. The guideline context make it easier for physicians to recognise and appreciate the rationale behind the graphs and alerts.

Alternate approach is to use data mining techniques to raw data and then compare the results to a guideline (e.g. [10]) This approach can be exploited either to improve the guideline or to detect exceptions in clinical workflow.

Conclusion

Authors extended the scope of previous research [1] by adding visualizations for individual patients as well as new types of alerts taking into account more than just one transition or just one therapeutic state. This approach is to be validated by a clinical study in next future.

Acknowledgments

Special thanks to Lubims Pty. Ltd. for providing the datasets and to Intersystems Inc. for providing licenses for Cache® and Ensemble.

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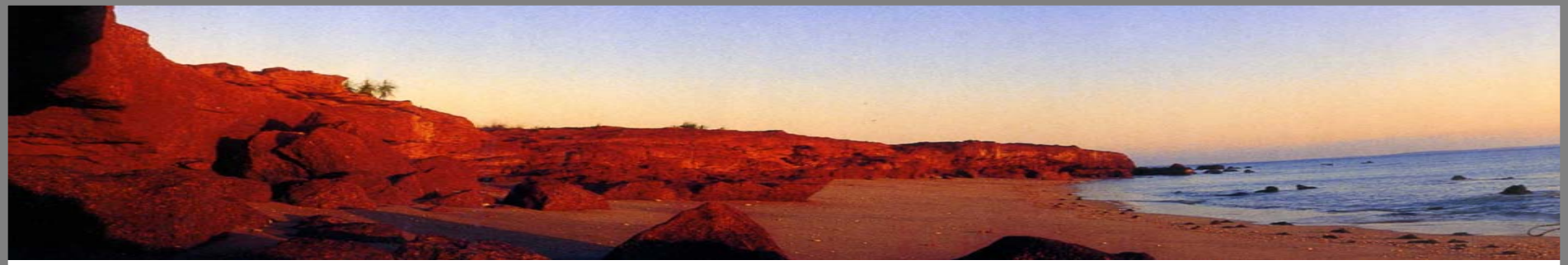

Guideline-based visualization of medication in chronic disease

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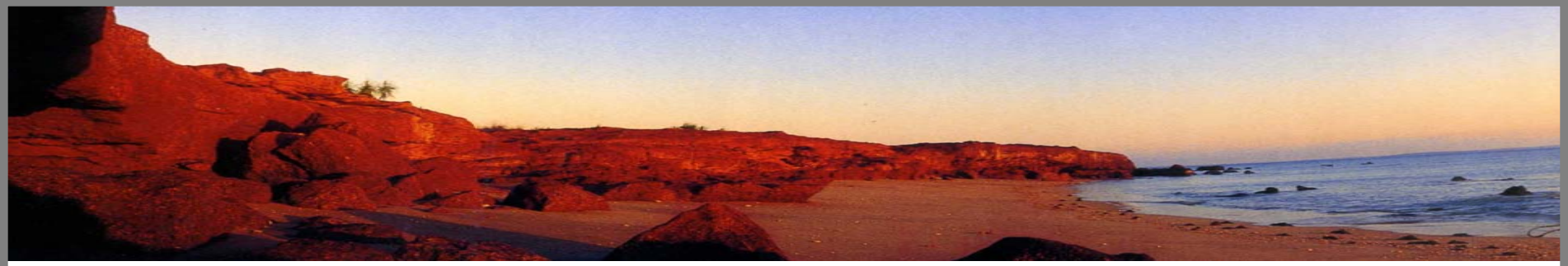
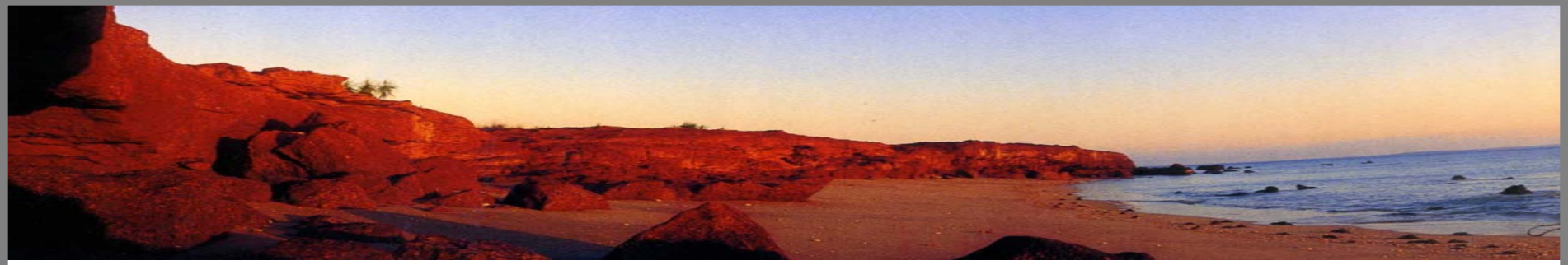


The problem

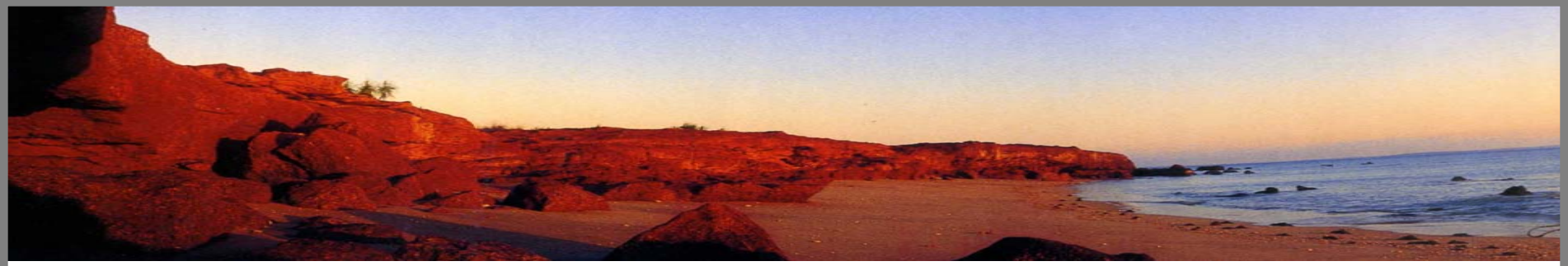
- Growing complexity of medicine
- Growing pace of change
- Growing focus on evidence and *demonstrated* quality of care
- Restricted budget – especially at GP level



Opportunity

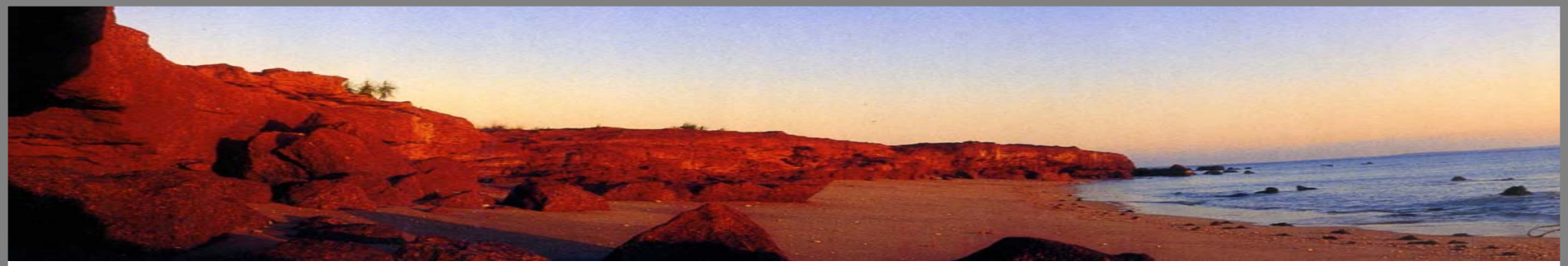
- Over 96% of Australian general practitioners (GPs) use computers
- Prescription data is the best data at GP level *)
- Treatment guidelines are available

*) Thiru K, Hassey A, Sullivan F, Systematic review of scope and quality of electronic patient record data in primary care. BMJ 2003; 326: 1070-80.



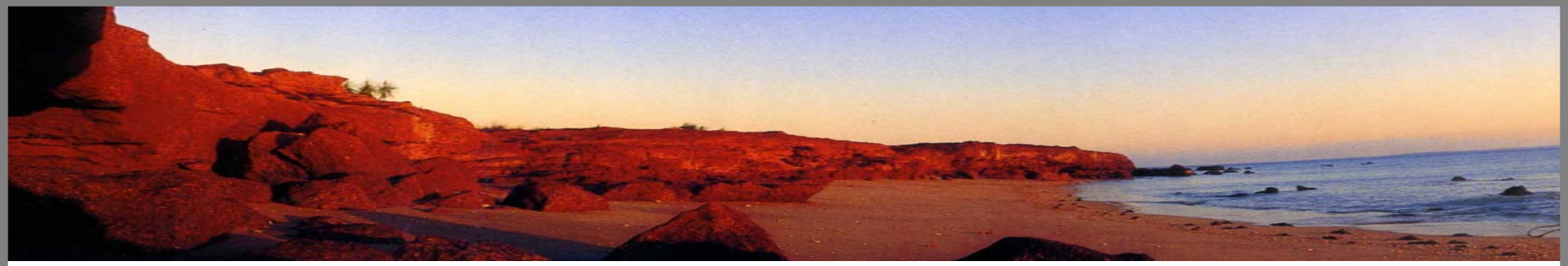
Hypothesis

1. Additional significant information can be extracted from routinely collected data in general practice
2. Feeding this information back to GPs is useful
3. This information can be presented in a way which does not require extensive user training of clinicians



The Project

1. Use guideline to structure the problem space (create state-transition model based on a guideline)
2. Fit relevant data from the GP electronic records into the model
3. Use the model for information syntesis and feedback to the practice

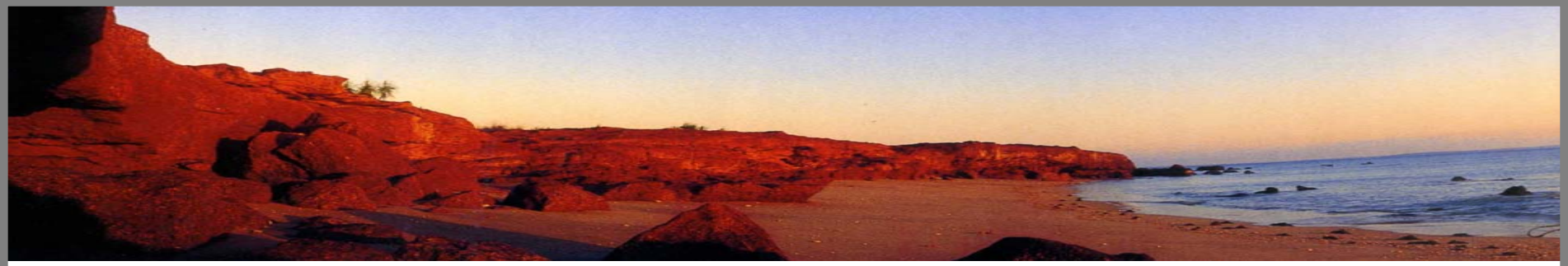


Project components

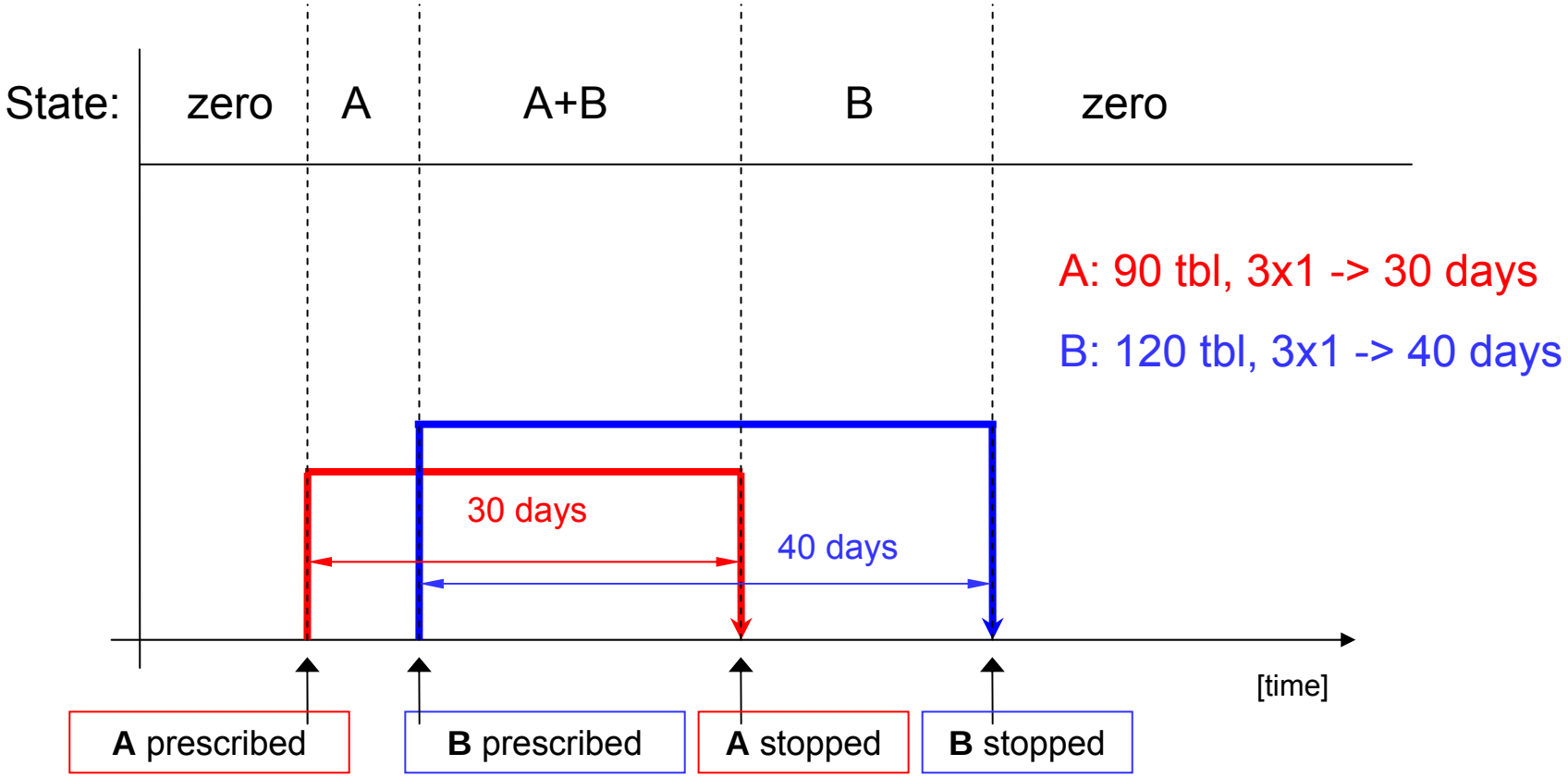
- Guideline: Treatment of hypertension in diabetic patients *)
- Prescriptions – drugs classified according to ATC and organised into groups reflecting the guideline**)
- Data extracts form GPs (70000 prescriptions across 6 years)

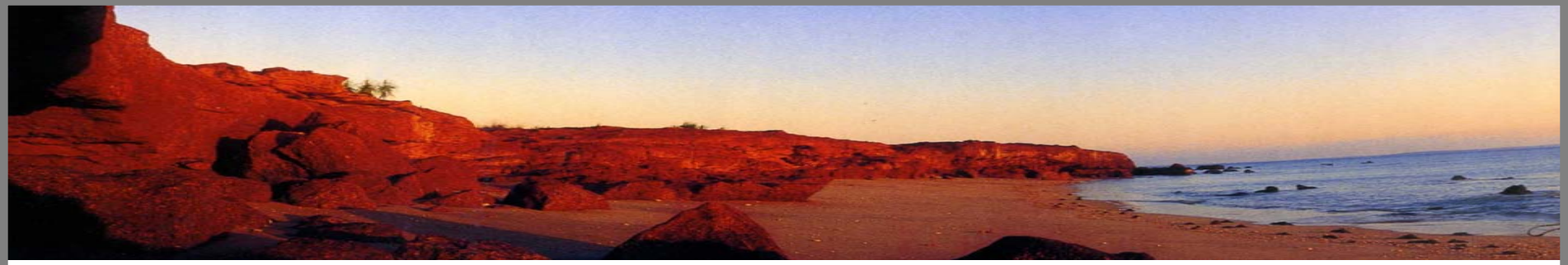
*) American Diabetes Association, Hypertension management in adults with diabetes. Diabetes Care 2004; 27:S65-S67.

**) Gadzhanova, S. et al.: Developing High-Specificity Anti-hypertensive Alerts by Therapeutic State Analysis of Electronic Prescribing Records. JAMIA, 2007;14, pp 100-109.



Converting prescription events into states:





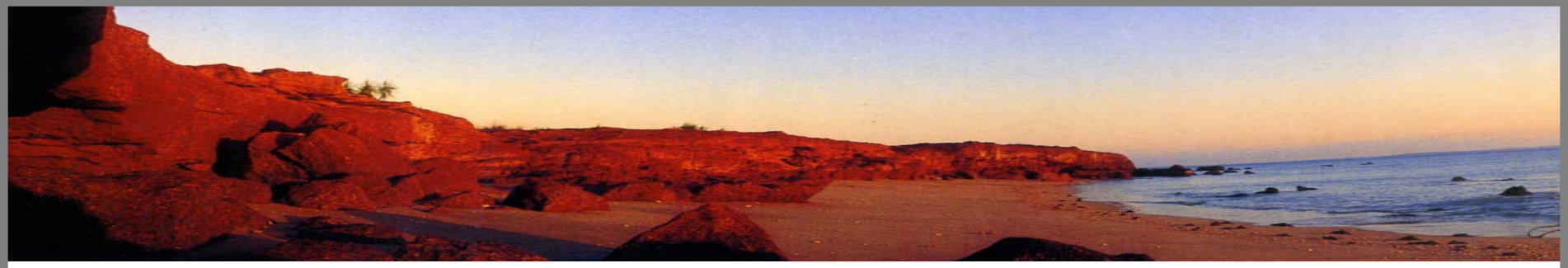
Results

Prescription path = showing the sequence of prescription events (**A** - **B**)

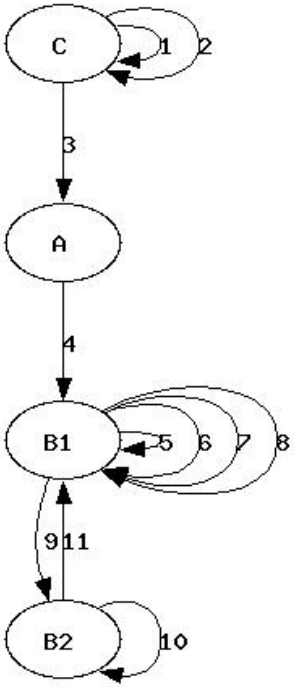
Treatment path = showing the sequence of guideline-derived states

(zero → A → A+B → B → zero)

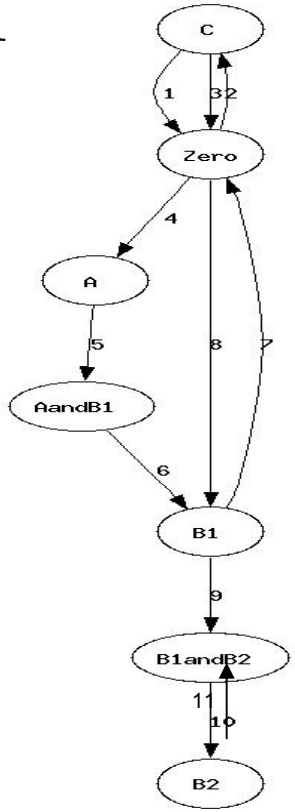
Zero indicates the patient does not appear to have any medication



Visualisation

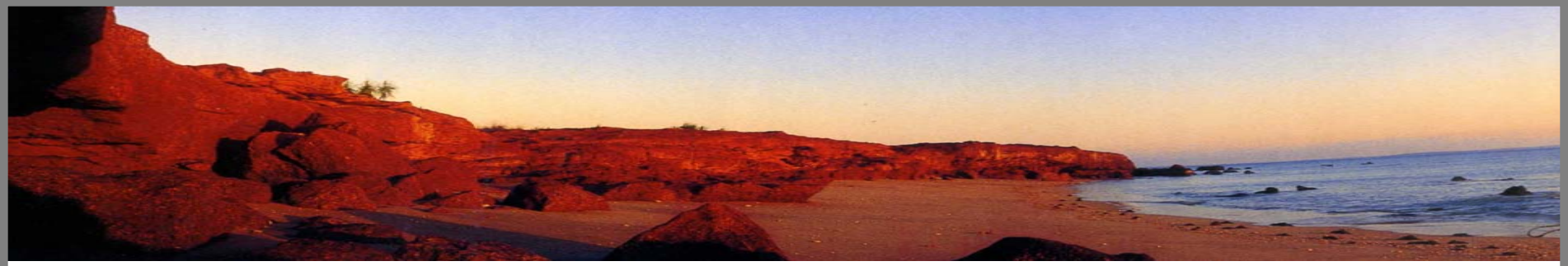


Prescription path



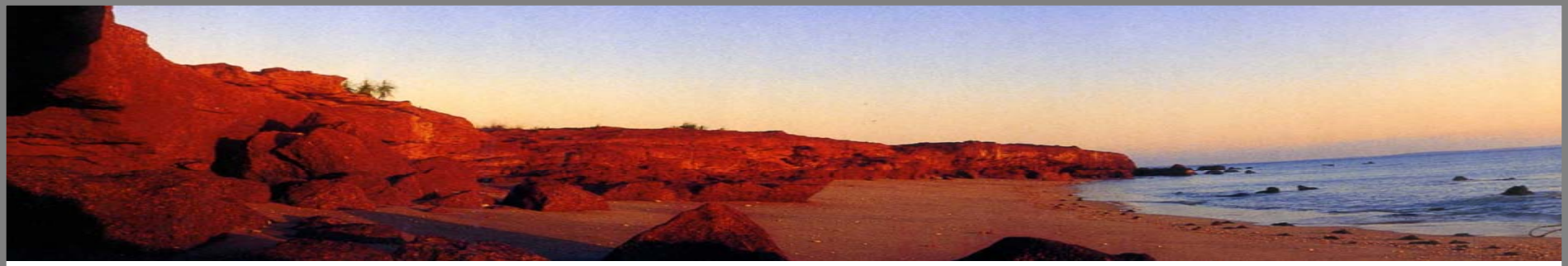
Treatment path

Group A: Angiotensine converting enzyme inhibitors (ACEi) - ATC codes C09A and C09C
Group B1: β-blockers (BB) - ATC codes C07AA, C07AB
Group B2: Diuretics - ATC codes C03AA, C03CA or C03D
Group B3: Non-dihydropyridine Ca-channel blockers (NCCB) - ATC code C08D
Group C: Dihydropyridine Ca-channel blockers (DCCB) - ATC code C08CA
Group D: α-blockers, hydralazines, clonidine - ATC codes C02CA, C02DB, C02AC



Use of the paths

1. Direct use:
   - both paths are directly related to the practice and (given the GPs know the guideline) readily understandable
   - Unusual paths can be picked from the image itself
2. Indirectly
   - both types of paths can be used to generate alerts (e.g. unusual states, transactions, cycles) – serving as a possible screening of unusual cases.



Related work

- Probably closest to our approach were authors*) using a guideline to lead their data-mining exercise, although on a smaller sample of patients in hospital setting
- Others**) too worked in a hospital, data rich setting and focussed more on intentions, guideline compliance and quality control.

*) Říha A., Svátek V., Němec P., Zvárová J.: Medical guideline as prior knowledge in electronic healthcare record mining. In: 3rd International Conference on Data Mining Methods and Databases for Engineering, Finance and Other Fields, 25-27 September 2002, Bologna, Italy.

Svátek, V., Říha, A., Peleška, A., Rauch, J.: Analysis of guideline compliance – a data mining approach. Praha 13.04.2004 – 16.04.2004. In: Kaiser, K, Miksch, S., Tu, S. W. (ed.). *Computer-Based Support for Clinical Guidelines and Protocols.* Amsterdam, IOS Press, 2004, s. 157–161. ISBN 1-58603-412-X.

**) Advani, A.,Shahar, Y., Musen, M.A.: Medical Quality Assessment by Scoring Adherence to Guideline Intentions. 2001 Annual AMIA Conference, Washington, DC, Hanley and Belfus 2001.

Chan, A.S., Coleman, R.W., Martins, S.B., Advani,A , Musen,M.A., Bosworth, H.B., Oddone, E.Z., Shlipak, M.G., Hoffman,B.B., Goldstein, M.K.: Evaluating Provider Adherence in a Trial of a Guideline-Based Decision Support System for Hypertension.MedInfo 2004, San Francisco, California, Sept 7 - 11. 2004.

Marcos, M., Berger, G., van Harmelen, F., ten Teije, A., Roomans, H., Miksch, S: Using Critiquing for Improving Medical Protocols: Harder than It Seems. In: Quaglini, S., Barahona, P., and Andreassen, S. (Eds.): AIME 2001, LNAI 2101, Springer-Verlag Berlin Heidelberg 2001, pp.431–441

Aigner, W, Miksch, S.: Supporting Protocol-Based Care in Medicine via Multiple Coordinated Views. Proceedings of the Second International Conference on Coordinated & Multiple Views in Exploratory Visualization (CMV'04), 2004.

Future directions

1. Clinical validation of assumptions of user-friendliness, utility and acceptability of our graphs and alerts
2. Linking therapeutic path and prescription path into a single graph and exploring utility of such representation
3. Exploring path-mining as a method for structuring the problem space*)

*) e.g.: van der Aalst, W., Weijters, T., Maruster, L.: Workflow mining: discovering process models from event logs. IEEE Transactions on Knowledge and Data Engineering, 16 (9), September 2004.

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Geographic and Management Information Systems Join Forces: Delivering More than the Sum of their Parts

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Abstract

Management and Geographic Information Systems have coexisted in the medical field with clearly defined boundaries. Recently, geovisualization toolkits like GoogleMaps™ have introduced freely-available high-resolution imagery and standardized APIs, lowering the barrier for a seamless integration of MIS data and GIS functionality. In this project, an existing MIS was extended by geovisualization functionality based on GoogleMaps. Sustainable usage scenarios were identified, including visualizations of patient origins, distributions of bacteria and drug-resistance patterns. It could be shown that geovisualization is suitable for location-based MIS queries.

Keywords:

Geographic Information Systems,
Management Information Systems, Data Warehouse,
visualization

Introduction

Management Information Systems (MIS) have been applied in the medical field since the early 1980s, providing consolidated data and analyses with an emphasis on administrative information needs, e.g. service performance and utilization or cost structures. Geographic Information Systems (GIS) have been increasingly mentioned in medical literature since 2000, with applications focusing primarily on the support of epidemiological studies at a regional or national level[1-4]. Early GIS development was hampered by a lack of freely available high-resolution map imagery as well as the necessity to implement proprietary application programming interfaces (APIs). With the advent of Google Earth™ and Google Maps™ in 2005, a simple-to-use API was made available together with high-quality digital satellite and map imagery under a license that permitted free non-commercial use. The simplicity of the API led to a rapid worldwide uptake, including the medical field[5;6]. As a virtue of this commoditization, GIS methods can now be leveraged to add a new dimension to MIS data analysis: visualizing service cost and utilization data geographically can further support management decisions on a regional or local level. Clinical users may also benefit by integrating workflow or infection surveillance data with a geographical representation. Erlangen University Hospital, Germany, has built an extensive MIS based on a data warehouse platform, integrating information from various administrative and clinical sources[7]. As the hospital is also distributed among several locations within the area, it would profit especially from a comprehensive geographic visualization of its MIS data. The goal of this project is to integrate the existing Erlangen MIS with GIS functionality and evaluate sustainable usage scenarios.

Materials and methods

The Erlangen MIS is based on the Cognos BI™ platform and imports data from all connected source systems on a nightly schedule. The reporting platform provides both standard relational and OLAP paradigms as well as the locally developed workflow visualization system *Pathifier*[8]. The geovisualization functionality was implemented as an extension of the *Pathifier* application. Geocoding of transactional data (e.g. patient addresses) occurred at run-time by means of freely available geocoding databases (OpenGeoDB, GNIS, GEONAMES), whereas coordinates for hospital locations were geocoded manually and permanently stored as additional attributes to the organizational dimension of the data warehouse. The geovisualization implementation was based on the GoogleMaps API, using a standard AJAX (Asynchronous Javascript and XML) pattern. Data warehouse-based measures (e.g. amount of cases selected, distribution of diagnostic tests ordered or antibiotic resistance) were dynamically rendered and overlaid on the maps. Detailed information on a specific icon was provided through pop-up windows. Icons were clustered dynamically depending on the chosen map zoom level.

Results

The GIS extension has been operational since mid 2006. Integration with the *Pathifier* application is seamless and delivers an intuitive graphical representation of fact data from the MIS. By clustering image elements on lower zoom levels, visual clutter is avoided. Geocoding worked reliably for full German address records including ZIP-codes. For records without ZIP-codes or international records it was necessary to rely on the less detailed GNIS and GEONAMES datasets which are susceptible to mis-

spellings as well as homonymous or synonymous location names.

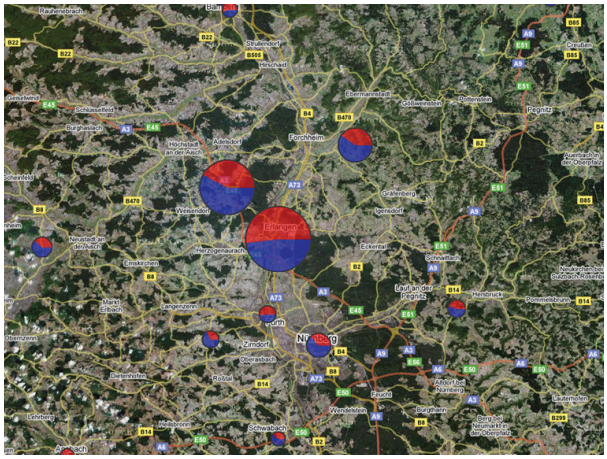

Figure 1 - Origin of Diabetes patients (2006) differentiated by sex (red=female, blue=male) on a regional level

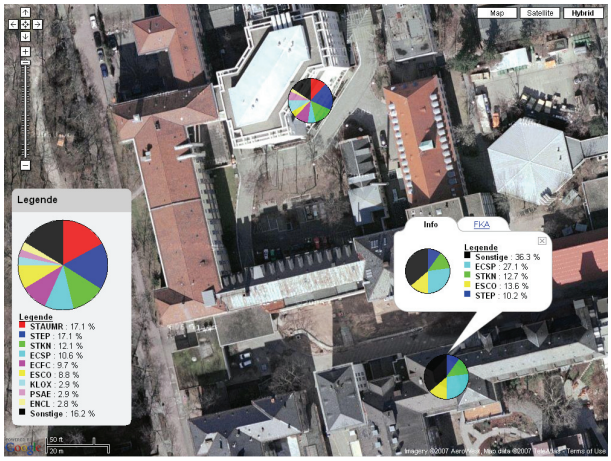

Figure 2 - Top 10 resistant bacteria strains at a standard care versus an intensive care unit

Discussion

In this project, we were able to achieve seamless integration of geovisualization functionality into an existing MIS by using freely available, standardized tools. Only limited effort was necessary to manually geocode hospital organizational units. Geocoding of address data was fully automated, but manual interventions might be necessary to disambiguate international or incomplete records with multiple or no matches in the respective geo-databases. Making use of the established GoogleMaps API and user interface provided users with a well-known navigational concept, making special training for the system unnecessary.

Preliminary feedback from users indicates that the new GIS functions are providing answers to common questions like "Which areas do my patients come from?", "At which wards are MRSA-infected cases?" or "What are the drug-resistance patterns throughout the hospital?". Data and corresponding tabular reports for all of these questions were available in the MIS previously, but the new visualization mode provides a faster overview and more intuitive. In comparison to epidemiological visualization projects published previously, using MIS data opens up a new field of view towards local developments occurring within organizational units, as well as providing detailed data updated on a daily basis. Data confidentiality is a concern, as an external service provider (Google) is taking part in the geovisualization process. However, geocoding takes place locally, and only aggregated iconic data is displayed within the map.

Conclusions and outlook

The synthesis of MIS data and GIS functionality is providing a valuable tool for both administrative and clinical users to visually explore location-based data in a way not possible previously. By being based on freely available standardized tools, the approach used in this project should be portable to other sites with a comparable infrastructure. Further development will include a formal evaluation of the system as well as further extensions of its visualization functionality. Areas of special interest will include infection surveillance and visualization of workflow patterns.

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Visualization of Preterm Birth Health Disparities

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Abstract and objective

Preterm birth is one of the leading causes of infant mortality in industrialized countries. There is a growing body of literature that suggests socio-economic and socio-demographic factors may be causal factors that either explain or confound birth outcome disparities. Understanding differential patterns in birth outcomes is necessary to develop effective interventions designed to decrease birth outcome disparities amongst pregnant women. This project used geographic information systems and publicly available birth records to explore geographic disparities in birth outcomes in North Carolina. Building on prior statistical and computational models, this poster presents the visualization of geographic variation in birth outcomes as associated with the following maternal demographic predictor variables: race/ethnicity; age; education level; and marital status. Birth outcomes associated with health history variables of cigarette smoking and the Kotelchuck Index are also visualized. Data visualization is an important step in exploring patterns and understanding the context of preterm birth. This research will help to identify target areas for future preterm birth prevention interventions.

Keywords:

premature birth, geographic information systems, population characteristics, health services research, informatics

Methods

The purpose of this study was to use geographic information systems (GIS) to explore geographic variations in birth outcomes associated with selected demographic and health history variables. This study is a retrospective, secondary analysis of de-identified, 2003 North Carolina birth record data.

Data source

This data set contained approximately 120,000 live births and included maternal, paternal, infant and health care system variables. When filtered for out-of-state births, induced or stimulated labor and multiple births, the data set contained approximately 73,000 birth records.

Data analysis

Both statistical and computational methods were used to investigate a parsimonious preterm birth prediction model based solely on birth certificate data. Methods included: logistic regression, neural networks, classification and regression trees, Support Vector Machines and Bayesian classifiers for model comparison. Receiver Operating Characteristics curves were used to compare results across methods. Individual predictor variables were visualized using GIS for geographic variation in preterm birth outcomes.

Results

Data visualization demonstrated wide geographic variation in preterm birth outcomes in the selected maternal demographic variables and selected medical history variables. Noticeably different patterns emerged for each variable. Descriptive variable pattern maps will be presented on the poster.

Conclusion

Data visualization is an important step in exploring patterns and understanding the context of preterm birth. The geographic variation in the demographic and medical history variables illustrates the need for incorporating context into prediction models. GIS visualization enhances researchers' abilities to discover patterns across variables that may not be readily apparent within numeric tables.

The next step in this research is to apply spatial statistics to the individual variables and to assess the geographic variation in the full statistical and computational model. This research will help to identify target areas for future preterm birth prevention interventions.

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A Pilot Evaluation of Fall Prevention Rooms in a Hospital Facility

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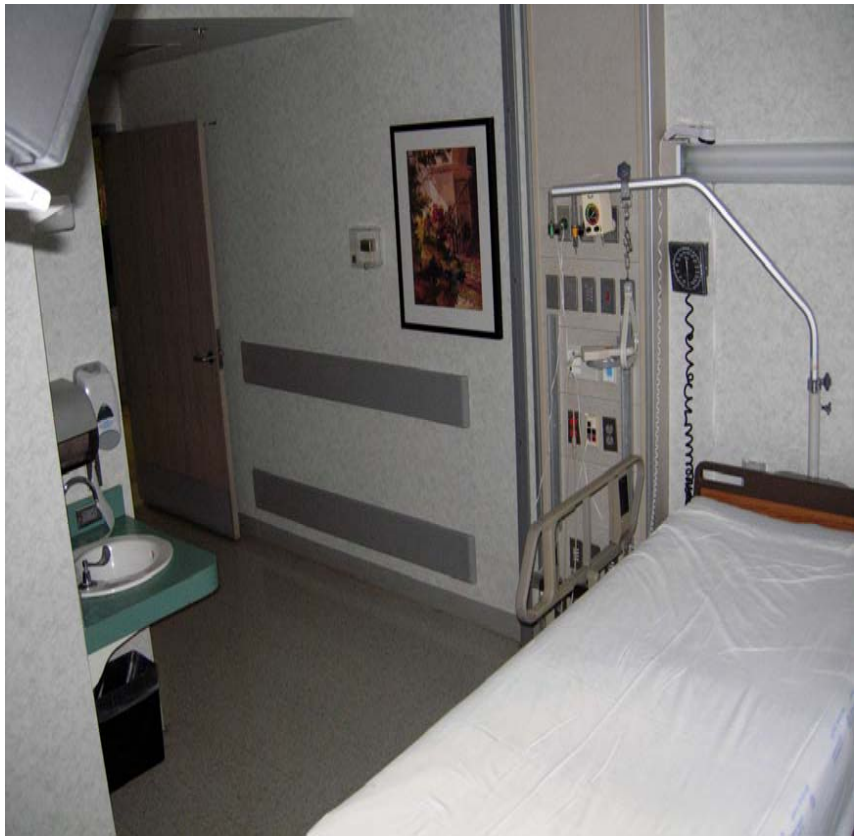
[c] The University of Texas, Health Science Center, School of Nursing, Houston, Texas, U.S.A.

Background

- *Falls continue to be a major safety problem for hospitalized patients.*
- *Measures for patients at risk for falling have been directed towards: prevention by identifying patients at risk & safer room design.*
- *The majority of reported falls and near falls are un-witnessed so data are not available to characterize these un-observed falls.*

Problem

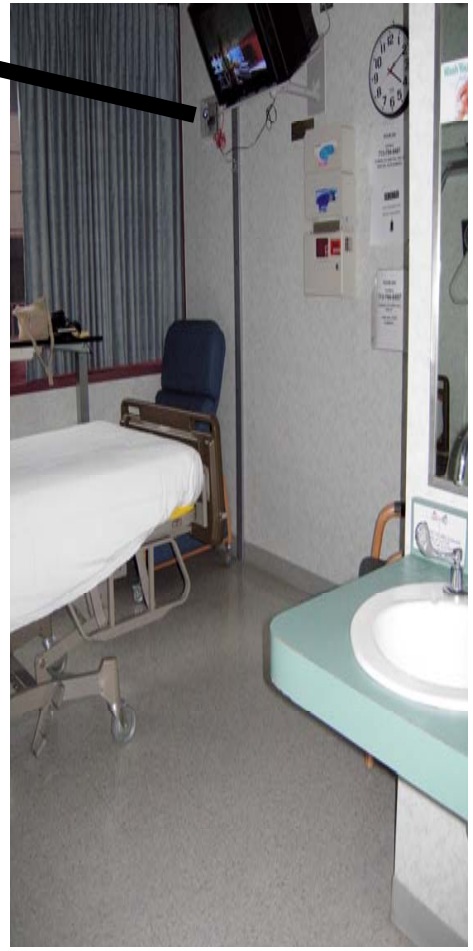
- *Some evidence indicates that patients may repeat circumstances or characteristics of the initial fall in subsequent falls.*
- *Since the majority of falls or near falls are un-witnessed there is no rigorous research available to provide data and/or support allegations concerning subsequent falls.*



Objectives

- *To evaluate the effectiveness of dedicated fall prevention patient rooms.*
- *To monitor patients identified at risk for falling using video cameras*
- *Establish a methodology to record and analyze falls that usually go un-witnessed.*

Methods



- Two rooms specifically designed for fall prevention were outfitted with video-cameras to record patient ambulation.
- Video surveillance of consenting adult patients occupying two fall prevention designed hospital rooms was maintained on a 24/7 basis.

Methods

- Video-images stored on hard drives were routinely collected and screened for any fall or near-fall incidents.
- Video recordings of fall or near-falls would then be subjected to further software analysis
- Any fall events would be documented and characteristics of the recorded falls and/or near-falls would be determined.

Results

- *Although no fall or near-fall events were recorded during the 1680 hours of video surveillance*
- *The equipment and methodology proved effective in monitoring patients*
- *The video quality was sufficient for further software analysis of fall events*.

Discussion

- Although fall prevention rooms are available for hospitalized patients identified at risk for falling the patients admitted to the rooms may not met the at risk criterion.
- The use of video surveillance for patients at risk for falling in hospital rooms with fall prevention measures can provide needed data to evaluate both the fall prevention rooms as well as determine the characteristics of usually un-witnessed patient falls or near falls.

Conclusions

- This pilot evaluation proved successful for establishing methodology for video monitoring of patients at risk for falls during hospitalization in rooms dedicated to fall prevention.
- Further monitoring of at risk patients is needed in order to record actual falls or near-fall events and submit the video observations to further video software analysis.

Implications

- The use of video technology can provide data concerning the effectiveness of identifying patients at risk for falling & the rooms designed for these at risk patients.
- Video technology can also provide data concerning the characteristics of falls or near falls and subsequent events.
- If it is determined that patients repeat circumstances and characteristics with subsequent fall events then an education/therapy program could be developed for these patients.
- Further studies may increase the ability of health care agencies to provide a safer environment for patients at risk for falling as well as result in a possible reduction in the incidence of falls.

References, Acknowledgements & Contact Details

- References:
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The Development of an Information System and Installation of an Internet Web Database for the purposes of the Occupational Health and Safety Management System

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Abstract

This paper is based on the research of the possible structure of an information system for the purposes of occupational health and safety management. We initiated a questionnaire in order to find the possible interest on the part of potential users in the subject of occupational health and safety. The depiction of the potential interest is vital both for the software analysis cycle and development according to previous models. The evaluation of the results tends to create pilot applications among different enterprises. Documentation and process improvements ascertained quality of services, operational support, occupational health and safety advice are the basics of the above applications. Communication and codified information among intersted parts is the other target of the survey regarding health issues. Computer networks can offer such services. The network will be consisted of certain nodes responsible to inform executive persons on Occupational Health and Safety. A web database has been installed for inserting and searching documents. The submission of files to a server and the answers to questionnaires through the web help the experts on their activities. Based on the requirements of enterprises we have constructed a web file server. We submit files so that users can retrieve the files which they need. The access is limited to authorized users and digital watermarks authenticate and protect digital objects.

Keywords:

occupational health and safety, workflow management, computer networks, World Wide Web, file submission, questonnaries

Introduction

The management of occupational health and safety constitutes a field which concentrates the interest of enterprises. Particularly the enterprises with a modern concept of management, not only care to comply with the legal obligations as far as it concerns the occupational health and safety, but also they implement a health and safety management system, in order to improve the work conditions. Quality management systems are developed and implemented to enterprises following some standards. For health and safety management, ISO 18001 is widely applied. For the development of such systems the workflow and information management between experts and enterprises is very important and interesting. The use of computer networks and the whole infrastructure is significant for this purpose. Such a system can be administered via the WWW. An external expert can handle the information in a way to correct and to intervene to improve the quality of occupational health and safety services. We have developed such a system in order authorized users, of each enterprise, mainly the responsible for the occupational health and safety, can communicate and submit files. On the other hand, we can use comments for each submission to explain in a more executive way the files and retrieve them. For the purpose of managing and detecting some very important workflows we use questionnaires; the processing of which are very useful for management and decision making in this field. The depiction of interest is important because we adopt new technologies and methods in order to accommodate the procedures for the occupational health and management system.

The interest of the potential users responsible of the occupational health and safety is included on the analysis cycle of the software. At the second phase we are searching about the requirements of the enterprises analyzing the answers of the questionnaires. The evaluation of the results by the experts will lead us to create pilot based applications for communication between enterprises and selected branches.

At the second phase of the implementation work we are developing a system which will be responsible to inform the interested parties about the subjects of occupational health and safety management system. On the other hand

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this system is going to store information about educational issues. A relational database is a scientific tool for the purposes of storing and retrieving useful information.

We insert new technologies to depict the daily situations on the working conditions and in order to support the work of the administration and the work of the employees. We initialize a measuring system based on ISO 18001 in order to evaluate and shape new working conditions. The instability at the working conditions forces us to initiate some rules to protect and promote health and safety of the employees. We are trying to develop a system which will be useful to the users. Such a system after the frequent use must be improved in order to keep the practical features and be more operational. The improvements of such a system is not an easy task. We must find the principle components which support our system and follow some equations to intervene to improve the state of the system. We should pose some limits for the states of the system. In case we exceed them we must enable some actions to correct and to prevent the unsafe conditions. We should restore to the initial regular state the system in case we find that we have exceeded the initial parameters.

In order to achieve the above ideas we should install some means of communication between enterprises. The internet support this communication. The protocol which the internet is based is the TCP/IP[9]. The address IP is a 32-bit number fundamental to Internet addressing and routing. It is also used for addressing the servers and clients. The TCP/IP provides a realiable transport service which is used by most Internet Applications. Examples of applications are the electronic mail (e-mail), the File Transfer Protocol (FTP) and the access of Web Pages through the World Wide Web via HTTP. The evolution of the e-mail was the incorporation into the web.

Some issues on computer networks

Interconnection networks play a major role in the performance of modern enterprise management. There are a lot of factors which can differentiate the design of each network.

- Performance requirements (on time and reliable decisions from the informations we collect): All operations are usually performed by explicit message passing or by accessing shared variables. To reduce the message latency, we reduce the idle time of processes and memory access time to remote memory locations [6]. The delay of information trasmission between two points is a very important aspect in case we take some useful decisions. The validity of information is also important, if we can collect information from all the enterprises we have reliable data, otherwise the latency of communication between the enterprises and the experts may cause an unreliable source of information.
- Scalability: As we add more enterprises in the network, we should proportionaly increase the network bandwidth, the I/O bandwidth and the memory bandwidth. If we are not able to use a scale factor for all the above requirements, at the network, it may become a bottleneck for the rest of the system decreasing the overall efficiency accordingly[6].
- Incremental expandability (example of ISPs): Customers are unlikely to purchase a computer network with a full set of computers and other electronic devices. More enterprises may be involved in the network until a system's maximum configuration is reached. We should find a way that the new nodes we add, do not decrease the performance. For example if we have 10 enterprises and we want to install an internet service provider we may not use a provider exactly for 10 enterprises, we should predict that after a long time we may provide our services to 15 enterprises, so we must use a provider with incremental expandability in order to reach the new requirements.
- Partition ability: It depends on the work we want to do. We devide the work in several partitions and then we dedicate certain tasks to computers of network [7]. This partition is very efficient for the performance of the network. We can use it also for the design of the network, we configure a network for the requirements of our work and we do not configure the work to the requirements of the network. For example we can use one node of the network as file server, another as database server, another as network server etc. Partition ability may also be required for security reasons[6].
- Simplicity: It is useful for the customers who understand the design and can easily exploit their performance. Otherwise the network may not be so efficient [6].
- Distance span, Locality: There are appropriate mechanisms which can reduce the noise during the transmission of the data, but there are a lot of constraints mainly on the distance between nodes on this domain. The use of optical links solve these problems equalizing the bandwidth of short and long links up to a much greater distance than when copper wire is used[6]. The locality is a very importat parameter, we must know where the enterprises are placed in a map in order to design a network.
- Physical Constraints: The operating temperature control, the wiring length limitation and the space limitation are constraints for the network design. We must be careful in case we put together a lot of wires, the overheating may cause damages to the wires [6].
- Reliability and Repairability: It should be able to transmit information reliably. In addition interconnection

networks should have a modular design allowing upgrades and repairs [6].

- Expected Workloads: The network design should be robust. The performance should be efficient independently of the wide range of traffic conditions [6].

Cost Constraints: We should find an optimal solution between the cost of the implementation and the performance of the network. A solution which is probably expensive it is not necessery and efficient [6].

Interconnection networks

At the design of a network we should predict its connectivity with other networks, such as wide area networks [17]. We may need to connect our network with a network of an enterprise and to communicate with an establishment of the enterprise, in order to find useful informations for our work. We can connect our network with leased lines of the telephone network, in order to use services such as voice over ip, teleconference, video conference etc. Interconnection networks exist between parallel and distributed systems[3], [4], [7]. In general purpose the usage of the above systems is the efficient solution of a problem. The network design help us to devide our work into small tasks and try each computer to solve these small tasks. Then we combine the solution of each node to the final[7]. For those systems the network should reduce the message latency in order to be efficient[3]. A decomposition technique based on interconnection network should care for the load balancing of the work between computers. A central unit can recursively divide the work, sending partition of work to nodes and control the overall work.

Meanwhile an application can not use general rules, the services we want the network offer to their users and the quality of services determine the parameters of a network. There are a lot of issues in network design[6], [25], [26]. First issue is how many routers we are going to use. Having a topological map of the whole network where shall we put them? The connections are going to be wireless (data links), which routing algorithm we are going to use, Dijkstra or smth else. There are also some challenging issues such as the network bandwidth and the time delay of packets. Computer networks individual for enterprises are crucial for their speeds in transfering data and for the internal communication.

Programming and configuring an internet web database

For the purpose of installing a web database we used the Apache Server Program and a Database Management System. The apache server enables some files of the host computer to be accessible from the Internet via the HTTP. For the communication of the database we use some script programs written in PHP language. The accessible files via HTTP are HTML forms which communicate with PHP programs[27]. For safety reasons we used some global variables (sessions) on php scripts in order only experts and executive persons from enterprises could administer the internet web database. The information on the Internet Site is accessible to everyone. On the site we can find which enterprises are interested on the domain of Occupational Health and Safety. We can find the executive persons of each enterprise which are responsible to communicate with us. We install a communication between the database and one program in java [8] in order to compute some interesting statistical values from the dataset. The internet web site which host a part of our work is located at the address http://healthandsafety.nurs.uoa.gr/sdyaergasia.php.

In order to construct an Internet Web Site, we find the system requirements and the users requirements. Then we design the web site in order every user to find easily whatever he wants on the domain of occupational health and safety. Then we configure the web site in order to achieve a communication between the site and the database. The updates for news on research in occupational health and safety are appropriate. The updates on the software are also important. The file management we present[27], uses the classic way of FTP. We insert documents, files, data and multimedia[20] in a directory which is structured in such a way for displaying into the www. Using some additional attributes to the above attributes we can cluster the data into groups[19]. The development of an Internet Web Site for efficient storing and indexing documents is a pioneering research work on the domain of Occupational Health and Safety. These attributes help the users to retrieve the data easily. They are inserted by the system administrator or by the composer of digital data. The metadata are all the appropriate elements which describe the uploading documents. Some operations that a system administrator can do are the uploading of a document and the updating of metadata using a simple web interface.

We develop this internet web site in order the executive person of an enterprise be informed about the issues of Occupational Health and Safety.

We are heading the semantic web[16]. This means that the internet can support workflow models. Workflow models are abstractions revealing the most important properties of the entities participating in a workflow management system. The workflows are 3 types, Human – Oriented (a person is responsible to execute a workflow), System – Oriented (we use databases and decision support systems,[15],[21] in order to find answers to our queries) and Transactional workflows (consisted from a mix of tasks, some performed by humans, others by computers and support selective use of the transactional properties for individual activities or for the entire workflow). The workflow models consist from entities which interact with

others in an Interconnection Network and they are participate in a management system[1], [16].

Administration by authorized users

The administration of internet web site could be performed via the web. The web interface is quite familiar to everyone who want to use it. We use html forms to upload documents. We insert metadata and documents in a database using php scripts. Experts on the domain of Occupationl Health and Safety are responsible to update the site with news and with the latest scientific research. The web interface which supports the administration can be seen at figure 1.

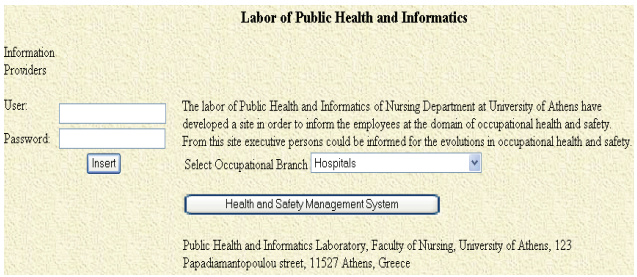

Figure 1 - Web Interface for administrating and presenting information on Occupational Health and Safety

There are some constraints at the insertion of data. We can insert only text documents, Microsoft Word Documents, and documents which can be read by the Adobe Acrobat Reader. Meanwhile we may need to insert files for educational reasons, such as power point files, video and images. On multimedia files we can insert a digital watermark in order to authenticate the constructor of the object [14]. We can insert a list of notes for each document in order to have a dialogue about certain ideas[27]. This dialogue is important for improvements in work.

The data we insert at the internet site are peer reviewed in order to be reliable. We also protect the authenticity of the digital objects inserting to them digital watermarks resistant to attacks such as compression, smoothing and geometric transforms[14] (mainly for multimedia data).

In the web site http://healthandsafety.nurs.uoa.gr/sdyaergasia.php, figure 1, developed in the Department of Public Health in the Nursing Department, University of Athens, we have configured the server to be able to find all the relevant information useful to this task. We can search the documents[19] placing keywords. There is also the possibility of browsing in all data lists.

Services provided by the system and applications on distant learning

The transmission of multimedia data in real time is critical for designing this system. We also search the number of clients a video server can serve with certain criteria of quality of services. The video on demand has as target to inform enterprises about the subjects of common interest. The subjects will be registered electronically among all the speakers and finally the revised lectures will be inserted in the information system in a corrected form. Meanwhile there are some difficulties on the transmission of multimedia data: firstly the subject about the quality of service second the decompression of the data and finally the removal of the jitter.

Another issue is that the system can provide training packages for the protection and promotion of health at the workplace and the implementation of safety procedures[24]. These packages are disseminated through the network or applied by e-learning techniques[2]. The function and the effectiveness of those packages will be evaluated at the ability of installing integrated solutions and applications to support experts on Occupational Health and Safety.

Conclusion

At this paper we have described a web application, which is administrated by authorized persons only. We intend to inform executive persons of each enterprise for the evolutions in Occupational Health and Safety. This site will inform and allow communication among enterprises. Documents and data based on ISO 18001 will be submitted, processed and presented in appropriate format in order to be useful to the interested executive persons. The corrections and the control of the whole infrastructure is significant to our work. Our target is to improve occupational health and safety, to find new policies, to design new systems, to control new procedures and finally to review the whole structure in order to be comprehensible to the users. An application has already been installed at hospital "Agios Savvas". The application will be evaluated continuously in order to achieve the standards of ISO 18001.

Acknowledgement

The present study was funded through the Operational Programme for Education and Initial Vocational Training (O.P. "Education") in the framework of the project "PENED 2003 – Support of University Research Groups" with 75% from European Social Funds and 25% from National Funds.

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Conducting Time Series Analyses on Large Data Sets: a Case Study With Lymphoma

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Abstract

We describe the application of our previously developed analytical infrastructure called RetroGuide to conduct an observational retrospective cohort study using a clinician friendly flowchart approach.

Keywords:

time series analysis, retrospective observational study, Hodgkin lymphoma, workflow technology

Introduction

Retrospective observational studies can provide important background knowledge for preparing expensive clinical trials. Our main purpose is to demonstrate the use of a suite of medical informatics tools called RetroGuide. The problem of investigating the pregnancy rate in women who underwent toxic therapy for Hodgkin lymphoma is used as a case study.

Methods

Intermountain Healthcare's Enterprise Data Warehouse (EDW) was used as the data source. It contains a lifetime Electronic Health Record (EHR) for each patient and it includes encounters from multiple healthcare facilities. RetroGuide was used to create graphical scenarios representing a temporal sequence of events of interest associated with analytical questions. RetroGuide uses a workflow engine to execute the modeled process on real retrospective data and produces a series of analytical reports about how well the model fits the data from EDW.

Women with a diagnosis of Hodgkin lymphoma between the age of 18 and 40, and with at least 5 years of follow up data were included in the study (140 subjects total).

Results

A simplified version of the executable flowchart addressing the main question about the pregnancy rate is shown in Figure 1. Arrows represent transitions and may contain a condition: e.g. "previous event found" (black) or "not found" (grey). The variables inside brackets show that the engine can remember the timestamp of a previously identified event. After the execution of this scenario, the resulting RetroGuide

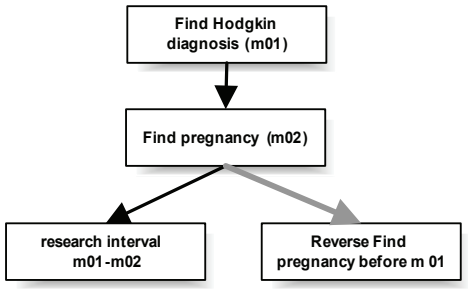

Figure 1 - RetroGuide Scenario (simplified version)

summary report showed that 22.9% of the patients treated for Hodgkin's lymphoma successfully completed a pregnancy within 5 years of the diagnosis (32/140; 95% CI 15.5-30.2).

Discussion

We found only one observational study investigating pregnancy after treatment for Hodgkin's lymphoma (prospective). Our results are comparable to this study, however the retrospective design is cheaper and faster to conduct, with results directly relevant to our local population. Additional advantages of RetroGuide when compared to traditional SQL-based database tools are: (a) user-friendly flowchart model as a shared logic formalism between the data analyst and clinicians; and (b) support for extensive "drill down" capability into available EHR data via a hierarchy of customizable reports. We have used RetroGuide to investigate 13 additional clinical questions relevant to lymphoma therapy and pregnancy.[1] We have also initiated a controlled study to evaluate the suitability of RetroGuide's methodology to empower champion clinicians to effectively utilize a large EDW. The value of our graphical tool will increase with a more widespread adoption of longitudinal and detailed EHRs.

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1 additional data available at http://workflow.minfor.net

Conducting Time Series Analyses on Large Data Sets: a Case Study With Lymphoma

(a RetroGuide Case Study)

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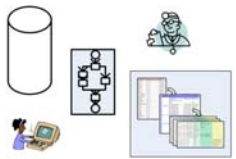
Intermountain℠ Healthcare

The University of Utah Biomedical Informatics



RetroGuide

clinician-friendly flowchart alternative to SQL !

Problem

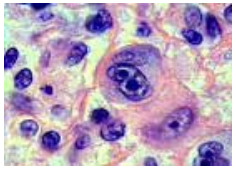
```
SELECT rownum, VAL_NUM2, T2TXT, times
FROM
(
SELECT  empi, VAL_NUM2, T2TXT, count(*) as times
FROM sandbox.ev9
WHERE VAL_NUM2 is not null
group by empi, val_num2, T2TXT
)
order by VAL_NUM2
```

- Amount of EHR data stored in databases grows exponentially
- SQL is currently predominant way of analyzing it
- Clinicians need extra analyst person in order to run advanced queries
- Clinicians can not review SQL code and effectively collaborate with the analyst
- SQL has limitations (e.g. temporal queries, GUI, learning curve)

RetroGuide

- internally developed analytical suite based on workflow technology
- uses standard process modeling language (XPDL)
- re-uses workflow editor as the modeling application
- provides set of external libraries called by the flowchart nodes

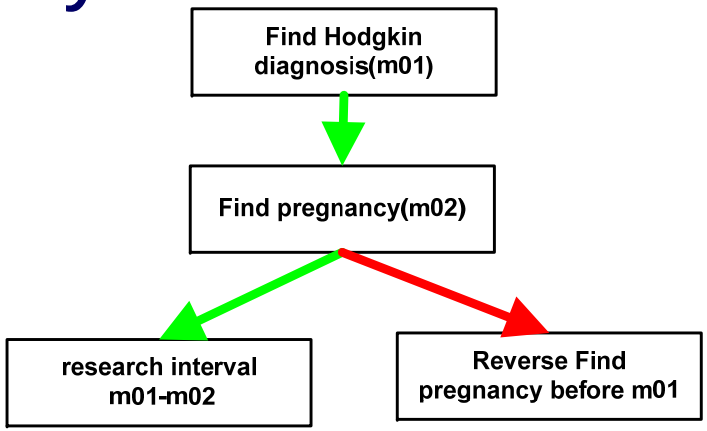
Lymphoma case study



- problem in cancer domain chosen as a case study to demonstrate features of RetroGuide
- retrospective observation study with 140 cancer subjects followed for 5 years
- primary outcome: rate of completed pregnancy after toxic cancer therapy

RetroGuide methodology

- 4 phases (data extraction, scenario creation, scenario execution and reports review)
- RetroGuide scenario has 2 layers
  - flowchart layer
    - (user-friendly to clinicians)
  - code layer
    - (makes the flowchart executable)



Analogy to manual chart review

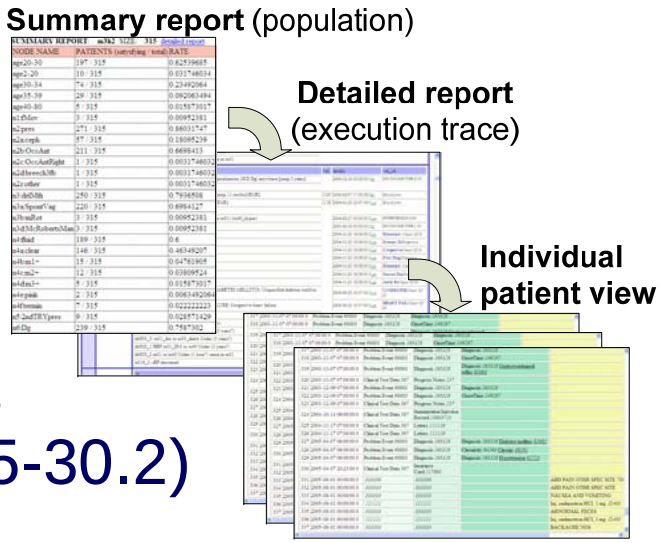
- RetroGuide scenario resembles instructions for manual chart review
- RetroGuide uses procedural approach as opposed to a declarative SQL code
- Analytical problems can be formulated having single patient in mind
- Ability to use constructs like “Time Jump” and remember values or timestamps by using variables

Intermountain's EHR data

- 3.2 TB large EDW covering 3+ million patients
- integrated lifetime EHR
- clinical data (lab, medication, clinical) combined with administrative data
- only coded data was utilized

Intermountain℠ Healthcare

Results



- 22.9% of the patients treated for Hodgkin's lymphoma successfully completed a pregnancy within 5 years of the diagnosis (32/140; 95% CI 15.5-30.2)
- Other clinical factors were investigated with RetroGuide scenario but necessary EHR data elements were present only in limited subset of patients
- Comparable prospective study with 85 subjects with 8.5 years follow-up time found 36.9% rate of pregnancy [1]

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Conclusion

- RetroGuide is a user friendly modeling and analytical approach based on established technology (Bussines Process Management)

- We have demonstrated the use of RetroGuide for conducting a retrospective observational study in cancer domain

RetroGuide advantages

- graphical element of the analytical model (middle layer)
- drill-down capabilities via linked reports
- ability to run code not covered by the query language
- combine multiple queries into one model
- single patient execution model resembling decision support mode of operation

Future

- RetroGuide use and potential will grow with more detailed EHR data and longer time-span available
- RetroGuide functionality is intended to be an exploration and feasibility study of alternative analytical approach to current code-only based methods

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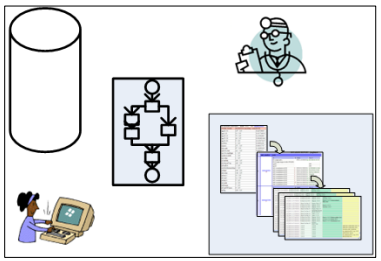

- RetroGuide project website: workflow.minfor.net
- Contact email: vojtech.huser@intermountainmail.org

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Collaborative Atlas in Upper Digestive Endoscopy

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Abstract

With this project about endoscopic images of the upper digestive tract, the matter is to build a collaborative atlas and a learning tool for junior endoscopists, to participate in the standardization of terminology in digestive endoscopy and to explore new ways to investigate the medical reasoning process. Previous work on endoscopic image indexing and retrieval has led to the development of a reasoning model of endoscopic diagnosis along with a determination of features to be used in finding and case descriptions. We present a web platform, based on this previous research, which creates a collaborative environment for indexing of endoscopic images. This is currently implemented using the 1500 endoscopic images collected from the data warehouse of the Clinical Outcomes Research Initiative (CORI) as published online in the OHSU Digital Resource Library. In addition, we describe our early investigations on similarity and the art of diagnostic reasoning.

Keywords:

endoscopy, gastrointestinal - image interpretation,
computer assisted indexing,
collaboration problem-based learning, internet

Introduction

Since its widespread use began in the late 1960's, endoscopic examination of the upper gastrointestinal tract (esophagus, stomach and duodenum), with its careful inspection of the mucosal surface, has expanded the understanding of numerous gastrointestinal diseases and has thus greatly improved patient care. During this time, advances in digital imaging have simplified the sharing of still images or video sequences. Collections of these images into atlases and, more specifically, their integration into a learning environment, presents new issues such as optimal indexing, communication, interactivity and collaboration. The aim of the Project is the development of collaborative tools for creating and sharing atlases and for teaching endoscopy.

In previous works [1], inspired by medical practice, we have defined a bi-leveled – disease and lesion – description language of diagnostic information in endoscopy in order to unify the representation of pathologies and of cases. Upon this analysis of the diagnostic reasoning process, all the elements were joined to a system of decision aid which suggests consistent diagnostic hypothesis and relevant cases according to the problematic case description. This system leans on two bases, one defines the endoscopic knowledge and the second corresponds to a case iconography. To identify potential cases within the same class than the problematic case, the similar case retrieval consists in a classification process upon the endoscopic knowledge. Potential cases are then sorted according to their similarity with the problematic case.

Now, it is the matter of presenting a web platform, based on these previous researches, allowing a collaborative symbolic indexing of the 1500 endoscopic images collected from the data warehouse of the Clinical Outcomes Research Initiative (CORI) - published online in the OHSU Digital Resource Library [2] – by using 150 already indexed pictures, excerpt of the Normedia atlas [3] - and allowing some experimentations to investigate the similarity and the diagnosis reasoning. The goal is to develop a learning tool, based on a previously limited and defined set of training scenarios that could be used in real conditions for demonstration and for evaluation with endoscopists.

The following section will describe the structure and processing of endoscopic information, the construction of knowledge and case bases, and their use for similar case retrieval. Next, in the 3rd section, the collaboration framework is sketched with the web platform allowing collaborative indexing and experimentations. After a discussion about investigations on similarity and reasoning, the proposed future works will conclude the paper.

Materials and methods

In order to help the endoscopist faced with a complex case, previous work [1] has been done in developing an “intelligent” endoscopic atlas. Such an atlas proposes consistent diagnosis hypothesis and relevant cases according to the endoscopist description of the case. At the same time this development has imposed to analyze the cognitive processes that underlay the medical decision making.

Endoscopic information structuration

Physician's reasoning [1] in endoscopy emphasizes, in the diagnostic process, two decision levels which refer to two information spaces: the endoscopical findings, i.e. the lesions, and the diseases. An interaction connects these two decision levels because the diagnosis of endoscopical findings meddles with the disease diagnostic decision. Inconsistencies in the final decision according to other information (medical context, other endoscopical findings) must lead to doubt about the validity of endoscopical finding diagnoses. At the disease level, the decision of assigning a diagnostic class also depends on the prevalence of this diagnosis in the current practice and on the endoscopist experience for rare cases.

The analysis of the medical context leads to distinguish two reasoning approaches. In one hand, the medical context is not specific. A systematic exploration of the organ permits to focus on lesions, according to abnormal variations of color, relief or anatomical repairs. Medical knowledge of lesion characteristics leads to the diagnosis of these elementary objects. The association of lesions compared with the knowledge of the endoscopic aspects of diseases induces to the generating of diagnostic hypothesis. In the other hand, a specific context earlier prompts to formulate diagnostic hypothesis and to consider endoscopic lesions whose association would confirm the diagnosis. Moreover, the endoscopist closely explores the regions where these lesions are usually found. During endoscopic examination, the two schematic approaches are not exclusive.

Information structuration

Drawn from the physician reasoning and from the Minimal Standard Terminology of the European Society of Gastro-Enterology (ESGE) [4], a bi-leveled description mode of the endoscopic imaging and of the gastro-enterology pathologies is illustrated by the concept of Scenes with Objects whence three types of Scenes with Objects.

Physical Scene: the file of an image or of an image sequence It visualizes an interesting part of the endoscopic exam, showing anomalies, that is the Objects.

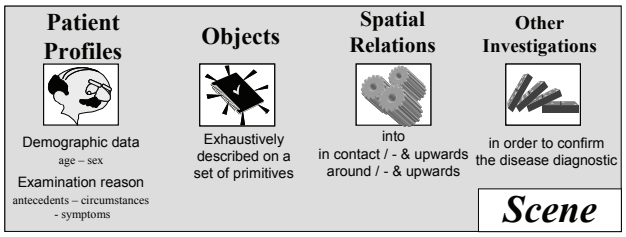

Figure 1- Logical and Conceptual Scene Information

Logical Scene: a medical interpretation of endoscopic imagery, i.e. an endoscopical diagnosis, which associates a peculiar patient context, one or several endoscopic Logical Findings or Objects and their eventual spatial relations (*Figure 1*).

Conceptual Scene: as abstraction of Logical Scene, the extended definitions of the upper digestive tract pathologies. Patient context, reasons for the endoscopy, one or several Conceptual Objects with their eventual spatial relations, and the complementary procedures to be advised, constitute the medical knowledge of these Scenes (*Figure 1*).

In these three kinds of scene, lesions or any element of interest, i.e. the "endoscopic findings", constitute the objects that can be depicted through an exhaustive description mode. To each descriptor or feature is associated a set of choices, representative of all possibilities and judiciously defined by the expert as shown *Figure 2*.

Knowledge and case bases

The Minimal Standard Terminology (MST) constitutes the framework for the identification and organization of endoscopic information and decisions while the basic concepts of the terminology imply the incompleteness of the description. However, the syntactic descriptors of endoscopic findings and the set of values for each descriptor can not be retrieved in MST while the terminology does not detail all the features of the endoscopic lesions. The finding descriptors refer to a lower implicit description level whose knowledge has to be acquired by endoscopic learning and training.

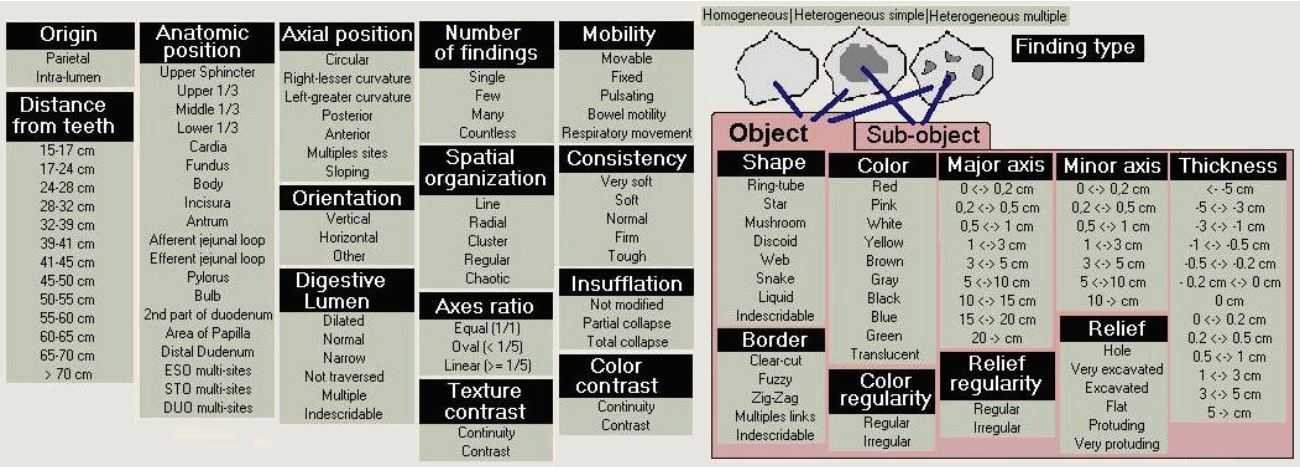

Figure 2 - Features and items of finding description

This approach leads to an a priori description of 150 Conceptual Scenes (diseases) and 100 Conceptual Objects (endoscopic findings).

The expert squeezes out his knowledge, using Linguistic Valuations (LV) instilling uncertainty or vagueness [5]. Each feature can be judged as without interest, impossible or of interest; in this last case, each feature item must be evaluated as *never, exceptional, rare, frequent* and *always*. A sixth level is also defined *doubtful* when the choice between never and exceptional cannot be stated: this level expresses the knowledge limits of the expert.

An object, identified with a code and a label is systematically described through 33 features as shown in *Figure 2*. To one feature corresponds several items which will be assigned a LV value. The actual number of considered items is 206. A scene is depicted by a patient profile (the sex and age prevalence features as well as a predefined whole of clinical contexts), by the objects (one of them must be "always") and by eventual spatial relations between objects.

The case base is constituted of indexed images; each of them represents an endoscopic diagnosis (Endoscopic Scene) with one or more findings, being described with one item by feature. The indexing is leisurely and fastidious task. Most of the images have been extracted from the Atlas of Digestive Endoscopy - Normed Verlag Editions (Homburg) [3] - with their authorization.

Reasoning with knowledge and cases

For a new situation, the similar case retrieval leans on the knowledge and case bases. Based on the knowledge base, the system looks for the potential finding and disease classes of the observed case. The retrieval is completed searching into these classes the more similar case according to similarity rules.

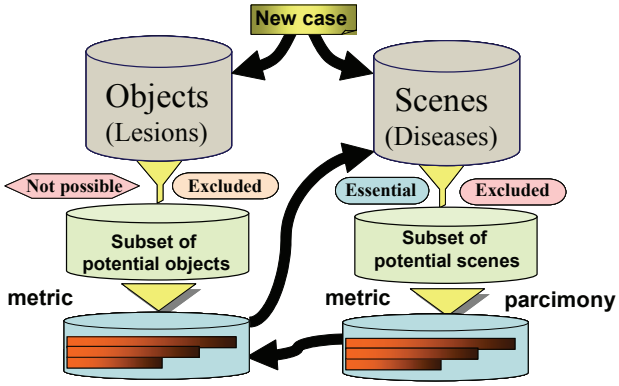

Figure 3 - New case classification

Lesion and Disease Classification, illustred by *Figure 3*, are the key points of the Scene analyze. With this intent, the questioning interface allows the user to depict an endoscopic exam, in other words the patient profile, the objects and possible spatial relations between objects. To avoid a boring description of objects, only 5 features (anatomical position, form, color, relief and type) are wanted at first; the other ones, according to their discriminating power, will be selected to refine the object recognition. After the object classification, the whole description of the exam is analyzed to identify one or several Logical Scenes - i.e. the diagnoses of diseases -. This analysis of scene still allows perfecting the classification of the lesions - i.e. objects-. Indeed, as the level of the image (or of the sequence) generally represents the endoscopic lesion level, the classification should especially insist on the objects in order to select a subset of candidate cases (the similarity playing upon those), while, from a medical point of view, the level of interest should surely envisage the pathology diagnosis.

The classification step having unveiled the objects and scenes potentially similar, it is a matter of illustrate them

by pertinent images. For this purpose, the new case is compared with selected cases according to three levels, characteristics, objects, and scenes. The Characteristic Similarity uses predefined tables for each feature with 5 values (incompatible - no similar - slightly similar - fairly similar - identical). Fusion of Object Similarities, of patient profile characteristic similarities and relation characteristic similarities complete the retrieval.

Such a system with evolved functionality is in keeping with the Pattern Recognition and Case Base Reasoning paradigms. A version of the endoscopic atlas is accessible via internet at http://i3se009d.univ-brest.fr/ -- Password medinfo2007. At the moment, then application contains around 150 endoscopic images (from Normedia) and 150 descriptions of 90 findings; it enables the user to describe an object or a scene in order to obtain the potential diagnoses and similar images. The reasoning model and the indexing criteria have been informally assessed by endoscopists with different levels of experience.

It is clear that the accuracy of the system to retrieve similar images depends strongly on the user's ability to analyze the endoscopic image. Faced with a diagnostically ambiguous image, it becomes difficult for the endoscopist to extract and describe the relevant features. This inherent weakness is common to other computer-assisted decision-making systems and limits their usefulness as real-time diagnostic aids. On the other hand, this work has demonstrated a method for precise description of the cases by experts, the flexibility of the research engine, the ability to store a large number of cases and to use web tools. With this background, we have continued to study the topics of similarity and reliability in the collaborative atlas Project.

Collaborative atlas project

The 1500 endoscopic images collected from the data warehouse of the Clinical Outcomes Research Initiative (CORI) as published online in the OHSU Digital Resource Library [2], constitutes a collection that may be sufficient for preliminary work, that is to say, to a reference atlas for further projects. This collection differs from the endoscopic case base described above, however, in that the images are not linked to patient information and are indexed with CORI terminology and not the MST-derived terminology described. Nevertheless, this collection allows us to explore issues in similarity such as the reliable assignment of indexing terms (including validation of images in the collection), comparisons of standardized vocabularities, metrics for similarities between images, and the technical and organizational requirements for collaboratively creating a shared, indexed case base for clinical care and education. Two projects have been initiated, the first in collaborative indexing, the second in development of educational scenarios for testing and education.

Collaborative indexing

In the setting of this collaboration, another web site http://i3se009d.univ-brest.fr/Collab - Email and Password: medinfo2007– is under construction and uses the 1500 endoscopic images from CORI as a base for collaborative image indexing and creation of a case base.

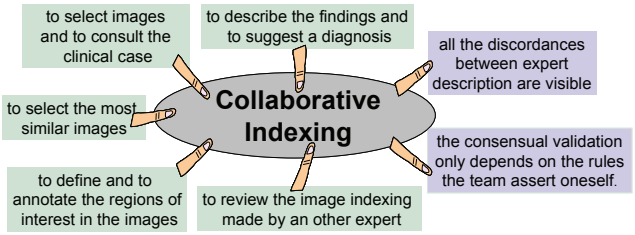

Figure 4 - Collaborative indexing

Already, the indexing module enables a domain expert to select images, to consult the clinical case, to describe the findings, to suggest a diagnosis, to select the most similar images from the atlas or to define the regions of interest in the images and to annotate them as seen *Figure 4*. The finding description is made easier by the ability to match the current image to a similar image already indexed - as shown *Figure 5* - and to adapt the description to its case; the validity is checked thanks to the Knowledge base; the expert can maintain a non valid description and, if necessary, the Knowledge base will be updated. Several experts can index the same picture and modify the descriptions. All of the discordances between experts are displayed; final validation of an image description depends on the rules which the team chooses.

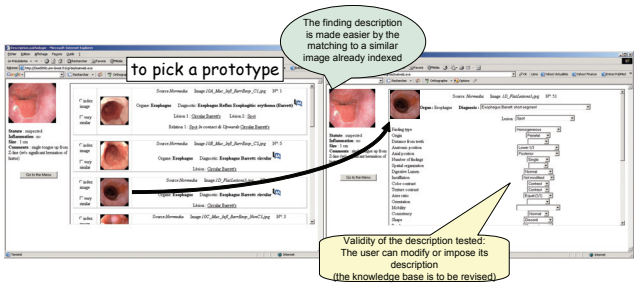

Figure 5 - Indexing thanks to previous cases

Educational scenarios

The educational/testing module is made up of HTML pages and combines images and test questions as presented *Figure 6*. For any learning scenario, the forms and their display order may be customized. Images within those forms can be displayed in a set order or randomly selected. The subject is given a scenario and one or more images

and answers questions about those images. In an educational mode, the subject may access the text description of the image and/or the case. In testing mode, following validation that all questions are answered, the responses are saved for subsequent analysis.

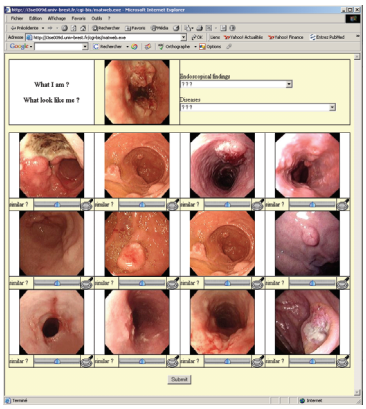

Figure 6 - Testing module

Preliminary work with this module suggests opportunities for development of some interactive tools and will enable to devise learning scenarios adapted to the reasoning methods of endoscopists and to the experience level of the apprentice.

Discussion

The difficulty by endoscopists in extracting relevant features from an ambiguous image and the interference of the diagnostic conviction in the description process leads to explore similarity in endoscopy.

Similarity exploration

A study of the similarity [6] in digestive endoscopy has been conducted first with endoscopists (both novice and experienced) and then with a group of college-level psychology students. The study used a library of 90 well-known endoscopic images and 3 study images. For each study image, the participants were asked to choose from the library the ten most similar images and, in addition, for the endoscopists, to list the most relevant diagnosis for each study image. A comparison of the subject responses according to diagnostic accuracy suggests there are correlations between the diagnostic accuracy, the perception of similar features, and the selection of images with the same expected diagnosis. One hypothesis could be that endoscopists choose images with similar diagnosis rather than in accordance with the aspect of the image. The choice of similar images would then depend predominantly on the diagnostic conviction of the endoscopist.

A comparison of the endoscopist and student responses suggests that similarity between endoscopic images can be perceived even by subjects who have no experience in the field of medicine. That is, similarity between images can be perceived based on intrinsic properties of image content but without requirements of knowledge and/or experience. A practical consequence of this finding might be that the search method for an endoscopic atlas could be based on a selection of similar images by the user, rather than on the verbal description of the case under investigation. Moreover, this study confirms the necessity of multi-expert in the image indexing task and validates the chosen collaborative approach.

Future works

As the verbal description or the query by similarity is influenced by the diagnostic conviction of the endoscopist, it will be indispensable to extract some features directly from the digital content of the images. A previous study with a global approach of the image numerical content did not have good results. But, with regions of interest in the picture defined by the experts at the time of annotation, some finding features will have to be obtained and interpreted by local numerical approaches. It will then be matter of developing new algorithms for the similar case retrieval, combining image analysis and text retrieval approaches.

In the future, the endoscopic e-learning could prepare resident to practice on real cases and thwart the inherent threefold weaknesses of the endoscopy teaching: “the unhappy patient, the unhappy student and the unhappy instructor”.

Acknowledgments

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Supporting Cooperative Updates of Clinical Guidelines

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Abstract

We propose an extension of the standard DB model in order to support cooperative updates to clinical guidelines, as needed both in the acquisition phase and when guidelines are modified to capture new therapies.

Introduction and background

Modelling guidelines is a complex task, which may require a cooperative effort of several participants. Alternative proposals may be generated, and a team of "supervisors" is needed in order to validate and choose between them. Maintaining the authors of each proposal and the history of the different versions of the guidelines is very important (e.g., to support the retrieval of past version of the guideline, to justify decision taken in the past). A temporal extension of the standard DB models is thus needed to support such a cooperative and dynamic environment.

Methods

In order to devise a modular, general, and system independent approach to face the above issues, we propose a three-layered architecture, consisting of:

1. a data model layer, defining the data model and providing the basic operations;
2. a query language layer, supporting an SQL-like high-level manipulation and query language, based on layer (1);
3. an interface layer, based on the previous ones, that provides users with high-level functionalities, accessed through a user-friendly graphical interface.

For the sake of brevity, in the following only the data model layer will be sketched. The data model must support temporal tables, in which both the *validity* time of data (i.e., the time when data are true) and its *transaction* time (i.e., the time when data are inserted\deleted from the DB) must be considered. Two levels of tables must be distinguished: (i) "supervisor" tables, containing data which have been validated (accepted) by supervisors, and "proposal" tables, concerning user proposals. Specifically, for each supervisor table r, we use three tables: (i) a table *propose_insert(r)* with the proposal of insertions in r, (ii) a table *propose_delete(r)* with the proposals of deletion, and (iii) a table *propose_update(r)* with the proposals of updates. While the first two tables contain standard tuples (plus their temporal part), *propose_update(r)* will contain pairs of tuples, the former representing the tuple to be modified, and the latter the new tuple to be entered.

Different manipulation operations are provided. Specifically, standard users can *propose* the *insertion, deletion* or *update* of tuples. Such operations will modify the proper proposal tables, while they will not affect the supervisor tables.

On the other hand, supervisors have the possibility to *accept* and to *reject* user proposals. The acceptance of a proposal will affect the corresponding supervisor table. For instance, the acceptance of a proposal of update will lead to the practical execution of the update on the supervisor table.

Subtle semantic issues need to be faced in the definition of operations. For instance, proposals of update concerning the same supervisor tuple must be managed as alternative proposals, in the sense that only one of them can be accepted (to resperct such an intended semantics, the acceptance of an update must modify the transaction time of each alternative update proposal to state that such proposals are no longer valid).

Results

We have defined an extended approach to temporal DB in order to support cooperative updates to a guideline.

Such an approach supports different levels of users (supervisors vs simple users) and supply proper operations for them, as required in guideline applications.

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Study of a Logistic Model with Mutually Correlated Variables Using a Generation Algorithm of Dichotomous Data with Arbitrary Sensitivity, Specificity and Correlation

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Abstract

Parameters of a logistic model were studied when the descriptive variables are not mutually independent. For this purpose a generation algorithm of multiple test data with arbitrary sensitivity, specificity and correlation was developed, and the effect of correlation on the parameters of the model was investigated. Based on the results, the possibility of a new modeling framework for logistic analysis was proposed.

Keywords:

logistic model, correlation, generation algorithm

Introduction

A logistic model

$$y = \log(p/(1-p)) = b_0 + \sum b_i x_i \quad (1)$$

with dichotomous descriptive variables x_i are considered, where p designates the probability of an event such as a particular disease. If the variables are mutually independent, we have the relations

$$b_i = \log(\text{Odds ratio of the i-th variable}) \quad (2)$$

for the coefficients of the model. However, this relation does not hold when the variable x_i is correlated with some other variables. The purpose of this study is to examine how the correlation between the descriptive variables affects the values of coefficients b_i.

Methods

A generation algorithm of multiple test data with arbitrary sensitivity, specificity and correlation was developed [1], and was implemented using MATLAB 7.1 (The MathWorks, Inc.). Various numerical data were created, e.g. mutually independent tests with the same sensitivity and specificity, data with a positive correlation coefficient between two variables, data with a negative correlation coefficient, and data with correlations among many variables. Logistic analysis was performed on each case and the estimated model parameters,

Table 1 - Contingency table of test x_i and the diagnosis D (=1: positive, =0: negative)

	D=1	D=0
$x_i = 1$	α_i	$1-\beta_i$
$x_i = 0$	$1-\alpha_i$	β_i

b_i, were examined. For the estimation of the model, the "logistic procedure" of SAS 9.1 (SAS Institute Inc.) and the "glmfit" function of MATLAB were employed.

The relationship between disease D and its clinical test x_i can be presented by a contingency table, Table 1. Variable D represents the state of the patient, having the disease by D=1 and not having the disease by D=0. Variable x_i represents the result of the i-th test, e.g., positive by $x_i = 1$ and negative by $x_i = 0$. The sensitivity and specificity of the test are represented by α_i and β_i, respectively. When D=1 the correlation coefficient between test i and test j is r_{ij}^{+}, and when D=0 the correlation coefficient between tests is r_{ij}^{-} .

Results

Test data was created by the generation program [1] and precisely reconstructed the given conditions of sensitivity, specificity and correlation coefficients for arbitrary number of tests. Effect of correlation on the parameters of the logistic model was examined by using these data. In the following the number of variables in the model was set to 4, and the interaction model

$$y = \log(p/(1-p)) = b_0 + \sum b_i x_i + \sum b_{ij} x_i x_j \quad (3)$$

was assumed for SAS procedure.

A. All variables are mutually independent

We assumed the following conditions of sensitivities and specificities and no correlation among the variables:

$$\alpha = \beta = (0.80, 0.75, 0.70, 0.65).$$

By applying the logistic procedure we get the model parameters b_i's that satisfy the relation (2).

B. Positive correlations between two variables

We assume that $\alpha = \beta = (0.7, 0.7, 0.7, 0.7)$ and $r_{ij}^{+} = r_{ij}^{-} = 0$ except for $r_{12}^{+} = r_{12}^{-} = 0.3$. The result is that the coefficients b_1 and b_2 decrease due to the correlation between tests 1 and 2.

Parameter	Estimated value	SE	p
b_0	-2.991	0.142	<0.0001
b_1	1.288	0.123	<0.0001
b_2	1.288	0.123	<0.0001
b_3	1.702	0.120	<0.0001
b_4	1.702	0.120	<0.0001
b_{ij}	0.000	0.000	1.0000

C. Negative correlations between two variables

We assume that $\alpha = \beta = (0.7, 0.7, 0.7, 0.7)$ and $r_{ij}^{+} = r_{ij}^{-} = 0$ except for $r_{12}^{+} = r_{12}^{-} = -0.3$. The result is that the coefficients b_1 and b_2 increase due to the correlation between tests 1 and 2.

Parameter	Estimated value	SE	p
b_0	-4.444	0.207	<0.0001
b_1	2.760	0.167	<0.0001
b_2	2.760	0.167	<0.0001
b_3	1.685	0.131	<0.0001
b_4	1.685	0.131	<0.0001
b_{ij}	0.000	0.000	1.0000

Diagnostic performances with the four tests and with the same α and β were represented in Figure 1 by the ROC curves based on the three cases of logistic model obtained above.

D. More complex correlations

We assume that $\alpha = \beta = (0.7, 0.7, 0.7, 0.7)$ and $r_{ij}^{+} = r_{ij}^{-} = 0$ except for $r_{12}^{+} = r_{13}^{+} = r_{12}^{-} = 0.3$. The result is that the coefficients b_1 , b_2 and b_3 decrease due to the correlation between tests 1 and 2, and tests 1 and 3. Parameter b_1 was not statistically significant and the interaction terms are quite complicated.

Parameter	Estimated value	SE	p
b_0	-2.487	0.190	<0.0001
b_1	0.012	0.282	0.9664
b_2	1.508	0.242	<0.0001
b_3	0.936	0.236	<0.0001
b_4	1.612	0.221	<0.0001
b_{12}	0.227	0.256	0.3769
b_{13}	1.719	0.258	<0.0001
b_{14}	0.086	0.252	0.7336
b_{23}	-0.535	0.255	0.0360
b_{24}	0.037	0.251	0.8829
b_{34}	0.098	0.244	0.6868

In general, values of b_i and b_j decreased when x_i and x_j had a positive correlation coefficient, and increased when they had a negative correlation coefficient, compared with the other parameters with no correlation. When the correlation exists in

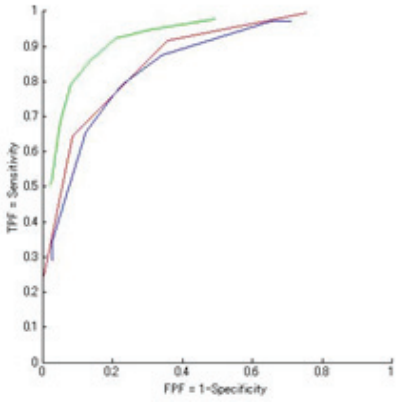

Figure 1 - ROC curve of diagnosis for cases A: independent (red), B: positive correlations (blue), and C: negative correlations (green). In all cases it was assumed that $\alpha = \beta = (0.7, 0.7, 0.7, 0.7)$

more than two pairs of variables, no simple rule predicted the results. Introducing the interaction terms, $b_{ij}\, x_i\, x_j$, did not improve the situation.

Discussion

Our results indicate that there is a need for a new modeling framework of logistic analysis, if we wish to separate the effect of each variable from their interactions, and to use the model parameters b_i for the diagnostic or risk evaluation purposes. Based on the theory of joint probability of dichotomous tests with correlations [2], we could show how the bi's are affected by the correlation coefficients between xi's.

Conclusion

The effects of correlation on a logistic model with dichotomous variables were examined. Correlation between explanatory variables made the coefficients of logistic model difficult to interpret. Based on the results, we propose a possible new modeling framework for logistic analyses.

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Study of a logistic model with mutually correlated variables using a generation algorithm of dichotomous data with arbitrary sensitivity, specificity and correlation

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Abstract

Parameters of a logistic model were studied when the descriptive variables are not mutually independent. For this purpose a generation algorithm of multiple test data with arbitrary sensitivity, specificity and correlation was developed, and the effect of correlation on the parameters of the model was investigated. Based on the results, possibility of a new modeling framework for logistic analysis was proposed.

Keywords:

Logistic model, Correlation, Generation algorithm.

Introduction

A logistic model

$$y = \log(p/(1-p)) = b_0 + \Sigma\, b_i\, x_i \qquad (1)$$

with dichotomous descriptive variables x_i are considered, where p designates the probability of an event such as a particular disease. If the variables are mutually independent, we have the relations

$$b_i = \log(\text{Odds ratio of the i-th variable}) \qquad (2)$$

for the coefficients of the model. However, this relation does not hold when the variable x_i is correlated with some other variables. The purpose of this study is to examine how the correlation between the descriptive variables affects the values of coefficients b_i.

Methods

A generation algorithm of multiple test data with arbitrary sensitivity, specificity and correlation was developed [1], and was implemented using MATLAB 7.1 (The MathWorks, Inc.). Various numerical data were created, e.g. mutually independent tests with the same sensitivity and specificity, data with a positive correlation coefficient between two variables, data with a negative correlation coefficient, and data with correlations among many variables. Logistic analysis was performed on each case and the estimated model parameters, b_i, were examined. For the estimation of the model, the "logistic procedure" of SAS 9.1 (SAS Institute Inc.) and the "glmfit" function of MATLAB were employed.
The relationship between disease D and its clinical test x_i can be presented by a contingency table, Table 1. Variable D represents the state of the patient, having the disease by D=1 and not having the disease by D=0. Variable x_i represents the result of the i-th test, e.g., positive by x_i =1 and negative by x_i =0. The sensitivity and specificity of the test are represented by α_i and β_i, respectively. When D=1 the correlation coefficient between test i and test j is r_{ij}^{+}, and when D=0 the correlation coefficient between tests is r_{ij}^{-} .

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Results

Test data was created by the generation program [1] and precisely reconstructed the given conditions of sensitivity, specificity and correlation coefficients for arbitrary number of tests. Effect of correlation on the parameters of the logistic model was examined by using these data. In the following the number of variables in the model was set to 4, and the interaction model

$$y = \log(p/(1-p)) = b_0 + \Sigma\, b_i\, x_i + \Sigma\, b_{ij}\, x_i\, x_j \qquad (3)$$

was assumed for SAS procedure.

A All variables are mutually independent

We assumed the following conditions of sensitivities and specificities and no correlation among the variables:

$$\alpha = \beta = (0.80, 0.75, 0.70, 0.65).$$

By applying the logistic procedure we get the model parameters b_i's that satisfy the relation (2).

B Positive correlations between two variables

We assume that $\alpha = \beta = (0.7, 0.7, 0.7, 0.7)$ and $r_{ij}^{+} = r_{ij}^{-} = 0$ except for $r_{12}^{+} = r_{12}^{-} = 0.3$. The result is that the coefficients b_1 and b_2 were decreased due to the correlation between tests 1 and 2.

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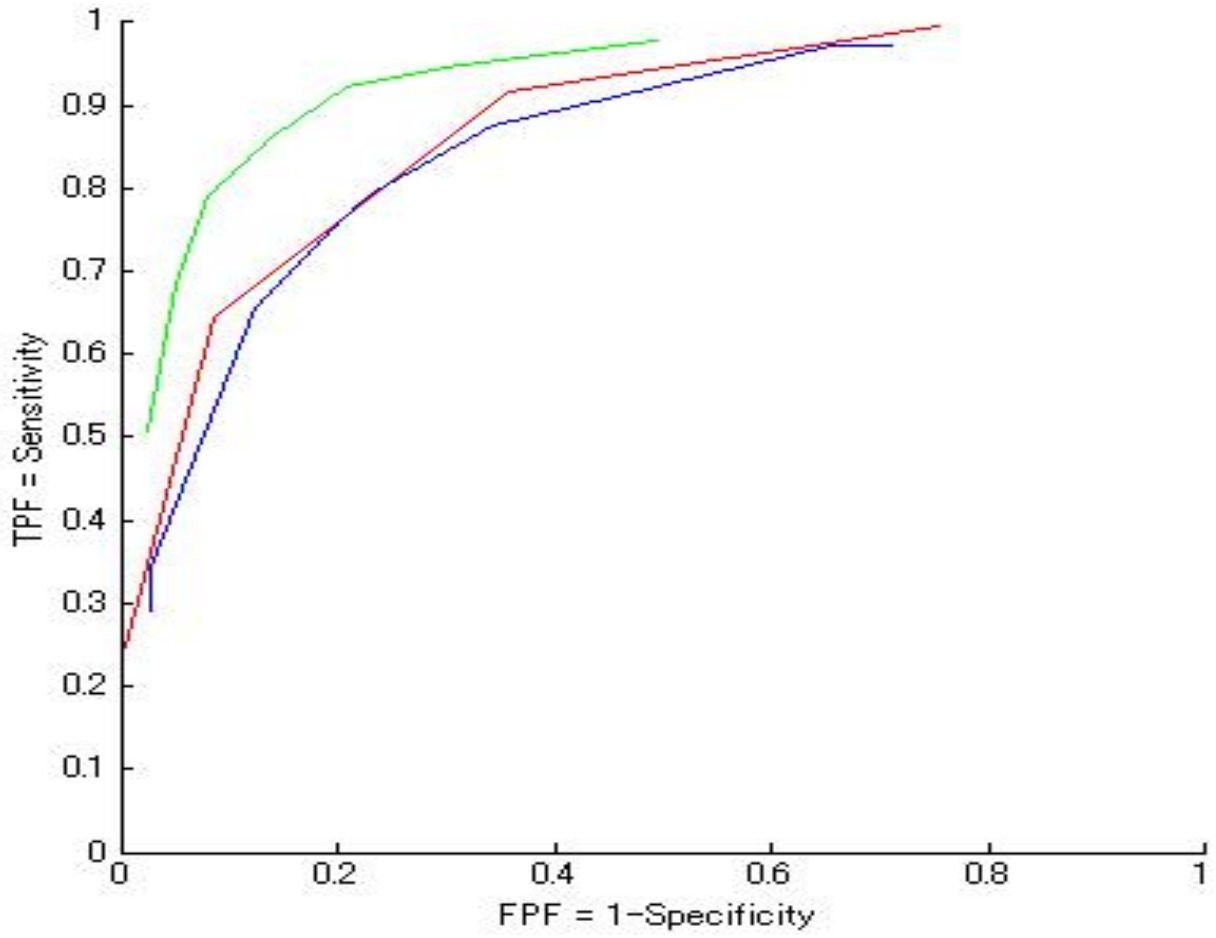
b_4	1.702	0.120	<0.0001
b_{ij}	0.000	0.000	1.0000

C Negative correlations between two variables

We assume that $\alpha = \beta = (0.7, 0.7, 0.7, 0.7)$ and $r_{ij}^{+} = r_{ij}^{-} = 0$ except for $r_{12}^{+} = r_{12}^{-} = -0.3$. The result is that the coefficients b_1 and b_2 increased due to the correlation between tests 1 and 2.

Parameter	Estimated value	SE	p
b_0	-4.444	0.207	<0.0001
b_1	2.760	0.167	<0.0001
b_2	2.760	0.167	<0.0001
b_3	1.685	0.131	<0.0001
b_4	1.685	0.131	<0.0001
b_{ij}	0.000	0.000	1.0000

Fig.1 ROC curve of diagnosis for cases A: independent (red), B: positive correlations (blue), and C: negative correlations (green). In all cases it was assumed that $\alpha = \beta = (0.7, 0.7, 0.7, 0.7)$.



D More complex correlations

We assume that $\alpha = \beta = (0.7, 0.7, 0.7, 0.7)$ and $r_{ij}^{+} = r_{ij}^{-} = 0$ except for $r_{12}^{+} = r_{13}^{+} = r_{12}^{-} = 0.3$. The result is that the coefficients b_1 , b_2 and b_3 decrease due to the correlation between tests 1 and 2, and tests 1 and 3. Parameter b_1 is not statistically significant and the interaction terms are quite complicated.

Parameter	Estimated value	SE	p
b_0	-2.487	0.190	<0.0001
b_1	0.012	0.282	0.9664
b_2	1.508	0.242	<0.0001
b_3	0.936	0.236	<0.0001
b_4	1.612	0.221	<0.0001
b_{12}	0.227	0.256	0.3769
b_{13}	1.719	0.258	<0.0001
b_{14}	0.086	0.252	0.7336
b_{23}	-0.535	0.255	0.0360
b_{24}	0.037	0.251	0.8829
b_{34}	0.098	0.244	0.6868

Discussion

Our results indicate that there is a need for a new modeling framework of logistic analysis, if we wish to separate the effect of each variable from their interactions, and to use the model parameters b_i for the diagnostic or risk evaluation purposes. Based on the theory of joint probability of dichotomous tests with correlations [2], we could show how the bi's are affected by the correlation coefficients between xi's.

Conclusion

The effects of correlation on a logistic model with dichotomous variables were examined. Correlation between explanatory variables made the coefficients of logistic model difficult to interpret. Based on the results, we propose a possible new modeling framework for logistic analyses.

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A Method for Categorizing Continuous Prognostic Variables Based on the Overall C Index

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Abstract

We propose a new method for categorizing continuous prognostic variables based on the overall discrimination index C introduced by Harrel. We show that this index is closely related to the area under the ROC curve for the original continuous prognostic variable and that the resulting categorized variables have predictive properties comparable to the original variable. However, like some existing approaches, the simple application of our method overestimates the predictive performance. To solve this problem, we propose a parametric method that minimizes this bias and assess its performance with the use of Monte Carlo simulation. The simulation shows that the parametric method is essentially unbiased for both the estimates of predictive performance and the cutoff points, and is a valid tool to create probability profile tables from prediction models for clinical practice.

Keywords:

projections and predictions, prognosis, cutoff point, sensitivity and specificity, categorization

Introduction

Multivariable regression models are useful for both diagnosis and prognosis. If we categorize all continuous independent variables, we can replace the risk function by a table of risks for all possible patient profiles, which is much easier to apply at outpatient clinic [1]. To achieve this, we need a way of optimal categorization. Although many methods have been proposed to dichotomize predictive variables, there has been no integrated method for polychotomization. In this study, we propose a theoretical and practical method for categorization of continuous independent variables.

Methods

For the categorization of continuous variables, we need to (i) define a measure for the predictive ability of prognostic variable with discrete values and then (ii) find the categorization in which the predictive ability is maximized.

We adopted the overall discrimination index *C*, or the pair consistency probability, introduced by Harrel [2] as a measure of the predictive performance of a categorized independent variable. The *C*-index is defined as the probability of the correct ranking of a normal-disease-pair. For instance, when we take a sample x_i from the normal group *N* and another sample y_i from the disease group *D* randomly; we can call this pair *concordant* if $r(x_i)<r(y_i)$, *tied* if $r(x_i)=r(y_i)$, and *discordant* if $r(x_i)>r(y_i)$, where $r()$ is the rank of the observed value among all values. The ranks are expected to be higher for the diseased cases. The *C*-index is then defined by

$$C = p_{\text{con}} + p_{\text{tied}}/2 \quad (1)$$

where

$p_{\text{con}} = \text{P}(r(x_\text{i})<r(y_\text{i}))$ and $p_{\text{tied}} = \text{P}(r(x_\text{i})=r(y_\text{i}))$

Let α denote the probability that x_i is greater than a cutoff point z for dichotomization, and let β denote the probability that y_i is less than z, i.e.

$$\alpha = \int_z^\infty f_N(x)dx = Fp \qquad \beta = \int_{-\infty}^z f_D(x)dx = 1 - Tp$$

Then the probability of the concordant case becomes

$p_{\text{con}} = (1 - \alpha)(1 - \beta)$,

and that of the tied case becomes

$p_{\text{tied}} = (1 - \alpha)\beta + \alpha(1 - \beta)$

Assigning these probabilities into (1), we have

$$C = 1 - (\alpha + \beta)/2 \quad (2)$$

Since sensitivity is $(1 - \beta)$ and specificity is $(1 - \alpha)$, the *C*-index becomes

$$C = (\text{sensitivity} + \text{specificity})/2 \quad (3)$$

Therefore the highest pair consistency probability is achieved when the sum of two kinds of errors, $\alpha + \beta$, is minimized, or the sum of sensitivity and specificity is maximized.

We can apply the definition of the *C*-index (1) for polychotomouse cases, and define the *ROC line graph* by joining the points (Fp, Tp) [3]. We can then proof that the *C*-index is equivalent to the area under the *ROC line graph* and the produced polychotomized variable's predictive

performance is comparable to the original continuous variable.

If we repeat the evaluation of the *C*-index to find optimal cutoff points, for instance by increasing the possible value of the cutoff point with a certain step (*repeated search method*), it overestimates the predictive performance. We therefore developed a practical parametric method in which

1. the distributions of the independent variable in healthy and disease groups are estimated;
2. the optimal cutoff points are found based on the estimated distributions;
3. the predictive ability of the categorized variable is evaluated based on the produced cutoff points.

We assessed its performance with the use of Monte Carlo simulation, both for cases where independent variables are normally distributed and cases where we cannot transform the distributions to normal distributions.

Results and discussion

The simulation shows that the parametric method is essentially unbiased for the estimates of the cutoff points and predictive performance (Figures 1 and 2). We repeated the simulations for various n_h and n_d (n_h=n_d) . Figure 3 shows that the estimation by the parametric method is almost unbiased even if the sample size is relatively small, whereas the naïve repeated search method shows non-negligible bias even when the sample size is large (n =300).

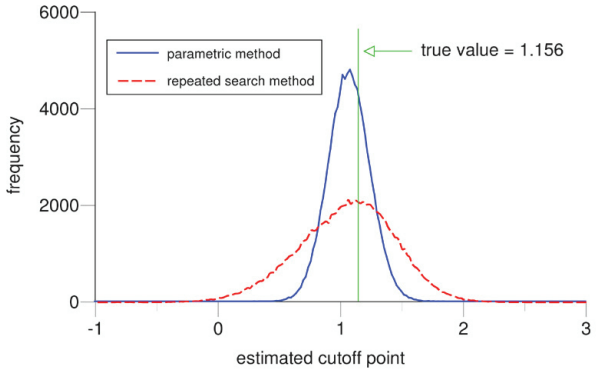

Figure 1 - The frequency distributions of the estimated optimal cutoff point in 100,000 simulations of dichotomization, with $f_h \sim N(0, 1^2)$, $f_d \sim N(2, 1.5^2)$ and n_h=n_d=30

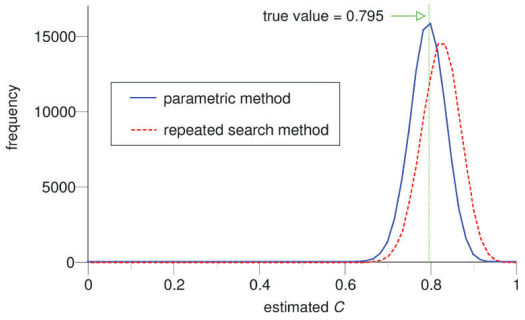

Figure 2 - Distributions of estimated pair consistency probability C in 100,000 simulations of dichotomization

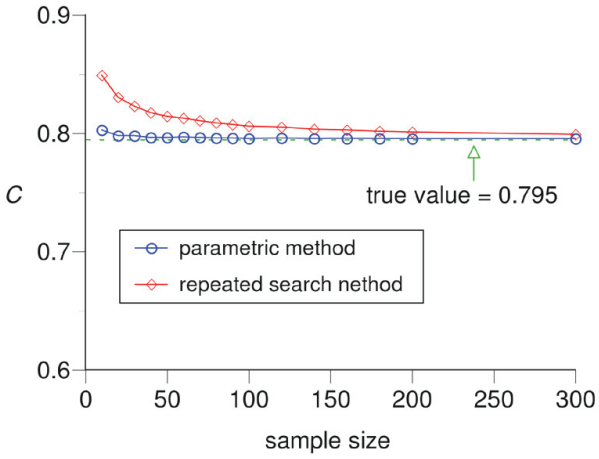

Figure 3 - Changes of estimated pair consistency probability C in dichotomization as a function of sample size

The results for trichotomization and categorization to four classes have a similar tendency for cases where independent variables are normally distributed [3] as well as for cases where we cannot transform the distributions to normal distributions [4].

If a certain type of distribution cannot be assumed, approximation of the distribution curve by a line graph or a restricted cubic spline function creates a workable situation.

Conclusion

We proposed a categorization method for continuous prognostic variables based on the overall discrimination index *C*. We evaluated a parametric method for this problem and showed that it performs well.

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A Method for Categorizing Continuous Prognostic Variables Based on the Overall *C* Index

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Introduction

Multivariable regression models are useful for both diagnosis and prognosis. If we categorize all continuous independent variables, we can replace the risk function by a table of risks for all possible patient profiles, which is much easier to apply at outpatient clinic [1].

To achieve this, we need a way of optimal categorization. Although many methods have been proposed to dichotomize predictive variables, there has been no integrated method for polychotomization. In this study, we propose a theoretical and practical method for categorization of continuous independent variables.

Methods

1. We adopted the overall discrimination index *C*, or the pair consistency probability, introduced by Harrel [2] as a measure of the predictive performance of a categorized independent variable (see the next slide for its definition).
2. We then derived a method for polychotomization mathematically and proved that the *C*-index is closely related to the area under the ROC curve and the produced categorized variable's predictive performance is comparable to the original continuous variable.
3. Since the naïve application of our method, like some existing approaches, overestimates the predictive performance, we developed a parametric method that minimizes this bias and assessed its performance with the use of Monte Carlo simulation.

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Pair Consistency Probability *C*

- Measure for the Predictive Ability of a Prognostic Variable -

Let x_i be a sample from the normal group *N*,

and y_i be a sample from the disease group *D*.

We call this pair

concordant if $r(x_i)<r(y_i)$,

tied if $r(x_i)=r(y_i)$,

discordant if $r(x_i)>r(x_i)$,

where r() is the rank of the observed value among all values and is expected to have a larger value for the diseased cases.

Pair Consistency Probability C is then defined by

$$C = p_{con} + p_{tied}/2 \qquad (1)$$

where

$$p_{con} = P(r(x_i)<r(x_i)) \text{ and } p_{tied} = P(r(x_i)=r(x_i)).$$

What we have to do next is to find a combination of cutoff points that maximizes the pair consistency probability *C*.

Optimal Cutoff Point for Dichotomization

Let α denote the probability that x_i is greater than a cutoff point z, and let β denote the probability that y_i is less than z, then the probability of the concordant case becomes

$$p_{con} = (1 - \alpha)(1 - \beta),$$

and that of the tied case becomes

$$p_{tied} = (1 - \alpha)\beta + (1 - \beta)\alpha.$$

Consequently,

$$C = (1-\alpha)(1-\beta) + ((1-\alpha)\beta + (1-\beta)\alpha)/2 = 1 - (\alpha+\beta)/2.$$

Since *sensitivity* is $(1 - \beta)$ and *specificity* is $(1 - \alpha)$,

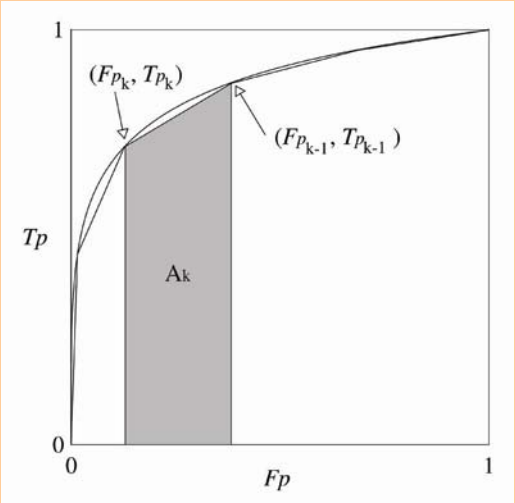
$$C = 1 - (\alpha+\beta)/2 = (sensitivity + specificity) / 2. \qquad (2)$$

Therefore, the highest pair consistency probability C is achieved when the sum of two kinds of errors, $\alpha+\beta$, is minimized, or the sum of sensitivity and specificty is maximized.

Extension to Polychotomization

We can also apply the definition of the *C*-index (1) for polychotomouse cases, and define "optimal" cutoff points by maximizing the *C*-index.

We then define the *ROC line graph* by joining the points (*Fp*, *Tp*), each corresponding to one of the cutoff points for polychotomization. We can then proof that the *C*-index is equivalent to the area under the *ROC line graph* and that the produced polychotomized variable's predictive performance is comparable to the original continuous variable [3].



NB: *Fp* = false positive fraction, *Tp* = true positive fraction

Parametric Method for Categorization

If we repeat the evaluation of *C* to find optimal cutoff points, for instance by increasing the possible value of the cutoff point with a certain step (*repeated search method*), it overestimates the predictive performance. To solve this problem, we developed a practical parametric method in which

(i) the distributions of the independent variable in healthy and disease groups are estimated;

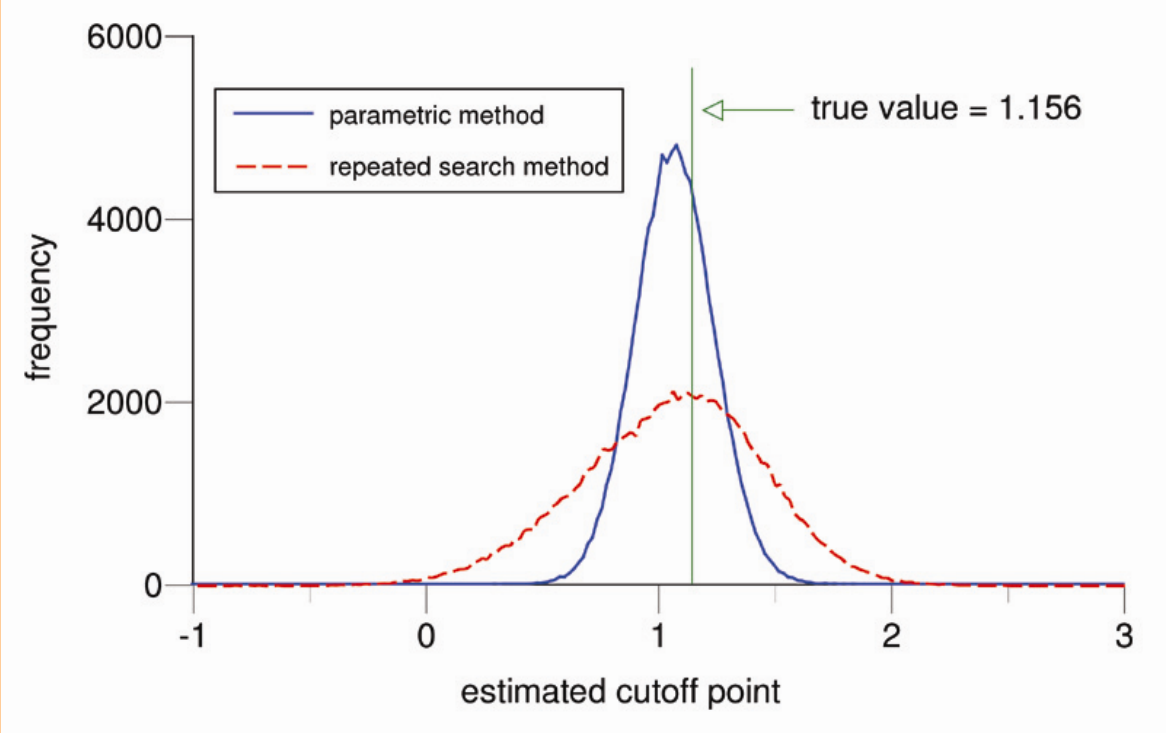
(ii) the optimal cutoff points are found based on the estimated distributions;

(iii) the predictive ability of the categorized variable is evaluated based on the produced cutoff points.

We assessed its performance with the use of Monte Carlo simulation, both for cases where the independent variables are normally distributed and for cases where we cannot transform the distributions to normal distributions.

Results

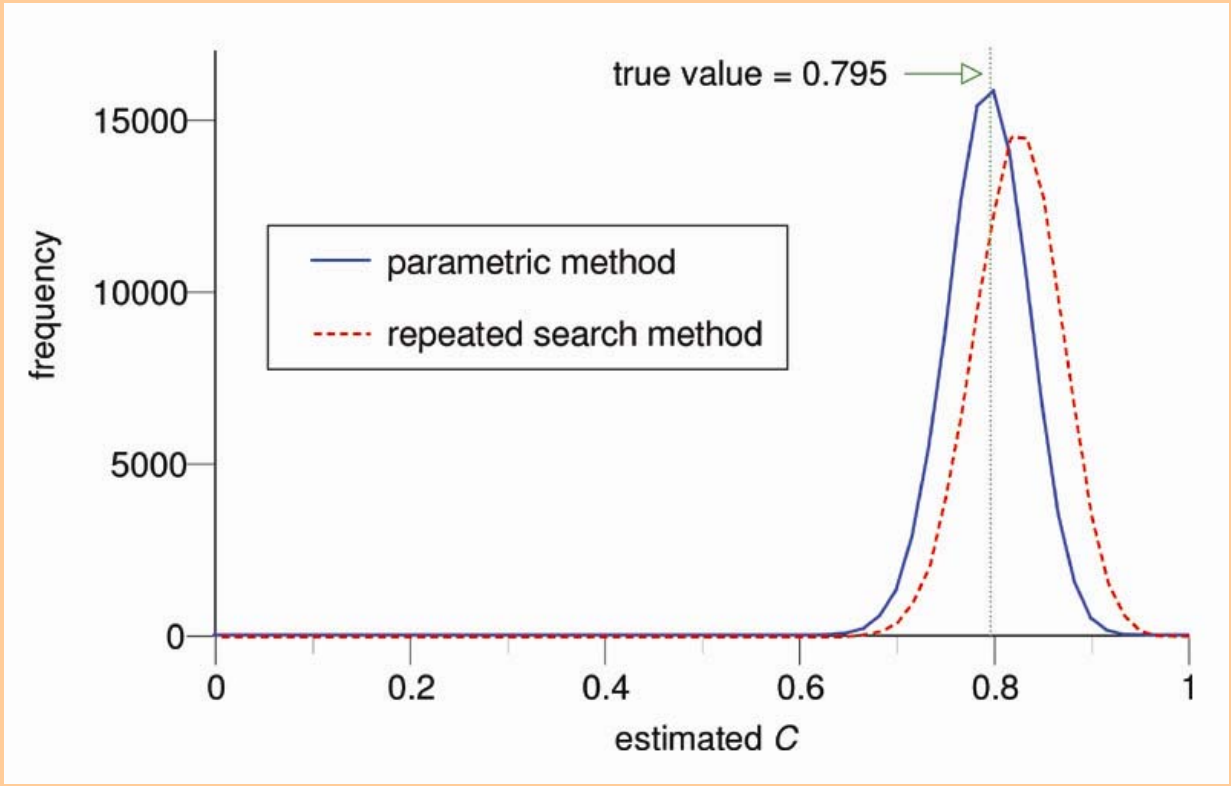
The frequency distributions of the estimated optimal cutoff point in 100,000 simulations of dichotomization



The parametric method provides a estimator for the cutoff point with higher precision.

($f_h \sim N(0, 1^2)$, $f_d \sim N(2, 1.5^2)$ and $n_h=n_d=30$)

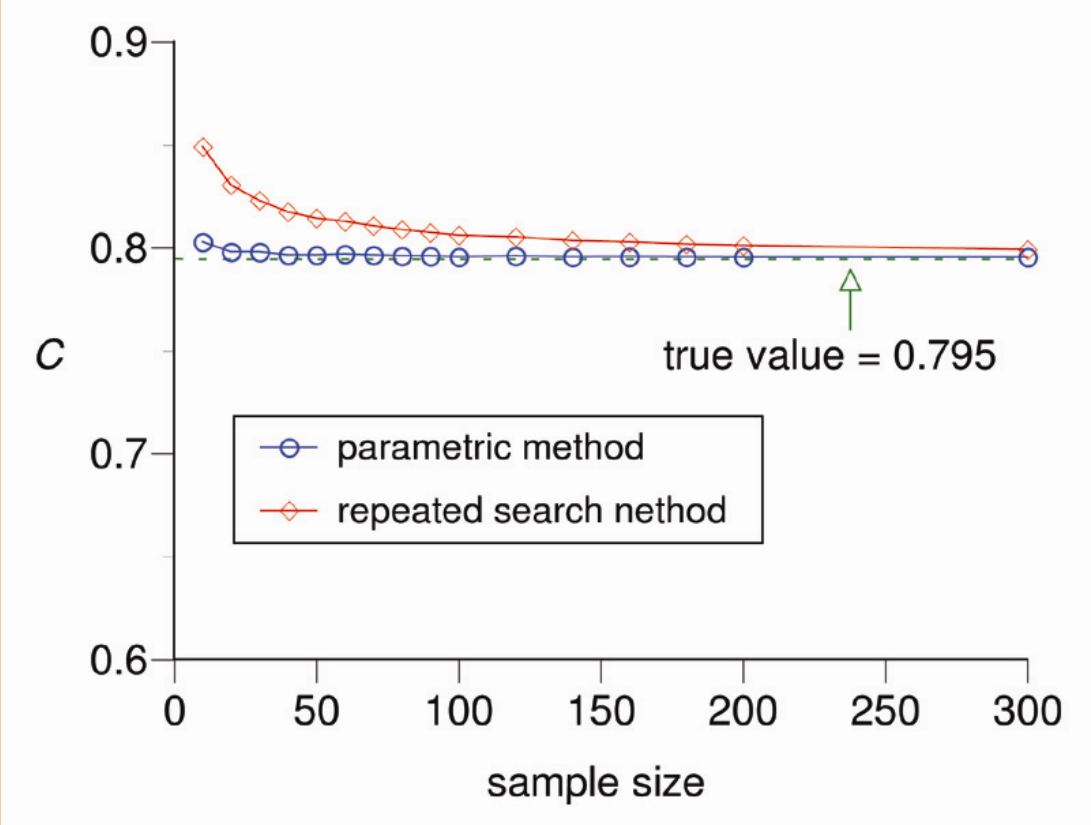
Distributions of estimated pair consistency probability *C* in 100,000 simulations of dichotomization



The parametric method is essentially unbiased for the predictive performance.

($f_h \sim N(0, 1^2)$, $f_d \sim N(2, 1.5^2)$ and $n_h=n_d=30$)

Changes of estimated pair consistency probability *C* in dichotomization as a function of sample size



The estimation by the parametric method is almost unbiased even if the sample size is relatively small, whereas the naïve repeated search method shows non-negligible bias even when the sample size is large (*n* =300).

Discussion

The results for trichotomization and categorization to four classes have a similar tendency, both for cases where independent variables are normally distributed [3] and for cases where we cannot transform the distributions to normal distributions [4].
If we cannot assume a certain type of distribution, approximation of the distribution curve by a line graph or a restricted cubic spline function creates a workable situation.

Conclusion

We proposed a categorization method for continuous prognostic variables based on the overall discrimination index *C*. We evaluated a parametric method for this problem and showed that it performs well.

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Decision Support for the Prescription of Hepatitis B Virus Tests in Cardiovascular Surgery

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Abstract

We aimed at developing an alert-system to decrease the inappropriate repetition of hepatitis B virus tests. We evaluated the impact of the alert by an interrupted time series of the proportion of repeated results and the physician's response to the alert by system execution traces archiving. The alert was successfully implemented. We validated our method for measuring expected outcomes. But the preliminary evaluation of the alert could not prove any effect on the HBV tests repetition.

Keywords:

Decision Support System, Laboratory Test Redundancy

Introduction

Several studies and systematic reviews have demonstrated the efficacy of computerized decision support systems, especially alerts and active reminders, for improving the quality of care and/or hospital practices [1, 2]. However, other studies have identified problems with the implementation of such systems in routine practice and with the accessibility of such systems to doctors [3].

The Georges Pompidou European Hospital is a university hospital with 880 beds [4]. It has a complete information system centered on the electronic health record, DxCare®, facilitating the computerized prescription of drugs, imaging and laboratory tests. During 2005, 216 (13%) of the hepatitis B virus (HBV) tests prescribed by the Cardiovascular Surgery Department were ordered less than 30 days after the previous order for the same patient. An active reminder system concerning the repeated prescription of HBV tests in this department was implemented as a mean of decreasing this redundancy. This paper presents the implementation of this intervention, and its evaluation.

Materials and methods

DxCare® permits both the prescription of laboratory tests and the viewing of their results. By default, the results shown are those for the current stay in hospital, but it is possible to search for all previous results for the patient. The alert system created in this environment triggers a new page concomitant with the prescription window, the moment of a HBV test is selected to be prescribed. This alert contains the date and complete result for the most recent last HBV test carried out for the patient (obtained less than 30 days previously and whether linked or not to the current hospitalisation). For the purpose of the evaluation, the system was developed so that traces of its execution be archived. They reflect the selection of HBV test for ordering, the display of any alert, and the time elapsed between any previous result and these events.

The impact of the intervention is measured by interrupted time series analysis of repeated HBV tests over a four-year period, with assessments at two-month intervals. As the system became functional at the end of June 2006, the "before intervention" period runs from January 2004 to June 2006 and the "after intervention" period from July 2006 to December 2007. The consequences of alerts on the repetition of serological tests are estimated from HBV results extracted from the DxCare® database. The corresponding indicator is the proportion of all HBV results that were repeated within an interval of less than 30 days (RT_{30}).

A trace is stored each time that the prescriber selects a HBV test, *i.e.* each time that he or she intends to prescribe that test. This makes it possible to estimate the proportion of all intentions to prescribe a repeated test within 30 days of the last one: RTI_{30}. Compliance with the alert is evaluated by comparing RT_{30} and RTI_{30}.

Results

During the "before intervention" period (January 2004 to June 2006), there were 3,671 results for HBV tests in 2,682 patients. 12.3 % (nb = 450) of the results were obtained within 30 days after a previous one (RT_{30}). During a preliminary "after intervention" period from July 2006 to April 2007, there were 1302 results for HBV tests

in 823 patients. 13.8% (nb = 180) results were obtained following the repetition of the test within 30 days (RT_{30}).

The preliminary segmented regression analysis of the time series for the rates of HBV repeated tests suggested no effect of the intervention. However, since only 5 bi-monthly rates were available for the post intervention period (and since neither seasonal variation nor autocorrelation of the data were observed), we preferred to perform nonparametric tests. Wilcoxon rank-sum test results showed no significant change in rates after the setting up of the alert-system (p-value=0.11)."

An analysis of the system's traces for the preliminary "after intervention" period revealed 1430 intents to prescribe, 165 (11.5%) of which corresponded to repeat tests within 30 days (RTI_{30}). The median interval between the previous test and the repeat test was 123 days, with an interquartile interval of 26.75 to 287 days. The comparison of RT_{30} and RTI_{30} showed a compliance with the alert of 8.3%.

Discussion

The alert was successfully implemented but its evaluation could not prove any effect on the HBV tests repetition. We hypothesized that doctors are not aware of the existence of a previous result at the time of prescribing. The effectiveness of the alert depended on the relevance of this hypothesis. Indeed, biological results are linked to a particular stay in hospital in our computerized information system. Consequently, a HBV test prescribed during a consultation is not visible during any subsequent hospitalization (considered as another hospitalization) unless the prescriber actively searches for previous biological results. Our hypothesis turned out to be insufficient and balanced by the fact that HBV tests have to be prescribed periodically according to predefined protocols. Moreover, there is no fully acknowledged delay for repletion of serology: the delay of 30 days was decided with the collaboration of one clinician of the Cardiovascular Surgery Department and a virologist. This was probably not sufficient to warrant a consensus of all prescribers.

Evaluation of the response of users to this support is based on the recorded traces of its functioning. The quality of these traces was ensured as part of the design of this support system, independent of the information system. Conversely, the impact of the alert on the repetition of HBV testing can only be evaluated using biological results extracted from the DxCare® database. The quality of the data used for evaluation depends entirely on the correct use of the information system. The interpretation of both indicators is therefore limited by the quality of their respective data sources.

Conclusion

The capacity of a computerized prescription system to alert the doctor to the unnecessary repetition of examinations and potential prescription errors is one of the characteristics included in evaluations of the quality of such a system [5]. However, although this type of intervention is generally effective [1], the implementation of alerts and the evaluation of their impact must be adapted to the local context. Indeed, it remains to be demonstrated that alerts are effective regardless of the context in which they occur.

Acknowledgments

This project was funded by a CIFRE grant from MEDASYS, subsidized by the ANRT (Julie Niès).

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Decision support for the prescription of hepatitis B virus tests in cardiovascular surgery

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[d] Service de Chirurgie Cardio-Vasculaire, Hôpital Européen Georges Pompidou, Paris, F-75015 France.

Introduction

- Computerized Decision Support Systems (especially alerts and active reminders) could improve the quality of care and/or hospital practices [Garg 2005].

- However, some problems remain with the implementation of such systems in routine practice and with the accessibility of such systems to doctors [Aarts 2004].

Introduction

- During 2005, 13% of the hepatitis B virus (HBV) tests prescribed by the Cardiovascular Surgery Department at the European Georges Pompidou Hospital were ordered less than 30 days after the previous test result for the same patient.

- An active reminder system concerning the repeated prescription of HBV tests in this department was implemented as a mean of decreasing this repetition.

Materials and Methods: Intervention

- **HBV alerts**
  - are displayed as a new page (in the EHR) concomitant with the prescription window,
  - appear at the moment of a HBV test is selected to be prescribed,
  - contain the date and complete result for the most recent last HBV test carried out for the patient (obtained less than 30 days previously).

- **Alerts traceability to reflect**
  - the selection of HBV test for ordering,
  - the display of any alert,
  - the time elapsed between any previous result and these events.

Materials and Methods: Impact

- **Indicator:**
  Proportion of all HBV results repeated within an interval of less than 30 days (RT_{30})

- **Method of analysis:**
  Impact of the intervention on practices is evaluated by an interrupted time series of two-month periods
  - "before intervention": Jan 04 - Jun 06 (9 pts)
  - "after intervention" :Jul 06 - Dec 07 (5 pts)

- **Data collection:**
  Indicator estimated from HBV results extracted from the EHR database

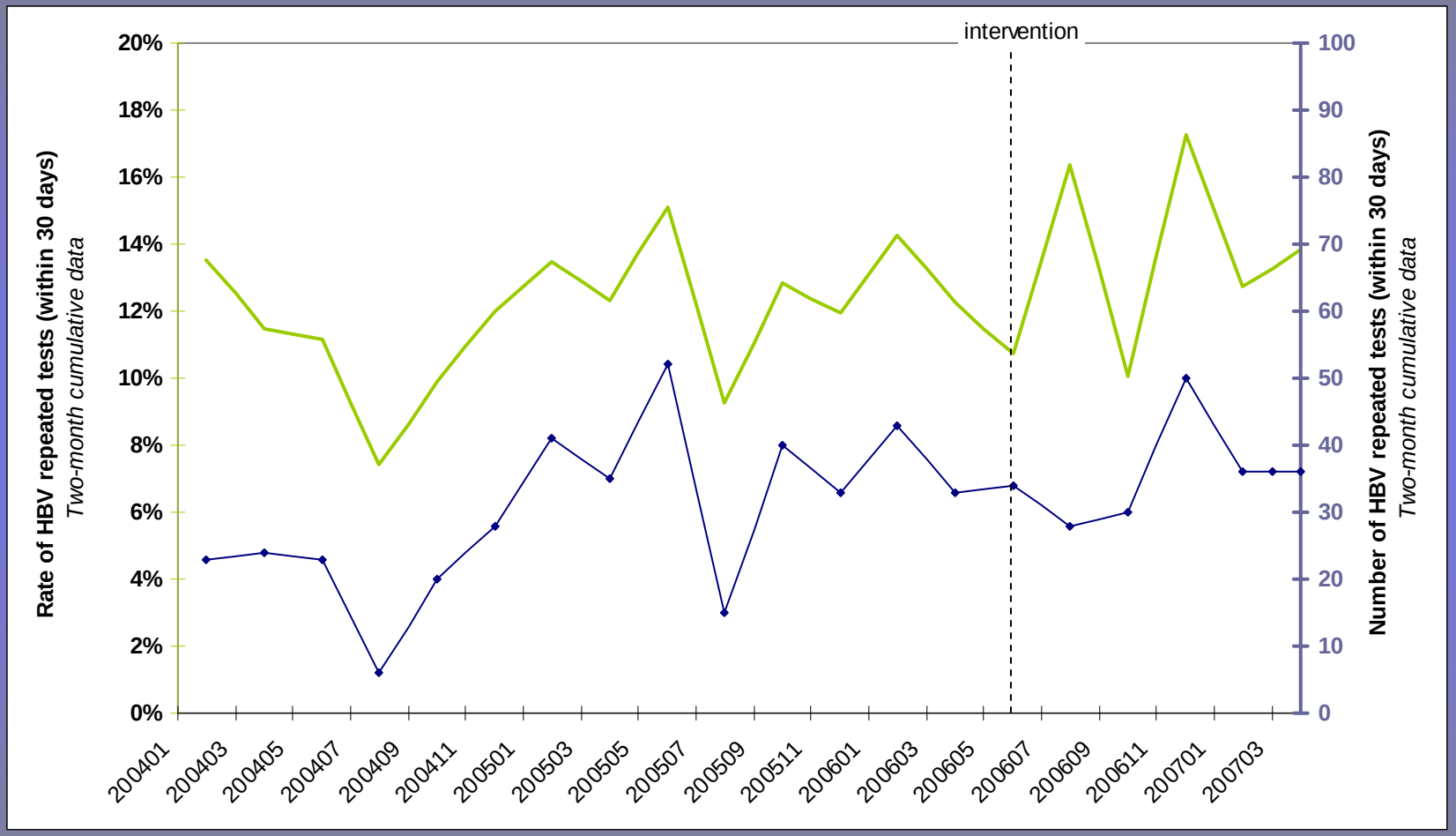
Materials and Methods: Compliance

- **Indicator:**
  Proportion of all intentions to order a repeated test within 30 days of the last one (RTI_{30})

- **Method of analysis:**
  Compliance with the alert is evaluated by comparing RT_{30} and RTI_{30} during the after intervention period

- **Data collection:**
  Indicator estimated from traces extracted from the decision support system database

Results: Impact of the intervention



Wilcoxon rank-sum test

no significant change in rates after intervention

p-value=0.11

Results: Compliance with the alert

- 1,430 intents to prescribe
- 165 (11.5%) intents to prescribe within 30 days after a previous HBV test result
- Interval between the previous test and the repeated test: median 123 days (interquartile range 26.75 - 287)
- 8.3% of compliance with the alert

Discussion

- Alert successfully implemented
- Data extraction from EHR database make possible decision support evaluation
- But the intervention seem to have no effect on the HBV tests repetition
- Disappointing results because this CDSS provides features of interest [Kawamoto 2005]
  - Automatic provision of decision support as part of clinician workflow
  - Provision of decision support at time and location of decision making
  - Promotion of action rather than inaction

Discussion

- Ambiguous source of knowledge used to provide the support?
  - no fully acknowledged delay exists for repletion of serology
  - 30 days-delay decided with the collaboration of one clinician and a virologist, probably not sufficient to warrant a consensus of all prescribers

- Next alert (HbA1C) based on incontestable arguments
  - indicated for diabetics patients follow-up
  - 3 months-delay of repletion due to HbA1C kinetic physiology

Conclusion

- The capacity of a computerized prescription system to alert the doctor to the unnecessary repetition of examinations and potential prescription errors is one of the characteristics included in evaluations of the quality of such a system [Kilbridge 2006].
- However, although this type of intervention is generally effective [Garg 2005], the implementation of alerts and the evaluation of their impact must be adapted to the local context.
- Indeed, it remains to be demonstrated that alerts are effective regardless of the context in which they occur.

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Experience of Adopting MLM engine for Drug-Drug Interaction

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Introduction

- Background
  - Efforts for nationwide dissemination of standard CDSS in Korea
  - We developed a prototype MLM engine, MLMPlusX
  - Problems in dissemination of MLM engine
    - Widespread questions about
      - possibility of successful operation
      - Safety
      - Usefulness
- Purpose
  - Develop, apply, and evaluate an Arden Syntax based MLM engine for practical use to prevent medical errors
- Refined our previously developed MLM engine
- Applied and validated the MLM engine
  - Adopted to a development server of Seoul National University Bundang Hospital (SNUBH), for drug-drug interaction (DDI) domain

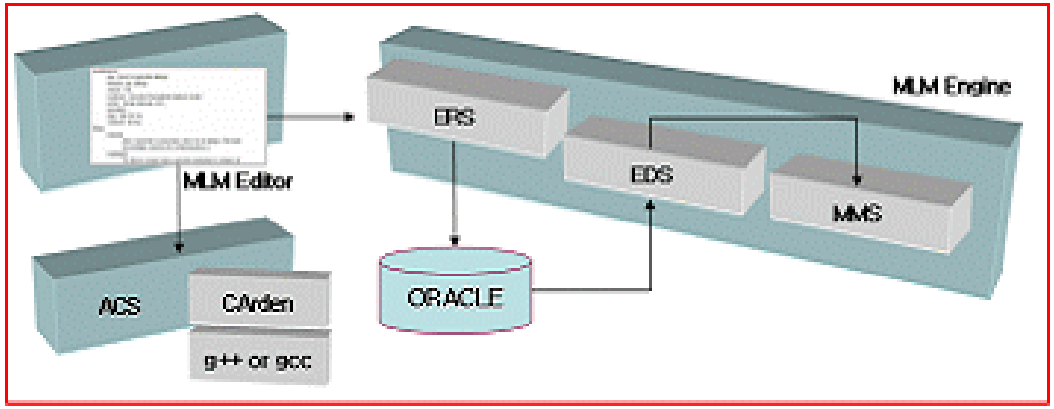
Preparation phase

- Focused on giving trust to the adopting institution and on understanding each other's system
- Tried to sufficiently communicate each other during nine months
  - Communication between MLM engine developers and system engineer group in SNUBH, ezCaretech Co. LTd.
  - Communication channel : temporal meetings, messengers, phone, and email
- Derived requirements
- Improved MLM engine design
- Decided to adopt our MLM engine to a development server in SNUBH

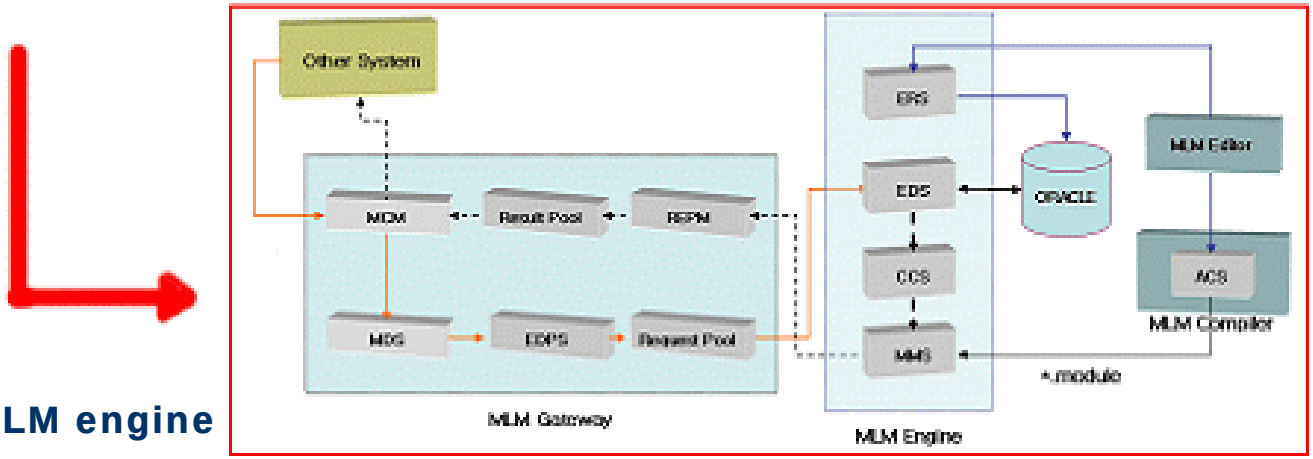
Refinement of MLMPlusX

- MLMPlusX
  - Our previous version of MLM engine
  - Core running environment for the Arden Syntax based decision supports
- Refined the MLMPlusX for practical use in HIS environment
- Improved interface to other systems it interacts
- Separated engine components independently
- Improved performance, accuracy, and reliability
- Simplified MLM system configuration setting work
- Added a MLMGateway
  - A middleware that handles HIS events between HIS and MLM engine
  - Added to minimize modification cost on the existing HIS application processes
- Changed event detection method

MLMPlusX and Refined MLM Engine



MLMPlusX



Refined MLM engine

Integration

- Integrated our improved MLM engine to development server in SNUBH
  - It was fast and simple work
  - Two person did it in three days
- Built DDI knowledge base
  - Converted 930 DDI rules used in SNUBH into 930 Arden Syntax MLMs

Evaluation

- Evaluated our MLM engine to validate possibility in practical use
- Method
  - Compared our engine with locally developed DDI system in SNUBH (local CDSS)
  - Metrics
    - Performance
    - Knowledge building and management cost
    - Integration and migration
    - Usability
- Evaluation environment
  - Zeon dual core 3.0GHz CPU, 4G memory, 80G SATA HDD

Evaluation Results : Performance

Input order	Avg. response time in MLM engine (ms/order)	Avg. response time in local CDSS (ms/order)
order -1	1.343	0.300
order -2	1.546	0.169
order -3	1.703	0.076
order -4	1.847	0.109
order -5	2.507	0.044
order -6	2.847	0.046
order -7	2.660	0.205
order -8	2.689	0.046

Evaluation Results : Knowledge Building and Management Cost

Measurement	Result	Evaluation
Knowledge building cost in MLM engine : time spent in building 980 DDI rules	1601 ms	low

Measurement		Result	Evaluation
Cost for Knowledge modification	MLM Engine	Directly modify the Arden Syntax by a domain expert Or, automatically converts to modified MLM if a domain expert enters modified information through DDI editing tool	low
	Local CDSS	A domain expert enters modified information through DDI editing tool	low
Cost for adding a new pattern MLM to knowledge base	MLM Engine	A domain expert directly writes a new MLM Or, an informatician writes a new MLM informed by a domain expert	low
	Local CDSS	A developer should program a new knowledge informed by a domain expert	**high**

Evaluation Results : Integration and Migration, Usability

- Integration and migration results

Measurement	Result
Time spent in integrating MLM engine to a development server of SNUBH	3 days
Number of persons participated in MLM engine integration work	2 persons
Modification list generated in MLM engine integration process	Only values of variables in a configuration file

- Usability results

Measurement	Result
Number of modifications in user interface when adopted MLM engine	0
Modification list in user interface when adopted MLM engine	none
Possibility of user interface improvements when adopted MLM engine	possible

Discussion and Conclusion

- Refined MLMPlusX for practical use
- Established the work process of integration process
- Applied the MLM engine to SNUBH development server of SNUBH
  - Built Arden Syntax knowledge base for DDI rules used in SNUBH
- Validated our system by comparing with DDI system used in SNUBH
- The evaluation showed promising results
  - Though performance was lower than local CDSS, it can be solved by modifying MLM engine design
  - Knowledge management cost was expected to be lower
  - There was no reduction in usability
  - The integration work was simple and fast
- Future work
  - Adoption of our system in real-time HIS

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Experience of Adopting MLM engine for Drug-Drug Interaction

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Abstract and objective

For nationwide dissemination of standard CDSS, we have developed a MLM engine for the Arden Syntax. As a first step of practical use of the MLM engine, we adopted it to a development server of Seoul National University Bundang Hospital (SNUBH), for drug-drug interaction (DDI) domain. We improved our previous version of MLM engine, and the work process of integration process was established. We evaluated the MLM engine to validate possibility of practical use. The overall evaluation results showed possibility that our system can replace existing DDI system and can reduce knowledge management cost.

Keywords:

Arden Syntax, CDSS, HL7

Methods

For successful integration of Arden Syntax based CDSS into an existing HIS, we had to give trust about our system that it is safe and give idea that this standard CDSS adaptation can be useful decision to the institution. And the MLM engine developers and system engineer group in SNUBH, ezCaretech Co. LTd., both needed to understand each other's system. We tried to sufficiently communicate each other via temporal meetings, messengers, phone, and email during nine months. From this preparation phase, we derived requirements, improved MLM engine design, decided to adopt our MLM engine to a development server in SNUBH.

We refined and improved our previous version of MLM engine, MLMPlusX. The MLMPlusX is a core running environment for the Arden Syntax based decision supports. In order to use the MLMPlusX in practical HIS environment, we improved interface to other systems it interacts, separated engine components independently, improved performance, accuracy, and reliability, and simplified MLM system configuration setting work. And to minimize modification cost on the existing HIS application processes, we added a MLMGateway, a middleware that handles HIS events between HIS and MLM engine, and changed event detection method.

We integrated our improved MLM engine to development server in SNUBH. It was fast and simple work that only two person did it in three days. And we also built DDI knowledge base. We converted 930 DDI rules used in SNUBH into 930 Arden Syntax MLMs.

We evaluated our MLM engine to validate possibility in practical use. Performance, knowledge building and management cost, integration and migration, and usability was measured by comparing our engine with locally developed DDI system in SNUBH (local CDSS). The evaluation environment was Zeon dual core 3.0GHz CPU, 4G memory, 80G SATA HDD.

Discussion & conclusion

We refined MLMPlusX that it can be used in practice. To validate our system, we applied the MLM engine to SNUBH development server of SNUBH and built Arden Syntax knowledge base for DDI rules used in SNUBH. The overall evaluation results were promising. Performance was lower than local CDSS but it can be solved by modifying MLM engine design. Knowledge management cost was expected to be lower when using our engine, and there was no reduction in usability. The integration work was simple and fast that it showed high migration property. For the future work, we plan to adopt our system in real-time HIS.

Acknowledgement

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Assessment of a Prototype Diagnostic Nursing Decision Support System for Inpatients with Type II Diabetes Mellitus

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Abstract

Nurses are often asked to make quick decision with incomplete information under time pressure. For clinical decisions, computerized clinical decision support system can be used as tools to help with these decisions when it is implemented appropriate. This study was performed to obtain opinions on a previously developed diagnostic nursing decision support system developed by these researchers in order to aid the further development of the system. Knowledge representation and the appropriateness of our approach were assessed based on user feedback of a prototype system. Twenty-five NANDA diagnoses and 145 clinical assessment variables were structured into a criteria table. Twenty-seven nurses from inpatient and ambulatory settings and a graduate course on nursing informatics were recruited, and a scenario-based preliminary evaluation was performed. Based on these opinions w described the advantages and disadvantages of the prototype system.

Keywords:

Decision Support System, nursing diagnosis,
user evaluation

Methods

To acquire the relevant knowledge, a systematic literature review was conducted iteratively to establish nursing diagnoses and clinical assessment criteria. Twenty-five NANDA diagnoses and 145 clinical assessment variables were structured into a criteria table as the knowledge base for a prototype Web-based stand-alone system. This system automatically generates a nursing problem list based on the input data and detailed explanatory information for each item on the list.

Feedback on the system was obtained from 27 volunteer nurses: 17 from inpatient units and 10 from ambulatory settings and a graduate course on nursing informatics. The nurses from inpatient units were using electronic nursing record system every day and providing diabetes mellitus care for more than 10 years. The nurses from ambulatory settings had specialties in educating diabetes mellitus patients.

We asked the nurses to read the scenario developed by researchers based on the case studies selected from the nursing textbooks, and to look at the results produced by the system. They then completed a questionnaire on their opinions on the functions and the nursing problem list generated by the system.

Results

The nurses' responses to the suggested nursing problem list were summarized below, categorized into advantages and disadvantages that were mentioned more than twice.

Advantages:

- Well organized, making it easy to determined patients' problems.
- Easy to understand due to the data-driven approach.
- Convenient to obtain the problem list automatically.
- Able to consider all the potential relevant problems (which can be used as a reminder).

Disadvantages:

- Insufficient expression of NANDA terminology.
- Tedious or difficult to input data.
- No suggestion of nursing actions for each problem.
- Discrepancies between the priorities of suggested and selected problems.

Conclusion

The feedback from the nurses was useful and qualitative insights on identifying the requirements of a CDSS for nurses. This information will be used when we consider designing and development issues of a diagnostic CDSS.

So far diagnostic DSS had been limited on being adopted in clinical settings due to several implementation issues such as data capturing and redundant data entry. However, the current movement toward an EMR or EHR systems encourages us to consider on how to design it more effectively in the manner of integrated with those systems.

Assessment of a Prototype Diagnostic Nursing Decision Support System for Inpatients with Type II Diabetes Mellitus

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Contents

Main goal of the study

- **To assess nurses' opinions on the prototype of Diagnostic Decision Support System designed for inpatient with Type II Diabetes Mellitus**

  - **Get feedback useful and qualitative insights on identifying the requirements of a DSS for nurses**
    - **Advantages**
    - **Disadvantages**
    - **Other concerns**

Background (1)

- For clinical practice, use of “Nursing Problem/Diagnosis”
  - There are inconsistencies in the way in which nurses use and state nursing diagnoses
  - There are the semantic ambiguity of the diagnosis language
  - Accuracy, Consistency, & Validating problems of diagnoses used by clinical nurses within units and hospitals EXIST
  - No consistently document a wide range of nursing diagnoses
  - Diagnostic expertise is a vital initial component of nursing practice

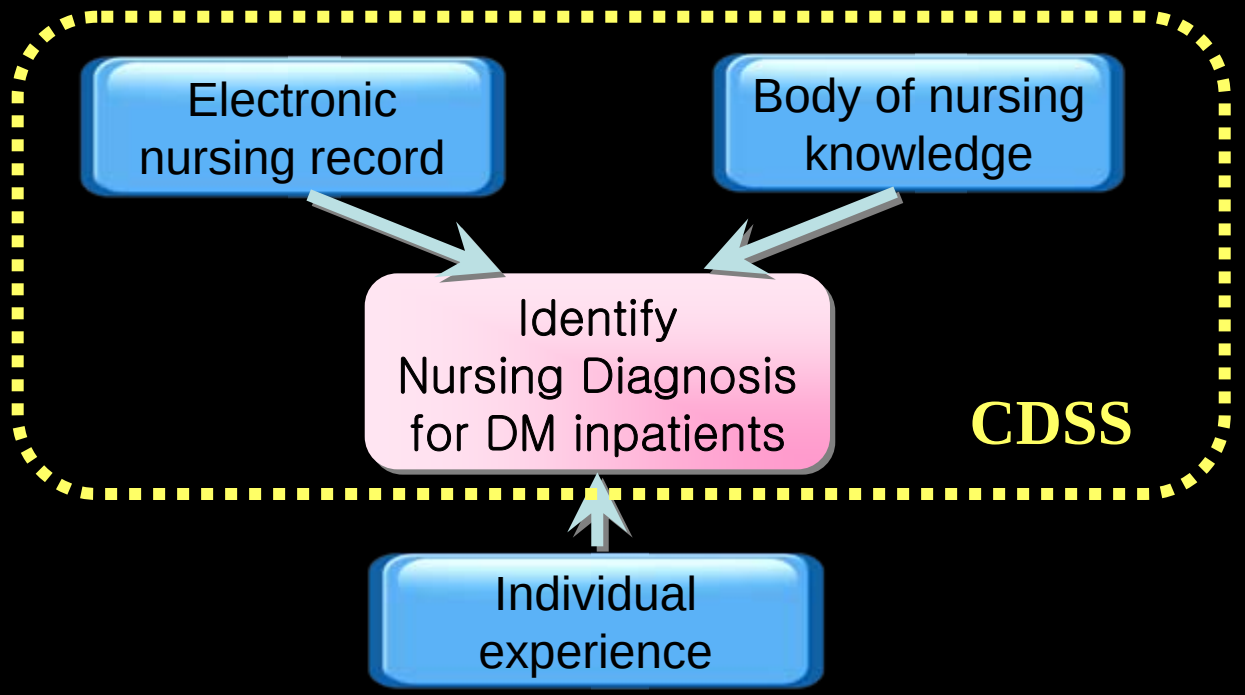
Background (2)

- Nursing Diagnosis needs critical thinking
  - "Judgment of conclusion that occurs as a result of nursing assessment"
  - Basis for selection of nursing interventions to achieve outcomes for which the nurse is accountable
  - Diagnostic skill is one dimension of expertise and diagnostic expertise has a high priority on research
  - Expertise is needed to access an extensive, organized cognitive network of specialized knowledge

  ➔ The use of Nursing Diagnosis have been limited in practice

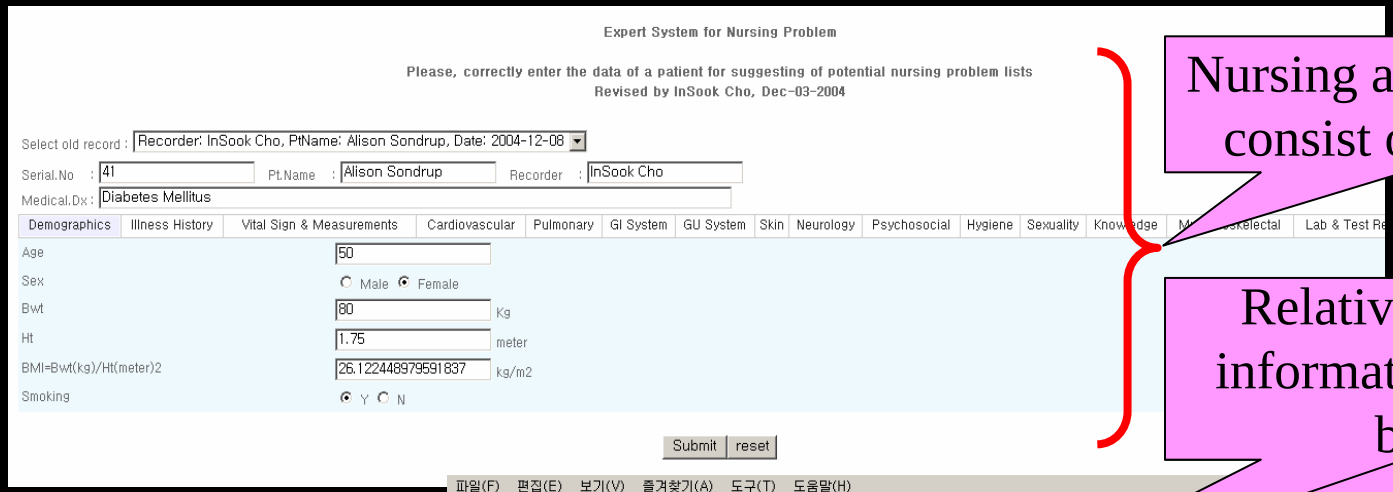
Conceptual Framework

- **Computerized Clinical Decision Support System**
  - **"…Current trend suggest that many of the formidable technological and conceptual challenges associated with representing nursing knowledge may be overcome and that decision support systems may significantly impact nursing practice…… "** (Ozbolt, 1988)



Materials and methods (1)

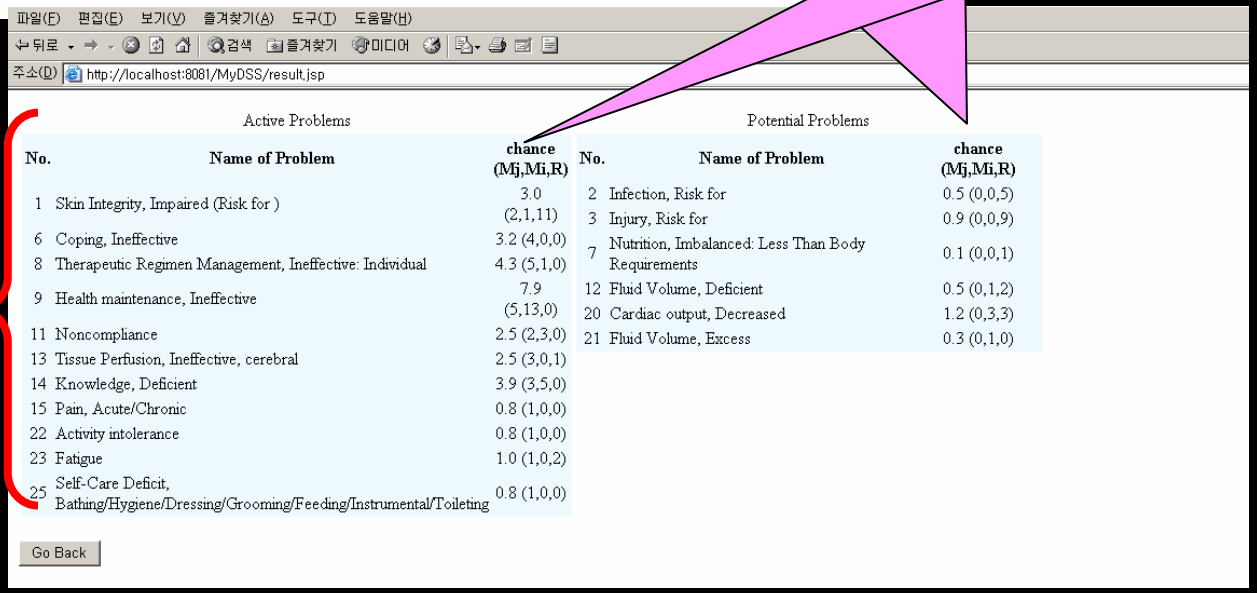
- **Web-based prototype**



Nursing assessment part: consist of 15 sub tabs

Relative probability information supported by data

The list of nursing problems suggested by system from the input assessment data



No.	Name of Problem	chance (Mj,Mi,R)
1	Skin Integrity, Impaired (Risk for)	3.0 (2,1,11)
6	Coping, Ineffective	3.2 (4,0,0)
8	Therapeutic Regimen Management, Ineffective: Individual	4.3 (5,1,0)
9	Health maintenance, Ineffective	7.9 (5,13,0)
11	Noncompliance	2.5 (2,3,0)
13	Tissue Perfusion, Ineffective, cerebral	2.5 (3,0,1)
14	Knowledge, Deficient	3.9 (3,5,0)
15	Pain, Acute/Chronic	0.8 (1,0,0)
22	Activity intolerance	0.8 (1,0,0)
23	Fatigue	1.0 (1,0,2)
25	Self-Care Deficit, Bathing/Hygiene/Dressing/Grooming/Feeding/Instrumental/Toileting	0.8 (1,0,0)

No.	Name of Problem	chance (Mj,Mi,R)
2	Infection, Risk for	0.5 (0,0,5)
3	Injury, Risk for	0.9 (0,0,9)
7	Nutrition, Imbalanced: Less Than Body Requirements	0.1 (0,0,1)
12	Fluid Volume, Deficient	0.5 (0,1,2)
20	Cardiac output, Decreased	1.2 (0,3,3)
21	Fluid Volume, Excess	0.3 (0,1,0)

Materials and methods (2)

- Participants
  - 27 volunteer nurses with agreement to participate
    - 17 from nursing units of inpatients
    - 10 from ambulatory settings or a graduate course on nursing informatics
  - Asked them to visit and make a trial with a written scenario
- Collection of data
  - Period: Oct. 2005 ~ Mar. 2006
  - Use a Web-based online self-report questionnaire
    - Demographics
    - three open questions

Results (1)

- **Demographic and professional experience of subjects**

Variables	Subjects (*n*=27)
Average age (SD)	35.1 (4.7)
Degree of education (%)	
Master	9 (33.3)
Bachelor	17 (63.0)
Diploma	1 (3.7)
Field of working (%)	
Inpatient care	17 (63.0)
Outpatient care or Nursing Informatician	10 (37.0)
Specialty (%)	
Yes	20 (74.1)
No	7 (25.9)
Mean years of clinical working (SD)	11.1 (5.3)
Mean years of computer experience (SD)	5.6 (2.2)

Results (2)

- Nurses' responses to a suggested nursing problem list automatically generated by the system

Advantages (n)
well organized, making it easy to determined patients' problems (10)
easy to understand due to the data- driven approach (8)
convenience of obtaining the problem list automatically (4)
are able to consider all the potential relevant problems (which can be used as a reminder) (4)
good being able to select the coverage of problems (1)
very helpful being given information on the likelihood of each item on the list of problems (1)
easy to use (1)

Results (3)

- Nurses' responses to a suggested nursing problem list automatically generated by the system

Disadvantages (n)
insufficient expression of NANDA terminology (6)
tedious or difficult to input data (5)
no suggestion of nursing actions for each problem (3)
discrepancies between the priorities of suggested and selected problems (2)
errors in data input may lead to incorrect diagnoses (1)
difficult to understand the likelihood score (1)
difficult to differentiate the major, minor, and risk factors (1)
not familiar with the use of English (1)
looks complex (1)

Conclusion

- **Implications of the advantages**

  A Diagnostic Nursing DSS has the potential for

  - **Stimulating the use of nursing diagnosis based on the data**
  - **Encouraging the use of critical thinking**

- **Implications of the disadvantages**

  A diagnostic Nursing DSS should

  - **Be integrated with an EMR necessarily**
  - **Consider the use of more expressive nursing terminology than only NANDA**

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Needs Assessment for the Computer-interpretable Hypertension Guideline at Public Health Centers in Korea

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Abstract

Computer-interpretable hypertension guidelines can make for the improvement of blood pressure control rate by assisting clinicians at the point-of-service to behave according to the evidence-based guidelines. We surveyed 117 public health centers in Korea to evaluate current hypertension management status with clinicians' performance, and to analyze the needs for the computer-interpretable hypertension guidelines. Hypertension control rate was 57%, while clinicians overestimated it as 79.5%. 60.4% of patients were treated with 2 or more anti-hypertensive medications, and most frequently used drug class was calcium channel blocker. Inappropriate prescription rate of contraindicated patients was 2.6%. Two-thirds of clinicians agreed to implement the computer-interpretable hypertension guideline. Implementation of computer-interpretable hypertension guideline is considered as a way to improve the hypertension control rate and to reduce the inappropriateness of the therapeutic choice.

Keywords:

needs assessment, hypertension, guideline, practice guideline

Introduction

For the prevention of cardiovascular diseases, hypertension management takes important portion. Yet world-wide hypertension control rate is known to be less than one-third, especially in Korea, it is about 17%. Computer-interpretable guideline is suggested as an intervention tool for the quality improvement of patient care as modifying clinicians' behavior. This is a preliminary study for developing computer-interpretable hypertension guideline, which is designed to improve hypertension control rate in primary health care. We intended to analyze current hypertension management status, clinicians' performance and needs for the CIGs.

Materials and methods

We surveyed 117 public health centers and 154 clinicians in Gyeonggi province. We extracted medical records of hypertension patients from the centers' clinical database during a 10-month period. Data included blood pressure, medication, comorbid disease, and others. Questionnaire was answered by the clinicians to assess their adherence to hypertension guidelines and needs for the CIG program.

Results

38,474 patients' data and 41 clinicians' survey was analyzed. 61% of clinicians agreed to implement the computer-interpretable hypertension guideline. Hypertension control rate was 57%. Clinicians overestimated as 79.5% of patients had controlled blood pressure. Over 60% of patients were treated with 2 or more antihypertensive medications, and calcium channel blocker was the most frequently prescribed. Based on JNC7 report, inappropriate prescriptions, such as monotherapy for the stage hypertensive patient, beta blocker only for the diabetes patient, combination of beta blocker and non-dihydropyridine calcium channel blocker, thiazide diuretics for the gout patient, and beta blocker for the asthma patient, were 2.6% (N=1001).

Conclusion

Clinicians overestimated the proportion of their patients with controlled blood pressure. Implementation of computer-interpretable hypertension guideline is considered as a way to reduce the inappropriateness of the therapeutic

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Making a Decision Support System with the Electronic Medical Record

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Abstract

We have been developed and used the electronic medical record system for 12 years. For integrate the text, data, and image, we have constructed the record that based on XML[1]. But, we had some problem for reporting and evaluation. We adopted the diagnosis and the unification of terminology for the common understanding. For the solution of these problems, we need the making the decision support system and the coding system. Thereupon, we make the model of the diagnosis process and make the preparation of the system. In this time, we did the evaluation of the system in the nursing region, because our database is established.

Keywords:

decision support, nursing process, medical record

Introduction

Our electronic medical record system has made the construction of the database by XML, for the purpose of that does information interchange. The correspondence to the tag of XML was a subject in the record of SOAP. The relation between the problem and goal are important in SOAP. Thereupon, it made to evaluate this relation.

We have made the nursing support system[2]. In its system, we had been needed the recognition of nursing diagnosis. So, we made the system of nursing process. In these ways, we think that the process state is important.

Thereupon, we tried that traces the changes of the process.

In the preparation of the plan, we make the goal corresponding to the problem. For example, we implement a plural plan while doing treatment. We evaluate the change in this process. As a result, we trace the problem and plan, and check the relation with the problem. The factor of judgment is analyzed from these relations.

We accumulate these analysis results as database and use to the support of the plan and assessment.

Methods

We made from patient information to SOAP that use as the record of the electronic medical record. However, it is difficult to trace the changes of the process with only this.

Thereupon, we added the part that registers the process of assessment, diagnosis and evaluation.

The flow of the system and data are shown in Figure 1.

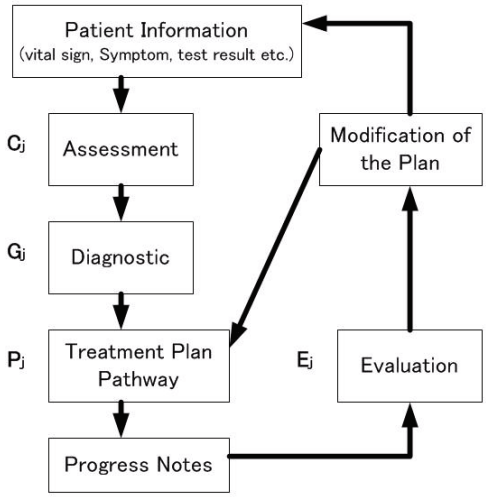

Figure 1 - System flow

The flow of the process is as follows.

1. It is making the problem list of patient information and summarized the symptom. (C_j)
2. It is making the goal corresponding to the problem. (G_j)
3. It is making the plan corresponding to the cause of diagnosis. (P_j)
4. It is making the evaluation to the plan. (E_j)

Where, G_j , P_j , E_j are recorded with the relation C_j.

We evaluate the change of this process by such a method. We make database this, from the result that evaluated. In such a period when treatment ends, it records the changes to these goals.

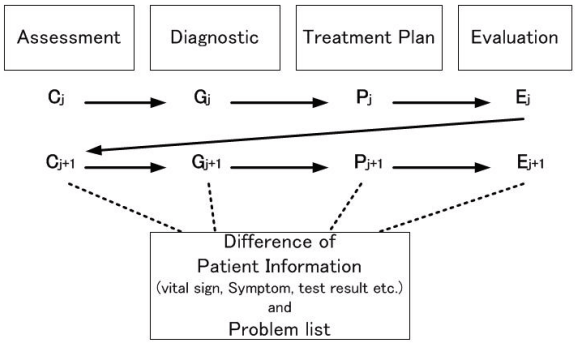

Figure 2 – Data Relationship

The data of this patient basic information are always held as even, the process of the diagnosis and plan are able to trace. Figure 2 shows the relation between the data and record in this system.

In addition to this, we record the skill and viewpoint of the user. These factor is used for the standard of the classification.

In this system, the candidacy of the diagnosis is selected from these data. These are not an automatic diagnosis in each process. Here is building a relation data of selecting and degree of preference.

Results

The system of the region of the physician is incomplete, although the system of the nursing region was finished. this reason is need the unification of terminology for using diagnosis.

However, It is possible to supports the process of the nursing diagnosis. The support of diagnosis and plan has obtained many satisfactions. As shown in this result, most users are answering this result as being that support was effective.

We are evaluating which item and template are effective in the critical pathway by using this system. This is useful for the preparation of the critical pathway.

This application effect of this system was investigated as a different viewpoint. This survey is classified by the experience years.

Furthermore, we are using to education and discussion such the analysis result.

Conclusion

In the nursing region, we are utilizing this system actually. By this system, we were able to unify the data on the record.

As this result, we ware able to analyze the condition of the branch on each problem list. By using this data, we are evaluating the diagnosis database.

However, the improvement is necessary about the user interface for the diagnosis support.

References

[1] Yamashita Y, Gejyo F. A trial Electronic Medical Recored System using the Markup Language. 9th world congress on Medical Informatics,Proceedings, pp.127-127,1998.

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Making a decision support system with the electronic medical record

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Introduction

- *We have been developed and used the electronic medical record system for 12 years.*
- *We adopted the diagnosis and the unification of terminology for the common understanding.*
- *We make the model of the diagnosis process and make the preparation of the system.*

What is necessary to us?

- Electronic Medical Record?
  - For data sharing?
  - For data exchange?
- What is the outcome corresponding to the effort?
  - Various searching?
  - Evidence
  - Evaluation of the process

Our trial system

- We made from patient information to SOAP that use as the record of the electronic medical record.
- We added the system that able to trace of the diagnosis process.
  - It is making the problem list of patient information and summarized the symptom. (Cj)
  - It is making the goal corresponding to the problem. (Gj)
  - It is making the plan corresponding to the cause of diagnosis. (Pj)
  - It is making the evaluation to the plan. (Ej)

Our Goal

- We intend the unification of terminology by using diagnosis.
- The plan should be able to be evaluated clearly.
- The clinical path should be able to be evaluated clearly.
- The physician and nurse are able to make a plan.
- Without relying on the experience years, the physician and nurse are able to collect at least necessary patient information in this system .
- By connecting problem information and the evaluation result in this system, we are able to evaluate the justifiability of diagnosis.

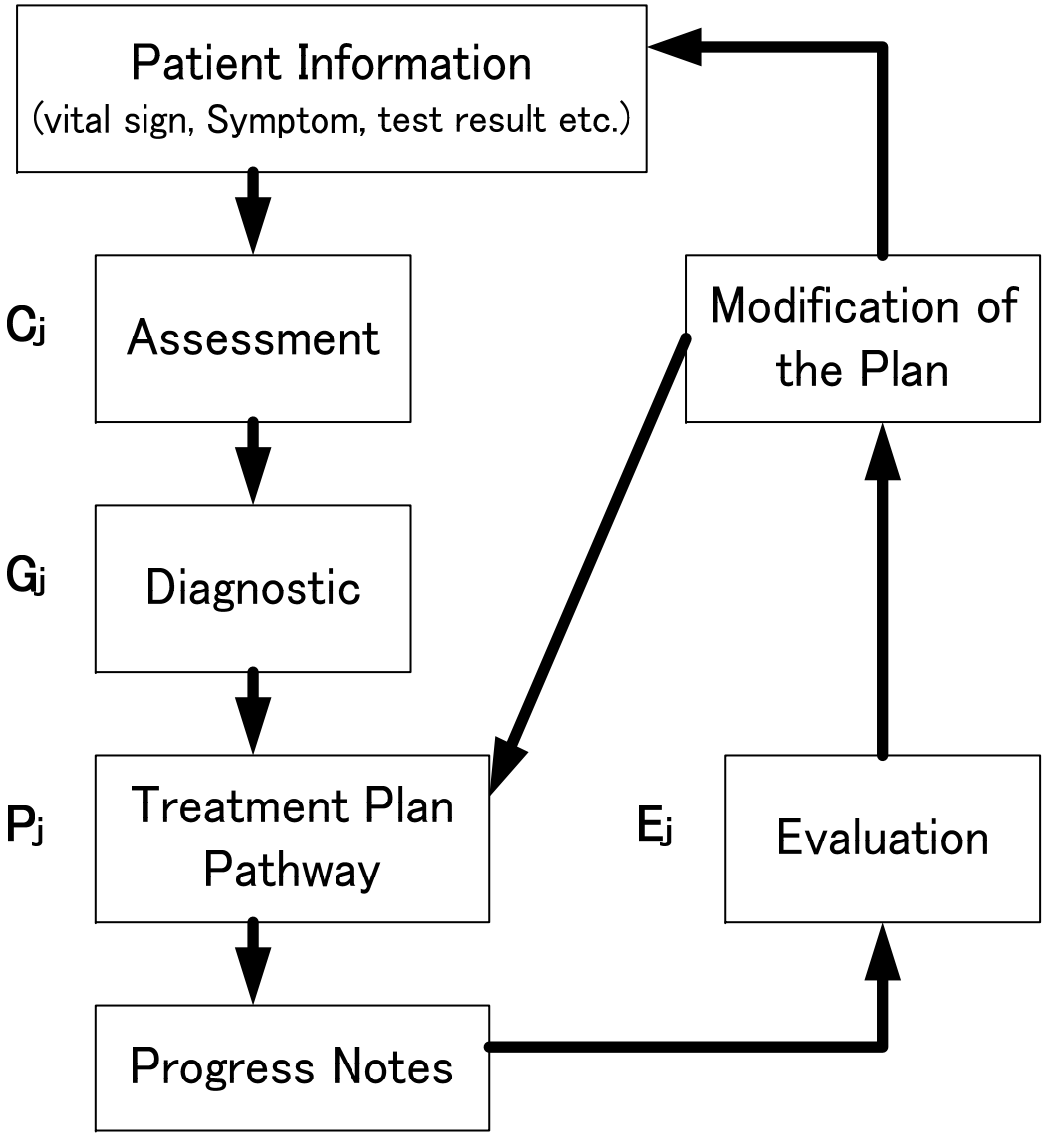

Figure 1 – System flow and Trace points

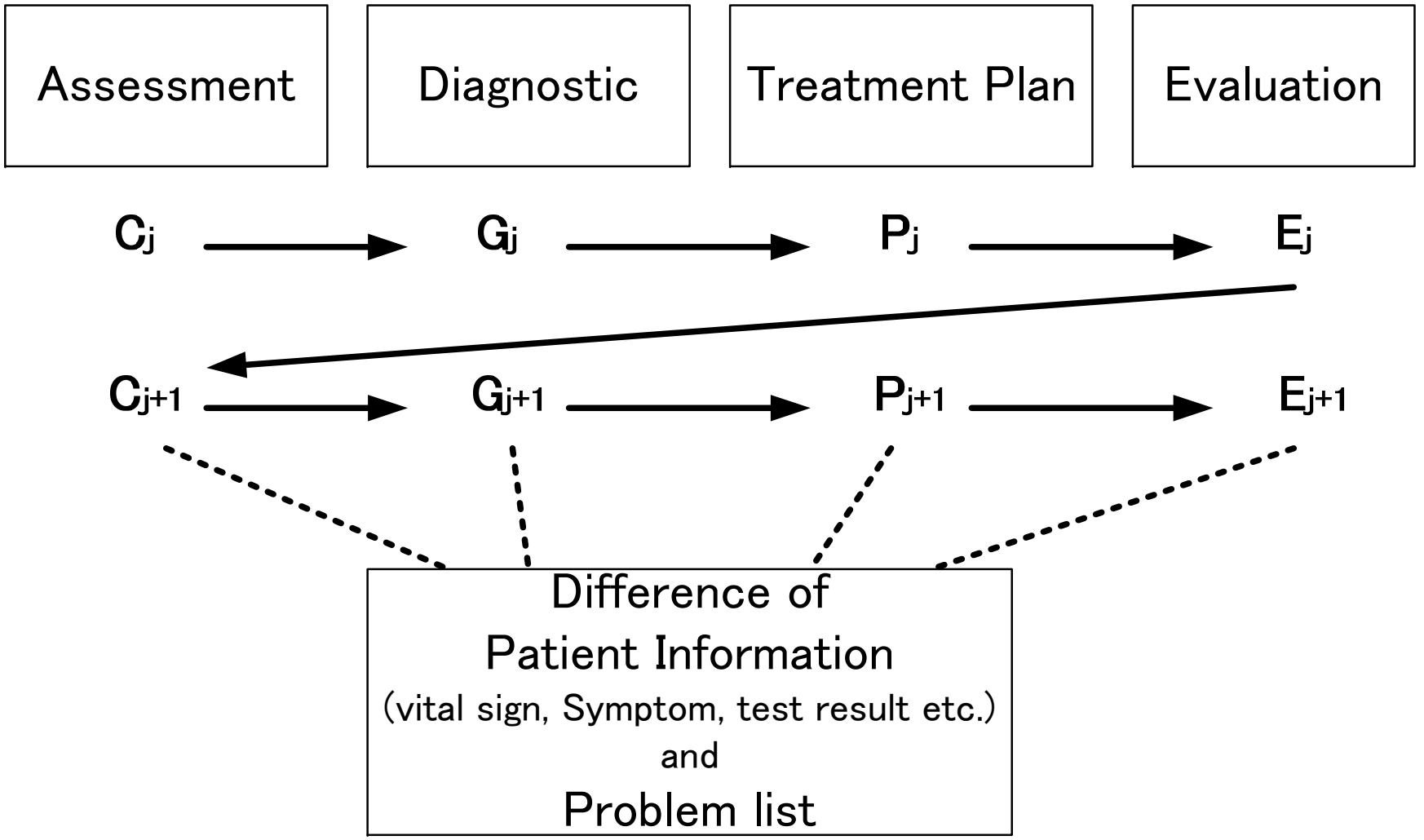

Figure 2 – Data Relationship and decision cycle

What kind of point became clear

- Process of diagnosis
- Information that contributed to diagnosis
- Evaluation of the critical pathway
- Difference of the process in the experience years
- Important point of judgment on process
- Factor of the changes of the process
- Factor of goal setting

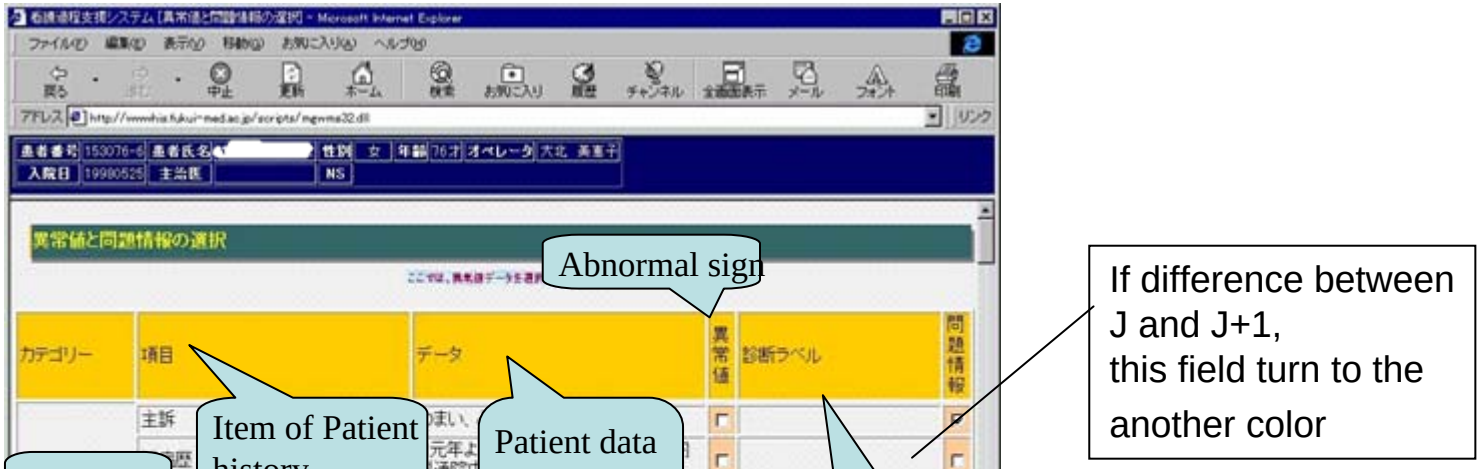

Figure 3 - Example screen of the Problem selection

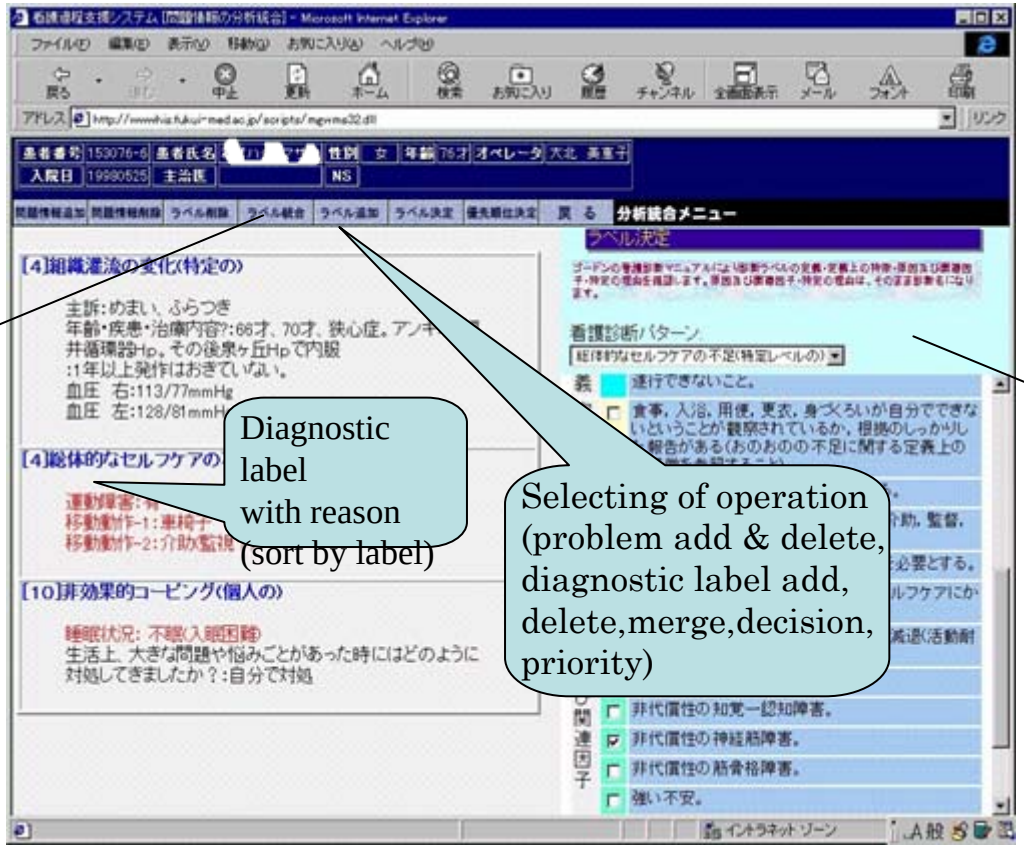

Figure 4 - Example screen of the Diagnosis

Results

- The system of the region of the physician is incomplete, although the system of the nursing region was finished.
- It is possible to supports the process of the nursing diagnosis. The support of diagnosis and plan has obtained many satisfactions.
- we are using to education and discussion such the analysis result.

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[1] Yamashita Y, Gejyo F. A trial Electronic Medical Re-cored System using the Markup Language. 9th world congress on Medical Informatics, Proceedings, pp.127-127,1998.

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Internationalization of Medical Logic Modules and Extended Time Operations in Arden Syntax Version 2.6

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Abstract and objective

Using Arden Syntax based systems in an international environment poses new requirements in terms of localization of knowledge. To support translatable, multi-lingual rules that can be maintained centrally, extensions to Arden Syntax have been defined and approved by HL7. Further extensions of this version deal with extended time operations. First international projects prove the usability of these extensions.

Keywords:

Clinical Decision Support, Arden Syntax

Introduction

Many factors affect the reusability of Arden Syntax 'Medical Logic Modules' (MLMs). While recent studies mainly focused on the curly braces problem [1], another important but neglected factor is the language of the message text of an MLM. Rules in multilingual countries or rules that are used in more than one country should always create messages in the language of the message recipient. Recent extensions to Arden Syntax defined a structured message format with natural language parts but did not address localized messages [2]. During the rollout of Orbis, a widely used hospital information system in Europe, this kind of localization of an MLM became an important issue in terms of reusability and maintainability. The natural text parts of an Arden Syntax rule that represent the result message have to be translatable, while the rest of the rule usually has to be centrally maintainable. Therefore, separation of an MLM's message part from the logical section should be possible. These requirements finally led to a set of extensions to the Arden Syntax in its latest version 2.6 [3].

This version includes further extensions dealing with temporal conditions to facilitate the readability of MLMs. Since the first version, Arden Syntax has placed emphasis on supporting rule authors to express temporal conditions and other temporal expressions in an easily readable way. For example, the blood glucose values from a list 'bg_values' that have been measured within the past three months can be selected by

```
bg_values where they occurred within past 3
months
```

Each information in an Arden Syntax MLM that has been read from the data base or from similar sources has an implicit attribute 'primary time' which defines the medically relevant timestamp associated with the information. This attribute is automatically used by temporal operators, as shown in the previous example. In a similar way, operations on other time ranges can be defined.

However, as these operators always refer to a timestamp that consists both of a date and a time, some expressions such as "this examination can be ordered only from 10 pm to 8 am" are hard to express. To support temporal expressions that do not refer to a specific date, a new data type "time of day" has been introduced.

Methods

Internationalization of Medical Logic Modules

Arden Syntax MLMs have been designed to serve as knowledge exchange format. One requirement was therefore that MLMs should always include all required information for making a decision. Whenever an MLM is transferred from one system to another, all required information is loaded into a text file in Arden Syntax format. To support MLMs with multiple languages for the result messages "resource bundles" have been added to MLMs that contain the required translations of all text fragments of the MLM that need to be available in more than one language. As an MLM is defined to consist of one file, all language resources of a localized rule have to be part of the individual MLM text file.

Up to Arden Syntax version 2.5, one Medical Logic Module is structured into the three categories "maintenance", "library", and "knowledge". These categories contain various unstructured and structured information ("slots") which describe administrative facts, such as author or version, background information, such as an explanation, and the decision logic. The logic is modeled as an algorithm within the knowledge category that contains the structured slots "data", "logic" and "action". For internationalization, in addition to these existing, mandatory categories of an MLM, a fourth category "resources" has been specified. This category contains all relevant text used in the logic or

action slots of the MLM. Entries in the resources slot are structured by sections that define translations for individual languages. Each language is identified either by a 2-character language code or by a combination of a language code and a 2-character geographical code, such as 'en', 'en_us' or 'de'.

Within such a section, all resources are identified by a unique textual key and the corresponding text, for example[1]

```
language: en
   'msg': "Caution, the patient has the following
           allergy to penicillin documented: ";
   'creat': "The patient's calculated creatinine
             clearance is %f ml/min."
;;
language: de
  'msg': "Vorsicht, zu diesem Patienten wurde die
     folgende Penicillinallergie dokumentiert: ";
 'creat': "Die berechnete Kreatinin-Clearance des
     Patienten beträgt %f ml/min."
;;
```

Like in the previous examples, translatable resources usually are message parts or format patterns. A new operator "localized" has been introduced that returns the translation of a text for the current language setting. It returns the localized resource whose key corresponds to the argument of the operator. For example, in an English setting the expression

```
creat formatted with localized 'creat'
```

returns[2]

```
"The patient's calculated creatinine clearance is
                0.33 ml/min."
```

while in a German setting the same expression returns

```
"Die berechnete Kreatinin-Clearance des Patienten
            beträgt 0,33 ml/min.".
```

This use of the operator implies that the implementing system is able to retrieve an implicit "language setting". In a multi-lingual system where the destination language cannot be implicitly detected, the localized operator can be used with an additional argument that defines the language or combined language-locale code.

Extended temporal operators

As described in the introduction, Arden Syntax provides a timestamp data type termed "Time" and various operators that deal with temporal aspects. In addition to this data type, a new data type "time of day" has been introduced. This data type is used to define temporal conditions such as "lab order was placed after 10 pm and before 6 am" in an easily readable and comprehensive way, for example

```
order_time was within 10:00 to 18:00
```

This expression returns true, if the order was placed within the defined time range without considering the date fraction of the 'order_time' variable. Special attention was paid to cases where the defined time range spans midnight. If a rule has to check whether an order is to be placed during night hours, the condition may be expressed by

```
now is within 22:00 to 03:00
```

Here, the operator checks whether the time of day is after 10 pm or before 3 am. The new data type has been applied for most temporal operators and conditional expressions and can be combined with normal "Time" values, for example

```
  irregualar_measurements := measurements where
measurements.time not occurred within 1 hour sur-
                rounding 14:00;
```

The last example selects those entries of a list of measurements that have not been measured within a time range of 13:00 to 15:00 and that may therefore not conform to a guideline.

Accordingly, another set of new operators and constants can be used to refer to a day of week to express conditions, such as "lab order was not placed on Sunday".

Results

The internationalization of MLMs allows commercial and academic suppliers to address an international range of users with rules that can be centrally maintained. This extension was limited to the textual parts of the structured algorithms that represent message sections. Other parts of the rule which also consist of free text, such as the explanation and description of the rule, have not been extended. The focus of has been set on those parts where localization in terms of communication to the users is crucial. However, as the rationale of other textual slots of an MLM was to increase transparency of the rules and to support user acceptance, also these resources may have to be localizable one day. While former versions of Arden Syntax were based on a 7-bit ASCII file format, for many international users UTF-8 encoded rules may be required.

The time of day data type allows an easy and intuitive definition of temporal conditions and harmonizes with existing elements of the Arden Syntax. The option to express temporal conditions independently from a specific date and the option to directly support week days was found useful by the members of the HL7 Arden Syntax Special Interest Group.

1 All examples have been cited from [3].

2 This example presumes that the variable ‚creat' represents a numeric variable with a value of 0.33.

Both extensions may be another step towards a broader use of Arden Syntax. They have been balloted as Arden Syntax version 2.7 by HL7 and have also been successfully implemented in Orbis.

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Internationalization of Medical Logic Modules and Extended Time Operations in Arden Syntax Version 2.6

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AGFA HealthCare

Arden Syntax V 2.6

- Arden Syntax for Medical Logic Modules
  - Knowledge representation & transfer format maintained by HL7
  - Knowledge bases consist of a set of individual rules
    - Medical Logic Modules (MLMs)
    - MLMs consists of Categories structured by slots
    - Each MLM should contain all knowledge for one specific decision
- Additions in version 2.6
  - Internationalization (I18N) of MLMs
  - Extended temporal elements and operators (“time of day” data type)

Rationale: I18N

- Usually, results of MLMs are textual messages
  - Contents are mostly unstructured
  - Arbitrary contents
- International use of MLMs in “Orbis”
  - Individual countries require messages in their own language
  - Some countries may require more than one language (US, Belgium,…)
- Requirement for broad reusability: good maintainability
  - “Orbis” Hospital Information System ~ 1200 installations in Europe
  - Decision logic of a rule may be valid without modifications for many countries
  - Goal: Split logic and translatable resources, but keep them in one MLM

MLM's Resources Category

- As knowledge representation format, MLMs keep information all information for the decision in one file

```
maintenanance:
   […]
;;
library:
   […]
;;
knowledge:
   […]
;;
resources:
   […]
;;
```

Information about author, version, state of the MLM

Explanatory information

Decision and data access logic

New: structured language resources

- MLM text file composed by "categories" structured by "slots"

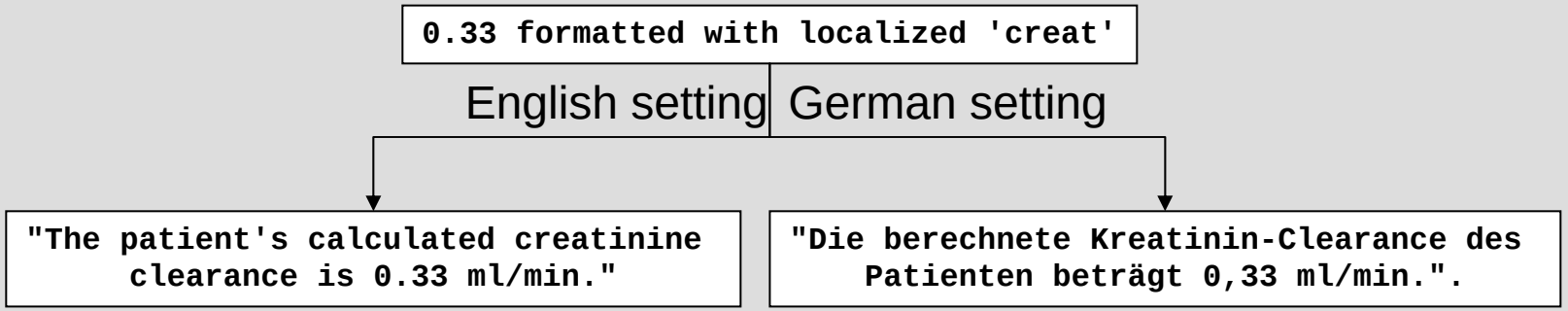
Structure of Resources Category

- All translations for the required languages defined in “language slots”
- Use of 2-character ISO 639-1 language code or combined language code and ISO 3166-1 geographical code

```
language: en
   'msg': "Caution, the patient has the following
           allergy to penicillin documented: ";
   'creat': "The patient's calculated creatinine
             clearance is %f ml/min."
;;
language: de
   'msg': "Vorsicht, zu diesem Patienten wurde die
        folgende Penicillinallergie dokumentiert: ";
   'creat': "Die berechnete Kreatinin-Clearance des
             Patienten beträgt %f ml/min."
;;
```

“localized” operator

- String operator that retrieved the translated resource from the resources category



- The simple use of this operator presumes that the implementing system is able to determine the current language setting
- If the current setting cannot be retrieved, either
  - a default code can be defined in the resources category or
  - the “localized” operator can be used with an explicit language code as additional argument

Arden Syntax I18N: Limitations

- Focus on crucial parts of message creation
  - Messages are usually built in logic or action slot of an MLM
  - Message parts can be translated
- Other free text sections of an MLM have not been extended
  - Explanation slot, description slot, etc.
- The resulting message that is written from the MLM to the implementing system is still “plain”
  - The message itself is not multi-lingual
  - Message handling depends on implementing system
  - Future extensions of Arden Syntax may be harmonized with HL7’s Reference Information Model (RIM) and be structured and standardized

Rationale: Extended Time Operators

- One focus of Arden Syntax lies on temporal conditions

```
bg_values where they occurred within past 3 months
```

  - selects those blood glucose values from a list that occurred in the last 3 months
  - Other operators allow additional kinds of time ranges
- Time constants are defined either by timestamps or by dates
  - Time constants always refer to points in absolute time
  - Temporal conditions that refer to a specific time of day without being affected by the day itself are hard to express
    - “Do not send an order to a specific lab from 20:00 to 06:00”
    - “Have all blood glucose measurements been taken after lunch?”
- A new data type “time of day” has been introduced
  - Existing operators have been extended to work with this data type
  - In addition, constants and operators for “week of day” have been defined

“Time of day” data type

- Time of day constants are defined in a similar way like Arden Syntax timestamps (“time” data type), for example
  - 20:00:00
  - 00:00:00.000 (midnight)
- Time of day values (constants and variables) can be used with most existing operators in Arden Syntax, for example

```
if now is within 20:00:00 to 06:00:00 then
    msg := "Orders to this organizational unit during night hours are
            not possible!";
endif;
```

or

```
irregualar_measurements := measurements where measurements.time not
occurred within 1 hour surrounding 14:00;
```

- As shown in the first example, time ranges may span midnight

Day of Week extensions & Delayed MLM Triggers

- "Day of Week"
  - extensions are based on
    - A set of constants (Monday, Tuesday, …, Sunday)
    - The "day of week" operator
  - Like expressions that refer to a time of day, this extension can be used for easy readable temporal conditions that refer to a day of

```
If Day of week of now is in (SATURDAY, SUNDAY) then
   msg := „Sorry, we‘re closed.";
Endif;
```

- Both extensions can be used in Evoke slot to delay execution, for example to execute an MLM at
  - Today at 18:00:00;
  - Tomorrow at 05:00:00;
  - Monday at 12:00:00 or Wednesday at 12:00:00;

Conclusion

- I18N of Medical Logic Modules
  - Focus on knowledge representation and exchange format
    - All information is stored in one file and one format
    - Implementing systems may organize their language resources in other ways
  - Important step for international reusability
    - Further extensions may be required to translate also explanatory sections
    - First, good experiences during roll out of Orbis in European countries
- Temporal expressions based on “Time of day” data type
  - Easy readable way to express temporal conditions that not refer to points in absolute time
  - Fits into Arden Syntax’ philosophy of dealing with time constraints
    - Usable by most existing operators
    - Low efforts to extend existing Arden Syntax based implementations

Thank you

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Integration of Medical Publications into the Clinical Routine Using HL7 "Clinical Decision Support Context-Sensitive Information Retrieval"

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Abstract

To support clinical staff in their daily decisions, a context-sensitive information retrieval mechanism has been embedded into a widely used health information system. This mechanism implements the HL7 "Infobutton" approach that has been extended to formalize the search result. These results consist of articles whose characteristics match the patient's information like diagnoses, gender and age.

Keywords:

Clinical Decision Support Systems, HL7 Infobutton, Context-Sensitive Search

Introduction

An important goal of Clinical Decision Support is to provide the right information to the right users at the right time. One approach to achieve this goal is to provide adequate medical articles to both clinical staff and patients. We integrated a context-sensitive information retrieval based on the HL7 "Infobutton"[1] approach into Orbis, a hospital information system (HIS) with over 1200 installations and more than 450,000 users. With "Infobutton", various medical information sources can be embedded into the clinical routine process.

Methods

The "Infobutton" technology

Based on an early specification of the "Infobutton" [1], we developed a component "Infobutton Manager" (IM) that is embedded in the client-platform of the HIS. The IM is able to query various content providers (e-resources) and is responsible for providing additional information from the enquiring user context, current task context (type of task the user is trying to perform) and patient context (gender and age).

The search request is well defined in the "Infobutton" specification and includes a set of main search criteria that can be either free-text or formalized values. The set of supported search criteria depends on the e-resource and is not restricted by the specification.

As a first e-resource, the ICD-based retrieval of medical documents has been connected. This provider uses an intelligent fingerprint mechanism to map ICD-codes to medical articles [2] from Medline. We were able to use ICD-10 codes as search criteria as in German hospitals diagnoses are already documented during the patient's admission and also during the whole clinical process.

Another e-resource enables semantic full-text retrieval in publication databases of publishers like Springer Medizin Verlag [3].

Both e-resources are web-services that use the Simple Object Access Protocol (SOAP) as the communication layer and as payload the XML "Infobutton" resource request.

In contrast to the outlined request, the "Infobutton" specification does not define a structured result format.

Searching for information

The general information search- and retrieval-workflow can be described as follows: The user starts a search by selecting diagnoses or full-text for which he needs more information. Then, the request is extended with contextual information and forwarded to the e-resource by the IM.

As a result, the e-resource sends a list of documents and related concepts back to the enquiring system. The user may either select documents for ordering or he can refine the search by adding or removing related concepts based on MeSH-terms or ICD-codes as search criteria.

The "Infobutton" specification does not define the result of the e-resource request, thus we have implemented two different approaches to model the search and retrieval workflow:

Structured result format

As a first approach, an XML structure has been introduced as request result. This structure contains meta-information on the documents such as title, authors, journal, related concepts and ordering information. The result-XML can be stored, processed by other applications or shown to the enquiring user in the search dialog. From here, the user is

1 HL7 "Clinical Decision Support Context-Sensitive Information Retrieval" (Infobutton)

able either to start another search-workflow if he modifies the search criteria, or to order a document.

Web-based result handling

As second approach, the e-resource result is a URL that serves as an entry point to the web-based search- and retrieval-workflow of the individual e-resource provider. The e-resource request is initiated only once. Then the resulting URL is forwarded to the web-browser in the enquiring system. Further refinement of search criteria and document orders are realized within the website via hyperlinks.

Results

The HL7 "Infobutton" approach can be used to integrate knowledge sources into the diagnostic and therapeutic process. Its open concept allows connecting to different knowledge providers but lacks a structured result format. Both introduced approaches have advantages and disadvantages.

Structured result format

The approach of using structured result formats has the major advantage that the receiving system can directly react on the result and integrate the information in its application framework.

- All parts of the result can be processed electronically.
- The result can be integrated into the HIS platform and processes with respect to the HIS vendor's design guideline and look & feel.
- It is possible to modify, add or remove both context-data and search criteria during the whole search process.

However, we also have to take the disadvantages of this method into account.

- This proprietary XML strongly reflects the structure of the special e-resource that was used. Without a standardized result, we have new implementation efforts to integrate the result handling for a new e-resource.
- Other types of information (e.g. picture or audio databases) are difficult to integrate with this special literature search.

Web-based result handling

Currently, from our point of view, the web-based approach is the preferred way.

- Processing the URL is easy to implement. The result is simply passed to the system's web-browser.
- The HIS vendor is not responsible for developing the user interface. The e-resource vendor can influence presentation of the result.

The web-based method implies disadvantages, too.

- For optimal user guidance, the e-resource web-result has to be developed with respect to the HIS vendor's design guidelines. This means that the e-resource has to provide different web-services for their customers.
- Once, the search is started, it is not possible to modify, add or remove context-data and search criteria by the HIS system. The context information and search criteria are collected only once, with the initial resource request. The modification of search criteria during the search process is a function, that has to be provided by the respective e-resource.

Conclusion

The integration of HL7 "Infobutton" approach is a good way to serve the clinical staff with up-to-date information.

Like the e-resource request, the result data should also be covered by the HL7 "Infobutton" specification.

In terms of semantic interoperability the use of formal codes instead of free text search criteria may also be an issue when used in an international context where code systems of e-resources and customers differ. In such cases, additional efforts to convert "Infobutton" queries are required.

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Integration of Medical Publications into the Clinical Routine Using HL7 “Clinical Decision Support Context-Sensitive Information Retrieval”

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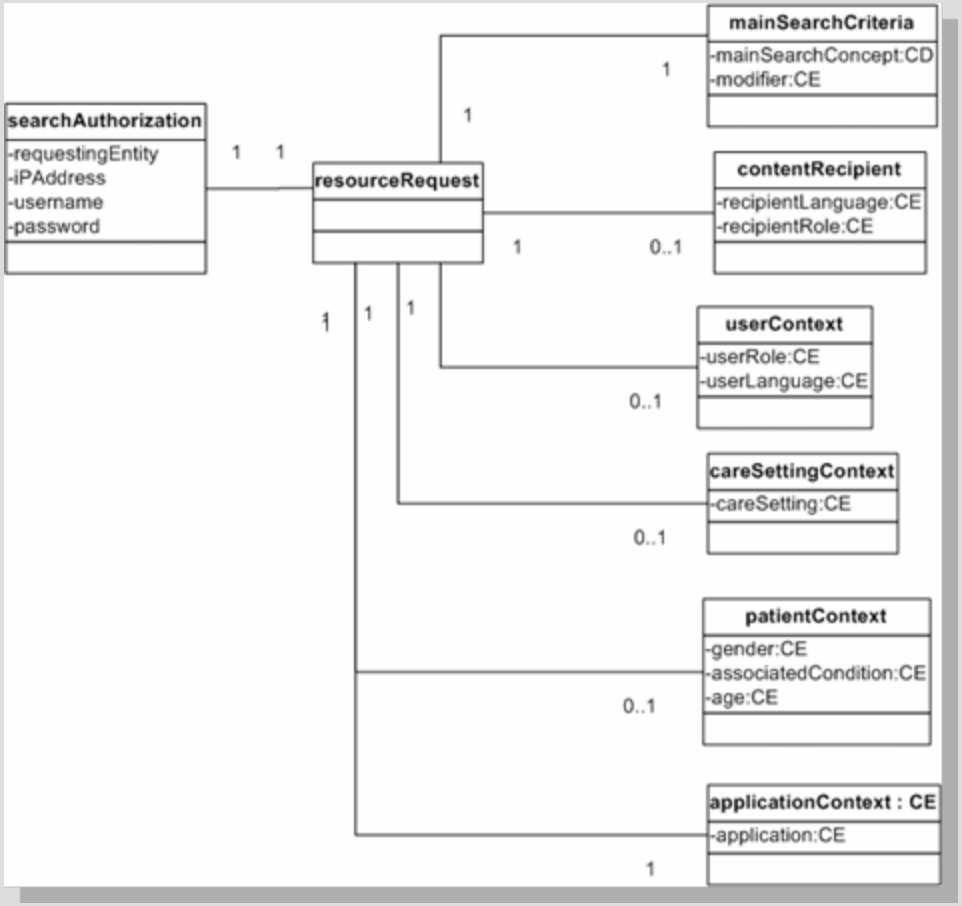
Rationale

Context-sensitive information retrieval to …

- serve the clinicians with latest medical publications directly in the application
- inform the patients about their treatment
- embed knowledge directly into the HIS
- detect lacks of knowledge in the hospital
- collect frequently asked questions or special fields of interest of the clinical staff

HL7 „Infobutton“ Approach

Parts of the „Infobutton“-request



User defined search criteria (ICD, full-text)

The Infobutton-Manager (IM) collects information about the current context.
That allows the e-resource to return the adequate information.

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„Infobutton“ – ICD-10 based information retrieval

- ICD-10 codes given as search criteria

```
<mainSearchCriteria>
   <mainSearchConcept code="A00.0" codeSystem="ICD-10">
     <qualifier>
       <name code="main" />
     </qualifier>
   </mainSearchConcept>
   <mainSearchConcept code="A00.1" codeSystem="ICD-10" />
</mainSearchCriteria>
```

- Multiple main search concepts allowed
- Qualifier labels the „main“ diagnosis

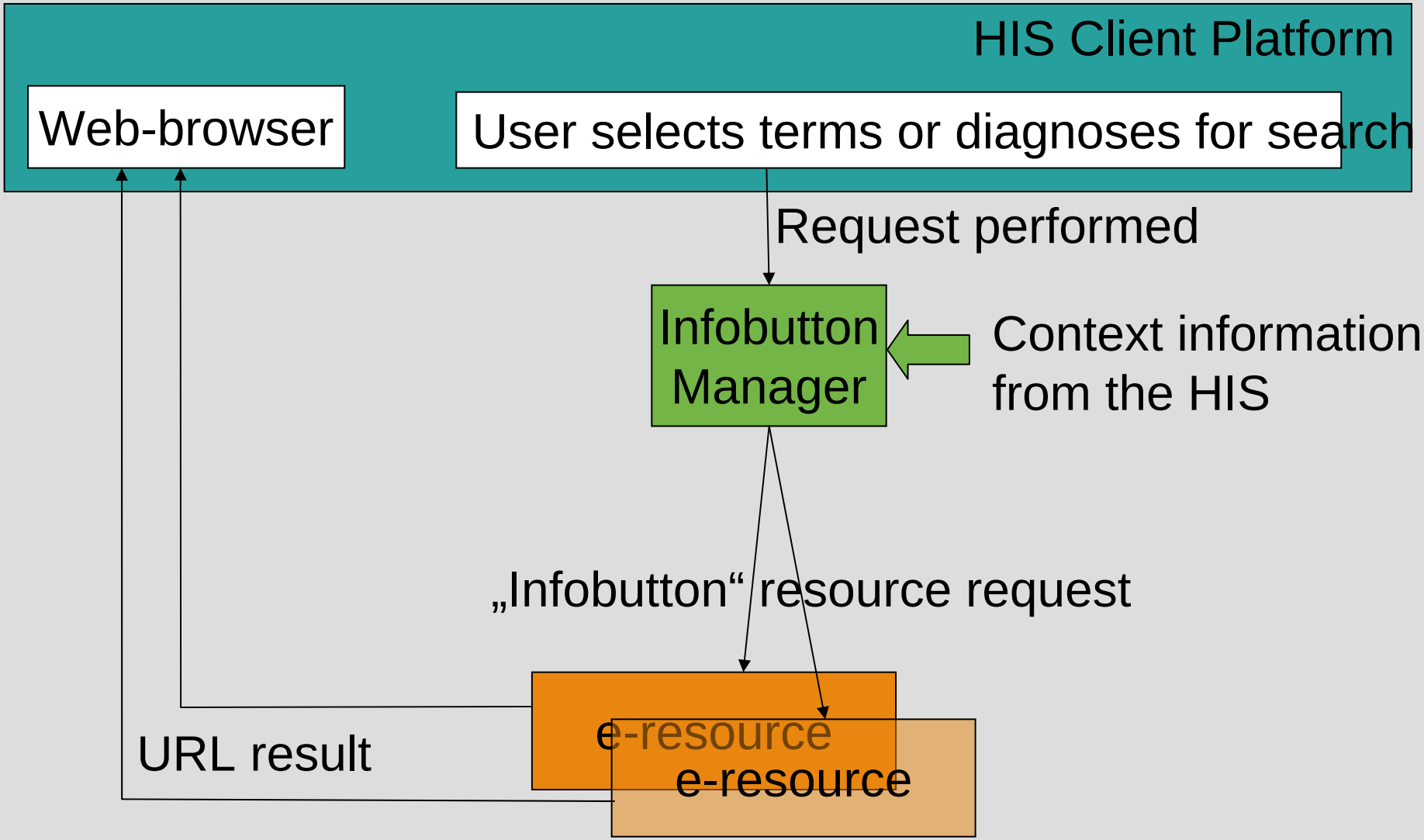
„Infobutton“ – Full-text information retrieval

- Full-text used as search criteria

```
<mainSearchCriteria>
     <mainSearchConcept displayName="colon cancer">
       <originalText>colon cancer adenocarcinoma</originalText>
     </mainSearchConcept>
     <mainSearchConcept displayName="adenocarcinoma">
       <originalText>adenocarcinoma</originalText>
     </mainSearchConcept>
   </mainSearchCriteria>
```

- Concatenation of the search string
  - AND
  - OR
  - NOT

Searching for Information



Web-based Result Handling

- The e-resource returns an URL that is passed to the web-browser in the enquiring system
- We consider the web-browser as a black box
- Refining the search by adding or removing of search criteria is only possible within the browser session and is implemented by the webservice
- The e-resource is responsible for presentation
- Presentation and data is mixed

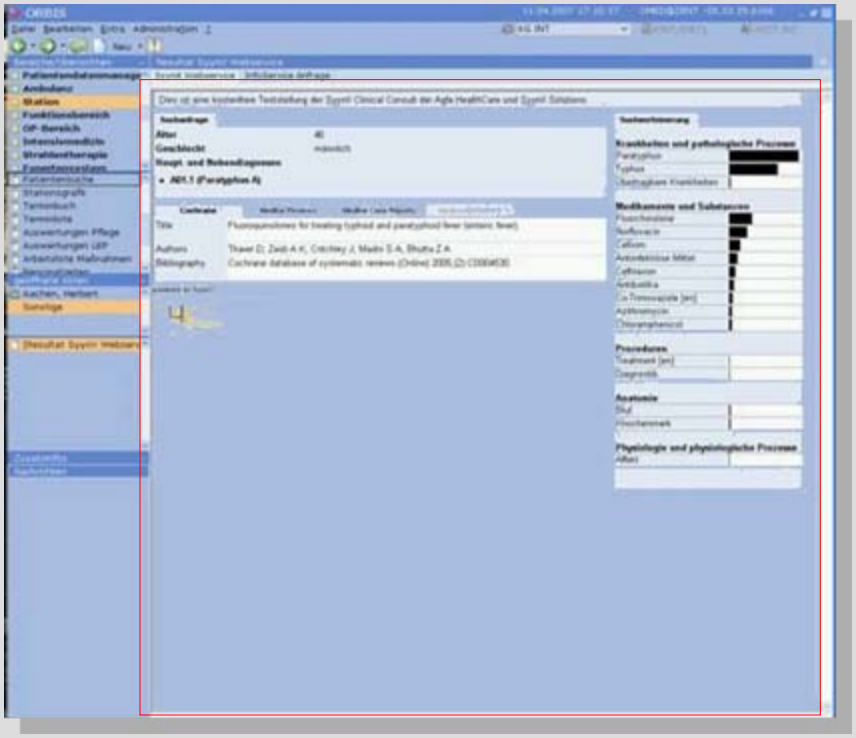
Structured Result Format

The proprietary result-XML contains meta-information of the document

- Title, authors and publication information
- The document‘s source (e.g. Cochrane, Medline Reviews, Medline Guidelines)
- Related concepts and categories, e.g.
  - Chemicals & Drugs: Cholera Vaccines, Vaccines, Toxines, …
  - Molecular Biology: Cholera Toxin, Evolution, …
  - Organisms: Vibrio cholerae, Bacteriophages, …

An Example – The Integrated Webbrowser

Agfa‘s HIS Orbis uses the embedded web-browser component to show the „Infobutton“-result in a convenient way.



Results and Conclusion

- The preferred way is the web-based retrieval
  - No development effort if the e-resource changes
  - All e-resources are treated in the same manner
  - Little time to connect new e-resources
- However, it is not possible to
  - Analyze the search- and refinement-process
  - Optimize the knowledge- / information management within the hospital

Discussion

- A standardized „Infobutton“ result would be the solution for
  - A better integration into the clinical routine process
  - An easier use of new e-resources
  - Better knowledge management and knowledge sharing in the hospital
- But, how can different types of information (like literature, pictures, audio or video) be standardized in the same manner?

Thank you

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Semantic Annotation of Patient Data in a Commercial Health Information System

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Abstract and objective

To facilitate reusability of information in a complex Health Information System, a semantic component has been created that allows for formal descriptions of clinical data at a very granular level. Through an extension to the clinical database, semantic concepts selected from controlled vocabularies residing on a terminology server can be directly linked to the patient data. The use of specifications such as LexGrid and CTS allows for cross-terminological information retrieval and interinstitutional exchange of clinical data.

Keywords:

terminology, semantics,
clinical decision support systems

Introduction

Understanding the semantics of a healthcare provider's data is crucial for use cases where this information has to be interpreted, such as for applying clinical decision support systems (CDSS). Such systems need to operate on formal information from controlled vocabularies whenever reusability of the knowledge base is required [1].

We added a semantic extension that operates on controlled vocabularies to Orbis, a hospital information system with more than 1200 installations in Europe. In contrast to other systems that are based on a central data model, Orbis allows its users to define an arbitrary amount of data structures during runtime by providing a visual tool for the definition of forms. Such forms have a graphical representation and are stored in a generic, entity-attribute-value (EAV) based data model. Through this mechanism, users can add implicit data structures that meet their needs in terms of documentation. The classification of such customized data structures necessary for use by CDSS is a major challenge that can be addressed by applying formal codes to the EAV model.

Methods

Large parts of Orbis' electronic patient record (EPR) consist of EAV structures in a generic data model [2]. These structures are termed 'forms' and are designed by administrative users. Later on, these form definitions can be instantiated by clinical users of the system during runtime ("form instances"). The flexibility of this approach empowers clinicians to define arbitrary forms which meet their specific documentation needs, instead of being limited to a central data model. The set of input fields that constitute a form represent a data structure which can be accessed within Orbis like a database table. Thus, in this context, a form is more than a user interface representation, since it also corresponds to a virtual data structure.

This openness implies that there are multiple ways to document the same clinical fact. For example, the administrative user who is required to offer the documentation of a patient's childhood illnesses in the scope of an anamnesis form is free to define a text field expecting free text or a select box offering a set of predefined values. Alternatively, the information request might be modeled with checkboxes or radio buttons. At runtime, the clinical user may document a childhood illness by selecting a checkbox (figure 1) or by filling a free text field (figure 2).

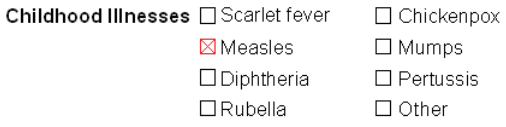

Figure 1 - Representation of infantile diseases as a set of checkboxes

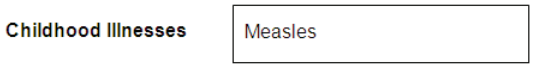

Figure 2 - Representation of infantile diseases as a free text field

To describe the semantics of such a form structure, each of its elements can be annotated by one or more formal semantic concepts. During design time, this annotation is performed manually by the form author or a coding expert and describes the attribute of the element, such as *'systolic blood pressure'*, *'allergy'* or *'infantile disease'*.

In the previous example, there are several possibilities to annotate the "measles" input fields of the form definition with a SNOMED code. One possibility is:

[14189004 Measles – disorder – Clinical findings].

Since the larger context is the patient's medical history, this code is incorrect, because the SNOMED code denotes an acute illness. Considering this, the following SNOMED code could be more appropriate:

[161419000 History of Measles – situation – Context dependent categories]

One important factor to reinforce valid coding is to consider the context clinical information is embedded in. To the clinical user, much of this context is obvious and presents itself in form of the document's graphical structuring. If 'context clues', such as the semantics of a field's label or of the embedding form, are not available during the annotation process, it can become impossible to deduce the correct code.

All formal concepts that describe these semantics are stored in the same relational database as Orbis' EPR and are linked to the attribute and value entries through foreign keys. Based on these links, queries have been added to Orbis that retrieve all patient information for a specific medical case whose semantic annotation equals the search criterion that is also a formal semantic concept. For example, querying 'allergy' for a specific patient, retrieves all form instance data whose semantic annotation corresponds to allergies. In the last example, the result would be a Boolean and a free text from a technical point of view.

Thus, during runtime, *values* entered by the clinical user should also be formalized if possible. Both user support through semi-automatic machine-aided selection of appropriate terminology items and fully automatic semantic tagging of medical terms in free text by natural language processing algorithms are possible. By this, the result of the query not only consists of the technical data types, such as "Boolean" or "text" but also of their semantic meaning as a formal code. Another special kind of information are numeric values, such as *'blood pressure'*. Queries on these elements retrieve both the stored values and their semantic type, such as *80* and *'systolic blood pressure (mmHg)'*. To specify units of numeric values, post-coordinated concepts are used.

The underlying data model for semantic annotation is open for all kinds of vocabularies and terminologies. For maintaining them and searching adequate concepts during the annotation process, we used an external terminology server. For this purpose, LexGrid [3], a data model and software developed by Mayo Clinics which provides a common data format has been has been connected using the HL7 Common Terminology Services interface. LexGrid offers tools to convert terminologies of different formats to the LexGrid database structure. For example, an attribute of an EPR annotated by a LOINC code could be retrieved, although the query searches for a synonymous SNOMED code.

Such queries have been applied to one of Orbis' rule based decision support systems that is founded on Arden Syntax for Medical Logic Modules (MLMs). Here, extensions in the data retrieval part of the rules allow to access clinical information identified by formal codes. The current implementation is limited to using formal codes in the rules that exactly match those used in the annotation of the EAV structures, but is open to future cross-terminological queries. In this way, information stored in arbitrary customized data structures can be retrieved by a single rule.

Results

By linking formal concepts to atomic data elements of Orbis' EPR we have been able to describe patient data semantics at a very granular level.

The combination of LexGrid and the NCI Meta Thesaurus empowered us to carry out cross-terminological and cross-lingual searches.

Instead of defining queries directly on the EPR, data retrieval works on an abstract, semantic level that focuses on individual concepts and follows their links to the EAV entries.

Discussion

However, the application of this method does have certain limitations when applied to compound concepts such as *'blood pressure'*, which consist of a set of individual EAV entries. Whether this aggregation can best be achieved by post-coordination or through an additional abstract layer that defines compounds or clinical archetypes [4], requires further evaluation.

Conclusion

Our bottom-up approach to semantic annotation ensures maximum reuse of the database's inherent knowledge by avoiding premature reduction of primary data as a side-effect of summarization. Thus, through the separation of annotation process from abstraction, the knowledge base is open for interpretation from various perspectives arising form different requirements. Further layers of semantic abstraction may allow the interpretation of the same knowledge from different views.

Semantic annotation has to be carried out in a way that ensures the retrievability of the documented data. The success of unambiguous annotation is dependent on the form element's data type and the form items' larger context.

Using the generic LexGrid data model for the administration of clinical vocabularies and a standardized terminology server interface, the gap caused by a proliferation of terminologies in different data formats can not

only be bridged, but the terminologies can also be shared among different institutions.

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Semantic Annotation of Patient Data in a Commercial Health Information System

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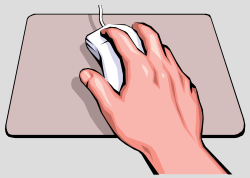
The ORBIS Hospital Information System

- ORBIS technologies allow both Agfa and the customer to
  - Define forms for medical documentation and to build applications
  - Implicitly define arbitrary data structures (as part of applications or customer specific)

Define forms



IT staff of the hospital

clinical users

Use of forms for documentation

ORBIS EPR
Form definition and instances

- Common applications: medical history (anamnesis), letter of discharge, nursing, etc.

Rationale

Orbis forms are stored

- as Enitity-Attribute-Value structures
  - Attributes are defined at design time, values are added by the clinical user during runtime
- in a generic data model

- The approach is extremely flexible (no restrictions through a rigid central data model) and renders the system extensible
- There are multiple ways to model the same clincial fact
- Utilizing the knowledge inherent in these forms requires semantic annotation

Semantic Annotation

- Semantic annotation of form elements is achieved through codes from controlled vocabularies
- These semantic annotations are stored in a set of tables located in the same database as the forms

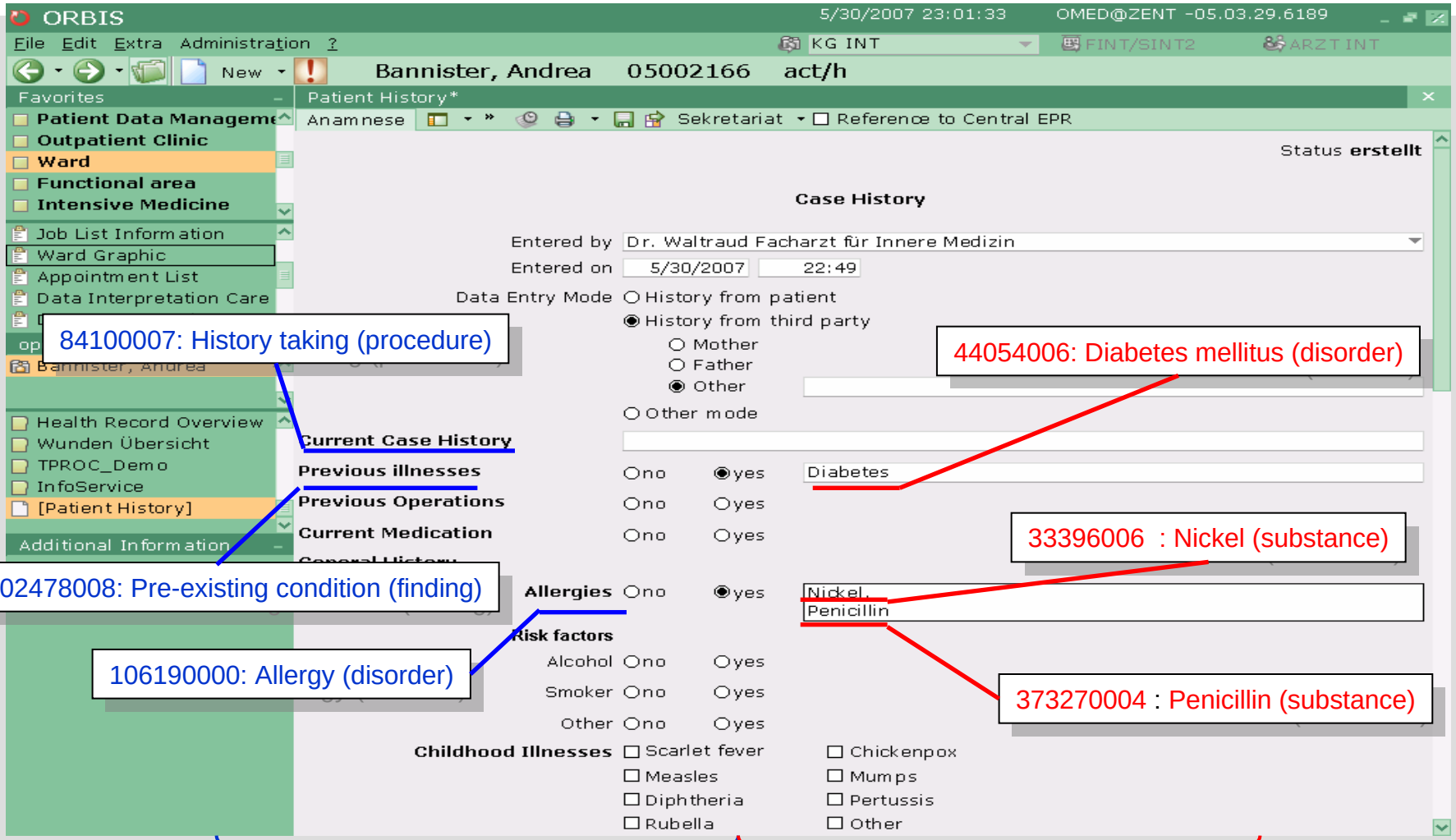
- ➢ Turns raw data into accessible knowledge
- ➢ Enables CDSS and other applications to exploit and structure this knowledge according to their own needs

The Annotation Process

- What is annotated?
  - Semantic annotation of form elements during design time (attributes)
  - Semantic annotation of form instances during runtime (values)

  How is the data annotated?
  - Manually (at design time)
  - Semi-automatically (at runtime)
  - User support through specific tools is essential for (Terminology Browser, NLP algorithms for semi-automatic text analysis)
  - Assignment of multiple semantic concepts is possible

Semantic annotation applied to a form



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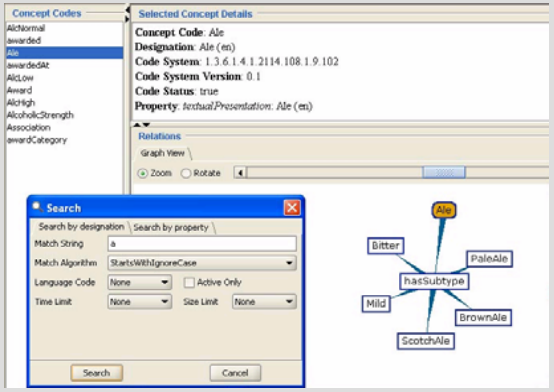
The Coding Interface
During form definition and during runtime

Form Composer

- Manually used by form author
- Result: Code, Terminology-System, Version



CTS Terminology Explorer [1]

Form

- Automatic evocation during runtime
- Information sent to coder: pre-classified information (Code, System, Version) plus raw data
- Result: Code, State

- LexGrid as a terminology server
- HL7 CTS to access terminological contents

Architecture of the Semantic Components

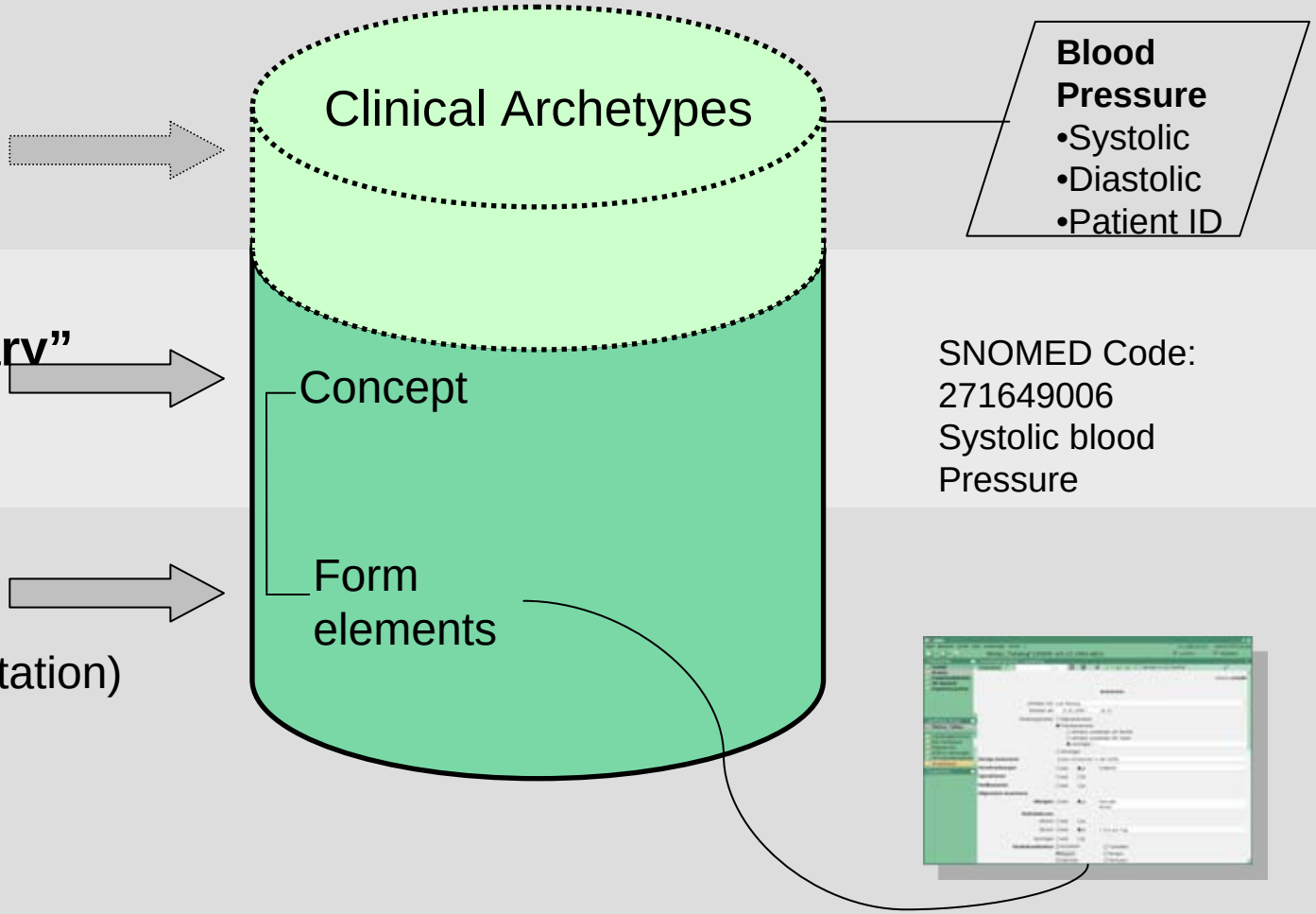
- The terminologies reside in a central terminology server
- HL7 CTS is used as a communication protocol to exchange data between the data repository and the terminology server
- ➢ Maintainability and interchangeability through usage of evolving standards and OpenSource Software
- ➢ Openness for all kinds of ontologies, terminologies and nomenclatures

Semantic Layers in the Generic Data Model

Possible further semantic layer

“Medical Dictionary” Layer

Form Data (Database Representation)



Information Retrieval

- Queries are SQL reports that are stored or user-defined
- The query terms search the database for matching form annotations
- Queries retrieve
  - the semantic code and label of the associated input fields (attributes)
  - the raw form data stored in the form instances (values) and their semantic codes
- Sample query

  “Get all information related to patient x which refers to allergies, except for allergies having occurred in his family history”

Results and Conclusion

- Through semantic annotation at a very granular level, the annotation process is separated from the abstraction
- A flexible architecture preserves openness for all kinds of terminologies
- Open for knowledge interpretation from different views (realized by additional semantic layers)

Thank you

References
[1] http://informatics.mayo.edu/LexGrid/index.php?page=ctsdemo. Accessed May 30, 2007.

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Probabilistic Asthma Case Finding – A Pilot Study using the CHICA System

Vibha Anand[1], Stephen M. Downs[1,2]

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[2] *Regenstrief Institute for Health Care, Indianapolis, IN*

Abstract

Identifying and prioritizing decision support messages can be a challenge. We use Bayesian Belief Networks as a strategy for modeling patients' clinical status with the goal of case finding in childhood asthma. ***Methods:*** *We compared two Belief networks, one developed by a domain expert and one mined using data from a retrospective cohort consisting of 16,187 children having wheezing. Data were used to derive a directed acyclic graph (DAG) for a Bayesian Belief network. We evaluated this mined network with a domain expert's belief network using two test datasets- (a) 1/3 of the data (5000 cases) from the 16,187 case training cohort (b) data from 2000 children collected prospectively from the clinic. We used Area under the receiver operating curves (AUC) to compare the ability of the networks to predict asthma.* ***Results:*** *For the retrospective test data (a) the expert's network had AUC=0.697, mined network = 0.708. For the prospective test data (b) the expert's network AUC = 0.637, mined network = 0.603.* ***Conclusion:*** *The mined Bayesian Belief network was able to detect asthma cases comparably to the expert's network in both test scenarios suggesting that this technique can be used for asthma case finding and dynamically prioritizing alerts in a decision support system.*

Keywords:

computer decision support, rule based systems, alerts and reminders, guidelines, pediatric, asthma, prevention, Arden Syntax, belief network, Bayesian Network

Introduction

Computer alert and reminder systems improve rates of preventive services [1-3]. However the number of services recommended by authoritative bodies exceeds what can be addressed in a typical clinic visit [4-6]. Providers are often overwhelmed with competing demands, [7] leaving little or no time to address patient specific services. Reminder systems should prioritize alerts to maximize the benefit to patients. Expected value decision making provides an attractive model for prioritization of these services [8]. In Nov. 2004 we developed and deployed a decision support system -Child Health Improvement through Computer Automation (CHICA) for pediatric preventive services and disease management in a busy Primary Care Clinic. [9-13]. CHICA has a static, global prioritization scheme that limits the flexibility of the system - The Arden Syntax Medical Logic Modules (MLMs) [14] that encode the CHICA knowledge are prioritized using a global priority scheme to address the most relevant questions and reminders. [8, 11, 15].

We are experimenting with Bayesian Belief networks (BN) as a strategy for modeling a patient's clinical status with the idea of calculating the expected value of making alternative recommendations to physicians, tailoring prioritization to the patient.[8] BNs are appealing because they can be derived from clinical experts or empirically from data. In this paper we compare BNs derived in two ways: 1) using a clinical expert to define the nodes and arcs in the BN and training the resulting BN using data or 2) using data mining techniques to derive the BN from data. We compare these approaches in the domain of childhood asthma.

Methods

CHICA Overview – CHICA provides decision support by collecting data from families before a clinic visit, using a prescreener form (PSF) and reminders to physicians on a Provider Worksheet (PWS). CHICA now has records of over 11,000 patients, with an average of 3 visits per patient. The question in Figure 1 is asked on the PSF to find children who may have asthma. If answered "yes," the physician is asked to consider the diagnosis of asthma. Such a question appears on the PSF because it is assigned a high global priority among the questions that could be asked. Potentially, for a given patient when other questions are relevant that have higher global priority the asthma question may not appear on the questionnaire. It has the same global priority regardless of data in the medical record that may indicate higher or lower risk of asthma. Therefore, a patient specific prioritization would be very desirable which takes into account the evidence and the expected value of decision making.

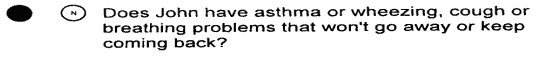

Figure 1 – Asthma question on Prescreen Form (PSF)

Model – Belief Networks (BN) and Influence Diagrams (ID) have been shown to represent domain knowledge with natural perception of causal influences [16]. They have been used widely in medical diagnoses because of their concise representation and ability for belief propagation [17]. We used Netica software [18] to construct a BN designed by our expert and the WinMine toolkit [19] software from Microsoft Corporation for mining a directed acyclic graph (DAG) directly from data. Netica was used for parameter learning from data in both BN models.

Table 1 – Data Variables for Model

Variable	Values
Race	White, Black, Hispanic, Other, Unknown
Sex	Male, Female
Eczema	True, False
Wheeze	ICD9 or clinic billing diagnosis before age 2 (True, False)
Asthma	ICD9 (493.*) or any clinic billing diagnosis after age 5 or at least 3 drugs from a specified list within 12 months after age 5 (True, False)
X-ray	Chest x-ray before age 2 (True, False)
Drug	Drugs from a specified list before (True, False)
Wz_hosp	Inpatient admission with hospital ICD9 as wheezing (True, False)
Wz_er	Any ER visit with billing ICD9 as wheezing (True, False)
Ins_cat	Insurance category - first available insurance in the same year of the first wheezing diagnosis (True, False)

Data – We compared the performance of the BNs on two datasets – (1) data from 16,187 cases from Regenstrief Medical Record Systems (RMRS) previously identified for a large retrospective cohort study of asthma predictors and split randomly into 2/3 of cases for a training set and 1/3 for a test set. (2) Clinical observations collected prospectively from children aged 5 and above collected by CHICA from the RMRS database for every patient visit. Data were filtered and preprocessed to extract the data variables listed in Table 1. At the time of the writing, the CHICA system had prospective data for about 2000 cases.

Expert's Design of BN with training using Netica: Using the predictor data variables in Table 1 as nodes and the domain knowledge for joining them with arcs, the domain expert (SMD) created a BN. This BN was trained with the training set and compiled using Netica. The BN showed prior probabilities of each node and an asthma prior probability of 18.6%.

BN Derived using Data Mining Techniques: The training set from RMRS data was used to derive the directed acyclic graph (DAG) for this approach. The software from WinMine toolkit was used to preprocess the data and to instruct the learning algorithm to derive the DAG. Using the structure from the data-mined DAG, we created the BN in Netica software. This BN was also trained and compiled using the same training set as the expert BN to get the prior probabilities. The asthma prior probability in this model was 13.9%.

Testing the Two Models - The two BN models were evaluated, first, using 1/3 of the retrospective data from our test set removed before data mining or network training; and, second, using the data set derived from CHICA database. Asthma, our outcome of interest was treated as an "unobserved node" in Netica. We derived the sensitivity, specificity, positive predictive value and negative predictive value. We compared BNs using Receiver Operating Characteristics (ROC) curves [20]. The area under the curve was used as a measure of overall test performance. The ROC curve was obtained by plotting pairs of true positive rate (sensitivity) and false positive rate (1-specificity).

Results

We had 5188 cases in our RMRS test set and 2000 cases in the CHICA test set. Both the Expert and the Mined BN were tested using these sets, the results of which are shown below.

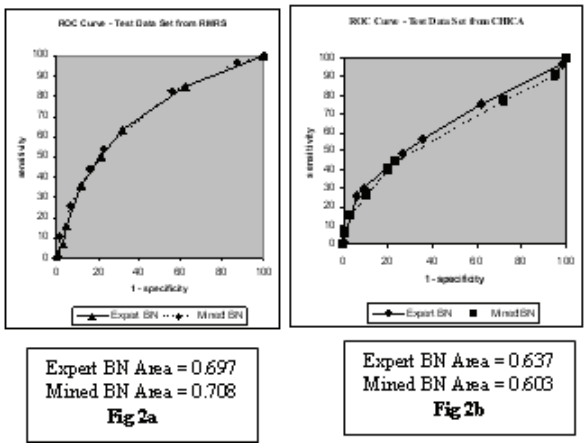

Figure 2a – ROC curves using test data from RMRS
Figure 2b – ROC curves using test data from CHICA

Discussion

The results of area under the ROC curve for both networks using the same test set are comparable. Both the expert BN and the mined BN performed better with the test data set from RMRS (for large retrospective study) when compared with the CHICA test data set. We attribute degraded performance when testing with CHICA test data set to less stringent inclusion criteria in the CHICA test set. For example, any chest x-ray observation will satisfy the inclusion criteria for CHICA data, where as X-ray finding before age 2 will satisfy the inclusion criteria for the RMRS test set.

Conclusion

Similar performance of each BN in each test scenario goes to suggest that the mined BN has a predictive value similar to an expert and hence can be used for case finding. We acknowledge that the performance of a BN would vary on the quality of data and the predictor variables used to model it however, we believe there is a value in the data mined approach. We can attach utility nodes for each of the desired outcomes in our model to drive the prioritization scores of prompts in the CHICA system using the expected values of case finding decision.

Our future work will involve developing a framework to mine the DAGs from data with in our system for many more preventive services such as lead screening and evaluating TB risk and utilizing the mined BNs with CHICA programmatically.

Acknowledgements

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Probabilistic Asthma Case Finding A pilot study using the CHICA System

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Introduction

- In pediatric primary care, eligible preventive services may exceed time available in a visit
- Decision support systems must prioritize what reminders are most important
- Bayesian belief networks provide a strategy for assessing patient risk and selecting reminders

Challenge

- Bayesian belief networks are acyclic directed graphs
- Nodes are random variables and arcs represent probabilistic dependencies
- “Learning” the probabilistic relationships can be challenging
- Expert judgment may be necessary where data are not available

Study Objective

- Compare the performance of two Bayesian belief networks for identifying children who will develop asthma
  - Network A developed by a clinical expert
  - Network B mined from data by a learning algorithm
- Probabilities for both networks were derived from data

Methods – Model Development

- Domain expert model:
  - Developed by a pediatrician trained in informatics and decision sciences
  - Using Netica Software (http://www.norsys.com)
- Mined model:
  - Directed Acyclic Graph (DAG) derived from clinical dataset
  - Using WinMine Toolkit software (http://research.microsoft.com/~dmax/WinMine)
- Both models trained on clinical data using the Netica software

Data Source

- 16,000 cases were extracted from the Regenstrief medical record system (RMRS)
- Cases randomly split
  - 11,000 training cases
  - 5000 test cases
- An additional 2000 cases collected prospectively to evaluate the model
  - These data were incomplete (missing values)

Variables in the Dataset

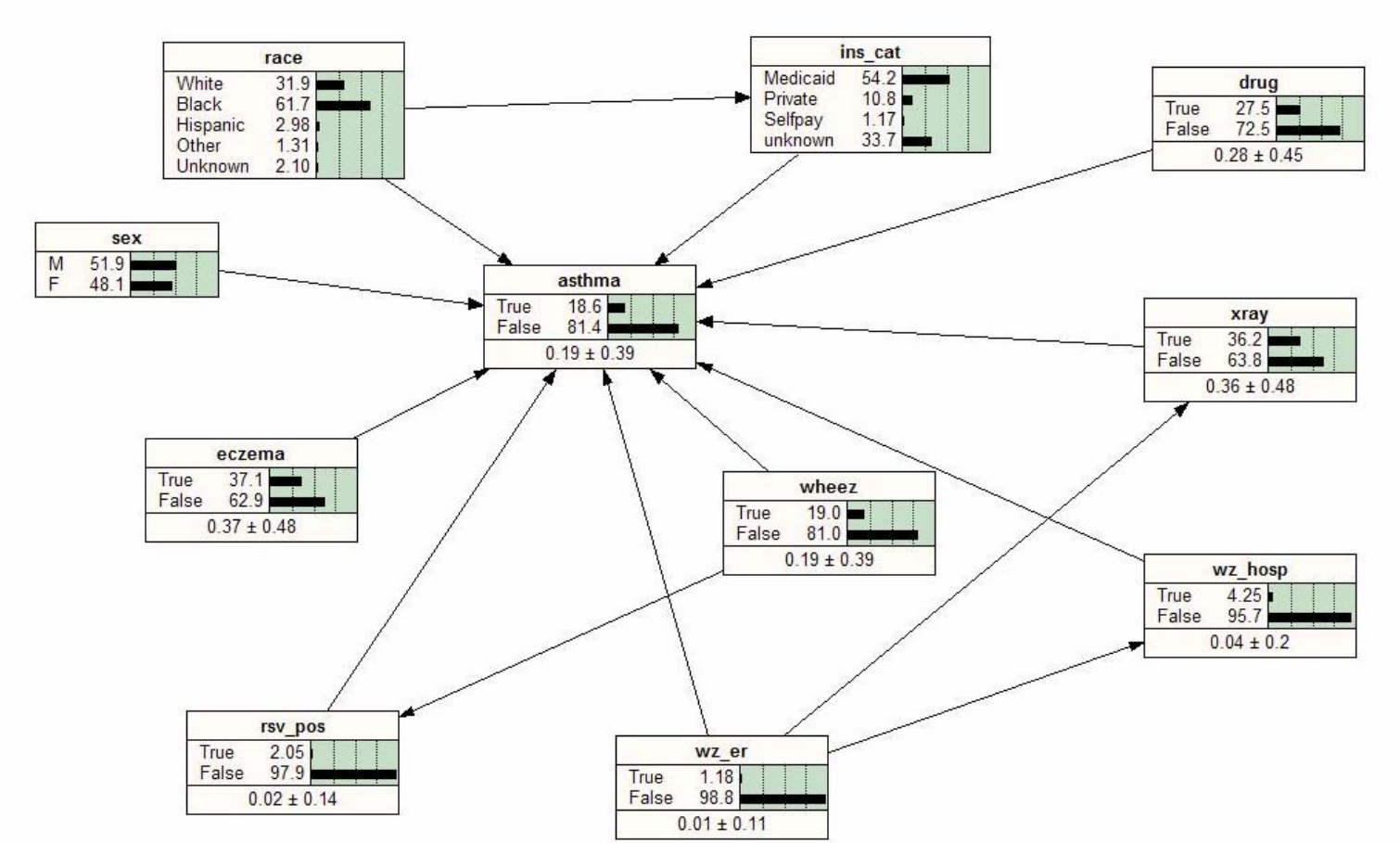
- Predictors measured before age 2 years
- Outcome asthma after 5 years

Variable	Values
Race	White, Black, Hispanic, Other, Unknown
Sex	Male, Female
Eczema	True, False
Wheeze	ICD9 or clinic billing diagnosis before age 2 (True, False)
Asthma	ICD9 (493.*) or any clinic billing diagnosis after age 5 or at least 3 drugs from a specified list within 12 months after age 5 (True, False)
X-ray	Chest x-ray before age 2 (True, False)
Drug	Drugs from a specified list before (True, False)
Wz_hosp	Inpatient admission with hospital ICD9 as wheezing (True, False)
Wz_er	Any ER visit with billing ICD9 as wheezing (True, False)
Ins_cat	Insurance category - first available insurance in the same year of the first wheezing diagnosis (True, False)

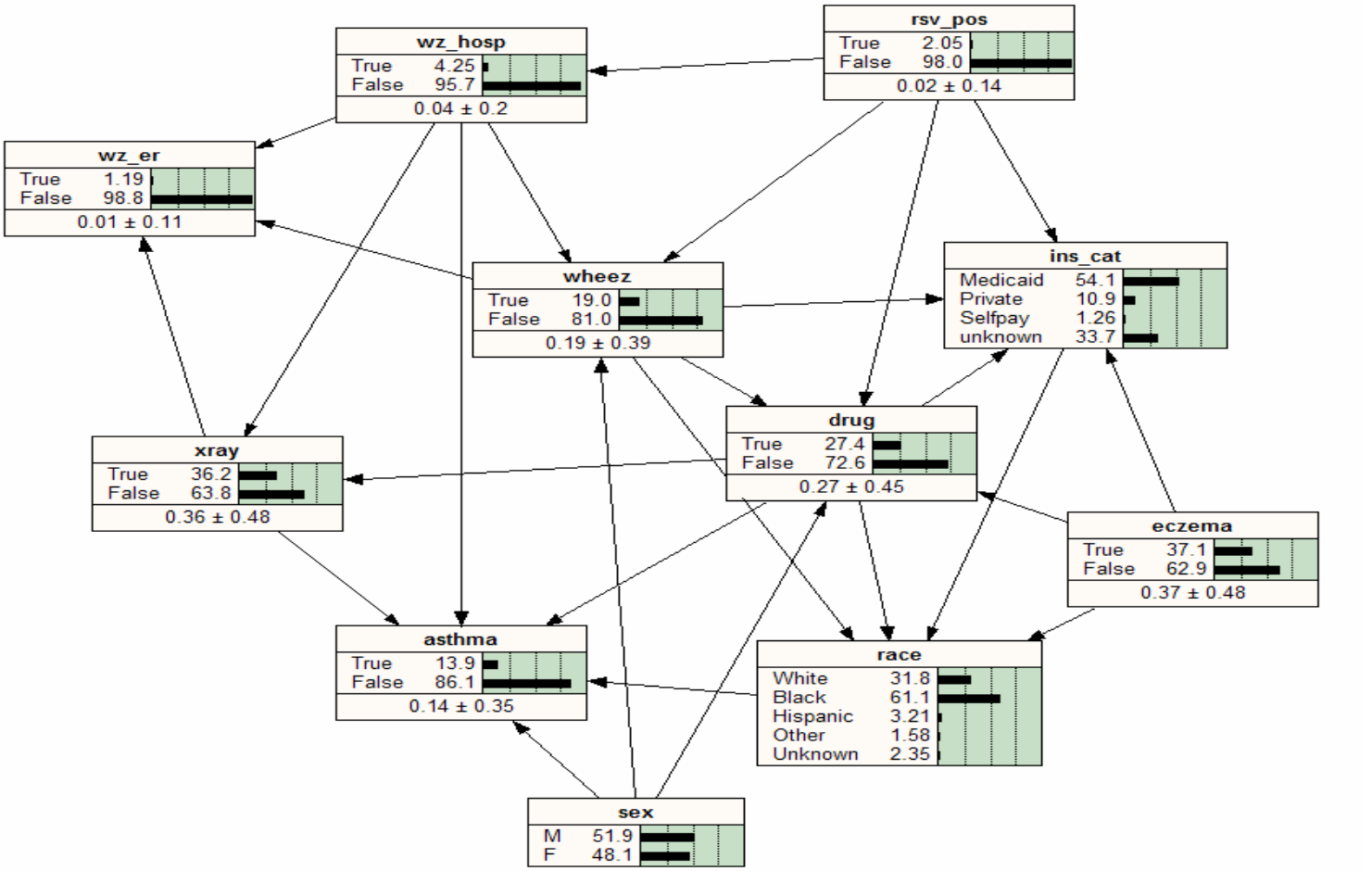
Evaluation

- Bayesian belief networks were trained on 11,000 training cases
- Ability of each network to discriminate children who develop asthma evaluated
  - 5000 test cases
  - 2000 prospective cases
- Power to discriminate was compared using receiver operator characteristic (ROC) curves

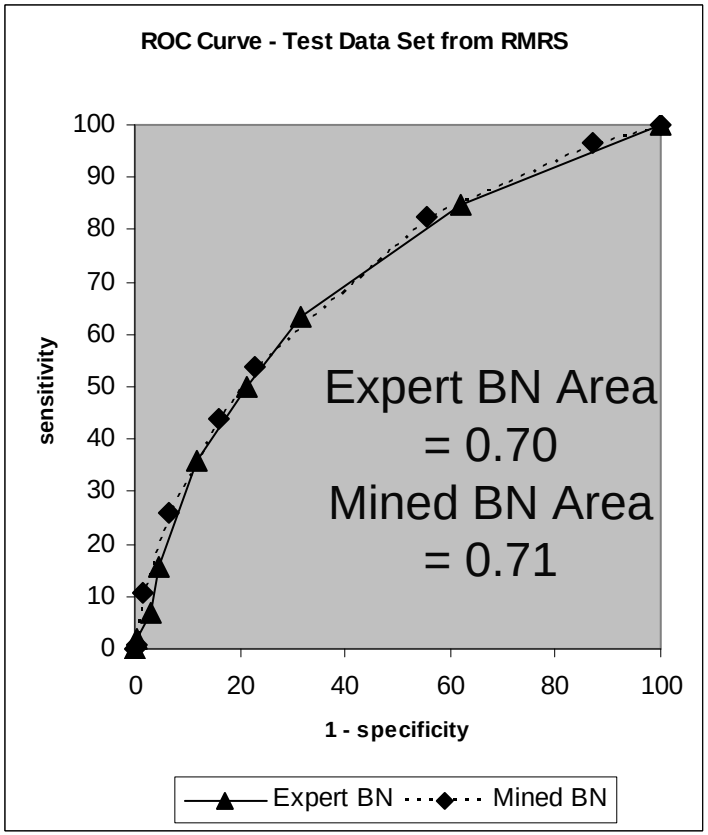
Belief Network Model (Domain Expert)



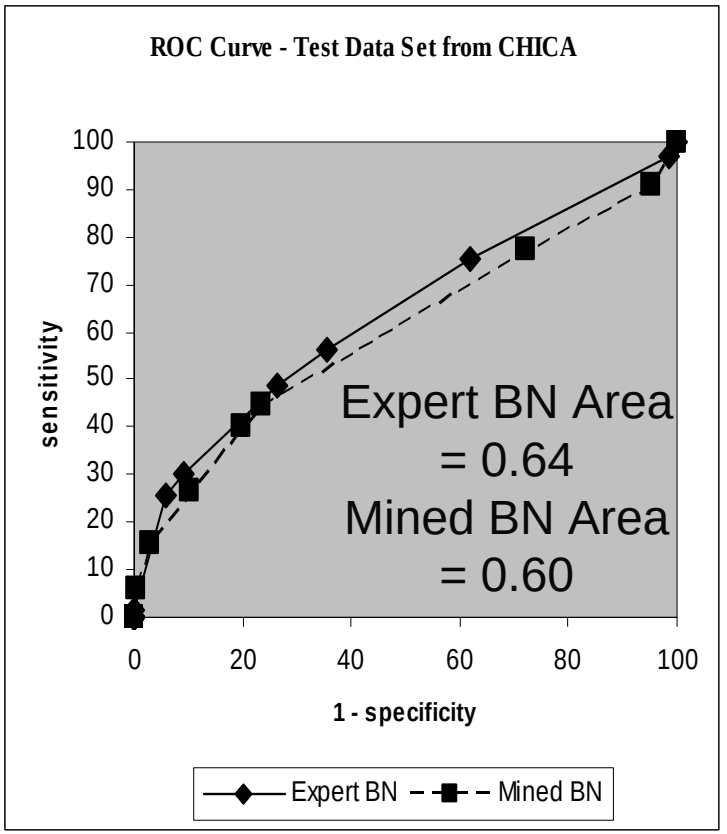
Belief Network Model (Mined from Data)



Results



ROC curve derived from 5000 test cases



ROC curve derived from 2000 cases collected prospectively

- Data Mined model had similar discriminative power to Domain Expert model.
- Slightly degraded performance when tested with prospectively collected data - data were incomplete.

Acknowledgements

- Drs. Downs, Biondich, Carroll
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Automated Surveillance for Catheter-Associated Bloodstream Infections

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Abstract

Traditional manual surveillance for catheter-associated bloodstream infections (CA-BSI) by an infection control specialist is costly and labor intensive. An automated computer-based surveillance system that utilizes existing laboratory, pharmacy, and clinical electronic information offers a more efficient and timely method of surveillance. We applied combinations of simple rules to patients with positive blood cultures in the intensive care unit (ICU) to determine whether automated surveillance is feasible. Compared to traditional manual surveillance, sensitivity and specificity of the best rule combination was 87.1% and 73.8%, respectively. This ruleset consisted of four rules: (1) culture collected > 48 hours after admission; (2) patient had central-venous catheter; (3) organism not a common skin contaminant OR either confirmed by repeat culture within 5 days or treated with vancomycin; and (4) organism not a coagulase-negative Staphylococcus. Monthly trends of infection rates rose and fell appropriately. This is comparable to previously reported results [1]. Additional rules may improve prediction performance.

Keywords:

algorithms, catheterization, Central Venous,
cross infection, Septicemia

Introduction

CA-BSI are a significant cause of patient morbidity and mortality in hospitalized patients. Surveillance of nosocomial bloodstream infections (BSI) is traditionally performed in the ICU by infection control specialists using medical charts, physician summaries, microbiology and pharmacy data. Standardized case definitions, usually those from the United States Centers for Disease Control and Prevention (CDC) National Healthcare Safety Network (NHSN), are used to identify CA-BSI. Yet, traditional manual surveillance is labor intensive and costly. Application of case definitions by infection control specialists requires considerable clinical judgment, and definitions are sometimes inconsistently applied. Electronic surveillance offers the potential for more efficient and timely detection of CA-BSI than traditional manual surveillance. An automated surveillance approach that utilizes existing laboratory, pharmacy, and clinical electronic information could shift infection control specialists' time towards prevention, rather than surveillance. Furthermore, development of an automated surveillance system could potentially extend surveillance outside of the ICU, where there is currently an absence of surveillance efforts at most hospitals. The aims of this study were: (1) to develop an automated computer-based surveillance system with the use of existing laboratory, pharmacy, and clinical electronic information; and (2) to compare traditional manual surveillance to electronic surveillance among ICU patients.

Methods

The study was conducted with patients in the ICU at Barnes-Jewish Hospital, a 1250 bed tertiary-care teaching hospital located in Saint Louis, Missouri. Positive blood cultures collected between July 1, 2005 and June 30, 2006 were evaluated; cultures were excluded if the same organism had been recovered from the blood in the previous 7 days. Infection control specialists reviewed each patient to determine presence or absence of CA-BSI using CDC NHSN definitions [2]. Simple "yes-no" rules and combinations of these rules, similar to those used by Trick et al. [1], were applied to electronic data to determine if a positive blood culture represented a CA-BSI. The rules were:

1. Culture collected > 48 hours after admission
2. Patient had central-venous catheter (CVC)
3. Organism not a common skin contaminant OR either confirmed by repeat culture within 5 days or treated with vancomycin
4. Organism not a coagulase-negative Staphylococcus
5. Organism not grown from wound or urine cultures after positive blood culture
6. Organism not grown from wound or respiratory cultures after positive blood culture
7. Organism not grown from wound, urine, respiratory, sterile other, or non-sterile other cultures after positive blood culture

Secondary culture sites such as wound, urine, respiratory, sterile other, and non-sterile other were considered, as well

as their collection time relative to the positive blood culture (i.e., before, after, or ever). Using infection control as the gold standard, we evaluated the ability of various combinations of rules to determine CA-BSI; sensitivity, specificity, predictive values were calculated. The agreement between infection control surveillance and the rulesets was assessed with the kappa statistic. Monthly rates of CA-BSI per 1,000 patient line-days were calculated for manual and electronic surveillance. Discrepancies of case determination were compared between manual surveillance and the best performing rulesets.

Results

During the study period 771 positive blood cultures from 540 patients were evaluated. Infection control specialists identified 70 (9%) CA-BSIs. The most common organisms were coagulase-negative Staphylococci (45%), Corynebacterium species (6%), *Candida albicans* (5%), *Staphylococcus aureus* (5%), *Enterococcus faecalis* (5%), *Enterococcus faecium* (5%), and *Klebsiella pneumoniae* (3%). Rules did not perform well individually. Performance of the best performing combination of rules is shown in Table 1.

Table 1 - Performance of combined rules

Rules	# BSIs predicted	Sens %	Spec %	PVP %	PVN %	Kappa
1,2	459	97.1	44.2	14.8	99.4	.118
1,2,3	362	95.7	57.9	18.5	99.3	.186
1,2,3,4	245	87.1	73.8	24.9	98.3	.287
1,2,3,4,5	230	80.0	75.2	24.3	97.4	.272
1,2,3,4,6	208	72.9	77.6	24.5	96.6	.267
1,2,3,4,7	184	62.9	80.0	23.9	95.6	.247

The combination of rules with highest agreement with infection control surveillance (kappa = .287) identified 245 (32%) CA-BSIs. This ruleset, which included rules 1, 2, 3, and 4, had a sensitivity and specificity of 87.1% and 73.8%, respectively. Although the rulesets with rules 1 and 2 as well as rules 1, 2, and 3 had higher sensitivity, this ruleset had higher specificity and better agreement with infection control surveillance. Augmentation of the best ruleset with cultures from secondary sites marginally increased specificity but decreased sensitivity and the kappa statistic. Secondary site cultures collected before positive blood cultures improved rulesets better than those collected after or ever. Manual surveillance detected 2.64 CA-BSI per 1,000 line-days while the best performing ruleset predicted 9.24 CA-BSI per 1,000 line-days. CA-BSI rates are displayed in Figure 1.

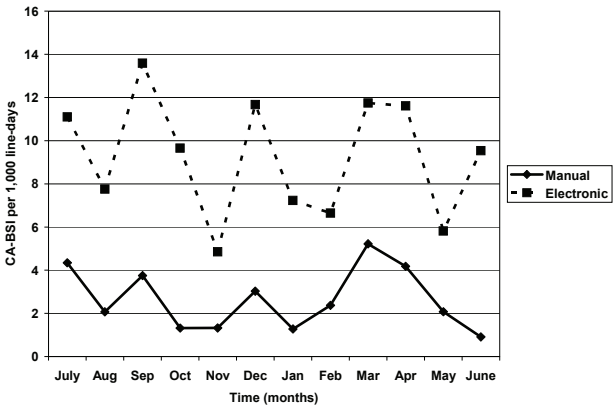

Figure 1 - Performance of rules in determining rates

Of 771 positive blood cultures, 193 (25%) were classified differently by manual versus electronic surveillance methods. Among 70 gold standard CA-BSI, the ruleset failed to classify 9 of these positive blood cultures as CA-BSI; 7 patients had a common skin contaminant, 1 had a community-acquired infection and a common skin contaminant, and 1 had misclassified CVC usage data. Among 701 positive blood cultures not classified as CA-BSI by infection control specialists, the ruleset classified 184 positive blood cultures as CA-BSI; 73 had a secondary organism grown from wound, urine, respiratory, sterile-other, or non-sterile-other sites. Other reasons for misclassification remain to be studied.

Discussion

An automated surveillance system that utilized existing patient data was able to identify CA-BSI with reasonable sensitivity and specificity. Our results are comparable to those reported by Trick et al. [1]. Although sensitivity and specificity need to be improved, trends of infection rates rose and fell appropriately. The high negative predictive value of our rulesets is promising. In the absence of perfect sensitivity, infection control specialists may benefit most from a list of patients without CA-BSI. As with any analyses dependent on electronic data, errors exist. For instance, 1 gold standard CA-BSI was not classified as a CA-BSI by the ruleset due to not having a CVC; yet the patient medical chart recorded CVC usage. In addition, July and August line-day information did not include PICC lines; a sensitivity analysis shows that this did not change CA-BSI rates substantially. Automated surveillance of CA-BSI has several advantages including consistent application of case definitions, reallocation of infection control specialists' time from surveillance to prevention efforts, and extension of surveillance outside of the ICU.

Conclusion

Automated CA-BSI surveillance may be useful for identifying trends for manual investigation. Future work will be to improve on the rulesets and to evaluate alternative methods of analysis, such as logistic or Bayesian prediction models.

Acknowledgement

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Automated Surveillance for Catheter-Associated Bloodstream Infections

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Funded by Barnes-Jewish Hospital Foundation Grant Award 00426-0805-01

Barnes-Jewish Hospital
BJC HealthCare

Washington University in St. Louis
Physicians

Introduction

- Catheter-associated bloodstream infections (CA-BSI) are a significant cause of patient morbidity and mortality
  - Adds approximately 20 days to hospital length-of-stay[1]
  - Increases costs by $35,000 to $56,000[2,3]
  - Attributable mortality of up to 35%[1]

- Traditional surveillance for CA-BSI
  - Performed by Infection Control Specialists
  - Apply United States Centers for Disease Control & Prevention (CDC) National Healthcare Safety Network (NHSN) case definitions
  - Use medical charts, physician summaries, lab & pharmacy data
  - Limitations
    - Time consuming & costly
    - Often limited to Intensive Care Units (ICUs)
    - Inconsistent application of case definitions

1 Pittet D, et al. *JAMA* 1994;271:1598–601.

2 Rello J, et al. *Am J Respir Crit Care Med* 2000;162:1027–1030

3 Dimick JB, et al. *Arch Surg* 2001;136:229–234.

Methods I

- Specific Aims
  - To develop automated surveillance system for CA-BSI by integration of existing electronically available data
    - Microbiology positive cultures
    - Pharmacy information
    - Laboratory data
    - Vital signs
    - Central venous catheter (CVC) usage
  - Compare automated surveillance to manual chart review (gold standard) with sensitivity, specificity, predictive values, kappa
- Study Population
  - Barnes-Jewish Hospital, a 1250 bed, tertiary-care teaching hospital affiliated with Washington University School of Medicine in St. Louis, Missouri
  - ICU patients with a positive blood culture between July 1, 2005 and June 30, 2006 (1 year)
  - Cultures were excluded if same organism recovered from blood in previous 7 days

Methods II

- Manual Surveillance
  - Infection Control Specialists identify patients with positive blood cultures from hospital informatics database
  - Review of medical charts, physician summaries, microbiology & pharmacy data
  - Application of CDC NHSN case definitions to determine CA-BSI

- Automated (Electronic) Surveillance
  - Patients with positive blood cultures identified from hospital informatics database
  - Additional electronically available data on these patients pulled by standardized query into an analysis dataset
  - Simple yes/no rules and combinations of rules applied to electronic data to determine presence or absence of CA-BSI

Simple Rules (Yes/No)

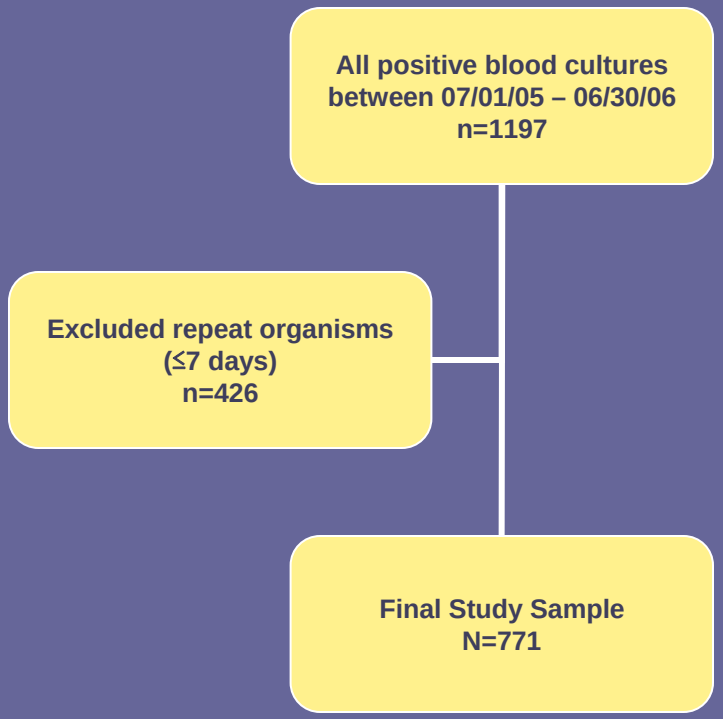
1. Blood culture >48 hrs after hospital admission*
2. Patient had CVC ≤48 hrs before blood culture*
3. At least one of the following:*
    a. Blood culture positive for non-common skin contaminant pathogen
    b. Blood culture positive for common skin contaminant
        - Confirmed within 5 days

          OR
        - Patient received vancomycin
4. Blood culture positive for organism other than coagulase-negative staphylococci*
5. No wound cultures before**
    – i.e., no wound culture positive for same organism before positive blood culture collection
6. No urine cultures before**
7. No respiratory cultures before**
8. No sterile other cultures before**
9. No non-sterile other cultures before**

*Similar to rules reported by Trick et al. *Emerg Infect Dis*. 2004;10:1612-1620.

**Cultures from secondary sites were also evaluated if collection was (1) after or (2) before or after blood culture collection

Results I



- Study Population
  - 771 positive blood cultures
  - 540 patients
  - 70 (9%) CA-BSI by manual review
  - 701 (91%) without CA-BSI
- Positive Blood Cultures
  - Coagulase-neg Staphylococci (45%)
  - Corynebacterium species (6%)
  - *Candida albicans* (5%)
  - *Staphylococcus aureus* (5%)
  - *Enterococcus faecalis* (5%)
  - *Enterococcus faecium* (5%)
  - *Klebsiella pneumoniae* (3%)
  - Other (26%)

Table 1. Performance of Rulesets

Ruleset	# CA-BSI Confirmed by Rules N (%)	Sensitivity %	Specificity %	PPV %	NPV %	Kappa *
1,2	459 (59.5)	97.1	44.2	14.8	99.4	.118
1,2,3	362 (47.0)	95.7	57.9	18.5	99.3	.186
1,2,3,4	245 (31.8)	87.1	73.8	24.9	98.3	.287
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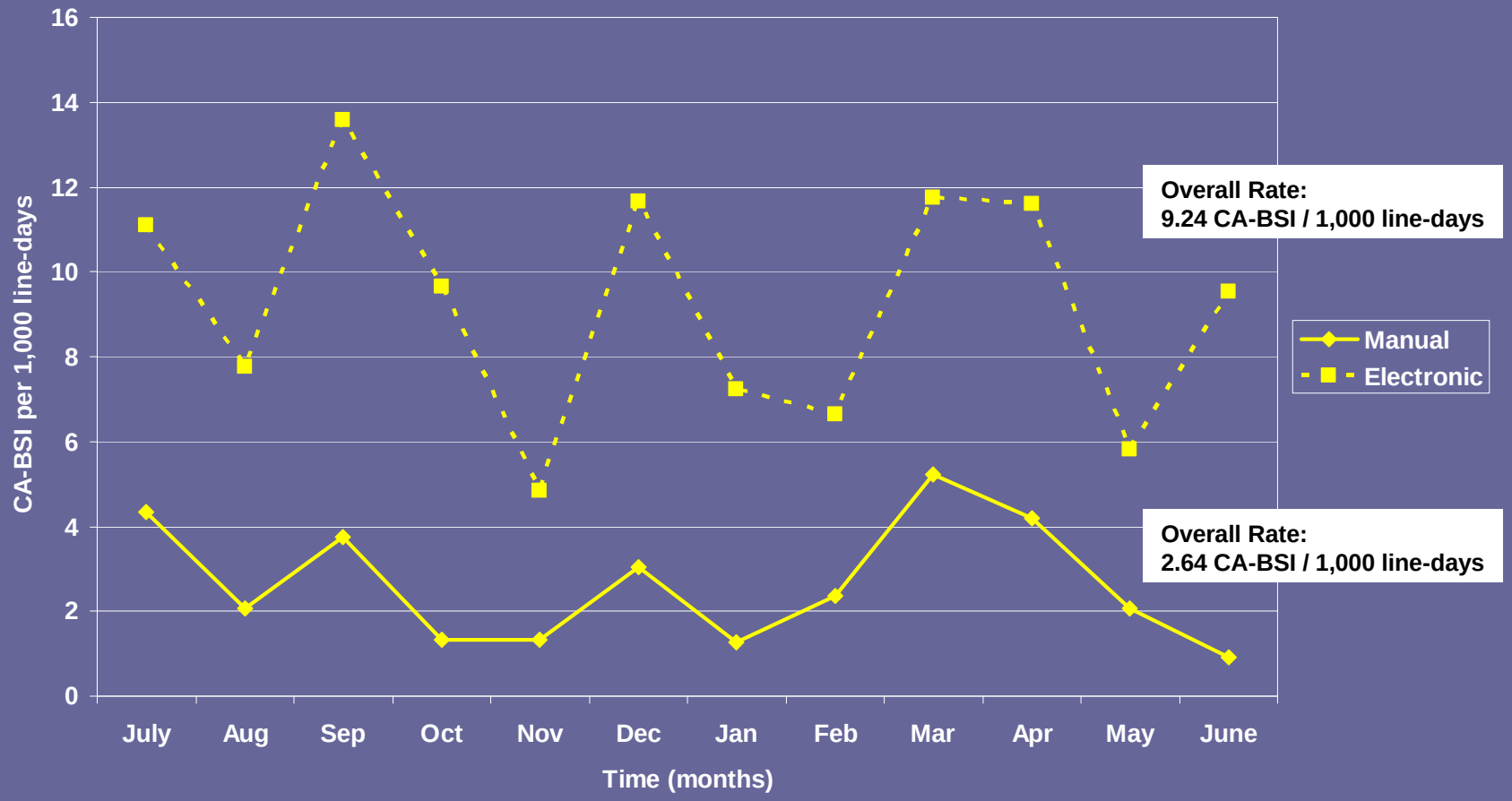
1,2,3,4,5,7	208 (27.0)	72.9	77.6	24.5	96.6	.267
1,2,3,4,5,6,7,8,9	184 (23.9)	62.9	80.0	23.9	95.6	.247

* 0 ≤ Kappa ≤ 0.4 denotes *marginal* reproducibility

* Secondary site cultures collected before blood cultures improved rulesets better than those collected after or ever

Figure 1. CA-BSI Surveillance Rates



Results II

- Of 771 positive blood cultures, 193 (25%) were classified differently by manual versus electronic surveillance methods
  - Among 70 gold standard CA-BSI, the ruleset with rules 1,2,3 and 4 failed to classify 9 of these positive blood cultures as CA-BSI
    - 7 patients had a common skin contaminant
    - 1 had a community-acquired infection and a common skin contaminant
    - 1 had misclassified CVC usage data
  - Among 701 positive blood cultures not classified as CA-BSI by infection control specialists, the ruleset with rules 1,2,3 and 4 classified 184 positive blood cultures as CA-BSI
    - 73 had a secondary organism grown from wound, urine, respiratory, sterile-other, or non-sterile-other sites
    - Other reasons for misclassification remain to be studied

Discussion

- Advantages
  - Consistent application of case definitions
  - Reallocation of infection control specialists' time from surveillance to prevention efforts
  - Potential extension of surveillance to non-ICU wards
  - High negative predictive value of rulesets provides infection control specialists with a list of patients that do not have CA-BSI
- Limitations
  - Errors in electronic data
    - Not all CVC usage captured by electronic data (e.g., 1 gold-standard CA-BSI with CVC usage recorded in medical chart was not classified as having a CVC in electronic data)
  - Line-day data lacks PICC line information for 2 out of 12 months
    - Sensitivity analysis: Adding PICC line information to CVC line data increased line-usage by 3.9%, on average. This did not substantially change CA-BSI rates.

Conclusions

- An automated surveillance system that utilized existing patient data was able to identify CA-BSI with reasonable sensitivity and specificity.
- Although sensitivity and specificity need to be improved, trends of infection rates rose and fell appropriately.
- Automated CA-BSI surveillance may be useful for identifying trends for manual investigation.

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A Conceptual Framework to Manage and Improve the Decisions of Multidisciplinary Committees in Oncology Using Computer-based Supports

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Abstract

Medical decision making and health care managements are more and more a multidisciplinary approach especially in the field of oncology. Multidisciplinary meetings have to be supported in order to improve decisions taken and patients care. To meet this objective, supporting the various decision making processes and facilitating the use of the best medical knowledge is essential. We have identified and explained six decision making processes to assist MCO (multidisciplinary committees in oncology). We are offering a conceptual framework aiming at pointing the means to be used for decision making in order to improve this process. Support for structuring and carefully presenting each patient's case, support for the selection of the most appropriate treatment using both computable guidelines and computable clinical trials is at the heart of our proposition.

Keywords:

professional staff committees,
decision support techniques, clinical practice guidelines,
clinical protocols, clinical trial, medical oncology

Introduction

Medical decision making and health care management are more and more a multidisciplinary approach especially in the case of complex or malignant diseases. Oncology is a typical example of such care organization. In many countries, multidisciplinary committees in oncology (MCO) have been set up in order to discuss patients' cases with the objective of optimizing each patient's healthcare management, taking into account the knowledge of the different domain specialists (including surgeons, radio-oncologist, pathologist, chemotherapist). Recently in France, a national plan has been launched to impose a mandatory consultation of such committees before any treatment strategy in oncology. These committees have to use multidisciplinary meetings, existing guidelines and standard protocols in order to provide patients with specific care recommendations according to the best accepted practices. Usage and compliance with guidelines and standards on care is one quality criteria explicitly mentioned in the French Cancer National Plan and have to be regularly reported by MCO.

As mentioned by Hammond et al. ten years ago [1]: "The number and wide variety of guidelines and protocols used in treatment trials, and the amount of clinical data generated suggest the need for computer-based support". Nowadays, because of the ever more important mass of information, we argue that using computers is mandatory if continuous quality improvement for patients care is required. Indeed, computable guidelines and decision support systems may be useful [2] at several levels for establishing and practically organizing a MCO. In this article, we present a conceptual framework which is efficient both in terms of improvement of the patients management, and in terms of producing and enriching the medical knowledge required for this improvement.

Our aim in presenting this conceptual framework is to offer an analysis that suggests decision support system solutions and organization principles that applies broadly to almost any situation in which multidisciplinary committees must be efficiently set-up and consulted in order to improve patient cares.

MCO Organization

There are several MCO in a care structure (one for each neoplasm domain: neurology, hematology, genecology …). These multidisciplinary committees follow similar work processes and often follow the same organization and planning in order to perform their tasks. The typical organization of a multidisciplinary committee in oncology has been analyzed by Castel et al. [3]. The MCO operational principle and the patient's case workflow on which a therapeutic opinion must be given can be summarized as follows:

- all cancer patients for whom the establishment or modification of an oncology treatment is required must be gathered and registered by the MCO secretariat;
- MCO regularly schedules Multidisciplinary Committee Meetings (MCMs) in order to provide therapeutic advice on the patients' cases submitted.
- each case submitted and registered is integrated in a summary clinical document used as basic information during each MCM to decide on the patient specific care management to recommend. It should be noted that those cases corresponding to a standard management procedure which has a multidisciplinary agreement translated into a clinical practice validated and up to date, are not systematically presented and discussed during an MCM. In some MCOs, an expert coordinator working in contact with the multidisciplinary committee members may decide for the most appropriate approach in compliance with the reference guidelines approved by this multidisciplinary committee. The expert's mandate aims at relieving the work load during MCMs who will then dedicate more time to complex and / or atypical cases);
- whether discussed during a MCMs or resolved by the expert, a written recommended therapy supported by reference practices and / or items of discussion stating any reason for non compliance to the existing reference guidelines, is given for each case;
- finally, the MCM's therapeutic recommendations are recorded and the referring practitioner is informed of the future management decision for the patient concerned.

MCO must organize and control the quality of the whole decision making process and the effective application of the opinion/recommendation given. Usage and compliance with clinical practice guidelines is a key point in this respect. Establishing procedures for controlling, monitoring and improving is paramount to check that the opinion given complies with the clinical practice guidelines approved by the MCO. The adequacy rate between the opinion given and the practice standards is one of the quality oriented indicators of the compulsory report activity required from any MCO.

The MCO typical workflow description must be supplemented with additional data for all MCO involved in therapeutic trials. In some care centers indeed, MCO have the responsibility to offer patients alternative treatments to the standard ones, informing them of the availability of one or several potentially promising therapeutic treatments they might benefit from. Improving patients' enrolment in on going therapeutic trials is a constant concern viewed as a supplement to a treatment or to standard alternatives possibly submitted to patients.

System design: objectives and features

The MCO workflow review highlights various processes in which several decision support systems might efficiently help optimizing the organization and improve the patient's management situation (figure 1):

1. **support for structuring the document presenting the case of each patient.** This document content is essential to the decision making process, given that therapeutic options are going to be founded on this information basically. It must contain all the relevant, rigorously informed decision making criteria. The decision focuses on the use of explicit criteria to which a value is attached [4]. The nature of these criteria is obviously dependent on the type of tumor (volume, lymph nodes, hormone receptors, chromosome deletion etc.). Within the collaborative medical decision making process framework, Christensen et al. [5] evidenced the relevance and importance of formatting and presenting problem-relevant information by means of such a document. This is conventionally a paper or an e-form filled-in before or during the MCM. The main objective of a system for structuring the case record of a patient would be to ensure that the relevant information for the patient's case and for the final decision is brought to light and shared by all members of the committee. All relevant information describing the patient's case must be drawn from decisional criteria available in the guidelines and protocols, from those cases already resolved and from on going therapeutic trials.
2. **support for selection of cases which have to be discussed within a MCM.** To that effect, a decision support system based on MCO approved guidelines is required. The system's main objective is to provide with recommendations relevant to the patient's case. When for instance such a system offers a standard therapy with no alternative solution, the expert may then support the system's decision and decide not to present the case to the MCM.
3. **decision and argument support for the MCM.** Such a system must make use of all the knowledge available to put forward alternative therapies issued from: 1) standard guidelines and protocols; 2) clinical trials in which the patient can possibly be enrolled; 3) the case database to identify similar cases for which a positive (or negative) therapeutic response was recorded. Using a case database presupposes the patient's follow-up and an adequate feedback on the effective observance of the therapy recommended by the MCO, with its effect on the patient. Rossille et al. [6] have proposed a system aiming at supporting the MCM in their decisions for non-standard cases (cases

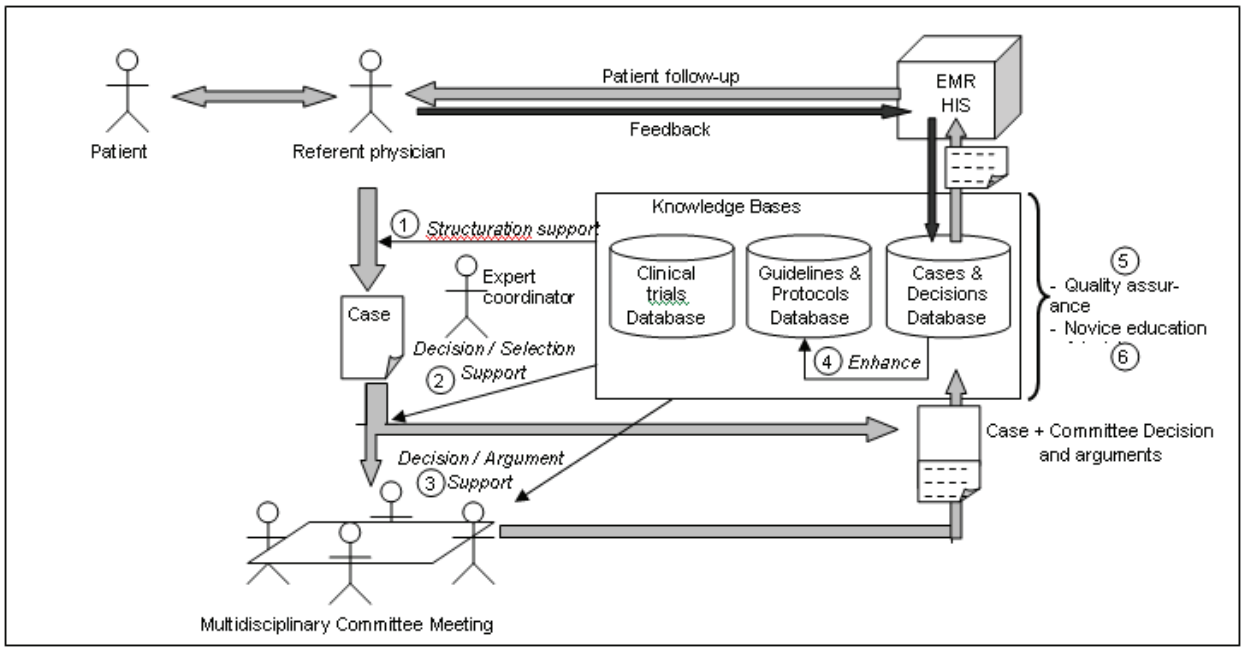

Figure 1 - MCO organization and workflow

that do not/cannot comply with guidelines' recommendations). This system technically used both rules basedand case based reasoning. In our opinion, such system could be improved taking into account clinical trials database in order to provide selection of relevant trials for a given patient. Using a comprehensive decision support system to decision making process would also be interesting used as a support to the discussion during MCMs and to support and evidence the committee's decision based on the system's proposition.

4. **guidelines improvement and local adjustment**. Sauvagnac et al [4]. argue that a multidisciplinary committee is the right place for advancement and particularization of protocols and guidelines. To that end, we must bear in mind that these care standards must be explicitly expressed in order to be clearly understandable and unambiguous for all the specialists. Computerization of guidelines is a good mean to achieve this in depth explanation. Guidelines become fully operational and can be checked and strengthened. In the same line, the decision criteria can be specified during to the computerization process and during their use within the MCMs. Thus, it can become a virtuous circle: guidelines operate for multidisciplinary committees; multidisciplinary committees operate for the advancement of the guidelines themselves. Improving the guidelines and their possible local adjustment or adaptation means using the knowledge derived from the MCMs decisions and using the information on the patient's follow-up (efficiency of the treatment, therapies available, side and noxious effects, quality of life, life expectancy,…). A review of cases for which a recommendation was put forward by the system and the MCM prescription who followed this recommendation on the one hand, and actions actually implemented for these patients on the other hand, is extremely useful in improving the Departments operational procedures (in those Departments treating these patients) and in assessing the guides and recommendations adaptation to the real clinical conditions.
5. **facilitating the quality control**. We need tools which provide help in order to analyze the cases for which the Committee has given an opinion beyond the usual guidelines. Setting up a cases and decisions database and computable guidelines database can facilitate the quality assurance process and results. A computable guidelines system can be used both 1) prospectively, to help the expert or the committee in their search of the best standard solution satisfying adequately the case of the patient; 2) retrospectively to identify and review those cases for which a non standard solution was recommended by the MCO.
6. **education and training**. Setting up and making available knowledge bases can also be used as tools for the physicians' formation and training. Such bases can be used to enrich a training environment and enable trained practitioners to look into the decision making rules, check their scope of implementation and identify their limitations.

Pilot implementations

Within our healthcare establishment's MCO, we have implemented the functionalities described above. This pilot implementation is based on a re-use of our guidelines development and dissemination platform described elsewhere [7].

Computable guidelines (neuro-oncology domain)

In a collaborative effort with the neuro-oncology MCO, we have established an I.T. based system using computable guidelines to facilitate the identification of standard and validated therapies applicable to each patient's case. Within this MCO, cases that will be reviewed during the next MCM are collected in a computer file and recorded in a proprietary database into the hospital information system (HIS).

We have developed a prototype focused on the treatment of gliomas. Textual guidelines provided by authoritative organization [8] have been successfully computerized using our platform. A software component has been built in order to couple this HIS database and the computable guidelines. This component is based on XSLT facilities in order to process the data extract from the HIS database into an XML document which can be processed by our computable guidelines system. The system output for each patient case is a synthetic and structured document on which the patient's data are summarized on the left hand side and the recommendations adapted to the patient's profile are displayed on the right hand side (figure 2). This document is designed for printing and use both by the MCO expert and by the multidisciplinary group during the MCM.

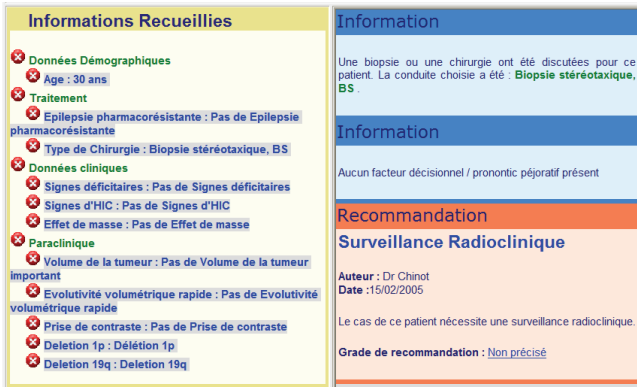

Figure 2 - Output of the computable guidelines system

So far we have computerized 4 guidelines focused on the different glioblastoma grades. We are working on computerizing other guidelines.

Clinical trials (thoraco-oncology domain)

In joint collaboration with the thoraco oncology MCO, we have developed a system aiming at improving the patient's enrolment rate in on going therapeutic trials.

To meet this objective, we have come up with additional developments to enrich and modify the functionalities of our decision support system and turn it into a management and reminder tool for those therapeutic trials in which patients are susceptible to be enrolled. The result is a definition of all inclusion criteria for the various therapeutic trials concerned and translation into the formal format used in our decision support system. The inclusion criteria correspond to the « rule-in » and the exclusion criteria are the « rule-out » elements of a conventional computerized guideline system. Here again we make use of a software component to link computerized therapeutic trials to the patients database used by the MCO (in this MCO they use a MS Access database). The software application is hosted in a laptop computer with real time use during the MCM. The screen displays the patient's data and possible inclusion protocols, and this is in turn displayed to the MCM participants (figure 3). For each individual patient, the system mentions inclusion or not within the therapeutic trials(top of the screen), the number and reason(s) for non inclusion in each trial (bottom right of the screen), and the relevant patient's data (bottom left of the screen).

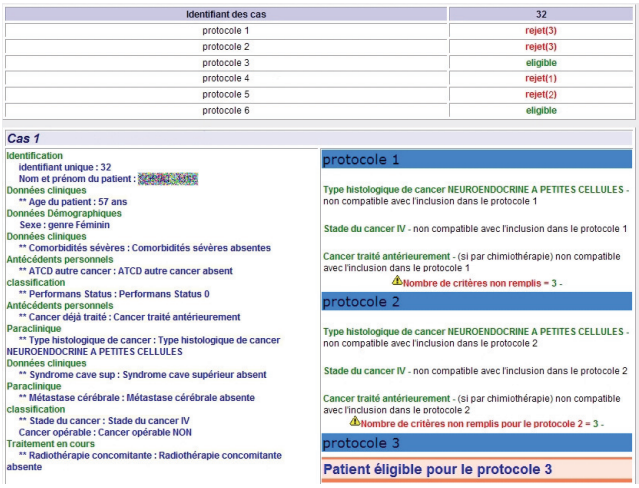

Figure 3 - Screen copy of the clinical trials selection system

Future work will be the enhancement of the graphical users interface and assessment of the efficiency of the system using a before- after study.

Discussion

The multidisciplinary decisions and management are a prerequisite to any medical act, especially when dealing with complex, intricate pathologies whose management

involves a delicate approach. As to oncology, MCO offer an organizational frame enabling to partly formalize the decision making process. The MCO ultimate objectives are to improve therapy management and to cut down any non justifiable deviation and disparity when managing patients. These objectives are best met when the various decisions making processes are supported to the best extent and when the best medical knowledge is used within the processes. We propose a conceptual framework to help identifying those decision support systems which should be used to improve the decision making process applied within the MCO. Support for structuring and carefully presenting case of the patient, support for selecting the most appropriate therapy using both computable guidelines and computable clinical trials is the core of our propositions.

Implementing computable guidelines is the way to make operational that knowledge directly in-bedded into the decision making process. The use of decision support systems which are based either on guidelines or/ and on case-bases validated within the MCO frames the approach while avoiding any drift when selecting therapeutic options. During the MCM, guidelines play a safeguard role in removing part of the unnecessary subjective opinions in order to opt for a treatment compliant with objective scientific data and meeting the patient's needs. Using guidelines for instance may contribute to put into perspective experts opinions and judgments which sometimes impact more than required on the final decision. The weight of the expert's knowledge during a MCM can indeed be deleterious if justified only by the authority representing the rule specific to that expert [4]. It should also be seen to it that the inevitable social component presiding during the MCMs becomes over important, and that the discussion should be turned into a « battle of experts » far from the standard, validated and shared knowledge [9]. To that effect, computerized operational guidelines may contribute to avoiding this type of deviation while refocusing the discussion on tangible, accepted and explicit facts and knowledge. Finally, a more rigorous use of data from the literature and from the guidelines should be encouraged given that it contributes to the strengthening and support of evidence based decisions taken during the MCM.

Another justification for implementing computable guidelines within the MCO comes from the need to optimize the case workflow for those patients for whom an opinion is required. Optimizing the time to processing a patient case is vital especially in the field of oncology where any delay in the therapeutic management can have a fatal impact. There are cases when the MCM discussion is fully justified when facing a special, non typical case, for which no guideline can rigorously be applied or when the wish of a patient may induce a reviewed protocol decision, assessing the risks generated by deviating from the approach recommended. But many are the cases subject to discussion during a MCM which actually pertain to the standard protocol decision making process [4] and could therefore be identified, as is our suggestions, by means of an I.T. decision support system based on computable protocols and guidelines. What is important is to identify those standard cases and improve their processing time to dedicate more time to complex patient cases.

Using guidelines within MCO is also beneficial to better adapt and upgrade guidelines themselves. National or international guidelines are seldom used "out of the box". They must be customized and require a preparatory work with the physicians so that they can be used more easily – computerization is part of this work- with update based on the latest publications or for strategic refinement. They must therefore be locally adapted before becoming fully operational. MCMs are the right forum for improving the guidelines given that this is where such guidelines can be upgraded not in the light of new data or knowledge but based on their actual use [4]. Such improvement is made possible if what is recorded following a MCM is not the decision only, but the features of the cases treated which must also be registered; above all the elements in the decision helping to better understand the reason behind the decision must be recorded. Thus, the 'discussion trace' must be rich: discussions should be recorded in full and not limited to the final decision taken; it should be justified, with other hypothesis presented, the reasons for discarding them, the knowledge not shared by all (i.e. over specialized) reported to all the meeting participants during the discussion. These elements must enrich the case database from which it will be possible to update or find new knowledge used in setting the healthcare management standards. What is essential is preparing a virtuous circle. This presupposes formalizing the MCO practices and having adequate tools which will be beneficially used for decision taking in these committees and for building up on medical knowledge. What we are proposing as a conceptual framework within the MCOs using these computer-based supports follow this line.

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A Model Proposal for the Rational Prescription of Antimicrobials in Intensive Care Medicine

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Abstract and objective

Inadequate prescription of antimicrobials has been associated with increased toxicity and selection of resistant strains that adversely affect patient's health, especially for the infections treated in the Intensive Care Units. The AB+K clinical decision support system gathers information from electronic patient records, laboratorial reports, radiological findings, bed-side monitoring devices, antimicrobials and pathogenic agents resistances databases aiming at the choice of a rational antibiotherapy, based on the current condition of the patient and available drugs.

Keywords:

pneumonia, anti-infective agents,
computer-assisted drug therapy, intensive care units

Introduction

Inadequate prescription of antimicrobials has been associated with increased toxicity and selection of resistant strains that adversely affect patient's health and increases the costs of care. This problem is especially relevant for the community and nosocomial infections treated in the Intensive Care Units (ICU) due to the severity and complexity of their patients.

The AntiBiotherapy+Knowledge (AB+K) project aims at the design, development and validation of a solicited decision support system for friendly clinical guidance on the use of antimicrobials in Intensive Care Medicine. The applied decision rules are expected to reflect the expert knowledge on the area but also to validate and, if possible, infer novel knowledge.

Through the combination of several information technologies, clinical expertise and pharmacological concepts, the AB+K system is expected to improve the prescription of antimicrobials in Intensive Care Medicine. The clinical decision support system combines information collected from an Electronic Patient Record (EPR), laboratorial reports, radiological findings, bed-side monitoring devices, an antimicrobials database and a regularly updated model of pathogenic agents resistances in order to help the intensivist in the choice of a rational antibiotherapy, based on the current condition of the patient, the available drugs, and of the resistance profile of the pathogenic agent(s).

This research project may contribute to improve clinical performance concerning the prescription of antimicrobials and to the study of the community and hospital epidemiology of infectious diseases. All this is likely to improve the clinical management of ICU and patient's outcome.

Methods

General architecture

The AB+K decision support module feeds from three main sources: the Intensive.CARE electronic patient record, the Antibio-therapy Knowledge Base and the Medical Guidelines Module.

AB+K is intended to be fully integrated with the EPR. Specific screens are added to the EPR's graphical user interface, allowing the health professional to introduce the patient related values for the decision related variables. Nevertheless, in order to minimize data input by AB+K users, interfaces for other Information Systems (IS) are implemented to enable automatic collection of relevant data. The main sources are administrative applications (such as the Hospital Admition System (HAS)), other EPRs, bed-side monitoring, and laboratory departmental systems, supplying respectively demographic data, clinical data, vital signs reports and laboratory results. All patient related data is stored in a proper database schema.

A different database schema holds the antibiotherapy related data. This database schema is regularly updated with the list of available drugs, their pharmaceutical characteristics, recommendation, possible alternatives, side effects and interactions. Likewise, a regular update is performed on the documented resistances to antibiotics developed by the known pathogenic agents.

Decision rules, expressing the clinical guidelines, are used to infer relations among the variables and suggest a therapy the health professional. The ability to explain thoroughly every expressed suggestion is required to the decision module; hence decision trees are to be shown in

user interfaces. The health professional is asked to validate or refute the suggestions, thus contributing to the evolution of the expert knowledge.

Auxiliary departmental systems

Most Portuguese hospitals use a common Hospital Admission System (HAD). A set of Web Services have been developed to integrate the AB+K system with the HAD, through the EPR. The Clinical Pathology data is also incorporated, via a database level interface that enables the transfer of data between AB+K and the Clinical Pathology Departmental System.

Automatic acquisition of vital signs

The automatic acquisition of vital signs improves the quality and speed of data collection, while enabling the assembly of large electronic archives. Most Vital Signs Monitoring Centrals feature network interfaces that broadcast data in the Health Level 7 (HL7) standard. To take advantage of such a powerful tool, the AB+K framework is provided with a HL7 communication handler. For the time being, received data conveys the patient identification, a timestamp and five physiological parameters: arterial tension (PNIs and PNId), temperature (T), arterial oxygen saturation (SPO_2), cardiac frequency (FC) and respiratory frequency (R).

The AB+K decision module

Arguably, the implementation of internationally accepted medical guidelines is the best way to emulate medical reasoning. The patient current status is usually described in a number of variables (age, sex, symptoms, diagnosis, etc.) that may derive medical guidelines, medical papers on related topics or from the expert own experience. For the time being, AB+K implements the American Thoracic Society guidelines for the management of adults with community-acquired pneumonia, regarding the diagnosis, assessment of severity, therapy and prevention.

Due to the actual scarceness of data, no advanced decision models, like Bayesian networks, Decision Trees or Neural Networks can be yet applied. For any given patient, the decision variables instances are handled as Datalog facts and guidelines are expressed as Datalog rules, evaluated by a Prolog meta-interpreter. The reaches conclusions and respective explinations are sent to the Intensive.CARE interface through a specialized Java-Prolog interface.

The decision process is divided in two phases. Decision variables associated with patient's symptoms, epidemiologic conditions, physical examination, laboratory and radiology findings are handled first, trying to fit the case at hand into one of four distinct etiologies. The health professional is then asked to sanction the reached conclusion, if necessary by navigating the returned decision tree. In case of disapproval, the health professional may override the system suggestion and manually select the correct etiology.

Phase two proceeds from this point on. Specific rules are applied to discover the best possible prescription taking under consideration the list of available drugs, the documented resistances and the patient medical history. Again, the final suggestion, as well as the decision trees, is sent to the interface and the health professional is asked to sanction them.

Expected results

Speed

AB+K is expected to spend no more than 60 seconds in answer computing and delivery, because that is the amount time we consider the health professionals are willing to wait in the intensive care context.

Presentation

Therapeutic suggestions will be presented in an intuitive manner, illustrating the AB+K rationale. This is expected to improve the acceptability of the system, as well as the detection of inappropriate suggestions. Arguably, it will also improve the knowledge of the implemented guidelines by the health professionals using the system.

Integration in daily activities

Whenever possible, the EPR's data forms will be automatically populated with already known values for decision variables, in order to improve usability. These values may originate from the EPR, lab results or other patient data sources. Special attention will be given to the transformation of existing data on current information systems into the input variables used by the clinical decision support system.

Conclusion

Despite the importance of decision support systems for rational antimicrobials prescription in Intensive Care Medicine, many difficulties arise in their practical implementation.

First of all, information is highly scattered through-out many different data sources, possibly with many different data support structures and data access policies. The isolation of some information systems, the non-adoption of communication standards between the already existing data exchanging systems and several other issues of bureaucratic nature constitute great obstacles for the implementation of specialized interfaces to help integrate data.

Another major faced difficulty is the absence of a standard medical ontology that relates several different concepts and denominations hardens the task of expressing medical knowledge. Moreover, medical guidelines are most often subjective, providing great degree of freedom for the interpretation of the rules.

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Conceptual Model as a Tool for Assessing Knowledge in Decision-Support Development

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Abstract

In the development of a decision-support system the domain knowledge as well as the target work environment need to be assessed in order to capture the knowledge to be integrated in and provided by the system. This work describes the model used for the assessment, which is based on Activity theory and case studies of patients investigated concerning suspected dementia. The purpose is to investigate to what extent the theory is useful for the assessment and for transforming the informal knowledge into formal descriptions for knowledge representation and design of interaction. The resulting structure provides the data and their sorts and qualities, the tools that are used in assessing the data, the actions of transforming the data and contextual factors such as who is responsible for a certain action. The semi-formal structure can be transformed into a formal structure for representation by using the structure to identify requirements for formalisation languages.

Keywords:

decision making, computer-assisted;
artificial intelligence; models, theoretical, logic

Introduction

The decision-support system COGITAMUS is being developed for assisting medical personnel in the investigation of suspected cases of dementia [1]. When focus is put on the clinical activity, issues such as the distinction between facts, judgements, qualities of evidence, what is normal vs. abnormal, levels of dysfunctions, distinction between acts of decision and acts of data collection, sources of evidence, etc, become essential to clarify in order to formalise the knowledge correctly. An analysis of the qualities of the medical domain knowledge expressed in clinical guidelines is needed [1] as well as a thorough activity analysis of how the actual clinical work is performed. This work presents the investigation of the informal structures in the use context such as decision making processes, clinical guidelines, patient's health, domain knowledge, actors involved, vocabulary and language, etc, and the process of transforming the informal knowledge into a formal structure useful in decision-support development. The main purpose is to investigate the use context of the system through a work analysis with the prototype system integrated, which can serve as a coarse system specification for further development and be used for future evaluations of the system in daily practice.

Tools are needed in the process to accomplish this transformation, which have the ability to capture both low level details about qualities of evidence and high level purposes and other ingredients of clinical activity. Important aspects are the dynamics of a changing and evolving work situation and individual patients' need when facing a degenerative disease such as dementia. While there are methods that can be used for assessing structures of tasks and data-flow, Activity theory provides in addition the dynamic perspective, means to define levels of skill and knowledge of actors and motives for activity [2]. These are important aspects when evaluating decision-support systems. We use the cultural-historical Activity theory as described by Engeström [3] as theoretical framework in the analysis of the clinical work situation, since the theory embraces the multi-purposes of a decision-support system. The theory evolved within Russian psychology in the 1930's [2] and has been extended since then, mainly within social sciences, CSCW and developmental work research [4, 3]. The theory however, is often considered too broad and general to be of use in concrete design or formalisation tasks when developing systems [3, 5]. Therefore, a second purpose of this work is to evaluate the theoretical framework in this perspective, and form a model based on the theory useful for assessing formal knowledge and for informing the design of the interaction with the system.

Materials and methods

The activity analysis is conducted as qualitative case studies of five patients in the setting of an out-patient ward at a geriatric clinic which investigates patient's cases with suspected cognitive diseases including dementia. The patient's encounters with a physician were observed during a period of investigation. The physician's use of the decision-support system was video-taped and interviews were conducted with the patient, relatives and medical personnel.

The data was analysed by categorising events by their purposes and what object was in focus, in terms of Activity theory. Themes were identified, and further categorisation evolved in the process. When a semi-formal structure was obtained, the patient's cases were re-analysed using this

structure in order to test the validity and usability of the structure. The structure was adjusted accordingly.

Results

We take as starting point, the view that the clinical activity of investigation essentially consists of two parts; the *clinical activity* with its actions and sub-processes, and an *activity system* in terms of Activity theory, which includes the object for activity, resources involved and their relations, and which imposes constraints on the execution of the investigation activity. A necessary property of the anticipated model is an ability to capture dynamic and changing situations and objects. We use the notion of *object* for data and phenomenon such as symptoms or diseases, when referring to what is in focus for each action.

The presented results include definitions of views on the investigation process, sorting of purposes of activity, definition of activity, and the relation between clinical actions, evidence and mediating tools.

Levels of activity

In the initial analysis of actions with different purposes as part of the main activity, three types of processes were identified. Two of these constitute *reasoning procedures* including medical decisions; the investigation of specific domains and the main reasoning process. Further, a distinction is made of the *logistic* or *administrative* process, which is imposed by the rules governing the whole process. The three types represent different views of the clinical investigation activity. The processes are executed in parallel, they are cross-fertilizing and dependent on each other, and are partly overlapping depending on circumstances in the environment. This dynamic view of the activity of investigating cognitive diseases will be used as a basis for the analyses in subsequent sections and they correspond roughly to the levels of activity defined by Activity theory.

Some of the sub-processes involved in the activity are viewed in Fig 1. The levels distinguished by lines in the figure indicate the different levels of complexity in the actions. As can be seen in the figure, the activities of analytic and decisive character are organised in the upper levels. The actions defined at this level are typically defined as necessary for the main activity to be executed, according to the clinical guidelines and the domain knowledge. However, the level of necessity can differ depending on which guideline is used as tool for reasoning.

The object-creating actions, which are typically automated processes (i.e. operations in terms of Activity theory) for the experienced actor, are organised at the bottom of the structure in Fig 1. They are automated in the sense that the actor does not have to put mental load or conscious thought on the execution, instead the actor can focus on the larger perspective and motive for the activity, of which the action constitutes a part. These actions are typically administration of tools, such as executing tests and examinations involving the patient. The actions defined at the lower levels in our analysis can be exchanged by other actions which produce equivalent information necessary for accomplishing the decisive actions. Typically, this is the case when the routines and priorities at different workplaces direct the usage of different tools in the process, for instance, which x-ray methods to use. Differences in which tools that are used can also be consequences of different habits and values hold by individual actors.

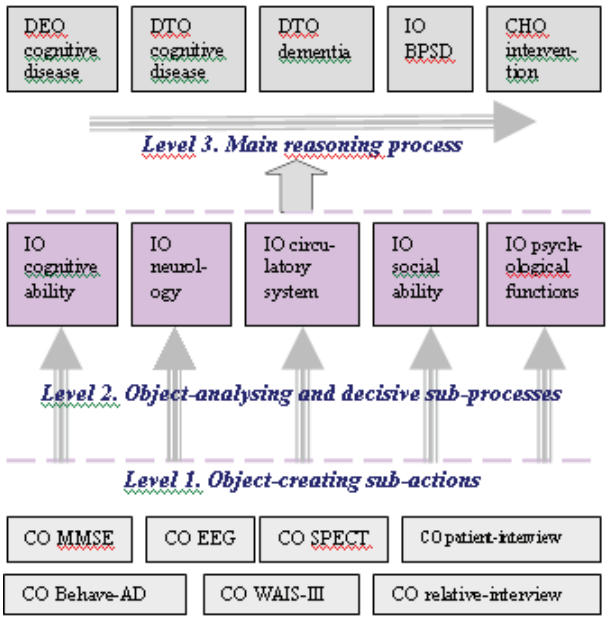

Figure 1 - Different levels of complexity in activities in the process of investigating cognitive diseases

The participation of patient and/or patient's family is necessary in the object-creating actions at the lowest level, however, not at the other levels. This gives suggestions on how a decision-support system should be designed and for what kind of clinical situations, depending on which kind of actions are to be supported. There may be less need of a support system in the clinical patient encounter situation for the experienced actor when the examinations for obtaining evidence are executed. However, at this level there are different clinically validated methods as well as ad-hoc methods that can be used. The less experienced actor can be supported in the choice of methods and in the execution of these sub-actions, as well as in the higher level actions of diagnostic reasoning.

A decision-support system should reflect the two-dimensionality of the reasoning process where one dimension can be seen as the gathering of data and interpreting the data into information, which is a process done with the general perspective of (healthy) function vs. dysfunction

(Level 2 in Fig 1). This process is orthogonal to the process of diagnostic reasoning and intervention, to which the information is fed as evidence in the reasoning towards diagnosis and appropriate choice of intervention. These two different purposes of actions are important to distinguish in the formalisation of the domain knowledge that is used in the transformation of information at the different levels. Basically, the first purpose is to value functionality per se and the second purpose is to value the function or dysfunction in the perspective of dementia diagnosis and intervention.

Sorts and typing of activity

When the investigation process as performed in the case studies was analysed, different sorts of actions were distinguished by the purpose, or the *goal* of a particular action (Table 2). Typically, the actions were aimed at either collecting raw data (CO); refining or interpreting raw data or knowledge (RO); using the interpreted data for higher level of reasoning for the purpose of determining the existence of a phenomenon (DEO); determining the type of a phenomenon, i.e., increasing the level of granularity in the knowledge (DTO); imposing changes to the phenomenon in focus, and valuing the effects thereof (CHO; ECHO). The actions of higher complexity which aim at a holistic assessment and change of a phenomenon we denote *investigation* actions (IO), which typically integrate all the other purposes. In addition, actions were identified which aim at controlling and directing the process (DA). Examples of such actions are referrals for examinations, involving colleagues for consultations, assignment of tasks to team-members and team-meetings. In Table 2 the sorts of actions are defined.

Table 1 – Sorts of action

Sort	Purpose	Examples of clinical procedures
CO	Create object	Laboratory tasks, executing clinical tests, interviews, etc
RO	Re-representation / refinement of object	Interpret test results, documentation
DEO	Determine the (amount of) existence of object	Value evidence, diagnosis
DTO	Determine the classification of object, increase granularity	Differential-diagnosis
CHO	Change of object	Interventions
ECHO	Evaluating results of change action	Follow-up
IO	Investigation of object	Include diagnosis, intervention, follow-up
DA	Direction of activity	Referral, delegation, consultation, teamwork

IO corresponds to the level of *activity* in terms of Activity theory. The definition implies both assessment of information about the object and change of the object, thus, including the other types of actions. In the larger perspective of investigation of dementia, activities of sort IO can also constitute actions. The basic difference between the different levels of activity in terms of Activity theory is the definition of the purpose of the task, where activity has a *motive* and is driven by a need, while actions have a *goal*, which constitutes a sub-goal for the activity they are sub-actions to. Operations have no consciously defined goal on their own. We make no firm distinction between the levels other than distinguishing the main activity as an activity. Whether the operations are interesting to distinguish from actions depends on the perspective of analysis. An evaluation of an individuals' use of the system needs to integrate the distinction in order to capture a learning process. However, for the purpose of the general analysis in this work we take the notion of *action* as the basic entity for all tasks independent of level of activity.

Definition of activity

All types of actions are executed by the same kind of structure, the *activity system*, here represented by *Actor, Tool* and the context-related sort *Community* which includes roles, rules and division of work. Further, since the foci of all actions are related to issues concerning the patient, a patient ontology contributes with the *Object* and *Motive* to the definition of activity. Lastly, the components which describe the execution of an action are added, such as the sort, state, outcome and information about the hierarchical structure of actions. We use the same constructor for all sorts of actions, where *Goal* defines the sort of an action and the sets of actions (*Act, A*) can be used to identify the position of an action in the main activity. Further, the actor, set of communities and set of tools (*Actor, T, C*) define the physical and social context of the activity. The following constitutes a general definition of *Action*:

action: [Motive, Goal, Object, Act, A, T, Actor, C, State, Outcome] −> Action

where *action* is the constructor, *Motive* is the anticipated, needed change of the *Object* in focus, *Actor* is one or several subjects representing the social organisation responsible for the execution of the activity, and C is the set of related social organisations or persons (communities) involved, including the rules and division of labour governing the behaviour of its members. *State* can be one

of the following at a certain time point: {*Not initiated, Initiated, Paused, Aborted, Completed*}. *Outcome* is simply the changed object when the state of the action is completed. *Act* is the set of "parent-actions" the action is a part of, which in the case of a main activity is the empty set. Consequently, the only distinction between activity and action in terms of Activity theory becomes a structural issue of in what context a certain action is executed.

Capturing the object of activity

The object in focus for activity can be an abstract mental construct such as medical knowledge or a physical entity such as the human body and its parts. The purpose of focussing the object in an activity is to monitor, or change it, therefore each object has measurable or describable qualities which are used in the clinical activity. These qualities are preferably captured and valued by using validated tools, such as cognitive screening tests. Therefore, the information about which tool or tools that were used in the execution is essential, together with the outcome of the valuation. The constructor for the Object becomes:

Object: [Entity, V] −> Object

where Entity is the object in focus, and V is the set of different valuations based on the usage of different tools: V_i={$Tool_i$, Qualifier}. At this level of analysis tool can be seen as the sort for the measure. In our work analysis we use the sort *Subjective* in the case when no validated tool is available and used.

The object and its qualities is the current state of the object at a certain time point, for instance, when the action is initiated. The outcome of an action, i.e. the Object and its qualities when the action is completed, is defined as the *Evidence*, which is used in subsequent clinical reasoning.

Clinical actions, evidence and tools

The different sorts of activity distinguished in Table 2 put different demands on the formal representation of the evidence and generate different types of outcome.

The first type concerns the actions which create data, or objects, where the outcome consequently constitutes the created object. The status of the object can be seen as the Boolean value *present* to distinguish it from before the action was initiated, when it was *absent*. One example is the executed cognitive screening-test, which exists, in the form of a test protocol in the electronic health record (EHR).

The second case is when an analysing or refining action (RO) is executed which aims at interpreting an object at a primitive state into a more useful state. Examples can be when thresholds are applied to numerical values in order to identify pathologic features or when the numbers in the cognitive screening-test protocol is summarised and documented in the EHR. There is a range of situations in which data and knowledge needs to be re-represented and/or refined in order to be communicated and documented in the process.

The third relates to the DEO type which determine whether a particular critical phenomenon is present or not (Boolean valuation), and if present, provide if possible a valuation of the degree of presence (qualitative or quantitative), preferably based on a clinically validated screening tool. Consequently, the outcome may be a set of valuations of different specificity of the same entity, using different tools. Ideally, these values can be mapped to each other in a valid and reliable way when a certain level of specificity is required.

In the case when the goal of the action is to differentiate between types of an entity (DTO), the level of specificity of the entity increases in the execution of the action. Consequently, the values will correspond to each type at the higher level of specificity, i.e. as a set of sub-entities, however closely related to (constituting sub-sorts of) the original entity.

The fifth case constitutes the completion of an investigation activity (IO), which provides an assessment of the situation in focus. If interventions have been executed, also the outcome of the interventions is included in the assessment. Typically, this information is documented in the EHR using natural language. If the information concerns the outcome of the main investigation activity, an answer to the initial referral is formulated and sent to the referring organisation in addition to the documentation in the EHR. A corresponding assessment is provided by the prototype system COGITAMUS, however, at a more specific level of interpretation.

Mediating tools

Tools are identified by its mediating function in the framework of Activity theory [2, 3, 4]. Three main categories of tools were identified for our purposes: 1) tools used for mediating physical actions, 2) tools mediating reasoning processes and 3) tools mediating the logistic process.

We chose to distinguish complex cognitive processes such as reasoning, decision making and learning from basic cognitive functions such as memory, recognition and language production. These basic functions are supported in the logistic work process, where tools are typically used for the storage and mediation of knowledge. These tools may also serve the reasoning process when a system integrates intelligent inferences, i.e., has mechanisms of transforming / refining data or presents information as if it does. One example is the list of data from laboratory examinations, which highlights measures which are abnormal.

In addition to these tools external to the actor who uses them, there are tools integrated (internalised) in the actor

such as knowledge, rules of thumb, conceptual models of interpretation, models of procedures, etc. A majority of those used for professional work were external tools when a person first used them, which have been internalised by practice and learning. Examples are terminologies and classifications of diseases. However, internal tools are also created as conceptual models of how things work and should be organised, models which are continuously modified in the interaction with the environment. Internal tools can be externalised when focussed as an object of re-interpretation, which is the case when internalised knowledge needs to be communicated to others.

The aim for the development of the decision-support system COGITAMUS is to provide knowledge and support to novice users, which may become internalised in the process of using the system. For both novice and skilled users, the system should support the externalisation of knowledge if needed in difficult cases in order to consult colleagues or the integrated guidelines. Furthermore, the knowledge integrated in the system constitutes a synthesis of external evidence-based domain knowledge and internal expert knowledge, which has been externalised by the participating domain experts in the development process.

The category of tools which are particularly interesting in the formalisation of evidence are those which are used for valuing features, qualitatively or quantitatively. External, validated tools are preferred to the internal subjective assessments, in order to assure equal care and reliable decisions based on objective common grounds. However, since there are several tools that can be used for the same purpose, and which may produce ambiguous evidence, the actor sometimes needs to value which tool to use and on which to base further reasoning. Further, in some situations there are no validated tools available, thus leaving the valuation to the actor. In the actions where the user's experience and internal knowledge is needed for valuation of evidence, these tools need to be assessed as well, in our analysis by referring to them as *Subjective*.

A knowledge tool such as a clinical guideline integrates both knowledge in the form of implicit rules and a set of values which can be used in the valuation of evidence. By identifying these qualities of a clinical tool, the basic elements (sentences and types) necessary for the integration of the knowledge into a formalism can be identified. As an example from the domain of dementia, a tool such as the clinical guideline DSM-IV-TR [6] may come equipped with a formalisation of the content in the form of a set of sentences as part of a logic language where $^{\text{DSM-IV-TR}}$ consists of a set of rules formulated in propositional logic [7]. A sub-set of these rules, $^{\text{DEO-dementia}}$, corresponds to sets of core features necessarily present or absent in a patient in order to establish the presence of a state of dementia, as formulated in the guideline. The result of a valuation using the guideline may become:

Evidence: [State of dementia, $\{^{\text{DEO-dementia}}, \textit{present}\}$].

The user can be provided the evidence interpreted within different contexts of valuation, contexts consisting of the tools used for the valuations, thereby giving the user access to clinical guidelines and an overview of evidence in a patient's case.

Discussion and conclusions

The presented work provides a conceptual model for a clinical investigation activity based on analyses of the domain knowledge and case studies of investigations of actual patients. The model is used to frame the investigation process, as an alternative method to the formal ontology and workflow approaches. The purpose is to identify relevant actions to formalise for decision support in the system and actions to support by the design of interactive reasoning. The model can be viewed as a bridge between the informal view on clinical actions obtained in field studies and the formal implementation of the reasoning using suitable formalisms for representation.

The framework integrates the domain knowledge, procedural knowledge, resources and constraints imposed on the investigation activity by the environment, and in particular, the framework is dynamic and patient-oriented in that it is the need of the individual patient that defines the investigation activity and corresponding activity system.

The conceptual structure is based on Cultural-historical Activity theory and forms a foundation for the formalisation of the knowledge. The adapted theory is well suitable for the purpose in the semi-formal version presented in this work. The structure provides the data and their sorts and qualities, the tools that are used in assessing the data, the actions of transforming the data and contextual factors such as who is responsible for a certain action. A key issue is how the semi-formal structure can be transformed into a formal structure for representation. A critical feature is the formalisation of the content of guidelines, treatment protocols, scales and values provided through the use of different tools in the process. In order to extend the model to include a framework for the formalisation, we use category theory as a meta language for the identification of the fundamental building blocks, independent of the logic language used in the implementation of the knowledge. To what extent the activity structure is useful for the integration of knowledge in the formal framework of category theory and institutions [8] is currently being investigated.

Since the work presented in this paper is based on a limited amount of patients and focussing a specific domain, the structure will be further evaluated and developed using

additional patient's cases and used for developing knowledge systems in different domains.

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Integrating Clinical Decision Support Rules Within Clinical Workflows in Rural Community Hospital and Clinics Guides Clinicians

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Abstract

The implementation of electronic health records in a rural setting generated new challenges. The preparation, implementation, and sustaining the operation of the electronic health record requires extensive attention to standards, content design, support resources, expert knowledge and more. The complexity associated with implementing alerts, reminders, and decision support was not taken lightly. The rural community hospital was able to use urban community designed clinical decision support rules (CDSR) to promote safety, prevent errors, establish current evidence-based practice (EBP), or support communication. The paper provides progress on evaluation of the electronic health record implementation using CDSRs. The descriptive research findings illustrate 13 clinical processes supported by 54 CDSRs used in a rural community hospital. The findings provide the goals (as experienced in urban sites) supported in the clinical processes. Rural community hospitals can rapidly overcome the barriers to preparation and implementation as well as sustain use of CDSRs with systemized approach and support structures. A model for implementation of nursing expert clinical decision support to use in workflow processes is presented. Future research is planned.

Keywords:

decision support systems, informatics,
clinical expert systems, formative program evaluation

Introduction

The implementation of electronic health records in a rural setting generated new challenges 18 months ago. This paper shares the formative evaluation of developing clinical decision support rules for a rural setting which was implementing an electronic health record (EHR). From this evaluation, the team shares a developing model to integrate the sciences of computers, information, and health to use medical and nursing evidence in clinical workflow processes. It was confusing to hospital clinical staff when the selection and design of CDSR were a separate piece of the EHR preparations. This meant having separate meetings for many of the components tied to implementing an EHR. In the end, it became easier for clinical end-users to integrate the three sciences upfront rather than overcoming the missed opportunity to include clinical decision support rules (CDRS) in the design of clinical workflow processes.

The formative evaluation on steps in the preparation processes highlighted the need for integration of decisions on CDSR with the redesign of clinical workflows. We will primarily focus on the inclusion of clinical decision support rules, but many other decisions for screen displays for data entry and view, computerized order sets and more design details need to be a part of the work effort by clinical teams when deciding on redesign of clinical workflows. There is nothing easy about the preparation, implementation, and sustaining the operation of the electronic health records. Each step requires extensive attention to standards, content design, training, user support resources, expert knowledge resources and more. Health care informaticians will find as we experienced the need to integrated decisions on design with the decisions on clinical processes. This included clinical decision support rules.

Clinical decision support rules

Clinical decision support was defined as any electronic or non-electronic systems designed to aid clinical decision-making in which characteristics of individual patients are used to generate patient-specific assessments or recommendations that are presented to clinicians to consider [1, 2]. More recently, clinical decision support is defined as "providing clinicians or others with knowledge and person-specific or population information intelligently filtered or presented at appropriate times to foster better health processes, better patient care, and population health" [3]. A clinical decision support rule (CDSR) is one

type of clinical decision support that is defined as an automated evaluation of a pattern of patient and/or clinician data elements that prompt a nurse, physician or other clinician to take an action. The automated evaluations of data patterns are initiated by an event called a trigger. A trigger, also called the evoke event, is defined as patient information generated within the EHR or passing form another application into the EHR system and initiates the automated evaluations of data patterns by aggregating and processing data to prompt the a decisive action. CDSR are used to express therapeutic recommendations, to formulate queries about relevant interventions for a patient, and to assess the effectiveness of a treatment. Decision support expert rules provide clinicians with alerts and reminders, data interpretation and patient diagnoses, patient management suggestions, and clinical protocols. There are multiple data components necessary to activate an expert rule within the EHR.

Methods

The formative and summative evaluation were used to study the implementation of a comprehensive integrated, electronic health record (EHR) system using uniform data standards, with computerized provider order entry, and clinical decision support tools in several rural health care settings (hospital inpatient units, ambulatory care, primary care and specialty clinics). This CDSR study is a part of a larger healthcare information technology study partially funded by the Agency for Healthcare Research and Quality (HS015196-01). In this 3-year study in its final year, 54 clinical decision support rules (CDSRs) are described for the rural hospital and 17 for clinics using a title name, the clinical process using the CDSR, the purpose for the CDSR, the explanation of the rules logic, the evidence supporting the clinical rule's use, the start date for the rules existence in the Cerner EHR, and whether the rule is used only by the rural hospital or is it used among the system by other organizations. The study described the number of times the CDSR was triggered and the number of times the action was completed, cancelled, voided, discontinued or remained as an action by the Cerner EHR system, if captured. The formative evaluation and descriptive findings on the types of clinical processes supported by 54 Expert Rules used in a rural community hospital and 17 for the physician clinics and the goal for supporting clinical processes are presented.

Formative evaluation of preparation

In this section, a formative evaluation describes the preparation processes that existed in 2004. The rural community hospital informatics specialist and clinical leaders received initial education on the steps for preparing for the electronic health record (EHR) in the spring of 2004. This education included learning about many key items. For the focus of this paper, we will discuss the education on redesigning clinical workflows, designing order sets, electronic forms, and selecting CDSRs. The training sessions were part of formal online and in-person training sessions. The preparation steps began by discussing the designing of current state and future state workflows with clinical teams. The formative feedback from informatics specialist and clinical teams were that every item was disjointed and done in "silos" and therefore, it was difficult to internally integrate the pieces of the EHR application. For example, evaluation revealed the workflow redesign was separate form the electronic forms, which was separate from the CDSRs. So the disjointed processes resulted in the design of order sets starting in June of 2004, the review of clinical workflows occurring in August 2004, and the electronic forms in October of 2004 and the steps on selecting CDRS did not begin until December of 2004. Hence, the formative evaluation of the preparation was that every step was disjointed and confusing.

In summary, this process lead to extensive resource use, missed opportunity to select the CDSR options and request new CDSRs. Despite the confusion in the 2004 preparation processes, the rural community hospital received remedial education and was supported in submitting 22 requests for CDSRs (previously operating in 3 urban hospitals) in February 2005. Subsequently, the informatics specialist was able to submit another 25 requests in March 2005, which 13 were previously used in one other urban hospital and 4 were new requests for CDSR. The research team's evaluation of the process for selecting and designing CDSRs for EHR application has lead to multiple recommendations to improve the process. The lead author, Discern Expert analyst worked with others to construct an improved process [4]. In 2005, the authors worked with clinical teams and information system analysts to integrate many recommended CDSRs into the patient-centered clinical workflow processes.

Evaluation of implementation

In this section, a description of the implementation and progressive evaluation of the implementation of Cerner PowerChart EHR which included the Cerner's Discern Expert computer application for providing clinical decision support rules (CDSRs). The activation of the redesigned clinical workflow processes with EHR were implemented during a 24 hours time period beginning July 8th 2005 as planned. This activation included the following components: Cerner PowerChart within hospital inpatient and outpatient settings; Cerner FirstNet Tracking system and PowerNote physician documentation in the Emergency Department; Cerner PharmNet verification and profiling for pharmacy services integrated with robotic bar coding dispensing system and Pyxis dispensing system; HealthQuest patient management quick and pre-registration processes; Cerner Profile Health Information

Management processes for coding, physician electronic signature and record management; and PeopleSoft financial billing and auditing processes. When the EHR was operating on July 9th the clinicians used computerized provider order entry within the Emergency Center and in all other areas. Additionally, nurses and ancillary professionals initiated electronic clinical documentation. Forms were 95% prepared from previous urban hospital use. At time of activation, 53 CDSRs were initiated to complement the already 17 adverse drug event rules using Cerner Discern Expert application. Other types of decision support included 43 emergency room PowerNote templates and over 250 service specific order sets for anesthesia, behavioral medicine, cardiology, cardiothoracic, critical care, EENT (ears, eye, nose and throat), medicine, neurology / neurosurgery, newborn /pediatrics, obstetrics /gynecology, oncology, orthopedics, radiology, specialty procedures, surgery, vascular services. All CDRS remain in operation today.

Results

Eighteen months after implementation, the rural hospital continues to use of 53 CDSRs for medication processes, adult inpatient nursing processes, medical care, and ten other clinical processes. The goals for CDSRs for all disciplines were designed to establish evidence-based practices, prevent errors, promote safety and support communication. See Table 1 for where the CRSR met two of the four goals for clinical workflow processes.

Table 1 - CDSR Goals for supporting processes

Clinical Workflow Process	# Rules	# To Prevent Error	# To Promote Safety
Medication	5	2	3
Medical Staff	4	0	1
Maternal-Child	9	0	0
Pediatric	3	0	0
Nursing Care	13	2	1
Behavioral Health	4	0	1
Nutrition Service	6	0	0
Infection Control	2	0	0
Respiratory Care	1	0	0
Diagnostic Radiology	3	1	1
Rehabilitation	1	0	1
Social Worker	1	0	1
Spiritual Care	2	0	0

Many of the CDSRs were supporting communication and evidence-base practices. Very few CDSR were categorized as other. Each of the CDSRs were analyzed for consistency in triggers over a three-month post-implementation period from July 22, 2005 through October 21, 2005. All the CDSR were functional as the end users expected.

Despite the many challenges, the rural community hospitals and affiliated clinics had overcome the barriers to preparation, implementation and sustaining clinical decision support. The results are rural hospitals and clinics can sustain use of expert rules with systemized support structures, change control procedures, and improved integration.

Discussion

The findings form evaluations to-date suggest integrating the CDSR selection within the decisions needed for clinical workflow processes is necessary to eliminate confusion between components of the EHR. The authors, information system analyst and nurse informatics specialist have initiated steps to design CDSR that are used in most settings to be designed into patient-centered clinical workflow processes. Therefore, the inpatient adult clinical workflow process includes eight CDSRs frequently used with the EHR applications because nurses now use those CDSRs in admission and daily care clinical workflow. The new design for patient-centered clinical workflow processes inclusive of CDSRs were used to prepare two subsequent urban hospitals and one rural critical access hospital for their alike EHR implementations. The change in method reduced confusion and improved the process for implementation. The new method required fewer changes to workflow processes after activation. This has led to the development of a model for CDSRs.

Conceptual model for CDSR in workflows

CDSRs were first integrated within EHRs merely 17 years ago for medicine, yet little has been done to provide guidance on designs and tests for clinical workflow processes. CDSR for nursing care were most prevalent, so the conceptual model for expert clinical decision support rules illustrates: the data sources for information patterns; the nursing workflow; and the evoke events, syntax logic, and action responses central to expert rules See Figure 1. Nursing informatics is built on the framework of three sciences (nursing science, information science, and computer science) operating together to produce nursing process results [5, 6] After observing nine hospitals in selecting, designing, implementing and using expert rules with the electronic health records [4], the model includes the steps that integrate the three sciences for the development of nursing expert rules. The model considers fit with factors used by the Patterson, Nguyen, Halloran, and Ash [7] decision support framework.

In the nursing expert decision support rule model, nurses' input and use of data to support decisions in patient care are illustrated. Data within the EHR are used to trigger the

expert rule operation and to evaluate the data to produce a response. The model (Figure 1) displays within the Information Science: Data Use how data are entered, downloaded from devices or transmitted into the EHR from other applications, as well as the required Computer Science: Expert Rule programming steps for "Event Input" and "Event Action," the "Clinical Decision Support Logic," and "Action Response." Patterson's team [7] also identified need for key contextual and design factor components for decision support. Finally, the "Nursing and Health Sciences: Workflow Process" in Figure 1 represents what Patterson's team [7] described as organization, team and individual factors. The "Change Control Procedures" provide an organization's stability and safety to sustain ongoing operation of expert rules. The clinical workflow processes are dependent on the health, medical and nursing evidence used to articulate team and individual roles with clinical workflow processes. Interdisciplinary roles interact with expert rule in initiator roles that triggers the events and receiver roles to decide the action responses. This model explains the nurse's interaction with the data used for the expert rules through the workflow of the nursing process. Another factor that has not been described in previous models but is central to expert rules is the translation of research evidence into practice by integrating knowledge into each of the steps to produce the best results [8].

The model illustrates the decision-making activities that impact the design and use of the expert rule. The evidence from health sciences guides what clinical findings and responses are collected during patient workflow, the patient care orders available for use, and the available patient diagnostic results to use. These three areas supply the clinical data used to evoke/trigger the conditions of the rule as illustrated by "event input." If not driven by the clinical data from the patient, the rule may be driven by the caregiver's actions of opening the record or performing functions in the electronic record as illustrated with "event action." For example, pharmacists use event action method to receive alerts when entering a record to know they are preparing medications for a patient with a latex allergy.

In summary this model is inclusive of the many components with expert rules for nurses to support the nursing process. The data entry process for the ERH impacts the design and accuracy of CDSRs. If the data are valid, the real-time triggers when working directly with the patient and the electronic record can reduce work in a patient encounter. If reliable and valid, expert rules change the nurse's workflow to facilitate the timely use of information.

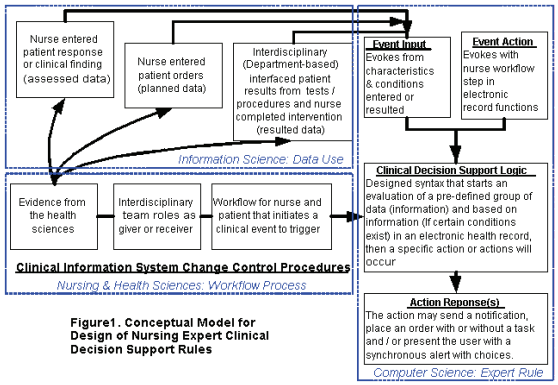

Figure 1 - Conceptual Model for Design of Nursing Expert Clinical Decision Support Rules

Conclusion

Little attention has been given to the clinical workflow processes that involve all the disciplines working directly with the patient. Nurses are the largest group of healthcare professionals that are deciding steps to coordinate and manage multiple patients' care and activities. Nurses rapidly learn and adopt the technology into their nursing workflow processes. Nurses do not hesitate to use the patient data entered or received in electronic health records. Nurses, dieticians, radiology technicians, pharmacists are requesting expert clinical decision support to achieve the four goals to support patient safety, prevent errors, establish evidence in daily practices and improve communication as identified for CDSRs. Nurses coordinate care for many disciplines and the goal to facilitate communication is important. The benefits in efficiencies and cost-effectiveness are unknown and untested with the new technologies that aid nurses' workflow and many other clinicians. This paper begins addressing the workflows for the largest group of healthcare professionals who interact with patients.

Further research is planned to complete the summation evaluation for this implementation in 2006. Other research is planned for testing validity and reliability of evidence-based content design with complex CDRS. This model will be used to test expert rules and guide others in the use of these electronic decision-driving interventions.

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Innovative Approach to Childbirth Decision Making

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About 25% of women give birth by cesarean section

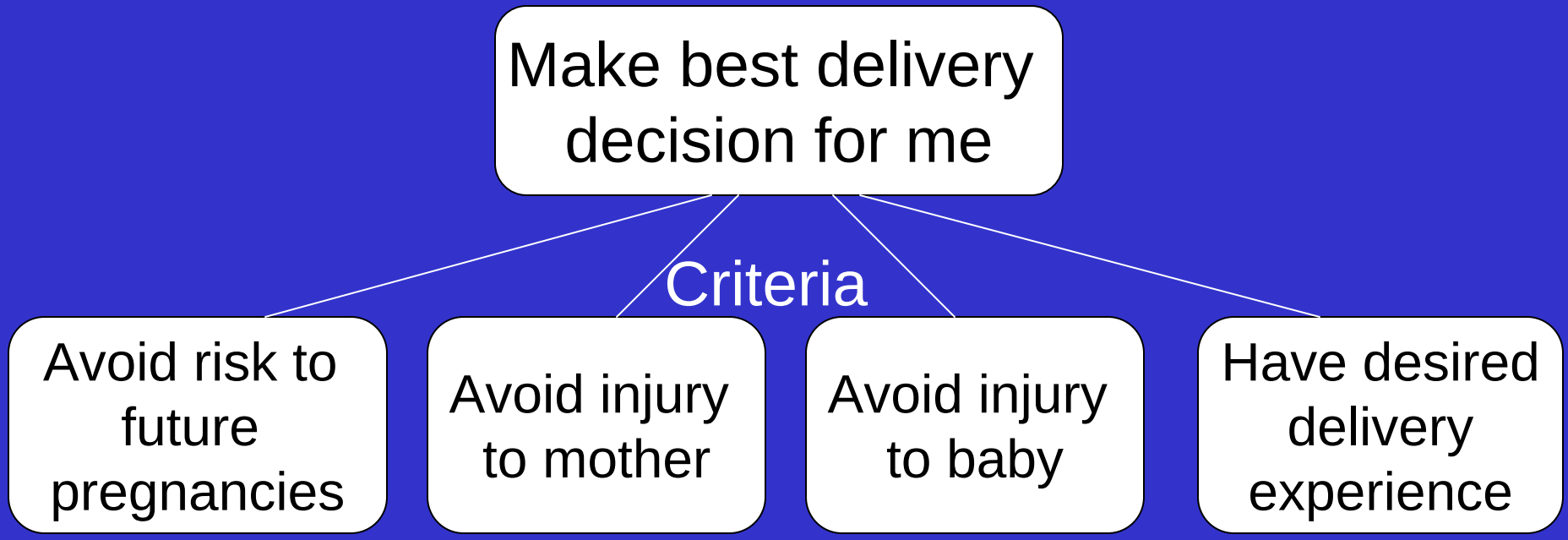
- Australia, 21%
- Canada, 19%
- Denmark, 18%
- Brazil, 35%
- United States, 29%

- Women with a prior cesarean face a difficult decision for their next childbirth as there are risks with either repeat cesarean or a vaginal birth after cesarean.

The study aims were to:

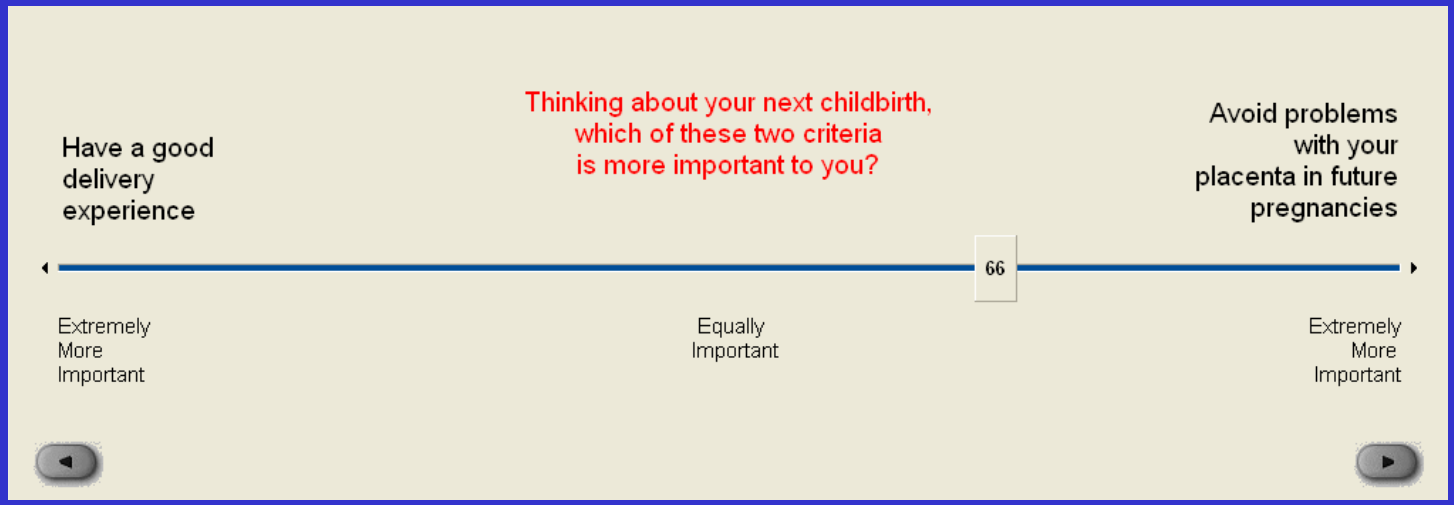
- Create a decision model for childbirth based on medical evidence.
- Create a computerized decision aid based on this model and evaluate its effect on decision making processes in a randomized trial.
- Compare two versions of the decision aid for measuring the patient's inconsistency in assessing preferences: a graphic-numeric scale versus a text-anchored scale.

Decision Model (Top Tier Only)

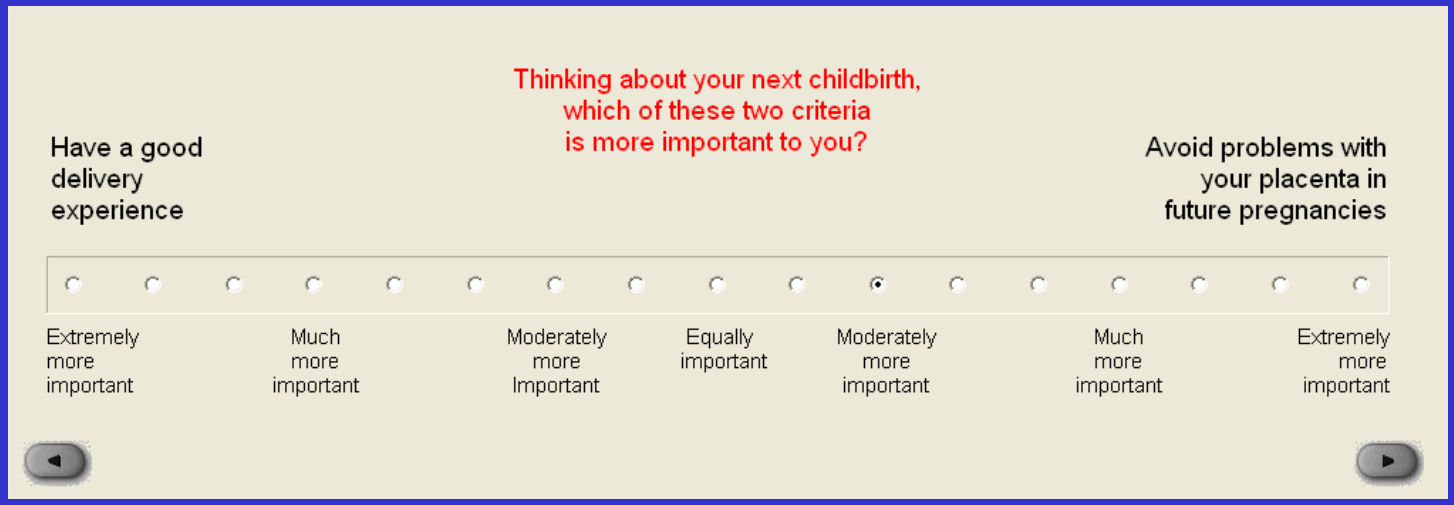


The women made pair-wise comparisons among the criteria to assess their childbirth priorities (or preference weights) in the decision.

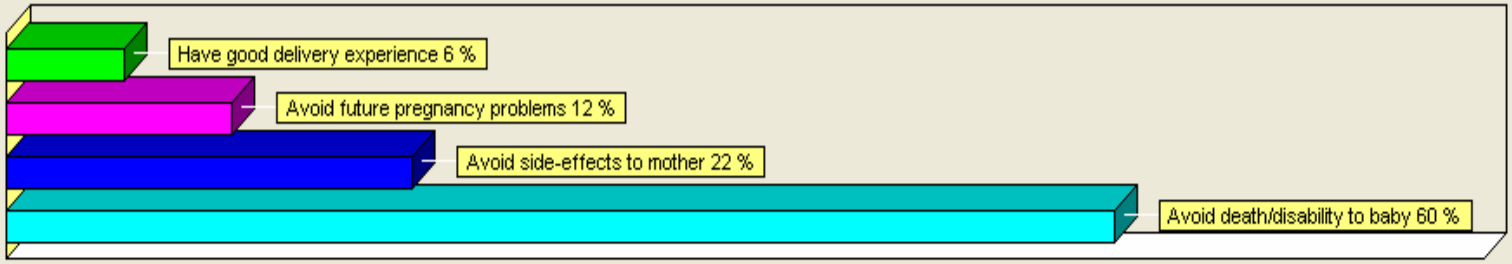
The women were randomized to use one of two formats for assessing childbirth priorities:



OR



Feedback on Childbirth Preferences



Based on your selections so far, it appears that you consider avoiding death or disability to your baby most important.

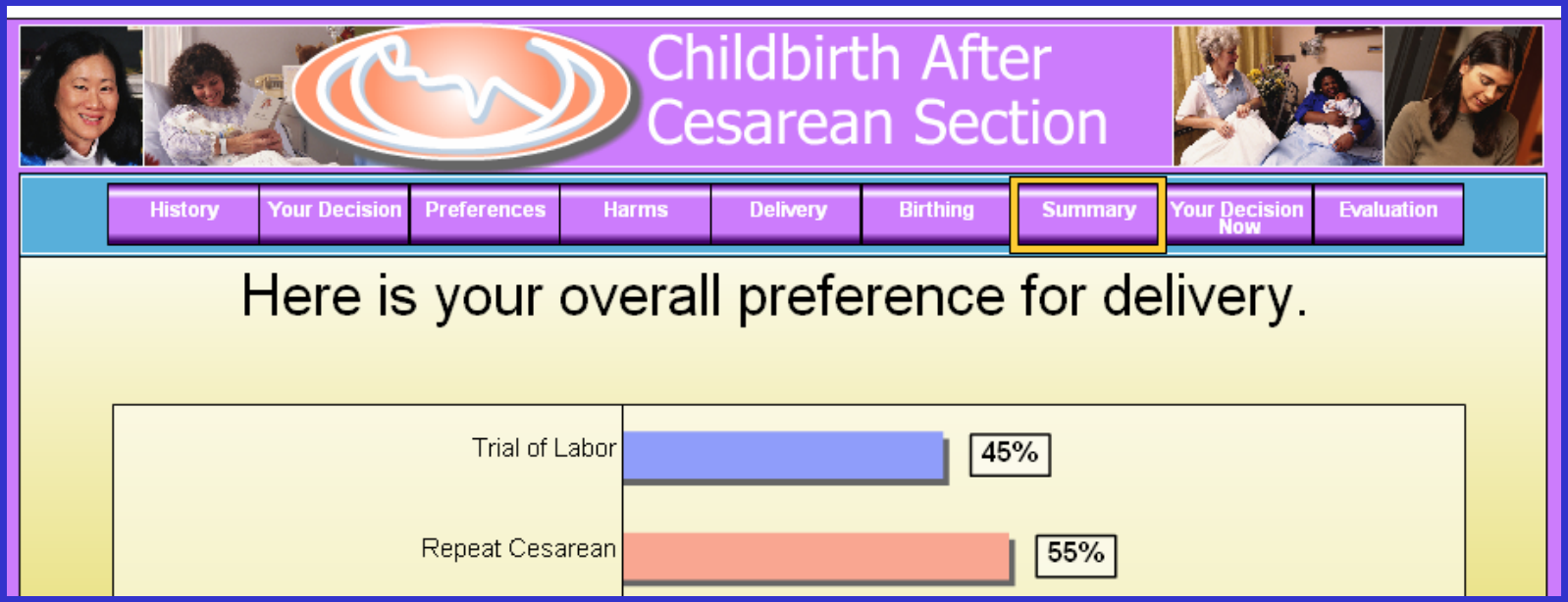
So far you have compared criteria based on your personal feelings. The table below lists the actual chances of some of these criteria. Do you want to adjust your choices now that you have reviewed the actual chances of these events occuring to you or your baby?

Baby	1 to 5 of 1000 babies may die; 2 of 1000 babies may be disabled from delivery.
Future Pregnancies	30 to 60 of 1000 women may have problems with their placentas in future pregnancies.
Side-Effects	70 to 140 of 1000 women may experience numbness by their incision; 2 of 1000 women may need a
	hysterectomy right after delivery; About 500 of 1000 women will leak urine by middle age.

Yes, let me adjust my answers | No, let's proceed

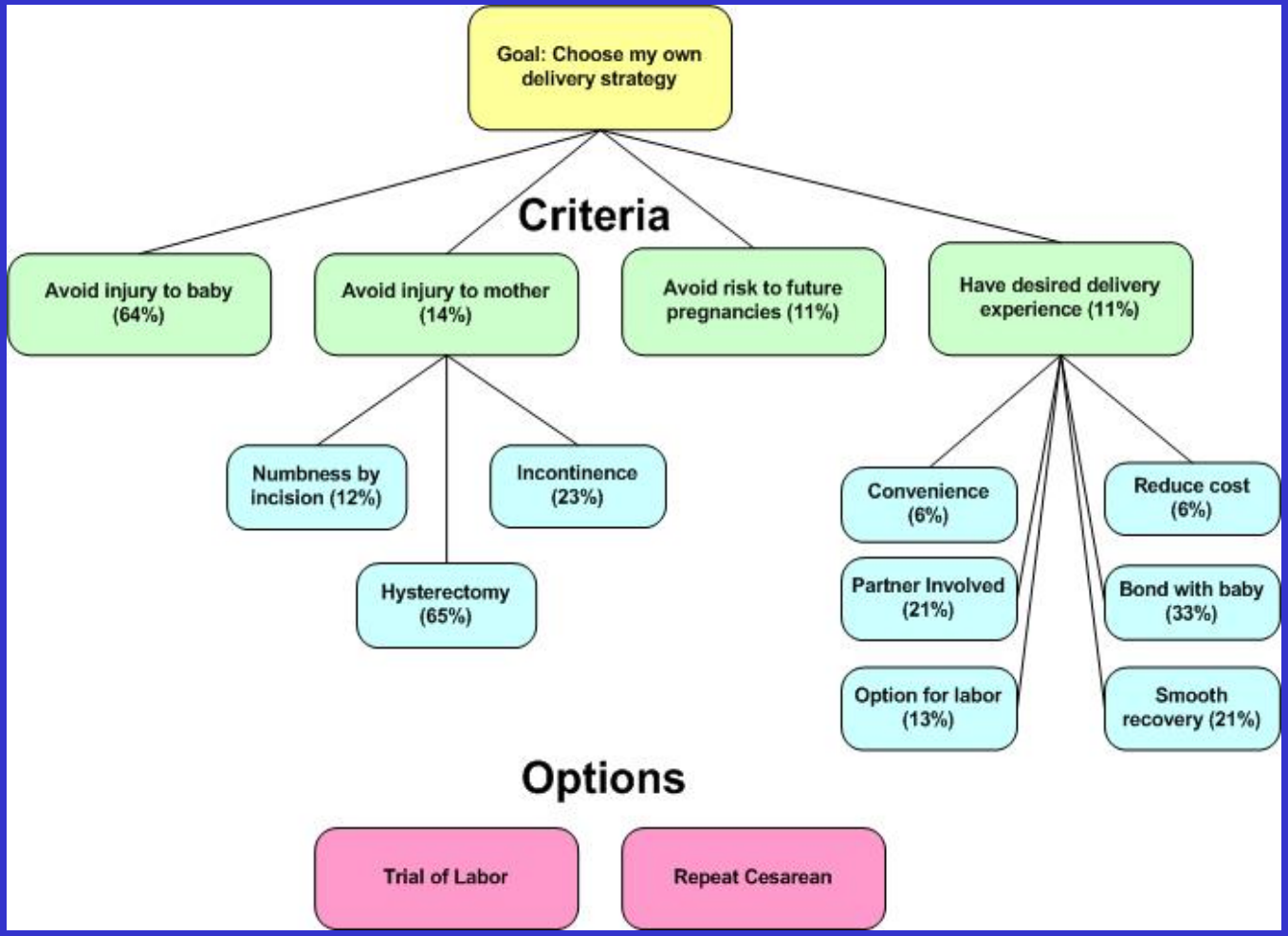
In this case, the woman placed the most importance on avoiding death or disability to her baby (60%) followed by avoiding side-effects to herself (22%).

Summary Feedback



The delivery option with the highest score is most closely matched to your specific childbirth preference weights.

Full Childbirth Decision Model with Average Preference Weights (n=96)



Impact on Decision Making Processes

	Baseline Mean	After Decision Aid Mean	P
Certainty about decision	33.9	33.9	.97
Felt informed about options	33.9	24.2	.00
Had clarity about preferences	31.9	21.6	.00
Felt supported in the decision	33.0	28.3	.00
Overall Decisional Conflict Score	33.1	27.0	.00

*From the Decisional Conflict scale (O'Connor, 1999). Uses five-point Likert scales scored with values ranging from 0.0 (best) to 100.0 (worst). Scores for Overall Decisional Conflict lower than 25 are associated with making decisions; scores exceeding 38 are associated with delaying decisions or feeling unsure.

Patients improved their decision making processes to the same extent regardless of format (graphic-numeric or text-anchored).

Observations of Patients Using Decision aid

- The patients found the decision aid easy to use and to understand.
- The decision aid allowed for “safe” decision making.
- The patients were forced to make trade-offs of factors they may have been “avoiding”.

Conclusions

- Several decision making processes were improved with the decision aid regardless of format.
  - Improved knowledge
  - Improved clarity of preferences
  - Improved support
  - Reduced decisional conflict
- Patients were more consistent in evaluating childbirth preferences when using the graphic-numeric format.
- The decision aid was well received by patients.

References:

Dolan, J. G. and S. Frisina (2002). "Randomized Controlled Trial of a Patient Decision Aid for Colorectal Cancer Screening." Medical Decision Making **22**: 125-139.

Guise J-M., M. McDonagh and J. Hasima, et al.(2003). *Vaginal birth after cesarean section (VBAC):* Rockville, Maryland: Agency for Healthcare Research and Quality.

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Acknowledgements:

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Innovative Approach to Childbirth Decision Making

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Abstract and objective

In the era of limited healthcare resources, patients will increasingly manage their own health including making decisions. We have developed a computerized decision aid to help a woman with a prior cesarean consider decision factors for a future delivery (vaginal vs. repeat cesarean). The objective was to evaluate the impact of the decision aid on the decision making processes in a randomized trial.

Keywords:

decision support techniques, vaginal birth after cesarean, response format, patient preferences, decision aid

Introduction

The childbirth decision aid is built on an underlying, evidence-based,[1] multi-criteria decision model. In using the decision aid the patients determined the importance of decision criteria and considered the two options, trial of labor (vaginal) and repeat cesarean. Because there was uncertainty about which scale format for measuring childbirth preferences was most accurate and user friendly, we compared a graphic-numeric scale to a text-anchored scale in a randomized trial.

Methods

We recruited 96 women who had just had a cesarean delivery from the postnatal unit of a large university hospital. After all patients completed a baseline computerized questionnaire, they were randomized to use either a graphic-numeric scale (n=48) or a text-anchored scale (n=48) for measuring their preferences. The patient made a series of pairwise comparisons to determine the importance of each decision criterion,[2,3] e.g., comparing the importance of "wanting convenience" of a scheduled delivery to "wanting a smooth recovery," using one of two formats (Figures 1, 2).

Figure 1 - Graphic-Numeric Scale

Figure 2 - Text-Anchored Scale

For both interfaces, the women received summary information on their preferences related to having a repeat cesarean or attempting a vaginal delivery. Our analyses focused on changes in the decision making process measures (baseline and after using the decision aid) and the patient's internal inconsistency using the two formats.

Results

The dominant criterion was "Avoiding injury to the baby" (64%) (Figure 3).

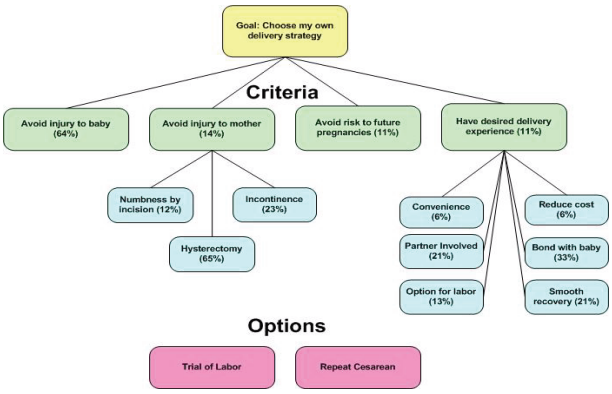

Figure 3 - Decision model and preference weights

Our ANOVA revealed that both groups of patients significantly improved several decision making processes: increased knowledge, $p<0.001$; increased clarity about childbirth values, $p<0.001$; increased sense of support, $p<0.001$; and reduced overall perceived decisional conflict, $p<.001$ to the same extent after using either scale format. The patients were more consistent in evaluating risk using the graphic-numeric format, $p<0.05$.

Conclusion

While both formats improved the decision making processes, patients were more consistent in decision making involving risk when the scale format was graphic-numeric.

Acknowledgement

This study was supported by grants from the OHSU Foundation, NIH K12 grant:BIRCWH, and the Agency for Healthcare Research and Quality.

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Sensible Decision Support System

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Abstract

The use of intentions in computer-based guidelines may help to make them more flexible, easier to adapt to local standards, easier to evaluate and to improve. We see possibilities of using intentions to reduce the number of unnecessary warnings sent to the user. Building guidelines with use of intentions gives the possibility to reduce the complexity of the guideline flowchart and the use of formalized language makes the description of every step of the guideline insightful for all users. In this contribution we present our approach to intention-based guidelines.

Keywords:

guideline, intention, decision support system

Introduction

Currently there is an increasing use of clinical practice guidelines (CPG) in medicine. CPGs improve the quality of healthcare, lower costs of treatments, reduce practice variability or prevent errors [1]. Clinical practice guidelines are mostly paper-based but the trend is to implement them in computer based decision support systems (DSSs).

Even though computer-based CPGs have a lot of advantages, the users face also some problems like for example lack of flexibility that causes unnecessary reminders or warnings. Reduction of practice variability is mentioned as one of the advantages. However, in some cases following the guideline is not the best treatment for specific patients. Sometimes physicians may choose an alternative treatment that is within the spirit of the guideline. Usually guideline systems will warn the physician, although that is not strictly necessary. When the physician gets too many unnecessary warnings he will stop using the system [2].

In the literature also approaches based on intentions hidden behind actions are discussed. Miksch et al. [3] presents intentions as temporal patterns of actions or states, to maintain, achieve, or avoid. Advani et al. [4] describes intentions as formal temporally extended goals and uses them to build a prototype medical critiquing application. In the Trauma AID project, Webber et al. [5] implement intentions as a commitment to use resources to try and achieve a particular goal. We think that the use of intentions may alleviate the problems mentioned above. Because intentions are stated, a guideline system for example can deduce whether alternative treatments are in the spirit of a guideline and if that is the case can postpone warnings.

In our work we made use of the heart failure guideline which in cooperation with the Cardiology department of the Academic Hospital Maastricht was implemented in the GASTON system [6].

We started our work with the formalization of the paper based guideline and local protocol for treating heart failure and implemented it with the help of the GASTON guideline editor. Figure 1 shows a part of the heart failure guideline flowchart. This is the flowchart at the highest level of the guideline where the guideline is entered. The flowchart is built from primitives, components with predefined logic. The top primitives of both charts are eligibility decisions which allow entering the flowchart only if predefined criteria as stated in the primitives are fulfilled. All white rectangular elements are sub-guidelines which represent other flowcharts containing primitives.

While designing the guideline we noticed that flowcharts become very complex and difficult to oversee. In Figure 2 the flowchart of how to administer angiotensin II antagonist is presented. This flowchart is part of a sub-guideline and in some cases can contain sub-guidelines as well. Without detailed knowledge about the implemented guideline it is very difficult for others to follow the logic or to find possible mistakes.

We evaluated our model with a cardiologist and we faced another problem; the model seems to be not flexible enough. Even though it was according to the guideline and the local protocol, in some cases physicians would like to bypass some steps. For example the protocol describes exactly in what dosage steps the drug should be increased while in some cases the physician would like to increase the dose faster. Current systems would send a warning to the user, but a system that uses intentions is accepting the choice of the physician, as it is in the spirit of the guideline.

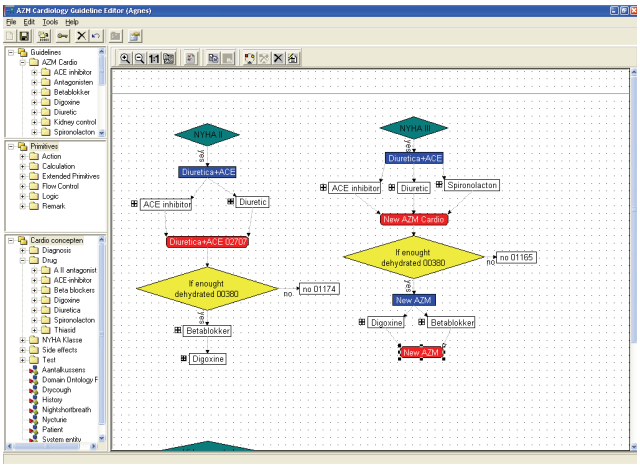

Figure 1 - Flowchart of the heart failure guideline

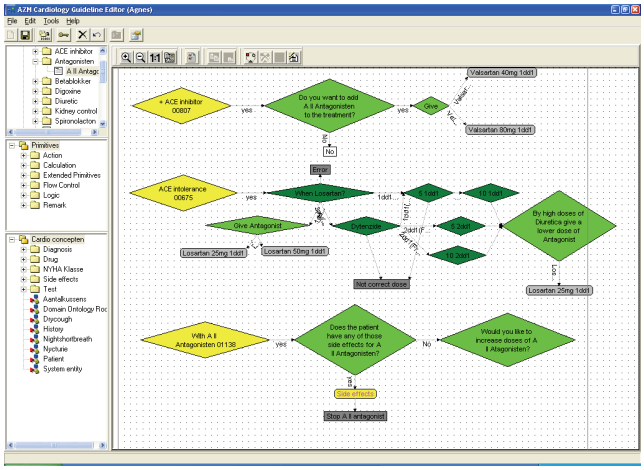

Figure 2 - Complex flowchart of how to administer angiotensin II antagonist

We also used the runtime version of the heart failure protocol for educational purposes. During the course third year medical students were confronted with the guideline and the system. The students had to enter patient data in an EPR that was interfaced with GASTON. After this data entry the students were asked to find out what the paper guideline proposed for treatment. Thereafter they could ask the system for advice. The system provided the patient specific advice very quickly and in this way they could experience the advantage of having system support.

Based on the experience we gained we decided to improve our system. The flowchart should be less complex, so that the maintenance of the flowchart will be relatively easy. Also users should be able to follow the logic of the flowchart and must be able to understand the rationale of the different steps. Also the system should be able to accept, at least initially, alternative actions that fulfill the same purpose. We therefore investigated the adequateness of the use of intentions, as already introduced in the ASBRU project. We want to show that use of intentions in building computer based guidelines can make them more flexible, insightful and reduce the number of unnecessary warnings.

Definitions

Before specifying intentions in more detail, we define some terms we use in association with intentions.

Intention. An intention is a determination to act in a certain way or to do a certain thing; is a high level goal which is abstract and not measurable.

Goal. A goal is an object of one's efforts; something to reach; is situation/state dependent; is concrete and measurable.

Plan. A plan is a proposed or intended method of getting from one set of circumstances to another. They are often used to move from the present situation, towards the achievement of one or more goals. A plan contains a series of actions to be carried out.

Action. An action is a work or an activity in a specific area or field.

Purpose. A purpose is an anticipated outcome that is intended or that guides planned actions.

System

Our system with problem solving methods (psms) related to intentions is being implemented as an addition to the GASTON framework that facilitates the development of clinical guideline application tasks. It consists of three parts: a guideline editor, where intention based guidelines are created; a knowledge base, where ontologies about medical knowledge and intentions are stored; and an execution engine, that during runtime reads data entered into the Electronic Patient Record (EPR) and uses these data to determine, on the basis of guideline information, the action that is the most appropriate for the current patient.

The physician communicates with the system via an EPR. The EPR has bidirectional communication with the execution engine. Further, the execution engine exchanges data with the guideline base and the knowledge base as shown in Figure 3.

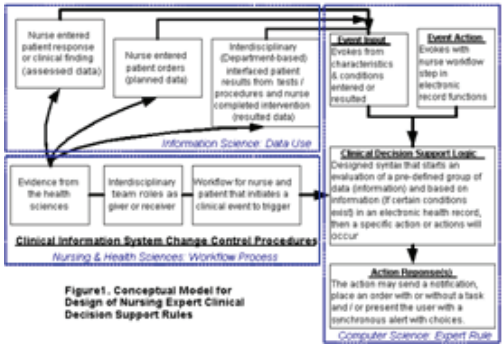

Figure 3 - General architecture of the system

The guideline is built in our system as a flowchart of intention psms. The intention psms can be carried out in parallel or in sequence. When it decomposes into other intention psms it is an intention psm on a higher level. When it does not decompose into other intention psms then it contains a flowchart of actions that fulfill the goal of the intention. The intention on a higher level is fulfilled only when the sequence of the intentions on the lower level is satisfied.

In the intention psm there is a possibility to write an explanation of the step or to make a link to the paper-based guideline where users can obtain more information about the current step of the guideline. Also the structure of the intention psm allows the designer to express if this intention psm decomposes into other intention psms, 'has sub-intentions' is on, or decomposes into a flowchart of actions, 'has sub-intentions' is off. If 'has sub-intentions' is on it means that success of fulfilling the current intention psm depends on the status of intention psms on a lower level. If 'has sub-intentions' is off it means that to fulfill this intention psm some actions have to be carried out. Further, the contents of the intention psm have to be defined, which are pre-conditions, abort conditions, and goal. The inside of the intention psm is shown in Figure 4.

During the design phase all parameters of every intention psm are defined. In the preconditions part all information needed to decide whether this intention psm may be entered or not are described. Abort conditions contain the description of situations when the execution of this intention psm has to be cancelled. The next part, goal, is a measurable part of the psm. The goal might be set in two ways: by the physician, based on the patient condition (e.g. blood pressure) or by the guideline designer, based on general medical knowledge (e.g. calcium level); also it might contain time constraints.

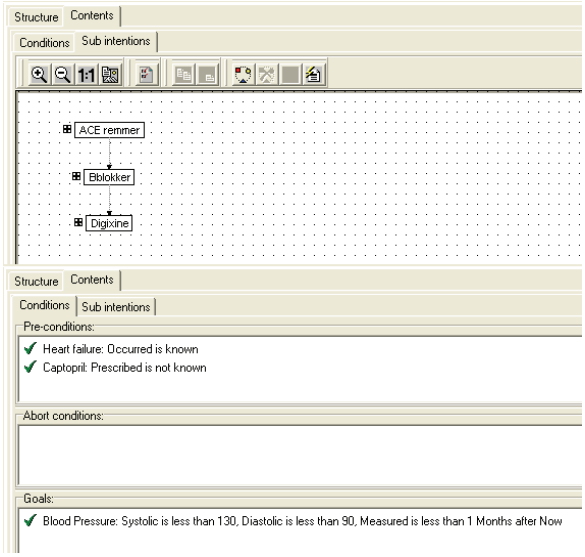

Figure 4 - An example of an intention problem solving method

Mechanism to reason with intentions

Information about the intention and the goal is used during the runtime phase. The execution engine uses that information together with data stored in the EPR and purposes of actions stored in ontology to provide flexible and adequate support to the user.

Before we explain how the mechanism of reasoning with intentions works we would like to introduce more information about the knowledge base (ontology). The ontology is a database where medical knowledge is stored. It is fully compatible with the Gaston system. All entries of the knowledge base have predefined properties. Dependent on the sort of the class of the data, we define mappings, attributes and purpose. For example, between attributes of the drug class we can distinguish prescribed, dose, or frequency; and between attributes of the diagnosis class, occurred or stopdate. Figure 5 shows properties of the drug class.

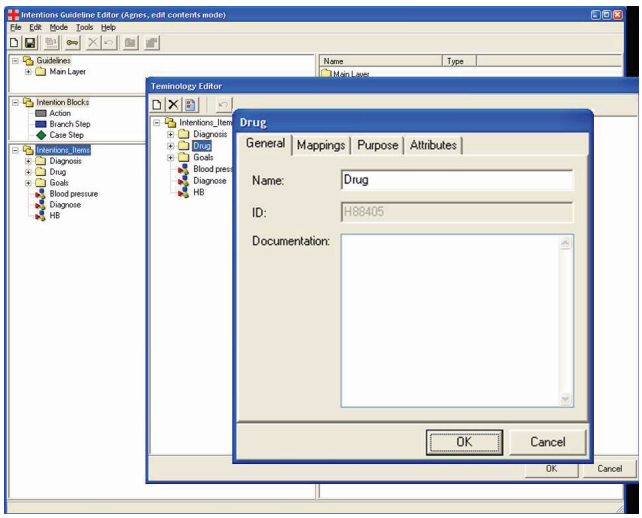

Figure 5 - Properties of the Drug class stored in ontology editor

All data in the knowledge base has a predefined purpose. Both intentions and purposes are standardized so that the system can see whether an alternative action is within the spirit of the guideline (purposes are equal).

The mechanism to reason with intentions and purposes is executed during runtime and compares those two pieces of information. If the action taken by the physician does not match the action stored in the guideline our system compares the purpose of the action stored in the EPR with the intention of the preferred action as mentioned in the guideline. No warning will be sent to the user if his decisions are made in the spirit of the guideline.

Real life data test

At the current stage of the project we concentrate on testing the system with real life patient data. In order to be able to test the guideline system we developed a simple EPR which cooperates with GASTON. Based on the results from this trial we want to see how the advice given by our system compares with decisions made by the physician; how flexible is system in giving advices when decisions are not exactly the ones mentioned in the guideline, but when they are still within its spirit.

The results of those experiments we would like to present during the conference.

Discussion

In this project we concentrate our efforts on extending existing software to obtain computer based guidelines that are easier to implement (reduced complexity), to evaluate, and are more flexible in processing received data. In this discussion we would like to point out the biggest advantages of our software.

Building guidelines with use of intention problem solving methods gives the possibility to reduce the complexity of the guideline flowchart. Figure 6 shows two levels of the heart failure guideline. The background window contains sub-intentions while the front window shows the inside of one of the sub-intentions.

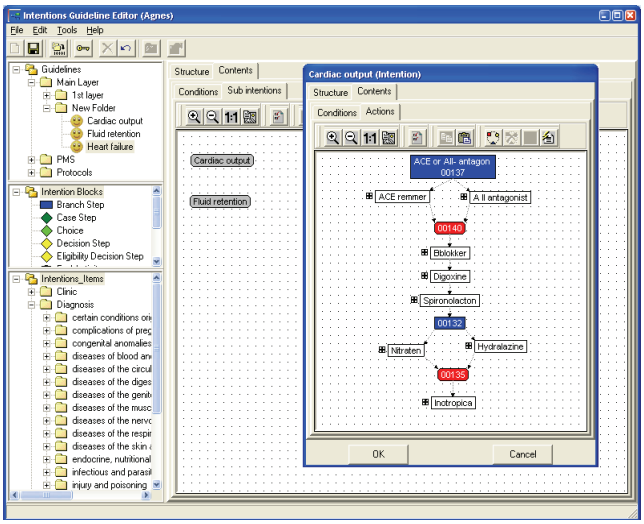

Figure 6 - A part of the heart failure designed with the use of intention psms

The user describes the preconditions, intentions and goals of every step by use of a formalized language. As Patel et al. [7] pointed out in her work, translating paper based guidelines into computer based ones is not easy. Already in the design phase we can make a lot of mistakes. Guidelines are developed by experts (e.g. physician) like also by non experts (e.g. computer scientist) and they may interpret information differently. Developers interpret the guidelines based on their knowledge, so different level of experience influence the way guideline is translated. When a computer scientist analyses the protocol he concentrates on surface information when given a text description of the clinical problem, while a physician includes the underlying clinical model.

The use of an ontology editor where medical knowledge with its attributes is stored has a number of advantages. By use of time-related concepts (e.g. prescribed, stopdate) it is possible for our software, based on date stored in the EPR, to follow the guideline and give relevant advice if needed. Another property, purpose, is used in the runtime and gives possibility to deliver flexible advice within the spirit of the guideline. Namely, the action stored in the EPR is compared with the one mentioned in the guideline. Even if the action taken is not the same as an action stored in the guideline, it is possible that the user will not receive any warnings. The purpose of the action taken by the user is verified then in the ontology and compared with the intention of the guideline. If user prescriptions are within the

spirit of the guideline, the system is accepting the choice the user made.

By use of intentions, we built a new kind of guideline flowcharts where the priority is set on fulfilling the goal than on following the guideline step by step.

The evaluation of our work will give us an answer to our hypothesis; is the use of intentions in building computer based guidelines making them more flexible, insightful and reduces the number of unnecessary warnings? In this study we have shown that the inclusion of intentions into GASTON is possible and intention based guidelines can be constructed.

Acknowledgments

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Development of Standardized Technique using EHR to Describe Clinical Processes

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Abstract

This study aimed at the development of a standardized technique, to describe the clinical care process comparison using Electronic Health Record. We divided the clinical process into three parts; input, process, and output. In the care process, the flow chart was automatically made from EHR. There were two methods of record of the process. Event type and continuous type. The event type is a treatment act done single-engined. The continuation type is treatment continuously done. It was thought that this technique was suitable to describe the clinical process.

Keywords:

electrical health record, care process, flow chart

Introduction

It is important to compare content of the diagnosis and treatment process between facilities for the purpose of quality improvement of the medical treatment. For this, the clinical pathway and the clinical indicator have been used. The clinical pathway is prospective approach. Treatment route is first designed, and the one to discuss the result. The other clinical indicator is retrospective approach, and the method of examining the factor that influences in the result.

The method of comparing the diagnosis and treatment processes using EHR (Electronic Health Record) has not been standardized yet. Then, this study aimed at the development of a standardized technique, to describe the clinical care process comparison using EHR.

Methods

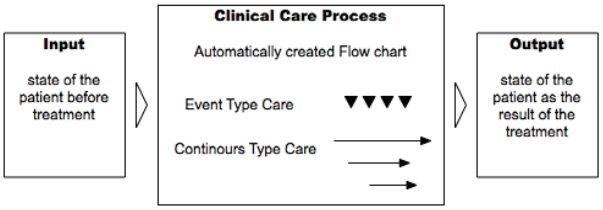
We divided the clinical process into input, process, and output. The state of the patient before the treatment was described in input. The state of the patient as the result of the treatment process were described in output. Flow chart, by the prescribed form, was made automatically from clinical information accumulated in EHR. The record of the patient of neonatal care unit was used.

Result

There were two methods of record of the process. Event type and continuous type. The event type is a treatment act done single-engined, such as endotracheal intubation etc. The continuation type is treatment continuously done, such as respirator and fluid infusion management etc.

Discussion

It was thought that this technique was suitable to describe the clinical process. A quantitative evaluation of the event type process was easy. A qualitative evaluation in the event type process became a problem. It was guessed that the continuation type influenced hospital days.



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Development of standardized technique using EHR to describe clinical processes

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Background

- We did the computerization of patient information in our hospital.
- Patient information was recorded in an individual data base.
- The standard method to retrieve by skewering two or more patients has not been established yet.
- We aim at operating analysis of clinical procedure.
- We aim at evaluation of the validity of care process.

Objectives

- To establish the methodology of clinical process analysis.
- To develop prototype application that use the methodology.
- To analyze the patient data by using the prototype application.
- To evaluate the methodology by assessment of analytical result.

Method 1: Definition of various events in clinical process

- INPUT: condition of the patient on admission.
- PROCEDURE: therapeutic intervention
- OUTPUT: condition of the patient at discharge

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Method 2: Type of Therapeutic Intervention

- Event type intervention
  - Endotracheal intubation, one shot injection, etc
- Continuation type intervention
  - Use of incubator, oral intake, tube feeding , etc.

Method 3: Treatment intervention analysis algorithm

- Patients are sampled according to the condition on admission.
- Treatment intervention data of the sampled patients are extracted from electrical flow chart.
- Various analyses are tried to each intervention.
- Analytical results are compared with the output.

Result 1: Development of prototype application

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Result 2: Difference of analysis method according to type of the record.

- Event type intervention.
  - It is possible to evaluate it quantitatively by the frequency.
  - Other table that describe quality of the record is required for a qualitative evaluation.
- Continuation type intervention (string data)
  - When the intervention is described on one record, the beginning day of the procedure, the end day of it, the continuation days are appreciable.
- Continuation type intervention (numerical value)
  - The beginning day of the intervention, the end day of it, the continuation days of it are appreciable.
  - The maximum value, minimum value, average value are appreciable.

Result 3: Analysis sample

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Discussion

- The study was retrospective study that had examined the analysis method based on an electronic record.
- In the event type intervention, a qualitative evaluation was difficult though a quantitative evaluation was easy.
- It is necessary to prepare the relation-table for a qualitative evaluation separately.
- In the continuation type intervention, it is necessary to structurize the accumulated database.
- If a related item is not described in the same record, the table that describes the relation of another record is necessary.

Conclusions

- The methodology of operating analysis of the clinical process was studied using the electronic hospital record.
- There were variety of operating analysis of clinical procedure by way of the various patient's extraction method.
- The importance of the construction of the structurized patient information data base was suggested.

References, acknowledgments and contact details

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Development of Data Capture System for Clinical Study by the Secondary Use of Electronic Health Records

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[a] *Department of Clinical Trial Design & Management, Translational Research Center, Kyoto University Hospital, Kyoto, Japann,* [b] *Outpatient Oncology Unit, Kyoto University Hospital, Kyoto, Japan*

Abstract

In conventional clinical studies, costs of data quality control and the burden of paper case report form collection tends to rise. We developed a data capture system for cancer which directly accumulates clinical study data from electronic health records. Cost reduction and quality improvement of clinical studies are expected from this system.

Keywords:

electronic data capture, electronic health records, cancer, outcomes research, clinical study, data warehouse

Introduction

In conventional clinical studies, costs of data quality control and the burden of paper case report form collection tends to rise, because of making and filling out a paper case report form based on each clinical study protocol.
The secondary use of electronic health records is expected for cost reduction and quality improvement of clinical studies, but current electronic health record systems are structured in which various clinical information is stored in mixture. Such information is not usable for a clinical study.

Purpose

The purpose of this study is to develop a data capture system for clinical studies to accumulate necessary information from electronic health records, and to evaluate the prognosis, prognostic factors, outcomes of treatment and safety of that.

Methods

In Outpatient Oncology Unit, Kyoto University Hospital, we developed a data capture system which includes a cancer clinical database system and a data warehouse for clinical studies.

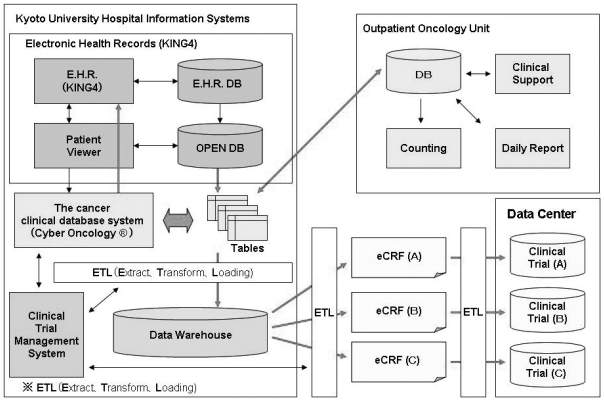

Figure 1 - Architecture of the system

The cancer clinical database system has structure which can file the results in the right data type, as well as high-level support functions to everyday clinical practice for cancer and on-line counting functions of stored data.

Data like laboratory values or patient characteristics are transferred from electronic health records directly and stored in the system. Data input into the system like adverse effects are transferred to electronic health records via copy and paste by the medical staff.

The stored information in this system is regularly transferred to the data warehouse, and become anonymity at the same time. Accumulated data in the data warehouse is used for analysis of adverse effect, interaction of drugs and outcome evaluation.

Data of individual clinical studies are extracted from the data warehouse from each protocol, converted into an electronic case report form, and forwarded to researchers to collect additional data. The researchers add necessary data to the electronic case report forms, transfer to a data-center, and databases for clinical studies are made there.

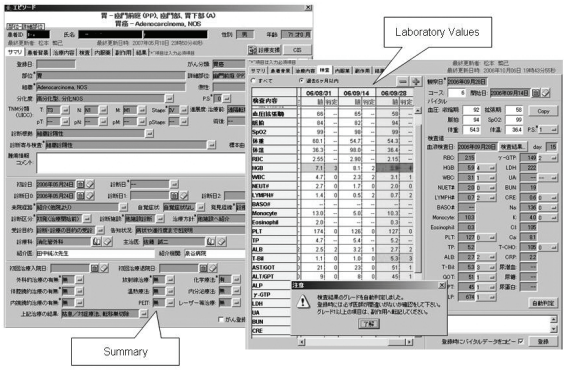

Figure 2 - Screen sample (summary, laboratory values)

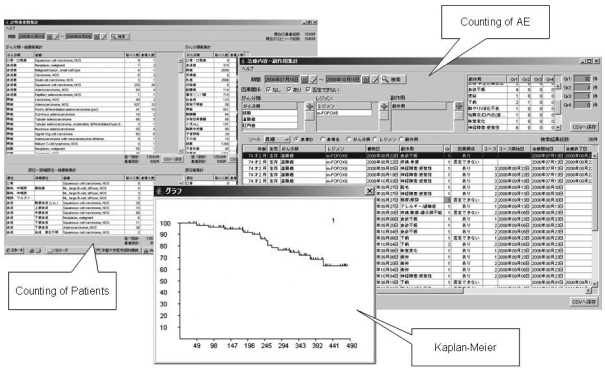

Figure 3 - Screen sample (on-line data analysis)

Results and conclusion

The system which directly accumulates clinical study data from electronic health records has developed. We are now evaluating the system.

We have planned to promote the cancer clinical database system in other institutions and collect data to the data warehouse to establish large-scale database for clinical studies of cancer in Japan.

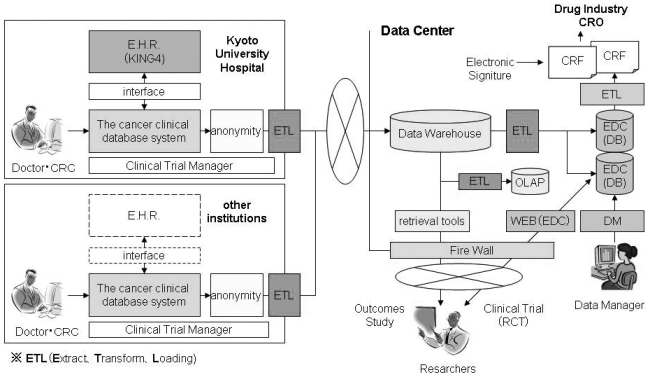

Figure 4 - Prospect

Cost reduction and quality improvement of clinical studies are expected from this system.

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Kyoto University Hospital, Kyoto, Japan

【 Back Ground 】

●In conventional clinical studies, costs of data quality control and the burden of paper case report form collection tends to rise, because of making and filling out a paper case report form based on each clinical study protocol.

●In Japan, medical information technology has promoted as a national strategy, and an electronic health record (E.H.R.) system was launched at the Kyoto University Hospital from January, 2005.

【 Back Ground 】

- The secondary use of E.H.R. is expected, but current E.H.R. systems are structured in which various clinical information is stored in mixture. Such information is not usable for a clinical study.

【 Methods 】

- In Outpatient Oncology Unit, Kyoto University Hospital, we developed a data capture system which includes a cancer clinical database system and a data warehouse for clinical studies.

- The cancer clinical database system has structure which can file the results in the right data type, as well as high-level support functions to everyday clinical practice for cancer and on-line counting functions of stored data.

【 Methods 】

- Data like laboratory values or patient characteristics are transferred from E.H.R. directly and stored in the system. Data input into the system like adverse effects are transferred to E.H.R. via copy and paste by the medical staff.

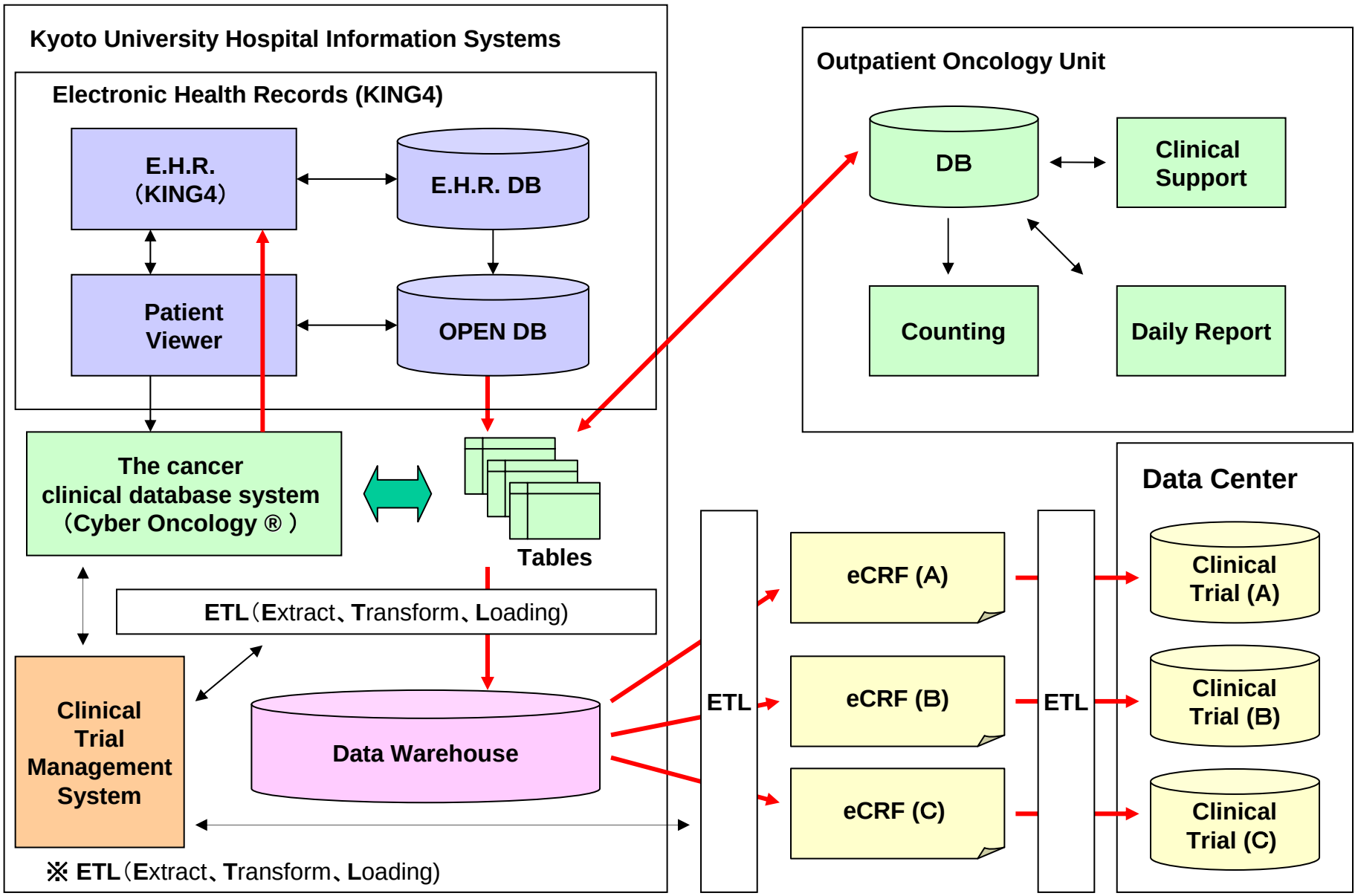
- The stored information in this system is regularly transferred to the data warehouse, and become anonymity at the same time. Accumulated data in the data warehouse is used for analysis of adverse effect, interaction of drugs and outcome evaluation.

【 Methods 】

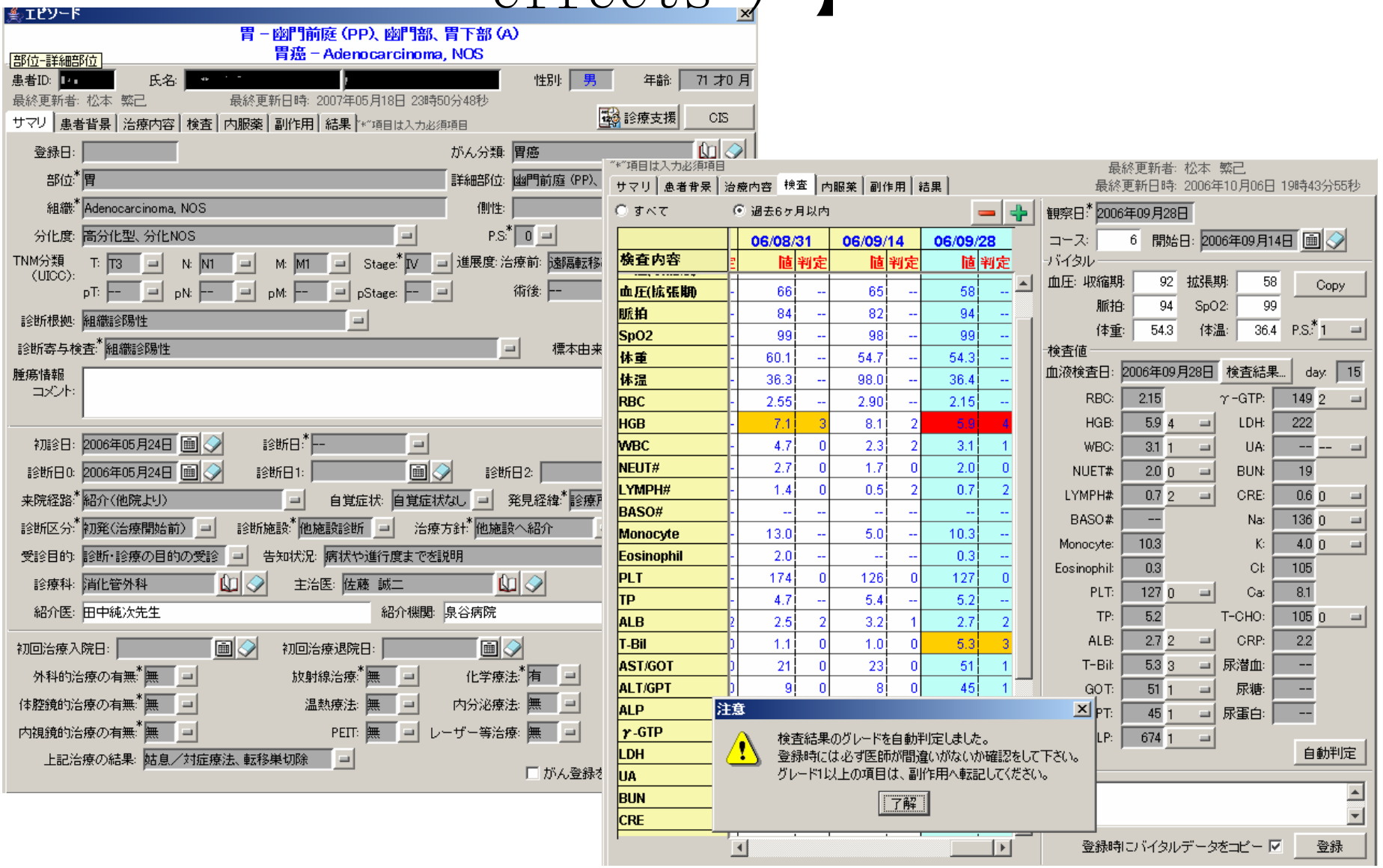
●Data of individual clinical studies are extracted from the data warehouse from each protocol, converted into an electronic case report form, and forwarded to researchers to collect additional data.

●The researchers add necessary data to the electronic case report forms, transfer to a data-center, and databases for clinical studies are made there.

【 Architecture of the System 】



【Screen Sample (Summary, Adverse effects)】



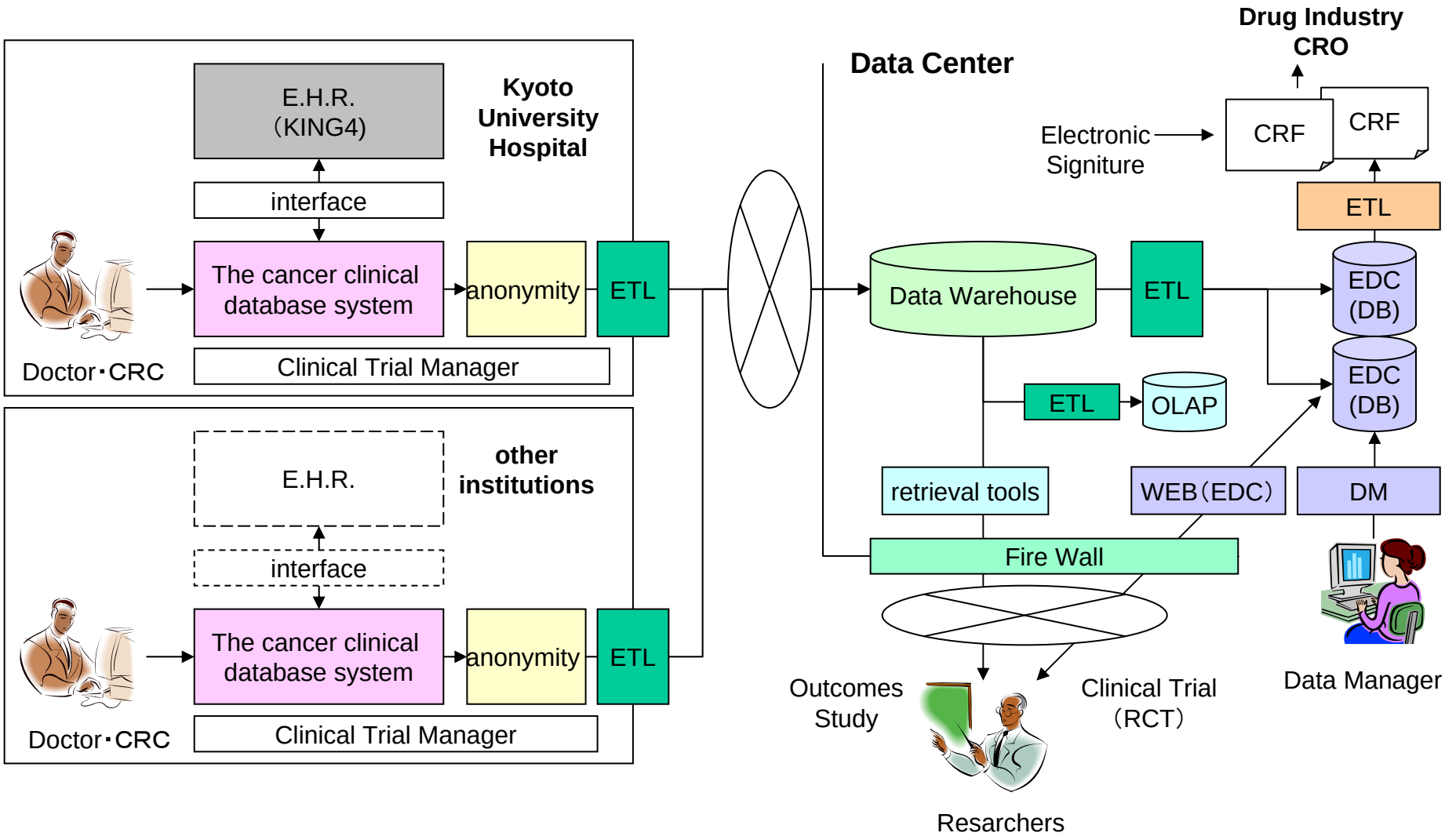
【 Results and Conclusion 】

- The system which directly accumulates clinical study data from E.H.R. has developed.
- We are now evaluating the system.
- Cost reduction and quality improvement of clinical studies are expected from this system.

【 Prospect 】

- We have planned to promote the cancer clinical database system in other institutions and collect data to the data warehouse to establish large-scale database for clinical studies of cancer in Japan.

【 Prospect 】



※ **ETL**（**E**xtract、**T**ransform、**L**oading）

Thank you for your kind attention!

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The Application of a Clinical Data Warehouse to the Assessment of Drug-Warfarin Interactions

Qiyan Zhang[a*], Yasushi Matusmura[a], Hiroshi Takeda[a]

[a] *Department of Medical Informatics, Graduated School of Medicine, Osaka University*

Abstract and objective

Studies on drug-warfarin interactions in human subjects were typically based on single case reports or extrapolated in healthy volunteers. In this study, we proposed a method to apply an institutional clinical data warehouse (CDW) to address this issue in a real-world setting. A case-control study was conducted by using the CDW in Osaka University Hospital from 2000/01/01/-2005/12/31. We randomly selected the steady-state outpatients who were under warfarin mono-therapy as Group A and those who were on the pre-existing warfarin therapy but with only the added medication X as Group B. The difference between the PT-INR values on one-month interval in Group A and those before and after taking medication X for one month in Group B was compared. The warfarin-Allopurinol interaction was illustrated as one example. We identified 25 cases in Group A and 15 cases in Group B respectively. The difference of the PT-INR values on one-month interval between the two groups was not significant (P=0.394,Mann-Whitney test), indicating that no warfarin-Allopurinol interaction was present. This method can be used as an alternative approach to assess drug-warfarin interactions.

Keywords:

clinical data warehouse, Warfarin, drug interaction, PT-INR

Introduction

Warfarin is an effective and commonly used oral anticoagulant agent for the treatment and prevention of thromboembolism in a variety of conditions. The risk of major complication- hemorrhage may be increased when concomitant drug therapy is required. Previous studies on drug-warfarin interactions in human subjects were based on single case reports or extrapolated in healthy volunteers. Clinicians need to balance the therapeutic benefits with the bleeding risk through monitoring patient's PT-INR values during warfarin therapy. In this study, we proposed a method to apply an institutional clinical data warehouse (CDW) in a real-world setting to reduce certain practical and ethical problems faced by studies drawn from healthy volunteers and aimed to provide an alternative approach to assess drug-warfarin interactions.

Methods

The CDW in Osaka University Hospital was built in 1995 as a subject-oriented database. The outpatient's prescription data and PT-INR results were picked up from 2000/1/1/-2005/12/31 through Business Objects 6.5.1. Data were processed via Microsoft Access 2003 and statistic analyses were performed via SPSS 11.0 Japanese Version for Windows. A case-control study was conducted. The steady-state outpatients who took warfarin consecutively for at least one month were considered as the eligible study subjects. We randomly selected those who were under warfarin mono-therapy as Group A and those who were on the pre-existing warfarin therapy but with only the added medication X as Group B. Then we compared the difference between the PT-INR values with one-month interval in Group A and those before and after taking medication X for one month in Group B. The warfarin-Allopurinol interaction was demonstrated as one example.

Results

For the chosen example, we identified 25 cases in Group A and 15 cases in Group B respectively. The difference of the PT-INR values on one-month interval between the two groups was not statistically significant (P=0.394, Mann-Whitney test), indicating that no warfarin-Allopurinol interaction was present.

Mann-Whitney test

	GROUP	N	Average Rank	Rank Sum
PTINR1	B	15	23.13	347.00
	A	25	18.92	473.00
	Sum	40		
PTINR2	B	15	24.87	373.00
	A	25	17.88	447.00
	Sum	40		
DIFFEREN	B	15	22.53	338.00
	A	25	19.28	482.00
	Sum	40		

	PTINR1	PTINR2	DIFFEREN
Mann-Whitney U test	148.000	122.000	157.000
Wilcoxon W test	473.000	447.000	482.000
Z	-1.104	-1.830	-.852
P (two-tailed)	.269	.067	.394

Figure 1

Conclusion

This method can be used as an alternative approach to assess drug-warfarin interactions.

The Application of A Clinical Data Warehouse to the Assessment of Drug-Warfarin Interactions

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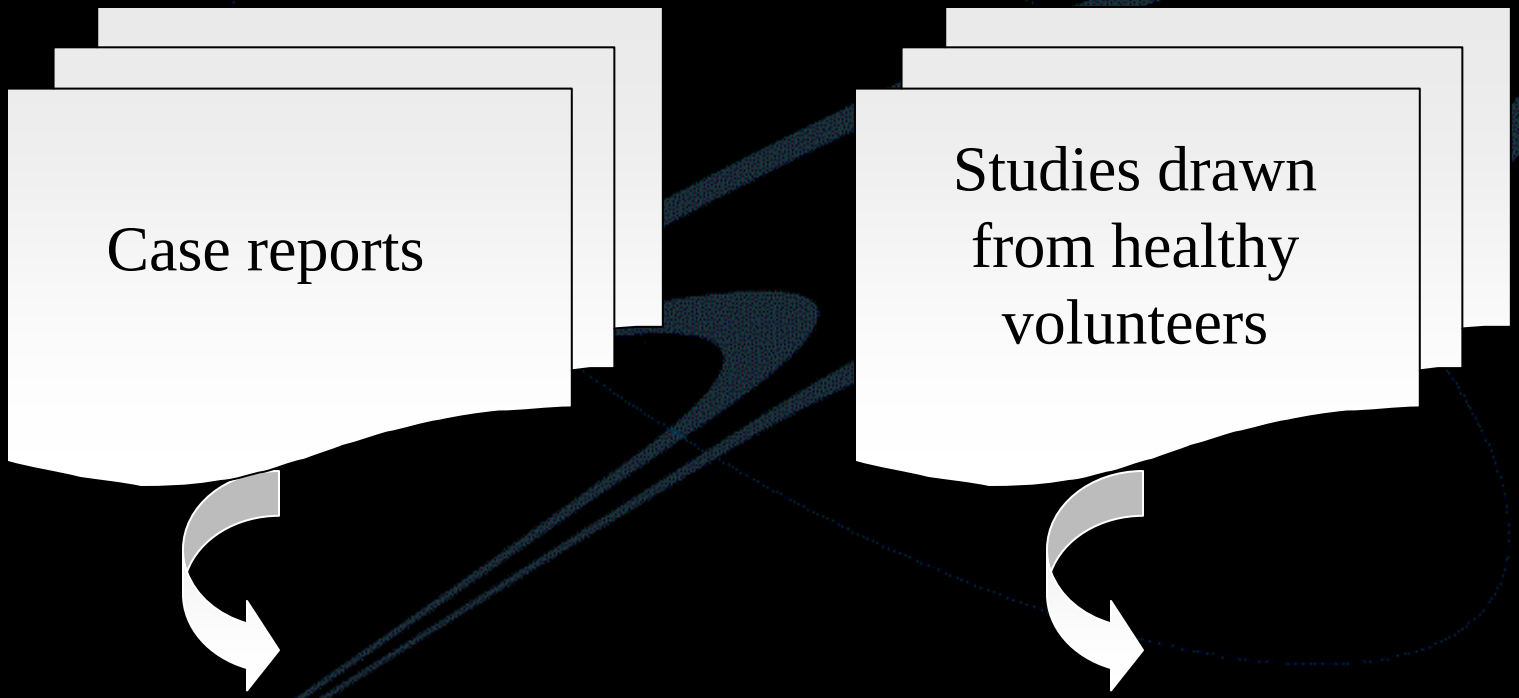
Department of Medical Informatics, Graduated School of Medicine, Osaka University

Introduction

Studies on drug-warfarin interactions in human subjects were typically based on



lower level of evidence

practical and ethical problems

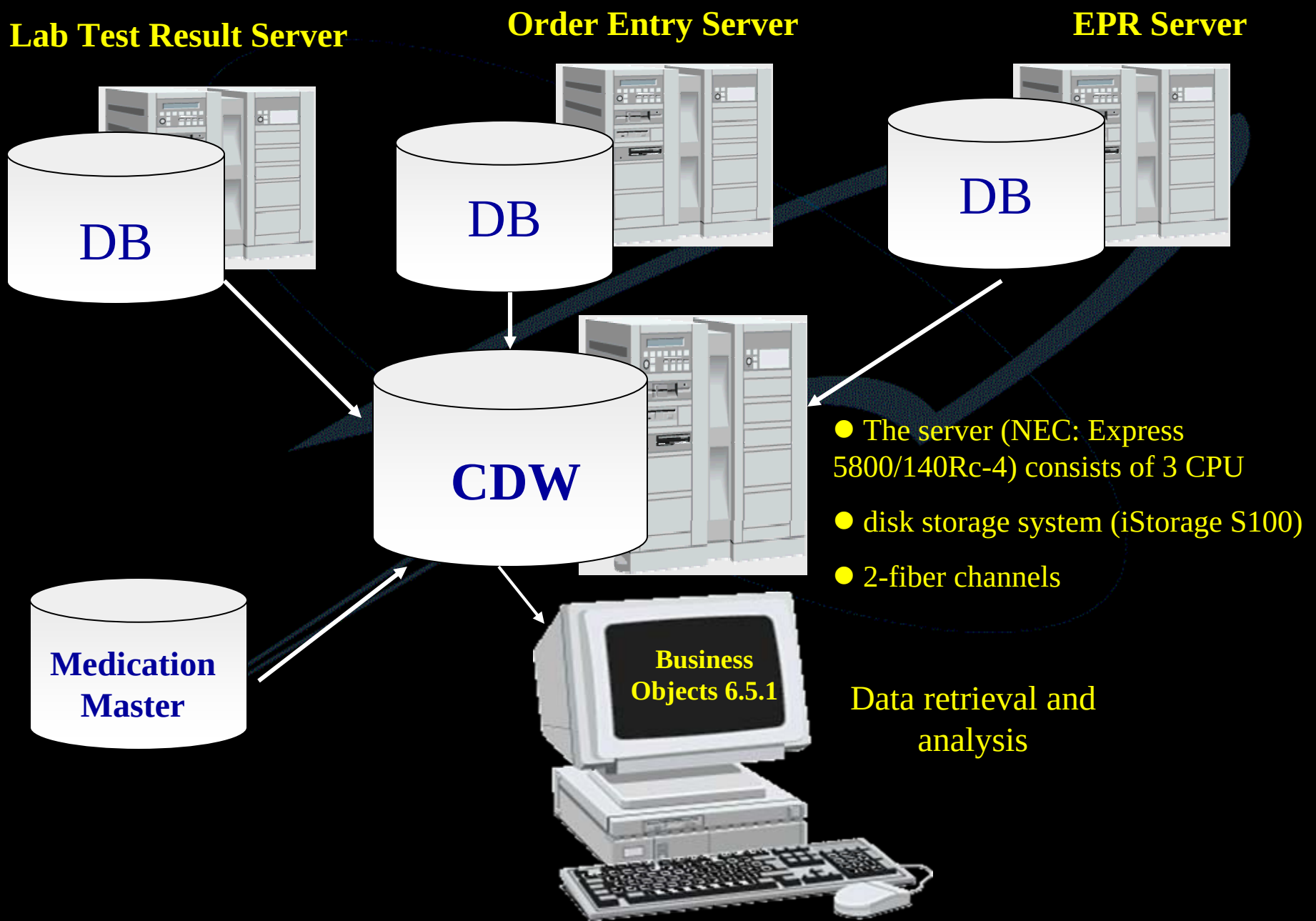
Purpose

- ***To propose a method to apply an institutional clinical data warehouse (CDW) as an alternative approach to assess drug-interactions in a real-world setting***

Materials

Data Source	Clinical Data Warehouse in Osaka University Hospital
Data Retrieval Tool	Business Objects 6.5.1
Data Processing Tool	Microsoft Access 2003
Data Analyses Tool	SPSS 11.0 J for Windows

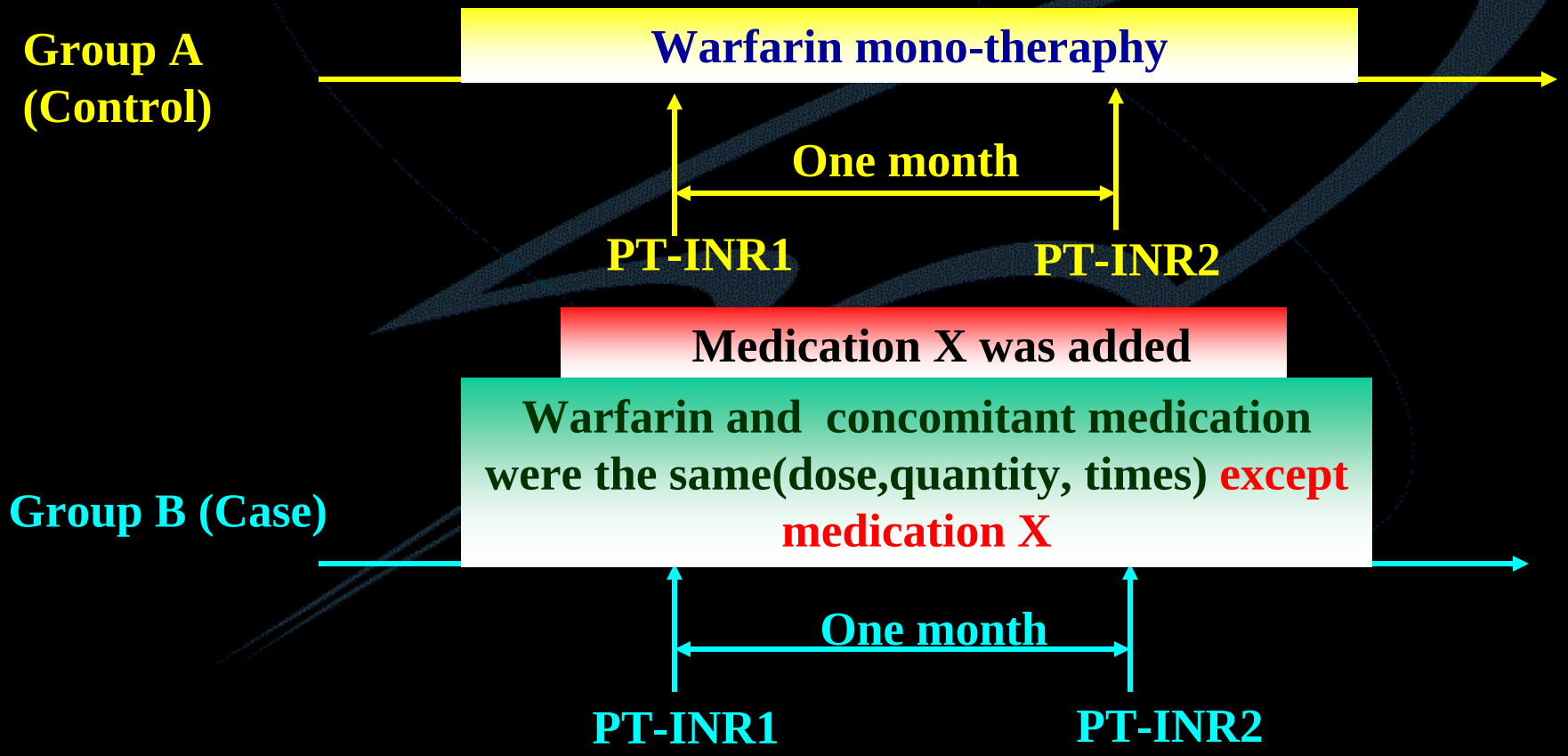
Methods - Outline of the CDW in Osaka University Hospital



Methods - Referred Data Sources,Tables, and Core Data Elements

Source of Data	CDW Tables	Core Data Elements
Lab test reporting system →	◆ Laboratory test results	PatientNo, OrderNo, PatientAge, Sex, CollectDate, TestitemCode, TestitemName, Result
Order Entry System →	◆ Prescriptions	PatientNo, OrderNo, PatientAge, Sex, StartDate, EndDate, MedicationCode, MedicationName, Quantity,Unit, Times, PrescribDays
Medication Master →	◆ Medication Master	MedicationCode, MedicationName, CatalogName

Methods - Study Design Diagram



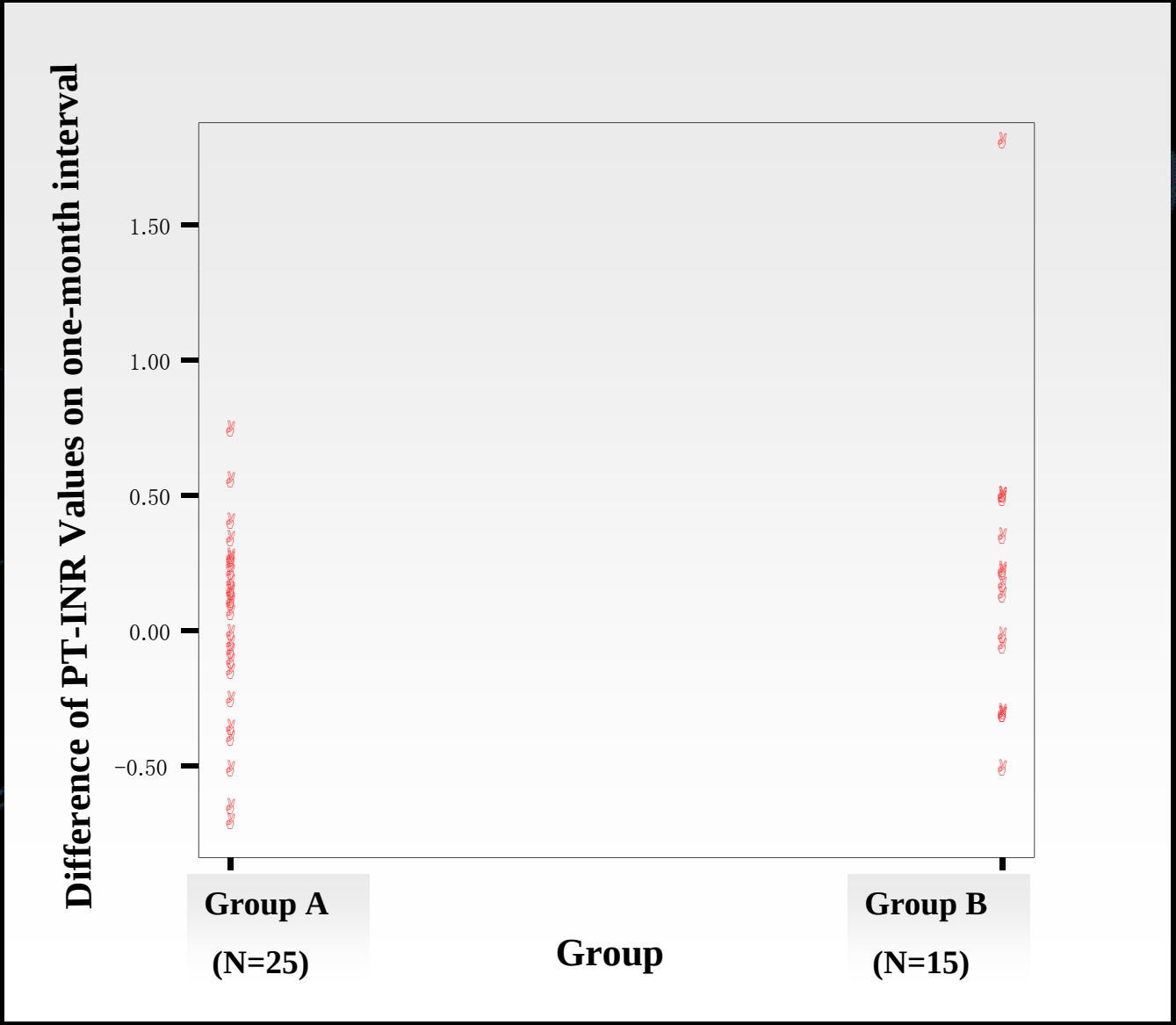
Results

Studied example: Warfarin-Allopurinol Interaction

Case -Group B: 15cases

Control- Group A: 25cases

Results


Difference of PT-INR Values on one-month interval
1.50
1.00
0.50
0.00
−0.50
Group A
(N=25)
Group
Group B
(N=15)

Results

Mann-Whitney test-Warfarin-Allopurinol Interaction

	GROUP	N	Average Rank	Rank Sum
PTINR1	B	15	23.13	347.00
	A	25	18.92	473.00
	Sum	40		
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Z	-1.104	-1.830	-.852
P (two-tailed)	.269	.067	.394

Conclusions

- No warfarin-Allopurinol interaction presents in this investigation.
- This method can be used as an alternative approach to assess drug-warfarin interactions.

Reference

Anne M. Holbrook, Jennifer A. Pereira, Renee Labiris et al., Systematic Overview of Warfarin and Its Drug and Food Interactions. *Arch Intern Med. 2005;165:1095-1106*

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A Web-based Service for the Management of Data Quality

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Abstract

We developed a guideline for the adaptive management of data quality in registers and cohort studies. The guideline is to focus on the adaptation of source data verification (SDV) and feedback to the actual level of data quality observed. 24 indicators for data quality are combined into one ordinal quality score, each with its individual relative weight. Sample sizes for source data verification are calculated so that the sample size will be larger for sites with bad data quality and smaller for those with good quality. The observed data quality is reported back to each site, optionally with open or anonymous benchmark data of the other sites. The recommendations as well as the workflow model for its use were implemented in a three-tier-architecture as web-based service. Through a web-browser or by upload of XML-files the input data are recorded. After execution of the guideline the recommendations are available in XML-format, as PDF-files or through the web-interface. Data quality becomes a crucial issue in the fast growing use of health-related data. The guideline and its implementation as web-based service is a major step towards a systematic and evidence-based approach covering respective challenges in data management.

Keywords:

data quality, feedback, quality indicator, source data verification, web-based service

Introduction

It is time to replace a skeptical position to mass data in health care with a systematical approach for the control of data quality. That should include the measurement of data quality, the interpretation of data quality parameters, and the linkage between data quality and data management procedures. As member of a meta-organization for networked medical research (called in German "Telematikplattform für Medizinische Forschungsnetze e.V.", cf. http://www.tmf-ev.de/) we conducted a project dealing with data management of registers and cohort studies.

Focusing on requirements of research databases we developed a guideline for an adaptive management of data quality and implemented a web-based service for a computer mediated application of its recommendations. The recommendations took also into account studies, concepts, and experiences from routine care, clinical studies, and other industries. To some extend the results are therefore applicable to non-research databases.

Adaptive management of data quality

Based on a detailed literature review and expert interviews the guideline identifies 24 quality indicators in the categories plausibility, organization, and trueness. A threshold differentiating between normal and problematic rates and a relative weight is given for each indicator.

A score of data quality is calculated in the following way. The rate measured by a project is compared with the threshold, either with its raw value or with a confidence interval. The weights of indicators with normal results are summed up. The sum is divided by the optimal sum of weights of the included indicators and multiplied with 100. That gives a score between 0 and 100 which is independent from the number of included (i.e. for the project at hand calculable) indicators. We defined 5 grades of data quality: 0 to less 20 points - very poor, 20 to less 40 points - poor, 40 to less 60 points - moderate, 60 to less 80 points - good, and 80 to 100 points - very good.

Within the scope of the guideline, the data quality grade is used twofold. First it is used to adapt source data verification, i.e. the comparison of registered data with source data as the paper-based patient record, to the data quality in such a manner, that resources are concentrated to sites with worse data quality. Secondly, the information on data quality is included in regular reports. Both actions are regarded as operations for quality control to reach a predefined level of data quality.

Source data verification (SDV)

SDV is an established procedure for the assessment of completeness and correctness of data quality. Its application could also raise data quality through the interaction with the responsible sites. The guideline offers recommendations for the volume (number of observation units e. g. patients), depth (number of data items), and frequency of SDV in a given interval. It takes into account the data quality grade, rates of the two indicators "agreement with source data referring to data items" and "agreement with source data referring to observation units" from the last analysis period, a precision parameter and the estimated total number of data items and observation units in the next period.

Sample size calculation of the volume is based on an estimation of the number of observation units with at least one wrong item. We assume a binomial distribution which is approximated by a normal distribution. The adaptation to data quality is controlled by the absolute value of the confidence interval's half width**,** which is smaller in case of poor data quality and larger in case of good data quality. We propose 0.01 for grade very poor, and an increment of 0.01 until 0.05 for grade very good. Sample size calculation of the depth is done identically. Frequency is calculated by spreading the necessary number of visits for the next analysis period regularly.

Feedback

Feedback improves data quality. In the guideline's recommendations three feedback strategies are offered: for a specific site no further data included, for a specific site with additional anonymous benchmark data for other sites, and for a specific site with additional open benchmark data of other sites.

The feedback consists of reports with information on data quality score, grade, and results of each included quality indicator with thresholds, weight, and rate. The reports are combined for the central data management as well as divided for each participating site.

Application

From the beginning it was planned to offer the guideline paper-based as well as mediated through a computer application. In consequence, the role of the guideline within data management was modeled using the Unified Modeling Language (UML) even in the paper-based form. UML was then chosen as methodology for software design as well. We complemented the activity diagrams with class and sequence diagrams. In addition to the requirements formulated in the guideline, the application should offer multi-subscriber capability, a history of recommendations, an interactive web-interface, input-/output-interfaces for data in eXtensible Markup Language (XML) and an output in Portable Document Format (PDF).

For the WWW-based service a three-tier architecture was chosen making special use of the Model-View-Controller (MVC) design pattern. On the data-layer (Model) the data are stored in XML-files. XML-files exist for the following data-subsets: general information on the project (input), numerators and denominator of each quality indicator (input), constants used for statistical calculations (input), summary covering quality indicators etc. (output), and results of the sample size calculation (output).

According to the web-based approach a standard WWW-Bowser is sufficient as user interface (View). The link between the user interface and the data is realized by Java Server Faces, a special extension of Java Server Pages enabling a simple definition of dynamic HTML-pages (Controller). The use of a secure protocol (HTTPS) insures the confidentiality of the transmitted data.

Further work

Focusing on research data bases as registers and cohort studies, the implemented guideline represents the utmost evidence in the field of management of data quality. Many thoughts will be relevant for data bases in routine health care as electronic health records as well. The delivery of the guideline through a web-based service offers a mean to overcome the obstacle of guideline implementation in daily practice. But some tasks to solve remain for the future.

Workload is still needed to apply the guideline, even by using the web-based service. In particular, the determination of numerator and denominator of each quality indicator by the central data management is labor-intensive. A generic interface to research data bases in medicine would be desirable, but was outside the attainable objectives of our project. Some years will pass until interface standards are available covering the details necessary for the determination of quality indicators.

Still needed is an empirical evaluation of the guideline's impact on data quality. We are in preparation of a randomized, multicentric and open trial with about 120 sites from a couple of projects. In this trial we will have three arms, one performing a full SDV, one following the guidelines recommendations using the web-based service, and one without any SDV. The guidelines itself could not be blinded, because it was published by the TMF.

Acknowledgments

The work presented here is a project for cooperative medical research on behalf of the "Telematikplattform für Medizinische Forschungsnetze e.V." and was funded by the Federal Ministry of Education and Research. We thank our project partners from the Competence Networks on Congenital Heart Defects, Dementia, HIV/AIDS, and Parkinson's disease for cooperation.

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Text Analysis Integration into a Medical Information Retrieval System: Challenges Related to Word Sense Disambiguation

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Abstract

We describe a high throughput, real-time modularized text analysis system integrated into a production medical information retrieval system at the Mayo Clinic. The system identifies clinically relevant entities and concepts from unstructured medical reports, e.g. drugs, diagnosis and concepts, as defined in RxNorm, SNOMED CT and UMLS. To achieve the desired performance, the text analysis components were either developed for or adapted to the clinical domain. In this paper, we discuss one of several required innovations, disambiguation of mapped concepts with respect to an ontology. The methodology for the identification of a set of problem ambiguities and the creation of a manually sense-tagged data set for each of them is presented. Based on this data set, methods for word sense disambiguation for clinical notes were developed. In this paper, we report one set of F-scores (range is 0.47-0.98) which are substantially above the majority sense baseline.

Keywords:

natural language processing, word sense disambiguation, UMLS, UIMA

Introduction

With recent advances in Natural Language Processing (NLP) technology, the biomedical community has begun processing large amounts of textual unstructured data for a number of tasks. The MedTAS system developed by IBM is a modular text analysis and search system for the Life Sciences domain based on IBM's Unstructured Information Management Architecture (UIMA) ([1], [2]), http://incubator.apache.org/uima]. A source of errors in any NLP-based system is the mapping of a word token to multiple concepts ([3], [4], [5]). For example, "ms" maps to 10 UMLS concepts in the test set we created. Concept-based indexing and retrieval involves the unique mapping to a single representation. This is the problem of word sense disambiguation (WSD). In this paper, we present the design and architecture of a large-scale, highly modularized, real-time-enabled text analysis system and the development of its WSD component..

Methods

Figure 1 shows the architecture for bulk and real-time processing of clinical documents for subsequent information retrieval (IR), in production since 2005.

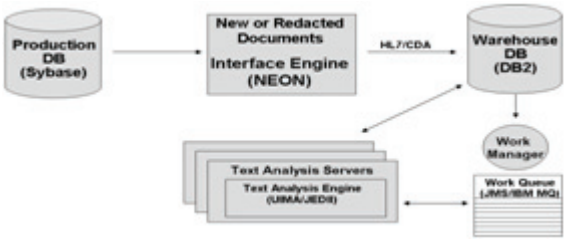

Figure 1 - Text analysis process flow

The UIMA-based text analysis system is a sequence of "annotators", each performing specific tasks. The annotators are native UIMA annotators, GATE-based and Open Source modules, and are either finite state automata or trained on hand-annotated corpora with a variety of machine learning (ML) algorithms. In addition to executing traditional NLP tasks on un-grammatical medical text, the annotators identify and extract named entities such as drugs, diagnosis and sign and symptoms allowing for concept-based indexing and retrieval. To increase retrieval results precision, multi-sense terms are to be uniquely mapped to a concept. Although there is a publicly-available WSD corpus derived from MedLine abstracts and manually sense-tagged with UMLS concepts ([5]), no comparable corpus for clinical ambiguities exists. We pose two specific questions: 1) are the most critical ambiguous terms in MedLine the same as those in the clinical domain, and 2) can the same algorithms be applied to both domains (biomedical literature and clinical text). Our first task was to create such a corpus.

The first step in the process was the identification of 50 frequent and highly relevant ambiguities from a medical retrieval perspective. We processed the entire 2002 collection of clinical notes through MetaMap ([6]), took the terms that mapped to multiple concepts and ranked them by their raw frequency. The top 1000 most frequent ambiguities were presented to four medical retrieval experts

who filtered them by relevancy for medical retrieval. The top 50 most relevant terms were included in our final WSD data set (referred to as Mayo WSD set). The corpus was then manually sense-tagged by four experts against UMLS. A "none of the above" category was added for those instances that did not have any sense representation in the UMLS.

The Mayo WSD set poses a number of challenges for any WSD annotator regardless of the technique employed. Some terms have over ten senses, e.g. "ac", thinly distributed over the 100 instances. Other senses have high representations of one specific sense, e.g. "ms". In addition, the "none of the above" category does not represent one monolithic sense.

Results

We used a ML approach to build the WSD annotator [7]. The experiments were based on 28 different feature sets on three variations of the corpus. The baseline F-score represented by the averaged majority sense is 0.6032. All feature sets performed well above the baseline. Detailed and comprehensive results will be presented in a subsequent paper. Here, we report one a set of F-scores, which was achieved by using a simple feature set of bag of unique stems filtered with a tf*idf formula within a window of 10 nonstop list tokens on both sides. This resulted in an average F-score of 0.776, well above the baseline.

Discussion

There are 9 ambiguous terms that overlap with the NLM WSD set described in [5]. Of note is that the senses themselves do not necessarily overlap. For almost all ambiguities, there are more senses in the clinical notes than in the literature abstracts, exemplifying that, in general, clinical notes are more complex than medical literature. Columns 4, 5 and 6 of Table 1 present the best results from three studies – [3], [4] and the current study. The first two studies worked with the NLM WSD set but excluded some ambiguities mainly because of the sparsity of the training instances. We experimented with the Mayo WSD set and achieved our best results with different feature sets than the one used to compute the F-score reported in the last column of Table 1. Extensive comparisons and error analysis will be presented in a subsequent publication.

Table 1 - Overlapping ambiguities between the Mayo WSD and NLM WSD set: number of senses in each set and best results from three studies

Ambiguity	Number of senses in Mayo WSD set (clinical notes)	Number of senses in NLM WSD set (literature abstracts)	Best F-score on NLM WSD set: Liu, Teller and Friedman	Best F-score on NLM WSD set: Leroy and Rindflesch	Best F-score on Mayo WSD set: current study
adjustment	5	4	not included in study	0.620	0.930
cold	6	6	0.909	not included in study	0.720
condition	6	3	not included in study	not included in study	0.900
discharge	2	3	0.908	not included in study	0.950
fit	5	3	not included in study	not included in study	0.740
lead	5	3	0.910	not included in study	0.900
sensitivity	7	4	not included in study	0.700	0.780
strain	9	3	not included in study	not included in study	0.690
support	6	3	not included in study	not included in study	0.740

Conclusion

We presented the Mayo Clinic IR system and part of our effort to incorporate a WSD component. For that, we created a manually sense-tagged set of 50 frequent and highly relevant ambiguities derived from the Mayo Clinic medical records, which is used to built and test a WSD annotator. In the future, we are planning to evaluate whether the disambiguation component indeed contributes to improved retrievals.

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Text Analysis Integration into a Medical Information Retrieval System: Challenges Related to Word Sense Disambiguation

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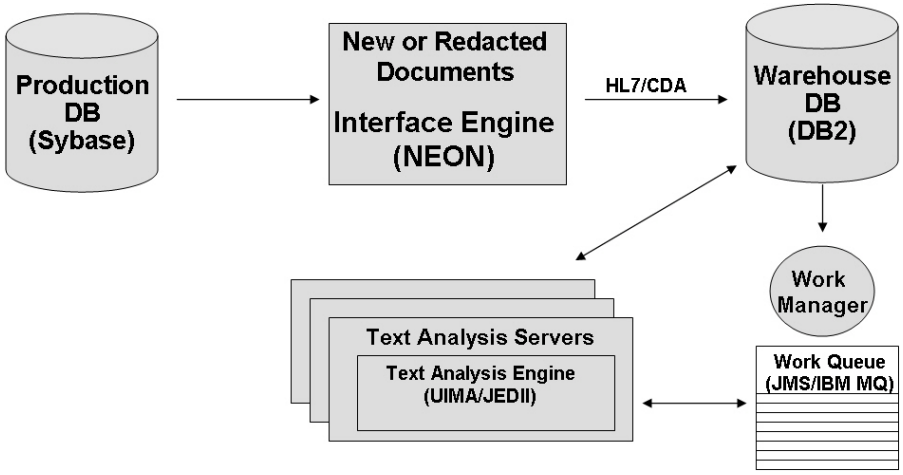
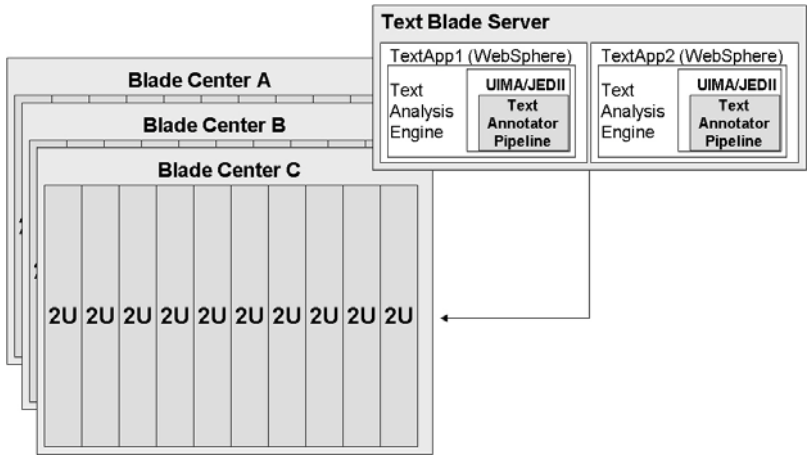
Text analysis production system

- **Large scale, highly modularized, real-time-enabled system**

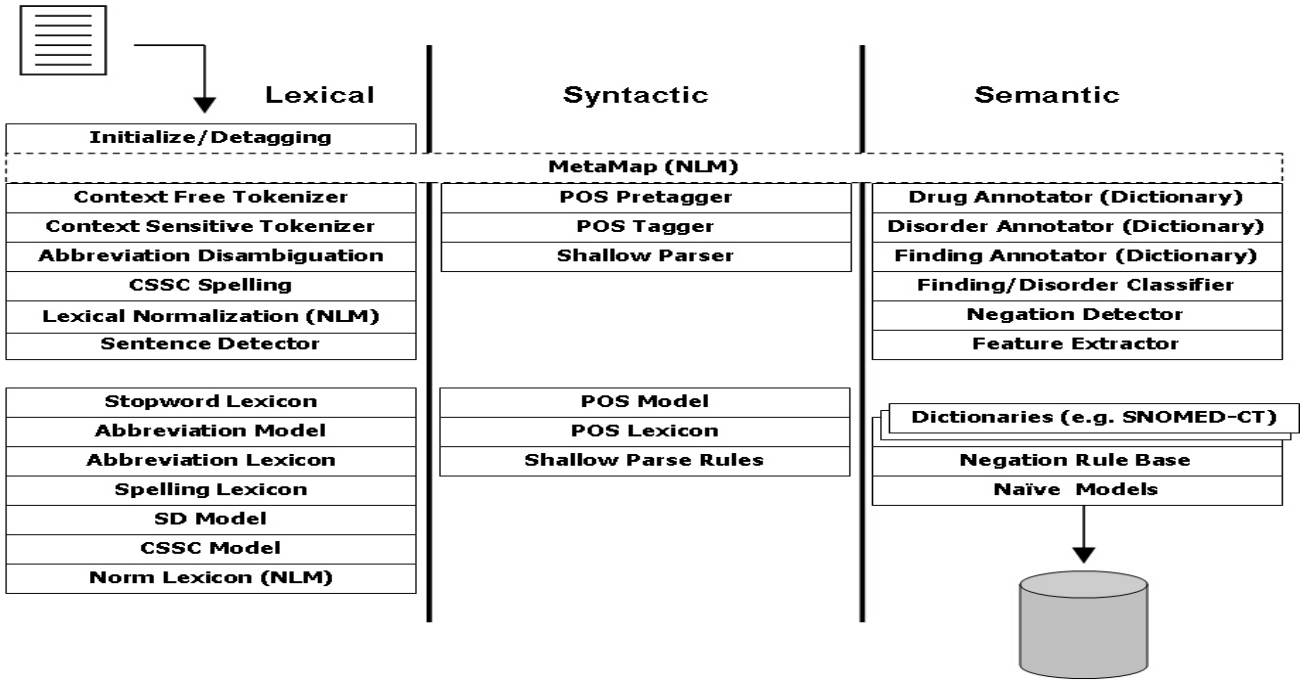


Text Analysis Process Flow



Text Analysis Deployment

Text Analysis System



- Finite state machine – tokenizer, shallow parser, dictionary lookup, negation detector
- Machine learning – abbreviation disambiguator, sentence detector, part-of-speech tagger, finding/disorder/drug classifier

Word Sense Disambiguation Corpora

- Publicly-available corpus based on MedLine abstracts – manually sense-tagged with UMLS concepts
- Built a comparable corpus for clinical ambiguities
  - 50 most relevant clinical terms/phrases
- Comparison
  - 9 terms in common between corpora

Manual Annotation

discharge				
CUIs	Definitions			
C0012621	Discharge, Body Substance			
C0600083	Discharge, Body Substance, Sample			
C0030685	Patient Discharge (Health Care Activity)			
Instance #	**Annotator 1**	**Annotator 2**	**Consensus**	**Text**
1	C0030685	C0030685	C0030685	Patient did not get to school after being **discharged** from the hospital due to there being multiple illnesses going around in the community.
2	C0012621	C0012621	C0012621	She and her family are instructed on signs and symptoms of wound infection including but not limited to pain, erythema, **discharge**, fever or chills.

- Interannotator agreement
  - Number of instances where the annotators agreed over all instances
  - Average: 0.772

WSD algorithm

- Built model for each ambiguity
  - Modification of Huber's robust loss for regression algorithm
- Experimented with 28 different feature sets
- Averaged majority sense: 0.6032
- Average F-score: 0.776
  - Feature set: bag of unique stems, filtered with a tf*idf formula, windows size=10, nonstop list of tokens

Clinical WSD corpus

Ambiguity	Number of Instances	Number of Senses	Sense 1 (majority sense)	Sense2	Sense3	Sense4	Sense5	Sense6	Sense7	Sense8	Sense9	Sense10	Sense11	Sense12	None (included in sense1-sense12)	IAA	F-score
ac	100	12	**59**	9	7	5	5	4	3	2	2	2	1	1	0	0.590	0.776
adjustment	100	5	**82**	12	4	1	1								1	0.740	0.859
affect	100	2	**50**	50											0	0.940	0.965
aid	100	5	**47**	39	9	4	1								9	0.490	0.714
apc	100	6	**84**	6	3	3	3	1							3	0.910	0.844
aspiration	100	2	**59**	41											0	0.990	0.910
block	100	9	**34**	19	13	13	12	3	3	2	1				12	0.220	0.623
burn	100	6	**82**	8	7	1	1	1							1	1.000	0.832
cat	100	3	**50**	48	2										0	0.970	0.960
cervical	100	4	**43**	41	14	2									0	0.900	0.869
cf	100	8	**62**	17	9	4	4	2	1	1					1	0.760	0.914
cold	100	6	**64**	14	14	4	3	1							1	0.920	0.643
compression	100	4	**56**	38	4	2									0	0.920	0.760
condition	100	5	**84**	9	5	1	1								0	0.740	0.859
dilatation	100	2	**52**	48											0	0.970	0.840
discharge	100	2	**65**	35											0	0.970	0.860
drain	100	4	**47**	29	23	1									0	0.820	0.573
dress	100	6	**35**	24	23	11	6	1							0	0.420	0.653
drink	100	4	**54**	42	3	1									0	0.370	0.563
fast	100	4	**85**	13	1	1									0	0.970	0.859
fistula	100	3	**78**	20	2										0	0.750	0.800
fit	100	5	**68**	13	11	6	2								6	0.850	0.710
glass	100	4	**55**	38	5	2									0	0.430	0.910
grade	100	6	**38**	31	17	9	4	1							0	0.520	0.764
interaction	100	5	**72**	20	4	3	1								4	0.910	0.784
iron	100	4	**70**	24	3	3									0	0.900	0.794
irritate	100	3	**84**	15	1										0	0.760	0.864
iv	100	4	**45**	23	20	12									0	0.810	0.590
lead	100	5	**47**	26	17	7	3								7	0.600	0.623
lift	100	7	**87**	5	2	2	2	1	1						0	0.590	0.909
ms	1000	10	**93.1**	47	6	5	3	2	2	2	1	1			2	0.978	0.933
pa	100	7	**56**	34	4	2	2	1	1						2	0.900	0.883
pack	100	5	**79**	15	3	2	1								3	0.140	0.874
patch	100	6	**73**	18	5	2	1	1							0	0.750	0.869
plaque	100	3	**49**	**39**	12										0	0.480	0.970
ra	100	9	**40**	23	20	6	5	3	1	1	1				5	0.710	0.837
relative	100	2	**53**	47											0	0.650	0.690
sense	100	4	**43**	26	18	13									0	0.460	0.810
sensitivity	100	7	**39**	22	21	12	3	2	1						3	0.450	0.684
sob	1000	2	**98.3**	17											0	0.990	0.983
splint	100	4	**70**	28	1	1									1	0.950	0.768
spot	100	8	**39**	20	14	11	7	5	3	1					20	0.700	0.513
stage	100	10	**28**	17	16	12	7	6	5	4	3	2			5	0.080	0.470
strain	100	9	**35**	18	17	10	7	6	5	1	1				18	0.570	0.535
stress	100	3	**77**	22	1										22	0.980	0.794
support	100	6	**38**	25	13	11	9	4							11	0.620	0.530
tear	100	7	**59**	17	11	6	3	3	1						3	0.900	0.653
transfer	100	2	**84**	16											0	0.840	0.980
valve	100	3	**52**	43	5										0	1.000	0.640
vesicle	100	3	**73**	25	2										0	0.220	0.760
average			**60.328**													**0.722**	**0.776**

Challenges

- Terms have many senses distributed thinly over 100 instances
  - Example: ac
- Terms have high representation of one specific sense
  - Example: ms
- “None of the above category”
  - Does not represent a monolithic sense

Comparison to NLM corpus

Ambiguity	*Number of senses in Mayo WSD set (clinical notes)*	*Number of senses in NLM WSD set (literature abstracts)*	*Best F-score on NLM WSD set: Liu, Teller and Friedman*	*Best F-score on NLM WSD set: Leroy and Rindflesch*	*Best F-score on Mayo WSD set: current study*
adjustment	5	4	not included in study	0.620	0.930
cold	6	6	0.909	not included in study	0.720
condition	6	3	not included in study	not included in study	0.900
discharge	2	3	0.908	not included in study	0.950
fit	5	3	not included in study	not included in study	0.740
lead	5	3	0.910	not included in study	0.900
sensitivity	7	4	not included in study	0.700	0.780
strain	9	3	not included in study	not included in study	0.690
support	6	3	not included in study	not included in study	0.740

Comparison to NLM corpus

- Senses do not necessarily overlap for the 9 terms between the corpora
- In general, more senses per term in clinical notes than in literature abstracts
- For best F-scores on clinical corpus, distinct feature sets for each term

Conclusion

- Built medical information retrieval system
  - Clinical notes accessible via keyword and concept search
  - Near real-time processing
  - Facilitates identification of patient cohorts
  - Nessary building block for other NLP applications
- Ambiguity of terms: source of errors
  - Create a manually sense-tagged set of 50 frequent and highly relevant terms in the clinical domain
  - Integrated a high accuracy sense disambiguator into the medical information retrieval system

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A Text Mining Approach to Explain What Being Actively Engaged in Life Means

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Abstract

This paper shows the findings and analysis of a national survey data on 'Active Ageing'. We examine the applicants responses on "what being actively engaged in life means to you?" with the text mining approach. The analysis shows that the 'Family', 'Friend' and 'Activity' were the most important concepts appearing across all age groups and both genders.

Keywords:

text mining, data mining, active ageing

Introduction

It is widely accepted that many first world countries are experiencing extended life expectancies and reduced fertility rates, which is resulting in an ageing population. A definition of active ageing is "the process of optimizing opportunities for physical, social, and mental well-being throughout life in order to extend healthy life expectancy [2]. The Australian Active Ageing (Triple A) study at the Queensland University of Technology (QUT) has conducted a national-wide postal survey to collect the responses of older people on a wide range of questions related to 'work', 'learning', 'social', 'spiritual', 'emotional', 'health and home', 'life events' and 'demographics'. The survey also included an open-ended question that the applicants responded to was "Briefly describe what being actively engaged in life means to you?". The purpose of this paper is to present the findings and analysis of the open-ended question in the survey using the text mining techniques [1]. This paper attempts to gain a better understanding of the impact of aging upon older Australians' engagement in society and their sense of well being. The findings and analysis are based on the responses from 2645 (45% response rate) participants over the age of 50 years residing across Australia.

Method: Text mining

Text mining extracts the important concepts and emerging themes from the collection of text sources using computation linguistics, machine learning and information science methods [1,3]. We utilize the Leximancer text mining application [3] to extract relationships from the text data. It is based on the bayesian theory using the words which make up a sentence to predict the concepts being discussed. Each *term* appearing in the text data is analyzed to form a *concept* and then many concepts are put together to form a *theme* based on the co-occurrence of terms and concepts in the text.

Data

The Triple A study data includes responses of 2645 members of a large Australia wide seniors organization on a wide range of questions related to their life. The survey includes 178 questions grouped into 8 sections covering the life aspects of social, health and home, emotional etc and an open-ended question. The sample included a reasonable balance of gender (57% female) and state representation (NSW: 32%, Vic: 24% and Qld: 20%). The respondents were quite comfortable financially, well educated and majority were living with a companion, in their own home in a metropolitan area.

Table 1 - Categorization by Age and Gender

Grouping	Category	Qty
All comments		1964
Grouped by age	55-64	1252
	65-74	474
	75 & over	238
Grouped by gender	Male	870
	Female	1094
Males grouped by age	55-64	523
	65-74	230
	75 & over	117
Females grouped by age	55-64	729
	65-74	244
	75 & over	121

Process

Preprocessing such as (1) removal of surveys (instances) that did not have sufficient information of age, gender etc, (2) application of spelling and grammar checking function in Excel in order to locate and correct the misspell words, incorrect abbreviations and slang, and (3) stop word removal and stemming were performed. The data file was then arranged and split into categories of both Age and Gender that allowed us to thoroughly compare and contrast the different combinations of categories (Table1).

Results and discussion

Comparison by age groups

Age group 55 – 64: The most significant concept and theme is 'Family'. 'Life' and 'Active' are next in the level of frequency. There is an integral relationship between 'family' and 'time' as well as having close ties with the 'enjoy' entity. 'Work' is considered a significant concept ranking highly for both males and females. 'Work' and 'Active' aspects comes to the fore in Males whereas 'Health' and 'Social' aspects are more frequent in the Females. This may indicate that Males place a greater importance in physically active aspects while Females signal social themes as figuring in their perception of active ageing.

Age group 65 – 74: This age group shows that they consider an active life to being engaged in it, living a full life, having a life with purpose and friendship in terms such as visit, involvement and participation. In this age group, males considered 'work' a more important concept than females. Both males and females emphasize on Family. However the terms that form the 'Family' concept in both groups differ. The females were concerned with interaction with emphasis on meeting, touching, visiting, whereas the males, although the terms indicate a need to be interactive, are less personal. Their terms include social, involved, community, and activities. Although it is a subtle difference, it could possibly indicate that for males, family is also a source of activity or social events. Whereas with the females, it could be perceived as a more emotional connection as opposed to as a source of activities or social connectivity.

Age group 75+: Ageing is perceived as having a close association with family and friends and maintaining an engagement in life through activities with these people. The concept of 'health' emerges as a significant concept, more highly ranked by the males than the females. This differs from the prior age groups indicating that this group may be considering health issues more frequently in relation to active ageing.

A very interesting difference that appears between male and female of this age group is the 'enjoy' concept. Female associate enjoy with life concept. However, male segregate the enjoy concept from either of family or active concept. Male population subtly emphasizes more on 'active' concept in comparison to female. Male population being actively means being involved with people. The female population seems to relate being actively with being involved with their loved ones, friends and social groups such as church.

Comparison by gender

All Females: Ageing is perceived as having a close association with family and friends and enjoying the activities with these people. Ageing is also perceived as being active in life through the time based work activities.

All Male: Ageing is perceived as being active in life and spending time with family and friends.

The most significant difference between the results of the males and females, are that where the females population were concentrated around 'Life', 'Family' and 'Friends', the male population seems to include a wider range of concepts including 'Active' and 'Work' as heavily weighted.

Using the whole population

To understand the behavior of the whole population including various age groups and all gender, we grouped the respondents according to the way they reflect active ageing using the clustering method [4]. This method also utilizes the computation linguistics to analyses the terms that mainly form a theme and consequently puts them into the same group. All respondents are grouped into 6 clusters. Following is the detail of each cluster including the few top-most terms due to which the respondents were put together in same group along with number of similar respondents in that cluster according to the written response.

Cluster 1: people, thing, good, new, health (1073)

Cluster 2: friend, social, work, child, grandchild (736)

Cluster 3: physical, mental, good, health, activity (175)

Cluster 4: mental, physical, happy, independent, family (136)

Cluster 5: help, other, helping, helping others (99)

Cluster 6: body, mind, help, good (89)

Cluster 1 is the biggest cluster in the dataset, which gives a general description for the meaning of active aging. The concepts covered are as follows: learning new things and skills, maintain good health, dealing with other people etc. Cluster 2 focuses more on the aspect of personal life, involves the family life, the friendship and the attitude to society. These respondents would like to enjoy with their family, look after their grandchild, stay with their friends, participate in social event and contribute to the society. Respondents in cluster 3 realize good health (mental and physical both) is the basis for happy life and are willing to participate in activities according to their health status. Cluster 4 respondents find the mental and physical health along with the family surroundings as key aspects for active ageing. People in cluster 5 wish to find out their personal values by helping others, in the aspect of daily life or whatever and wherever others need. The responders in cluster 6 wish to be interactive with other people to make their body and mind active as well as help the others.

These clusters show the various characteristic that each group of common respondents have. Further drilling to each group will identify more common concepts and themes.

Conclusion

A strong common themes across all groups, male, female and age groups were that 'Family', 'Friends' and 'Activities'. The younger age group considers 'Work' an important variable in active ageing, and this drops off to be important for only males in the next group, and is not ranked in the 75 and older group. Within the eldest group however, 'Health' emerges as an important concept, and given that this group is in a minority in the population as a whole, could explain that lack of representation overall of health concerns. These trends seem to indicate that the respondents are considering factors that are relevant to them in the immediate timeframe when responding to the question without consideration toward their future. There are various areas where these results may have impact and warrant some consideration such as future planning for government funding of community activities.

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[4] SAS Text Miner. (Accessed September 8th, 2006) http://www.sas.com/technologies/analytics/datamining/textmine

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Time-Series Data Analyses for Healthcare-Data-Mining Based on a Personal Dynamic Healthcare System

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Abstract

The healthcare-data-mining presented here extracts personally useful information, such as rules and patterns concerning lifestyles and health conditions, from daily time-series personal health and lifestyle data stored on a personal dynamic healthcare system by using mobile phone and web technologies. This paper focused on time-series data analyses in the healthcare-data-mining process. Interesting results concerning the relation between soybean protein ingestion and body-fat percentage were obtained.

Keywords:

personal healthcare, Internet, data mining,
time-series data

Introduction

We have developed a personal dynamic healthcare system (PDHS) utilizing the Internet. It enables time-series daily-health and lifestyle data to be stored in a database by using mobile phone and web technologies. Users of this system can input their daily data through a mobile phone and can transfer this data to a web-application server via the Internet. The web-application server provides a data mining service and notifies users, through a mobile phone, of important rules relevant to their health and lifestyle data. Here we report details of the time-series data analyses for the healthcare data mining and also present interesting results concerning the relations between lifestyle and health data for a volunteer user.

Methods

Healthcare-data-mining algorithm consists of two processes.

First process

We determined effective input fields by pre-examining the correlation between time-series lifestyle data and health data of interest as shown in Figure 1, where *e* is the given lifestyle data and *h* is the given health data. Here h_n is the value of *h* at date *n* and e_i is the value of *e* at date *i*. Assuming that lifestyle data affect health data with some delay, we defined a retarda-tion parameter *s* (=*n*-*i*).

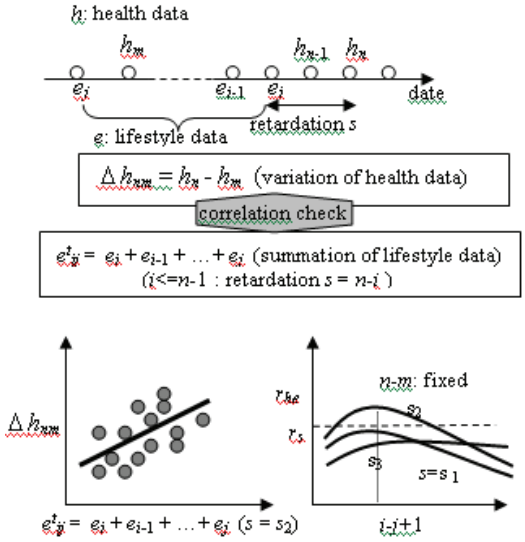

Figure 1 - Time-series data analysis

The correlation between Δh_{nm} and e^t_{ij} in time-series data was checked by changing *n-m, i-j* and *s* as parameters and calculating Pearson's product-moment correlation coefficient r_{he} for each (*n-m, i-j, s*) set. Here,

$$r_{he} = s_{he} / s_h \cdot s_e \quad (1)$$

where s_{he} is the covariance and s_h and s_e are respectively the standard deviation of Δh_{nm} and the standard deviation of e^t_{ij}. If, as shown in Figure 1, for some (*n-m, i-j, s*) set the r_{he} is larger than the threshold value r_s, then e^t_{ij} is selected as an input field. Actually, an input field is defined according to the values of *i-j* and *s* at which r_{he} becomes largest.

Second process

The second process is a rule induction from a number of time-

series data sets consisting of defined input fields and an output (target) field. An example of data set and a rule induction algorithm are shown in Figure 2.

Example of data set — input fields Y — output field X

date	Energy expenditure 5 (kcal)	Ingestion at meal 5 (kcal)	Alcohol intake	Body-fat index
10/06	1000	12000	much	higher
10/07	1200	11000	little	lower
10/08	800	13500	much	higher
……	……	……	……	……

Rule: If $Y = y$, then $X = x$ with probability p.
Y: input field, y: condition X: output field, x: value

Rules having higher-J-measure survive in the rule table

J-measure:

$$J(x|y) = p(y)\left(p(x|y)\log\frac{p(x|y)}{p(x)} + (1-p(x|y))\log\frac{(1-p(x|y))}{(1-p(x))} \right)$$

$p(y)$:probability of the rule's antecedent matching an example from the data set
$p(x)$:probability of the rule's consequent matching an example from the data set
$p(x|y)$:conditional probability of the rule's consequent conditioned on the antecedent

Figure 2 - Algorithm for rule induction

Input fields in the example of data set are defined by the first process. Energy expenditure 5, for example, is the summation of energy expenditure for 5 days. Output field (in this case, body-fat index) values are categorized into three classes, each having a symbolic value such as "higher", "moderate", or "lower". Border values used for this classification are determined so that the data frequency is similar in each class. In this rule induction algorithm, J-measures are estimated for all possible rules, and rules having higher-J-measure survive.

Results

In the automated healthcare-data-mining, the two processes described above are executed successively. The first process itself (time-series data analysis), however, produces interesting results. Here, we will report effects of soybean protein ingestion for an example.

Soybean protein is well known to lower blood cholesterol. Soybean β -conglycinin is thought to lower triglyceride levels and decrease body fat. One volunteer user (female, 22 years old) ingested different amount of soybean milk each day for about 6 months and measured her body-fat percentage almost every day under the same conditions.

The correlation coefficient r_{he} between body-fat percentage and the summation of soybean milk ingestion is, for various values of the retardation parameter s, shown in Figure 3 as a function of summation-day number (i-j+1). Negative correlation coefficients mean that ingestion of soybean milk was associated with a lower body-fat percentage (Figure 4). It should be noted that the r_{he} between body-fat percentage and the sum- mation of soybean milk ingestion strongly depends on (i-j+1) and s and that its absolute value is greatest when i-j+1 =12 and s = 4.

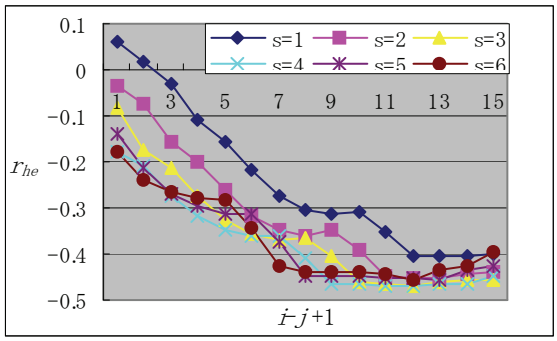

Figure 3 - Correlation coefficient r_{he} between body-fat percentage and summation of soybean milk ingestion as a function of summation-day number (i-j +1) for various values of retardation parameter s

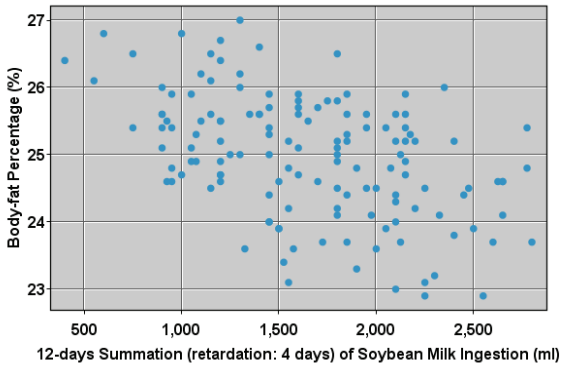

Figure 4 - Typical scatterplot of body-fat percentage (n:139, max:27.0 min:22.9, med:25.0, SD:0.906) versus soybean milk ingestion (correlation coefficient: -0.470)

Discussion

Body-fat percentage lowering may be due to an action of soybean β -conglysinin, which is reported to act on genes related to fat metabolism and thereby decrease triglyceride level. If so, Figure 3 suggests that in the human body the effect of β -conglysinin is gradual: for this volunteer user, the absolute value of the correlation coefficient r_{he} was maximum at i-j +1 = 12 (twelve days successive ingestion) and s = 4 (four days delay). These values of i-j and s at which correlation coefficient becomes largest may differ from person to person.

In the automated healthcare-data-miming process, the correlation between Δh_{nm} and e^t_{ij} in time-series data is checked by changing n-m, i-j, and s as parameters (n-m = 1-10, i-j = 0-9, s = 1-3). Time-series data analyses described here, however, suggest that ranges of i-j and s values should be extended more.

Conclusion

Time-series data analyses for healthcare-data-mining process in the personal dynamic healthcare system produced interesting results concerning the relations between soybean protein ingestion and body-fat percentage for a volunteer user of our PDHS.

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Time-Series Data Analyses for Healthcare-Data-Mining Based on a Personal Dynamic Healthcare System

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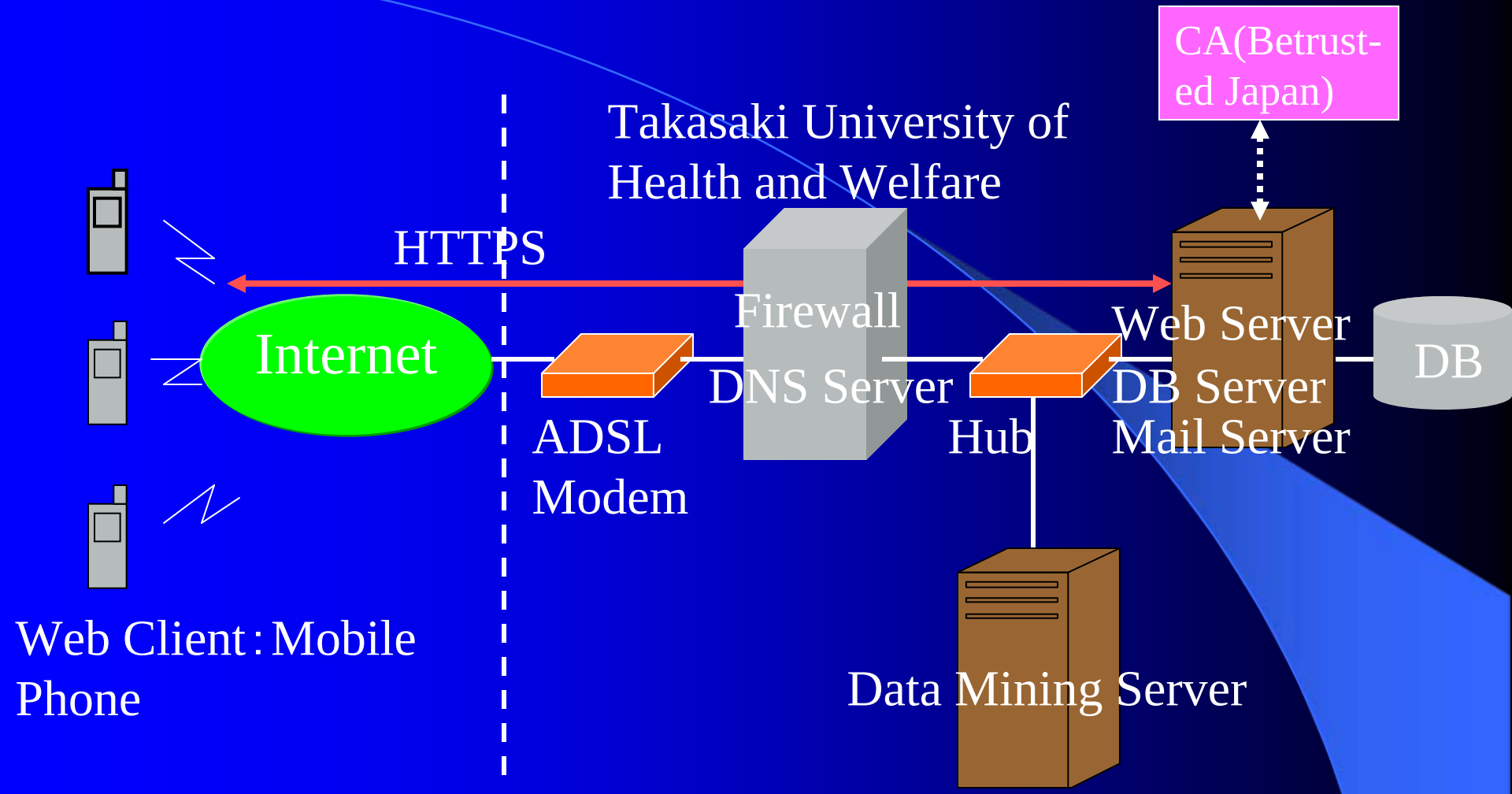
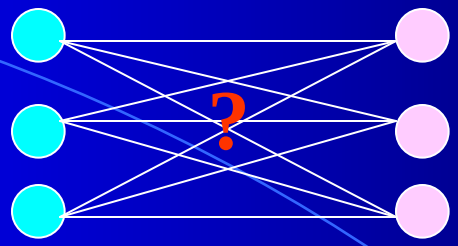


Configuration of personal dynamic healthcare system

lifestyle data
(input fields)



health data
(output fields)

Extracting personal rules relating lifestyle and health data

ingestion

energy expenditure

sleep

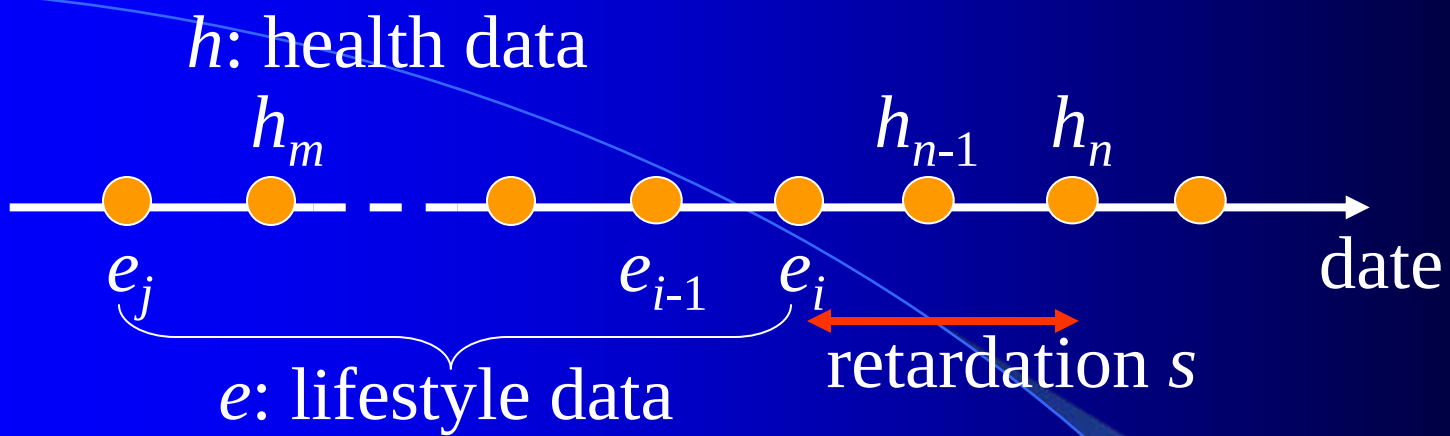
alcohol intake

smoking

daily vital signs

(blood pressure, body-fat index, body-temperature etc.)

Concept of healthcare-data-mining



$\Delta h_{nm} = h_n - h_m$ (variation of health data)

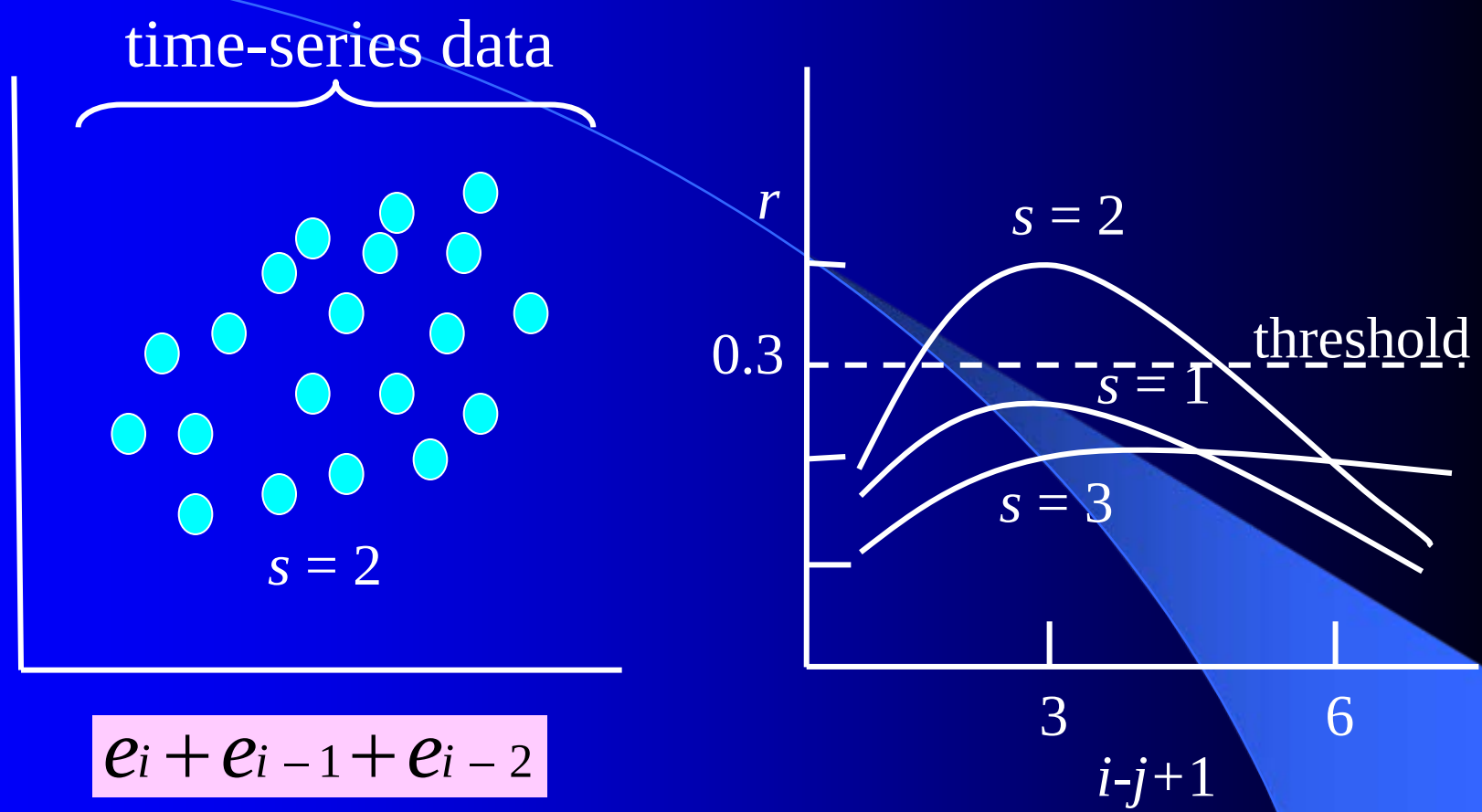
Correlation check

$e_{ij} = e_i + e_{i-1} + \ldots + e_j$ (summation of lifestyle data)

$(i <= n-1 : s = n - i)$

Calculate correlation between Δh_{nm} and e_{ij} in time-series data while changing *n-m*, *i-j*, and *s* as parameters

Algorithm for defining the input field (1)



$$e_i + e_{i-1} + e_{i-2}$$

(i = n-2)

r : correlation coefficient

input field is $e_i + e_{i-1} + e_{i-2}$ (i=n-2) in this case

Algorithm for defining the input field (2)

Data set Y_i X

Date	Energy expenditure 5 (kcal)	Ingestion 5 (kcal)	Alcohol intake	Body-fat Index
06/06	1000	12000	much	higher
06/07	1200	11000	little	lower
06/08	800	13500	moderate	moderate
....	....	....	....	....

Rule

If Y_1 is y_1 and Y_2 is y_2, then X=x with probability p.

Y_i : lifestyle data item, y_i : condition X : health data item, x : value

Rules having higher-J-measure survive in the rule table

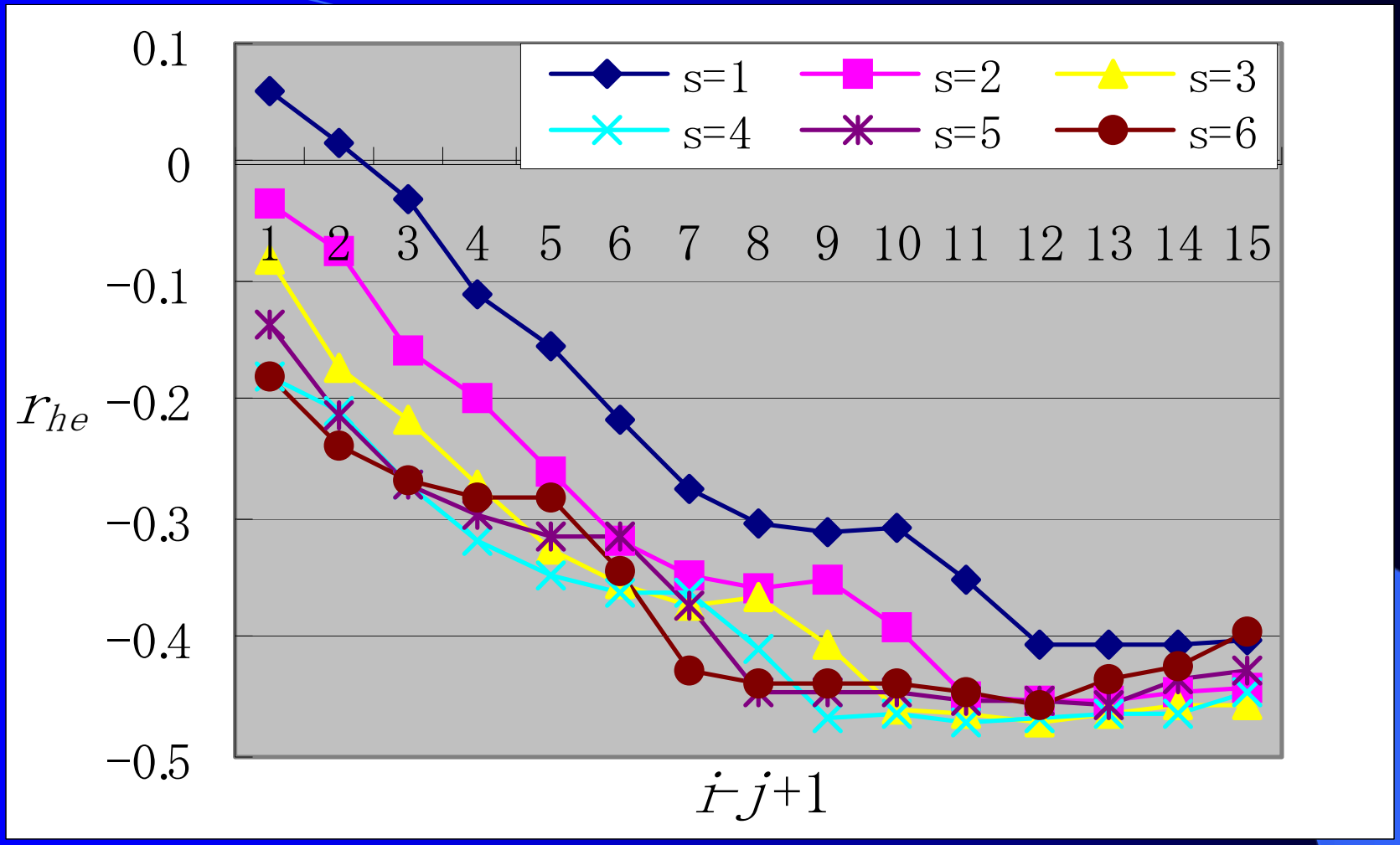
J-measure

$$J(x|y) = p(y)\left(p(x|y)\log\frac{p(x|y)}{p(x)} + (1-p(x|y))\log\frac{(1-p(x|y))}{(1-p(x))} \right)$$

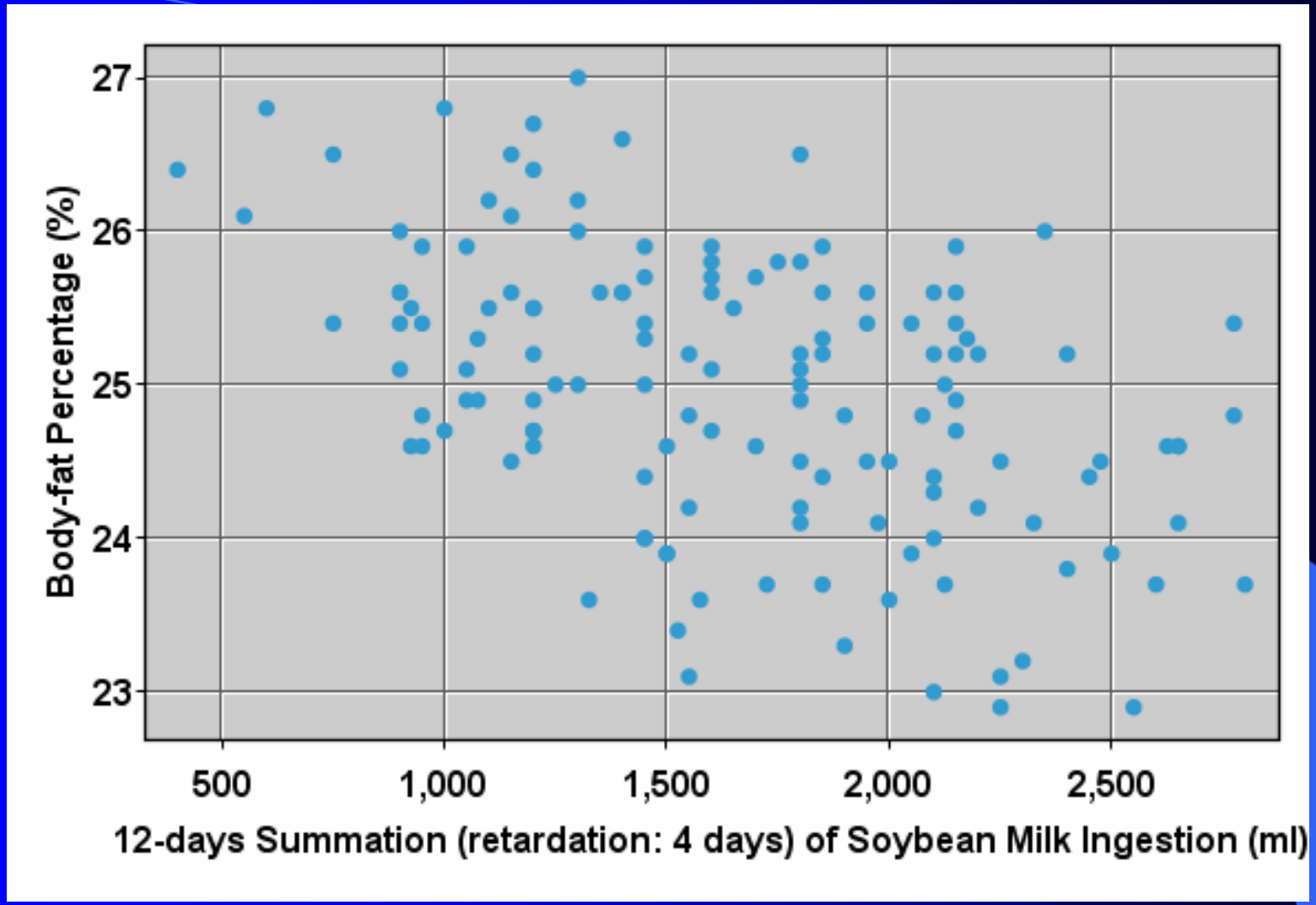
$p(y)$, $p(x)$ } probability of the rule's { antecedent, consequent } matching an example from the data set

$p(x|y)$: conditional probability of the rule's consequent conditioned on the antecedent

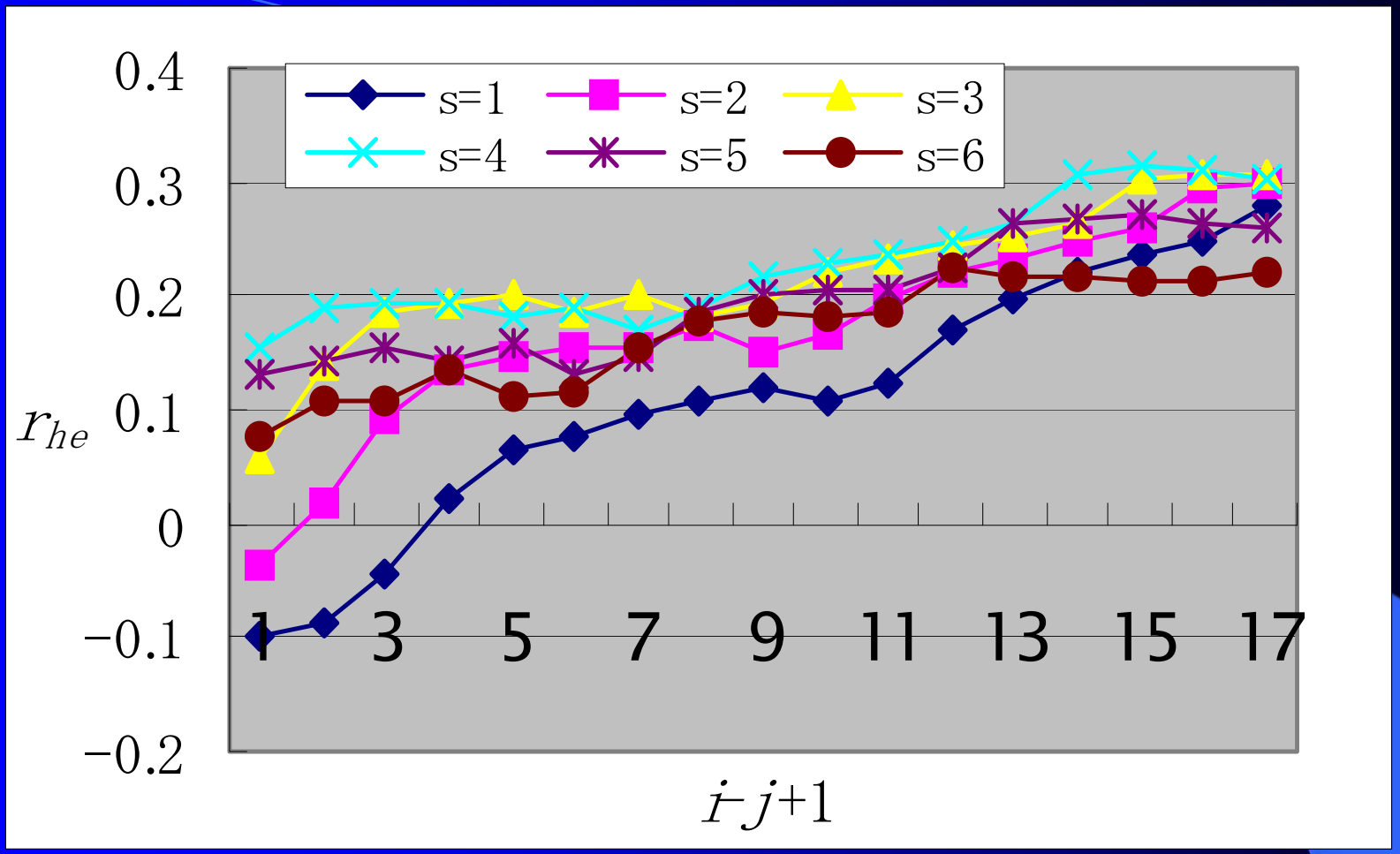
Algorithm for automated rule mining



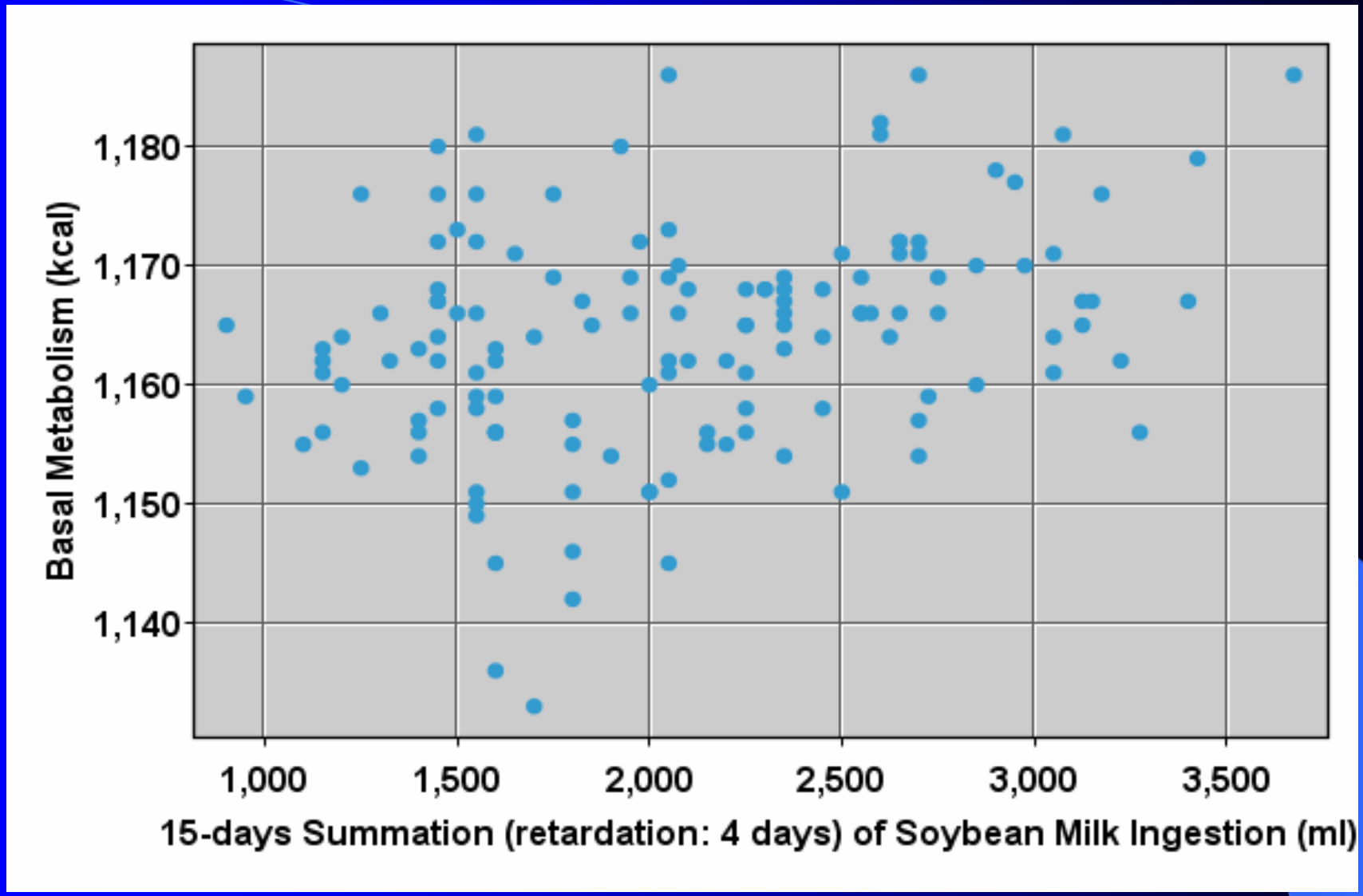
Correlation coefficient r_{he} between body-fat percentage and summation of soybean milk ingestion as a function of summation-day number ($i-j+1$) for various values of retardation parameter s



Typical scatterplot of body-fat percentage (*n*:139, *max*:27.0, *min*:22.9, *med*:25.0, *SD*:0.906) versus soybean milk ingestion (correlation coefficient: -0.470)



Correlation coefficient r_{he} between basal metabolism and summation of soybean milk ingestion as a function of summation-day number (i-j+1) for various values of retardation parameter s



Typical scatterplot of basal metabolism (*n*:138, *max*:1186, *min*:1133, *med*:1160, *SD*:9.48) versus soybean milk ingestion (correlation coefficient: 0.313)

Conclusion

Time-series data analyses for healthcare-data-mining process in the personal dynamic healthcare system (PDHS) presented here produced interesting results concerning the relations between lifestyle data and health data for volunteer users of PDHS.

Example: Daily soybean protein ingestion gradually decreased body-fat percentage (12 days successive ingestion was most effective with 4 days delay), and gradually increased basal metabolism (14 days successive ingestion was most effective with 4 days delay).

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Index and Query of Clinical Documents Complied with HL7 CDA Documents Using Weighted Navigational Expression

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Abstract

The Health Level 7 (HL7) Clinic Document Architecture (CDA) is an American National Standards Institute (ANSI)–approved, document markup standard that specifies the hierarchical structure and semantics of clinical document (such as a discharge summary, progress note, procedure report) for the purpose of information exchange. In this paper, a method is developed for index and query of CDA documents using weighted navigational expression. The method is based on templates that define the weighted navigational expression to guide the processes of index and query of clinical documents, so it is configurable. With the method, the index and query of clinical documents is fast and reliable. The method can be easily implemented in a distributed, heterogeneous environment such as a web application and adopted to different clinical settings.

Keywords:

clinical documents, CDA, retrieval, index, query

Introduction

HL7 CDA documents are encoded in Extensible Markup Language (XML). CDA documents derive their machine processable meaning from the HL7 Reference Information Model (RIM) and use the HL7 V3 Data Types. The CDA specification is richly expressive and flexible. Document-level, section-level and entry-level templates can be used to constrain the generic CDA specification. A CDA document can be transferred within a message, and can exist independently, outside the transferring message, with the characteristics of persistence, context, and wholeness. To be able to fully exploit the potential the CDA documents, one has to be able to effectively index, archive, and retrieve such clinical documents and more, query in a manner that takes advantage of the structured nature of such documents.

In the presentation, a weighted navigational expression method is developed to index and retrieve the clinical document, which precisely addresses this concern. The method is based on templates that define the weighted navigational expression to guide the processes of index and query clinical documents.

Methods

The first step of the weighted navigational expression method is document analysis, which analyzes the document *structures,* metadata, XML fragment and value, the filter terms of index and query, and stop context. A XML fragment is structure data represented and a part of a clinical document. The paths of the data fragments are specified in the index template. The filter terms are the content or attribute of atomic elements of XML data fragments. The textual contents of metadata, data fragments, and filter terms are analyzed based on linguists, thesauri or ontology. There are some dependencies between analysis steps because some results of the one analysis are helpfully or even necessary for the other analysis. Term position must be determined before stop word elimination because some terms are not counted and some phrase query may fail. Stop-word elimination should be processed before stemming because stemming is expensive depending on the number of words. Stop words such as ('the', 'a' 'if' etc) that increase the overhead but add no value during query are removed here.

After CDA documents are analyzed, an index process extracts metadata, XML data fragments, ranking terms, filter terms, and their relations to the content. The weighted data to be ranked according to the importance of data and the structure relationship among different levels of data fragments in the clinical documents are profiled in an index template. Figure 1 illustrates some data fragments and its tree structure. The structure relationships are used with the method as paths to locate and extract data from the clinical documents. The context of an individual CDA document, a set of the documents, or multiple sets of the documents are navigated and extracted to generate an index dictionary with different granularities to facilitate the flexibility of the query of the clinical documents. The indexes of clinical documents, their collection, their context, and the clinical setting are stored dictionary which is stored as a set of files. The indexes can be in-memory or map to a RMDS database specified by the index template.

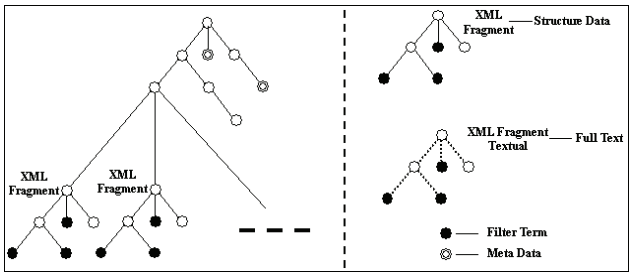

Figure 1 - Filter Term Nodes and XML Data Fragment Nodes

After the index dictionary is generated, users can query and retrieve the documents and can select the query context. If a single collection is selected, users can either specify an individual, multiple, or all the clinical document(s) in the collection. A query agent can perform query parse, query evaluation, pattern matching, and then present the query results. The query agent can perform both information retrieval (text query) and structure query (XML data fragments). The text query expressions can be constructed with simple keyword search, combining keywords within Boolean expressions, or querying for phrases, sentences etc. It can query the metadata, the textual content of XML data fragments, the element values or attribute values of filter terms. The XML Path Language is used to query structure data. The path expressions are embedded in the query template. Path expressions are also used to specify the return document fragments since often not the whole XML document should be referenced in the query result but only a certain fragment. By default, references to the root nodes of the matching documents or matching XML data fragments are returned depending on which how results are presented.

Results

The method has been successfully implemented as web application as shown in Figure 2. The implementation includes two major modules – index module and query module. The index module has an index user interface (UI) and an index agent. The query module has a query UI and a query agent.

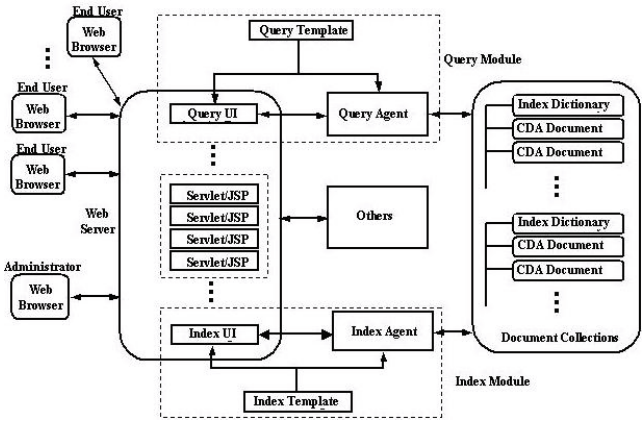

Figure 2 - Implementation of the weighted navigational expression method

Indexer agent performs document analysis, extracts data from the clinical documents, and stores index information to the index files in the server. Both index UI and index agent is configurable with the index template.

The query UI allows users to specify the query range. Users can query information from keywords and can be scoped down with filter terms. The query agent queries data from indexes and performs query parse, query evaluation, pattern matching, and present the query results. The query results are presented to users with two ways. All resulting data fragments are organized together and send back from query agent to query UI, where the results can be displayed either in a HTML page or PDF document depending upon the preferred style.

All matched clinical document names are listed in query UI. Users can select and look their interested document in detail. The matched contents are highlighted in the clinical document. The view of the document can also be displayed either as a HTML page or PDF document depending upon the preferred style

Discussion

There are two kinds of information retrieval IR approaches that deal with the retrieval of structured documents:

The structural approaches enrich text query by conditions relating to the document structure, e.g. that words should occur in certain parts of a document, or that a condition should be fulfilled in a document part preceding the part satisfying another condition, but generally do not support weighting or ranking [3].

Content-based approaches aim at the retrieval of the most relevant part of a document with respect to a given query, but do not allow for structural conditions [4].

Only a few researchers have dealt with the combination of explicit structural information and content-based retrieval. Mayan and colleague [5] use belief networks for determining the most relevant part of structural documents, but allows only for plain text queries, without structural conditions. The FERMI multimedia model [6] presents a general framework for relevance- based retrieval of documents.

In the paper, a weighted navigational expression method is developed to index and retrieve the clinical document, which precisely addresses this concern. The method is based on templates that define the weighted navigational expression to guide the processes of index and query clinical documents. The method can be easily implemented in a distributed, heterogeneous environment such as a web application and adopted to different clinical settings.

Conclusion

The weighted navigational expression method is an easy, effective, and configurable method of index and query of CDA documents. The method is implemented as a web application. The method can also be implemented as a stand-alone application or can be integrated with other web application.

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A Transition Model for Patient Conditions Based on Hospital Information System Data

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[c]*Department of Medical Informatics and Economics, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan*

Abstract

For efficient use of hospital beds, it is important to know each patient's stage of hospitalization and be able to estimate when the patient may be discharged. In this study, we constructed a time-related transition model based on hospital information system (HIS) data in order to recognize the stage of hospitalization by classifying patient's daily conditions into clusters, and calculating the transition between these clusters for all patients. To classify all patient's daily conditions into clusters, we applied Ward's method, a hierarchical aggregative clustering method. We then constructed a transition model of patients with brain infarction using HIS data of the University of Tokyo Hospital from April 1 2004 to March 31 2005. Validation of the model and generalization of this method to other data sets and diseases are future goals for this project.

Keywords:

Transition Model, Cluster Analysis, Hospital Information Systems, Brain Infarction

Introduction

In large hospitals where many patients are treated, the proper management of inpatients and efficient use of beds is vital. In order to achieve this, it is important to know each patient's stage of hospitalization. The overall goal of this study is to devise a general method for constructing a reference model, based on hospital information system (HIS) data. Prior to generalization of the model, the objective of this preliminary study is to construct a time-related transition model, from admission to discharge, for patients with brain infarction. By comparing the condition of a new inpatient to the transition model, we can elucidate the patient's current stage of hospitalization, predict possible changes in the patient's condition, and estimate when the patient may be discharged.

Methods

Construct of the transition model was carried out in three steps.

Defining patient's daily condition

The accounting data, part of the recorded HIS data, of inpatients diagnosed with brain infarction on the day of admission or on the following day was used for analysis. Three kinds of items were excluded from the data.

- Items unrelated to the medical intervention; e.g., additional fee for special room.
- Items showing the names of drugs or laboratory tests; e.g., AST (aspartate aminotransferase).
- Items that appeared only five times or less.

As a result, 57 items of medical intervention (intravenous drip, physiotherapy, chest X-ray roentgenogram, etc.) were selected, and a patient's daily condition was defined based on the status of these 57 items (being carried out (= 1); or not being carried out (= 0)). Each condition was then plotted on a 57-dimensional binary space.

Classifying patient's daily conditions

The daily conditions of every patient were classified by applying Ward's method ([1], pp.142-145), a hierarchical aggregative clustering method, in the 57-dimensional binary space, to form five clusters.

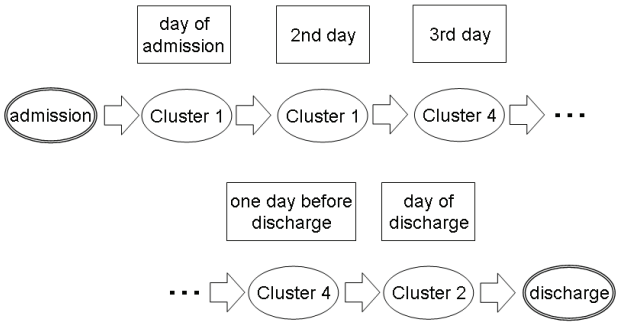

Figure 1 - Transition of one patient's conditions.

Constructing time-related transition model

The transition of each patient's conditions was represented by listing the clusters that the patient was classified into, from admission, the first transition condition, to discharge, the final transition. An example of the transition of one

patient's conditions is shown in Figure 1. A time-related transition model was then constructed by measuring the transition rate between clusters for all patients.

Results

The transition model was conducted using the accounting data stored in the HIS of the University of Tokyo Hospital from April 1 2004 to March 31 2005. The data for 60 inpatients (mean age, 68.2 years (SD = 15.2); male, n = 43; female, n = 17) were selected for analysis, and the total number of inpatient days was 2,561. The characteristics of the five clusters, referred to as Cluster 1 - Cluster 5, are shown in Table 1. Almost all patients were classified into Cluster 1 on the day of admission, and more than three quarters of all discharges followed a Cluster 2 classification (Figure 2).

Discussion

If accurate accounting data can be obtained for a patient on any given day, the cluster in which the patient's daily condition exists can be calculated using Ward's method in the 57-dimensional binary space. This indicates the patient's stage of hospitalization, and calculation of the discharge date and discharge rate of the patient can then be performed by comparing this to the transition model constructed in this study. In order to use this model for this purpose, it is necessary to examine the validity and reproducibility of the model, particularly when created from other data sets. It is also necessary to generalize this method, in order to apply it to other diseases. These challenges will be undertaken in the next stage of this project.

Conclusion

A new method was proposed for constructing a time-related transition model of patient conditions for patients diagnosed with brain infarction, using HIS data. Validation of the model and generalization of this method are future goals of this project.

References

[1] Anderberg MR. Cluster Analysis for Applications. New York: Academic Press; 1973.

Table 1 - Cluster characteristics. This table shows the appearance rate of five items in each cluster. The item with the highest appearance rate in each cluster is shaded

Cluster No.	intravenous drip	subcutaneous injection or intramuscular injection	gastrogavage	physiotherapy	central infusion
Cluster 1	0.873	0.172	0.007	0.318	0.005
Cluster 2	0.054	0.347	0	0.235	0.015
Cluster 3	0.318	0.811	0.992	0.273	0
Cluster 4	0.125	0.040	0	0.863	0
Cluster 5	0	0.017	0	0.473	0.757

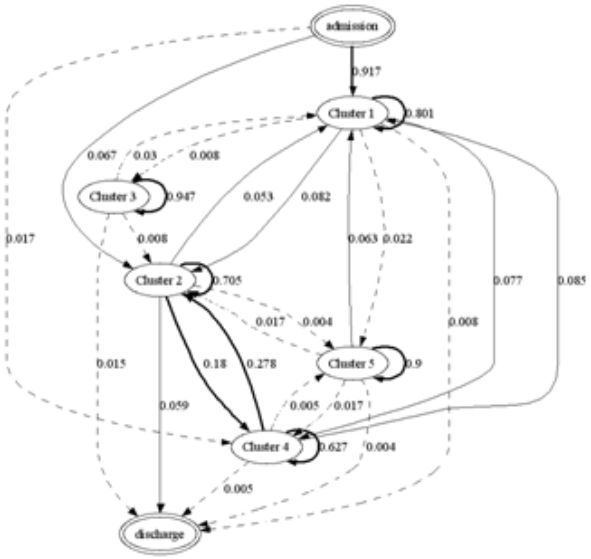

Figure 2 - Transition model of patient conditions. Bold lines indicate a transition rate over 0.1; while dashed lines indicate a transition rate under 0.05. Numbers indicate transition rates.

Address for correspondence

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A Transition Model for Patient Conditions Based on Hospital Information System Data

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c *Department of Medical Informatics and Economics, Graduate School of Medicine, The University of Tokyo, Tokyo, Japan*

Introduction

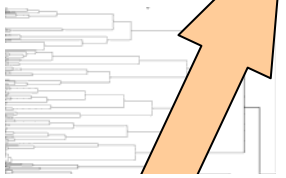
- The proper management of inpatients and efficient use of beds is vital.
- In order to achieve this, it is important to know each patient's stage of hospitalization.
- The overall goal of this study is to devise a general method for constructing a reference model, based on hospital information system (HIS) data in order to recognize the stage of hospitalization.
- Prior to generalization of the model, the objective of this preliminary study is **to construct a time-related transition model, from admission to discharge, for patients with brain infarction**.

Methods - Overview

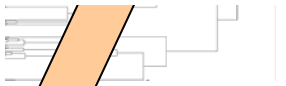
Date	Patient No.	Item
2006-06-01	Patient01	intravenous drip
2006-06-01	Patient01	additional fee for special room
2006-06-02	Patient01	chest X-ray roentgenogram
2006-06-02	Patient02	physiotherapy
…	…	…

Data for analysis (the accounting data). Excluded items were shaded.

Defining patient's daily condition by plotting on a 57-dimensional binary space



Classifying patient's daily conditions by applying Ward's method



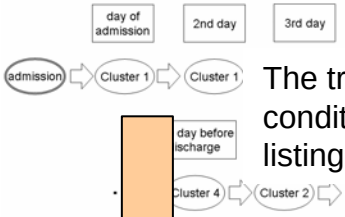
Patient No.	Days from hospitalization date	Item name (57items)			
		intravenous drip	chest X-ray roentgenogram	physiotherapy	…
Patient01	1	1	0	0	…
Patient01	2	0	1	0	…
…	…	…	…	…	…
Patient60	97	1	0	1	…

"item name" = 1 (being carried out)

or

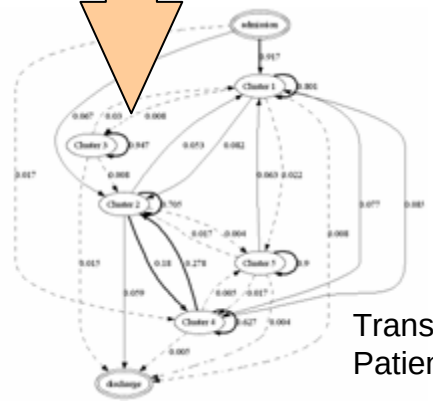
"item name" = 0 (not being carried out)

Patient No.	Days from hospitalization date	Cluster No.
Patient01	1	Cluster 1
Patient01	2	Cluster 1
…	…	…
Patient60	97	Cluster 2



The transition of each patient's conditions was represented by listing the clusters

Constructing time-related transition model by measuring the transition rate between clusters for all patients



Transition Model of Patient Conditions

Methods - Defining patient's daily condition

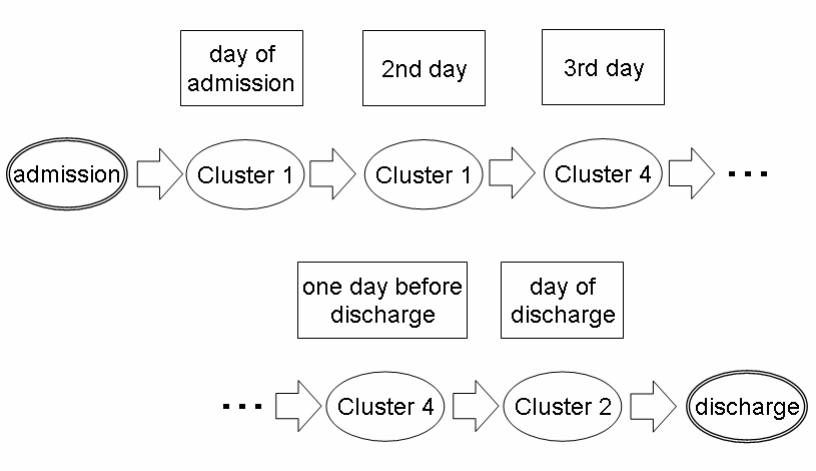
- Data for analysis
  - The accounting data (part of the recorded HIS data)
  - The data of Inpatients diagnosed with brain infarction on the day of admission or on the following day
  - 57 items of medical intervention were selected.
    - intravenous drip, physiotherapy, chest X-ray roentgenogram, etc.
    - Three kinds of items were excluded from the data.
      - ✓ Items unrelated to the medical intervention
        - additional fee for special room, etc.
      - ✓ Items showing the names of drugs or laboratory tests
        - AST (aspartate aminotransferase), etc.
      - ✓ Items that appeared only five times or less.
- Defining patient's daily condition
  - Defined based on the status of these 57 items
  - Each condition was plotted on a 57-dimensional binary space.
    - "item name" = 1 (being carried out)
    - "item name" = 0 (not being carried out)

Methods - Classifying patient's daily conditions

- Ward’s method ([1], pp.142-145)
  - a hierarchical aggregative clustering method
- The daily conditions of every patient were classified by applying Ward's method.

Methods - Constructing time-related transition model

- The transition of each patient's conditions was represented by listing the clusters that the patient was classified into from admission to discharge.



An example of the transition of one patient's conditions

- A time-related transition model was constructed by measuring the transition rate between clusters for all patients.

Result

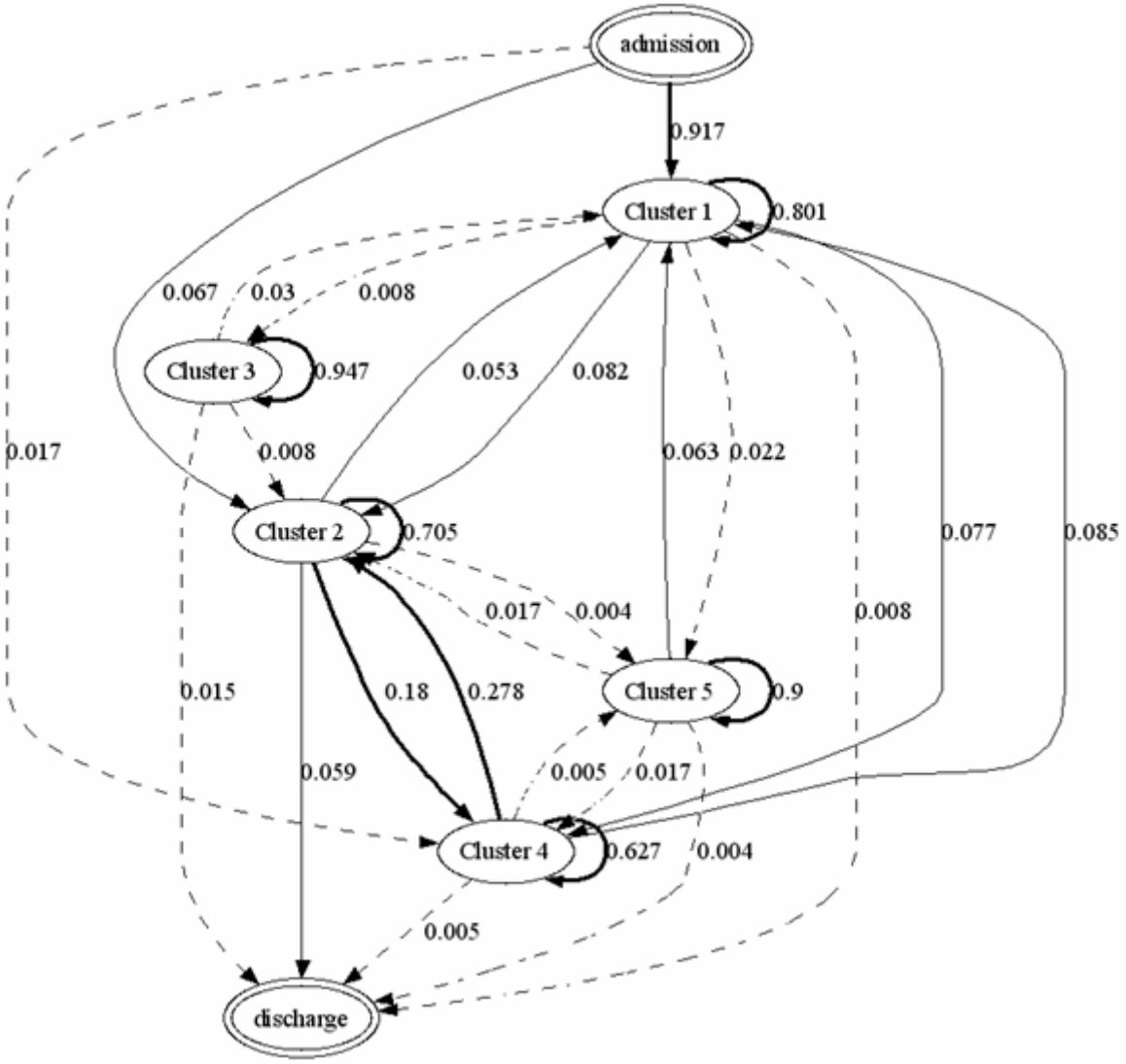
- Data for analysis
  - The accounting data stored in the HIS of the University of Tokyo Hospital from April 1 2004 to March 31 2005.
  - 60 inpatients
    - mean age, 68.2 years (SD = 15.2)
    - male, n = 43
    - female, n = 17
  - The total number of inpatient days was 2,561.
- Almost all patients were classified into Cluster 1 on the day of admission, and more than three quarters of all discharges followed a Cluster 2 classification.

Result - Cluster Characteristics

Cluster No.	intravenous drip	subcutaneous injection or intramuscular injection	gastrogavage	physiotherapy	central infusion
Cluster 1	0.873	0.172	0.007	0.318	0.005
Cluster 2	0.054	0.347	0	0.235	0.015
Cluster 3	0.318	0.811	0.992	0.273	0
Cluster 4	0.125	0.040	0	0.863	0
Cluster 5	0	0.017	0	0.473	0.757

This table shows the appearance rate of five items in each cluster. The item with the highest appearance rate in each cluster is shaded.

Result - Transition Model of Patient Conditions



Bold lines indicate a transition rate over 0.1; while dashed lines indicate a transition rate under 0.05. Numbers indicate transition rates.

Discussion

- If accurate accounting data can be obtained for a patient on any given day, the cluster in which the patient's daily condition exists can be calculated.
- This indicates the patient's stage of hospitalization, and calculation of the discharge date and discharge rate of the patient can then be performed by comparing this to the transition model constructed in this study.
- It is necessary to examine the validity and reproducibility of the model, and generalize to apply it to other diseases.

Conclusion

- A new method was proposed for constructing a time-related transition model of patient conditions for patients diagnosed with brain infarction, using HIS data.
- Validation of the model and generalization of this method are future goals of this project.

References, Address for correspondence

- References

[1] Anderberg MR. Cluster Analysis for Applications. New York: Academic Press; 1973.

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Generating a Comprehensive Disease Pattern of Obstructive Sleep Apnea: A Data Mining Approach

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Delta Sleep Research Unit, Discipline of Exercise and Sport Science, The University of Sydney

Abstract

Obstructive sleep apnea (OSA) is a sleep disorder with a wide range of comorbid conditions. Despite its known aetiology and manifestations, the strength of its association with comorbid conditions has not been fully explored. This research explored a large dataset (1999-2004) derived from the New South Wales Inpatient Data Collection, using a data mining approach, to provide a comprehensive disease pattern of OSA. All diagnoses were coded with the International Classification of Diseases (ICD)-Australian Modification codes. A total of 60,197 OSA cases (4% of total records) were identified. Their onset of occurrence was age-related with a peak occurrence at age 50-59y for both genders with a higher incidence in males. Comorbid conditions, in order of strength of association with OSA, were essential hypertension, obesity, hyper cholesterolemia, type 2 diabetes, and ischemic heart disease. When categorised according to disease systems, all cormorbid conditions clustered mainly into endocrine/ metabolic, cardiovascular and respiratory systems. The data mining approach unveiled the full OSA disease pattern and illustrated the progression of comorbid conditions.

Keywords:

obstructive sleep apnea, data repository, data mining, ICD-10I

Introduction

Obstructive sleep apnea (OSA) is characterised by repetitive, complete or partial occlusion of the posterior pharyngeal airways during sleep [1]. It affects approximately 2–15% of the general population [2]. The symptoms of OSA are snoring, transient cessation of breathing, and excessive daytime sleepiness. OSA patients suffer a poor quality of life due to fragmented sleep and a wide range of comorbid conditions of obesity, diabetes and cardiovascular diseases (CVD) [3]. Although much is now known about its prevalence, demographic characteristics, risk factors and comorbid conditions, a comprehensive disease pattern of OSA remains to be explored.

Data mining is the non-trivial process of identifying valid, novel, potentially useful, and ultimately understandable patterns in data [4]. It assumes no prior knowledge but has the potential to uncover previously unknown relationships. The study aimed to apply a data mining technique to a clinical data repository to identify any unknown disease patterns and relationships with OSA.

Materials and methods

Data sources and definition of OSA

The data repository for this study is the New South Wales (NSW) Inpatient Data Collection. All public and some private hospitals report monthly all inpatient data to the Department of Health. A random dataset (1999-2004) was extracted. All diagnoses and procedures were coded with the International Classification of Diseases (ICD-10) Australian Modification (AM) codes [5]. G47.32 is the code for OSA. When comorbity conditions were subsequently explored, 4th and 5th digits for sub-classification were ignored. The number of codes generated for a patient can range from 5-20.

Data mining technique

The technique used was the association rule analysis that aims to discover the conjunctions of attribute-value pairs that are statistically related in huge data repository [6]. Association rule is an implication of the form X $\rightarrow$ Y, where X and Y are itemsets and X Y= Φ to predict that 'if X occurs in a transaction, then Y will likely also occur in the same transaction'. Each rule has two measures of its strength called support (the frequency of causality) and confidence (the strength of the causality):

$$\text{Support} \quad (X \rightarrow Y) = \frac{|\{t \in T \mid (X \cup Y) \subseteq t\}|}{|T|}$$

$$\text{Confidence} \quad (X \rightarrow Y) = \frac{|\{t \in T \mid (X \cup Y) \subseteq t\}|}{|\{t \in T \mid X \subseteq t\}|}$$

Identified dataset containing a diagnosis of OSA was a *focused dataset*. Frequency patterns discovered by association mining were noted as *focused patterns.*

Results

The dataset contained a total of 1,511,078 patient records (47.5% males and 52.5% females) from 1999-2004. A total of 60,197 (4%) had a diagnosis of OSA, listed as either principal or secondary diagnosis. Of these OSA cases, 72.2% were male and 27.8% were female (Figure 1). Comorbid conditions in order of the strength of association with OSA were essential hypertension, obesity, and type 2 diabetes mellitus (IDDM2), ischaemic heart diseases (IHD), hypercholesterolemia, congestive heart failure (CHF), cardiac arrhythmias, chronic obstructive lung disease, hypertrophy of tonsils/adenoids and disorders of nose and nasal sinuses, and joints problems such as gout, arthrosis, gonarthrosis and osteoporosis. Figure 2a,b show the age distribution for obesity, IDDM2, hypertension and IHD.

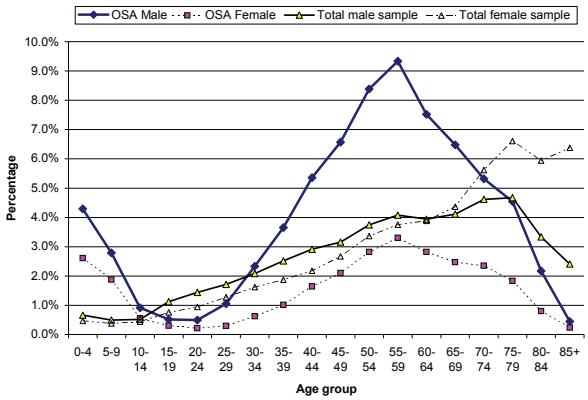
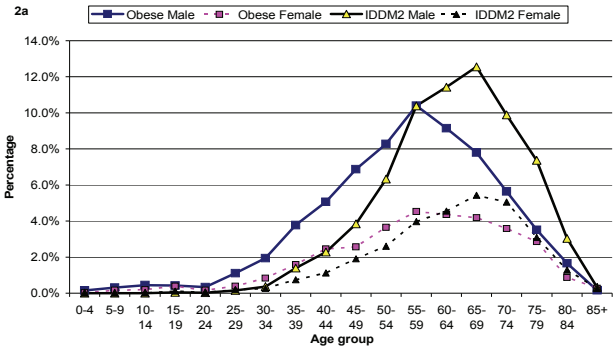


Figure 1 - Age and gender distributions of the sample and OSA cases



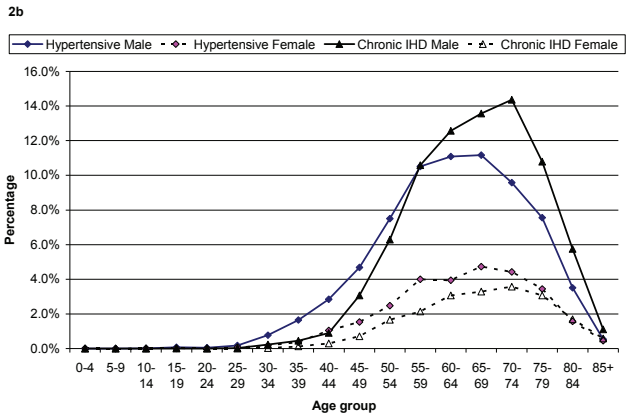


Figure 2 - Age and gender distributions of obestity and IDDM2 (2a), and hypertension and chronic IHD (2b)

Past or current use of tobacco was frequently listed in OSA patients. The comorbid conditions were clustered into the endocrine/ metabolic, cardiovascular and respiratory systems. There was high usage of health services amongst these patients (data not shown).

Discussion

This study has for the first time generated a comprehensive disease pattern of OSA. It confirms previous findings of a higher male prevalence, obesity as a risk factor, and associated comorbid conditions, namely IDDM2, and CVD (hypertension, IHD, CHF) [3].

The strong association of obesity, CVD, hypercholesterolemia and the metabolic syndrome with OSA suggests that a complex relationship of cause and effect exists between these conditions. Increase in obesity cases preceded that of hypertension, diabetes, and IHD. Such observation is in keeping with the knowledge of development and progression of disease patterns. Smoking may be a contributory factor to IHD and pulmonary diseases [7]. Joint diseases (arthrosis and gonarthrosis) are comorbid with OSA, although they are much less common compared to CVD. This observation has not been previously reported. Heavy use of health services related to treatments of OSA and comorbid conditions directly bear on the cost of health services and health burden on society.

In conclusion, data mining uncovers complex relationships between OSA and its associated comorbid conditions, and age and gender distribution of OSA. It offers an insight into the health cost of OSA and management of the disease.

Acknowledgements

We would like to thank the Centre for Epidemiology and Research, NSW Department of Health, for providing the dataset.

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[2] Young T, Peppard PE, Gottlieb DJ. Epidemiology of obstructive sleep apnea. Am J Respir Crit Care Med. 2002;165:1217-1239.

[3] Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. JAMA 2004;291: 2013–2016.

[4] Brossette SE, Sprague AP, Hardin JM, Waites KB, Jones WT, Moser SA. Association rules and data mining in hospital infection control and public health surveillance, J Am Med Inform Assoc. (1998);5:373–381.

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[7] Shepard JW Jr. Cardiopulmonary consequences of obstructive sleep apnea. Mayo Clin Proc 1999;65: 1250–1259.

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The University of Sydney

Generating a comprehensive disease pattern of obstructive sleep apnoea: a data mining approach

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3. Discipline of Exercise and Sport Science, The University of Sydney

INTRODUCTION

- Obstructive sleep aponea (OSA) is a disorder characterized by repetitive, complete or partial occlusion of the posterior pharyngeal airways that results in frequent wake-up during sleep
- Sleep fragmentation often leads to lack of concentration and poor performance.
- OSA has been reported to be associated with a wide range of disorders such as obesity, diabetes, and cardiovascular diseases.
- However, a full clinical pattern of cormorbid conditions associated with OSA is not known.

AIMS

- To explore the common conditions associated with OSA
- To generate a full pattern of the comorbid conditions

METHODS

Data source

- A random dataset (1999-2004) was extracted from the Inpatients Data Collection, a clinical repository for New South Wales (NSW) Hospitals
- The data set consisted of patients' demographics and clinical diagnoses
- All clinical data have been coded with the International Classification of Diseases (ICD)-Australian Modification (AM) codes

METHODS (cont'd)

Data mining

- **A commonly used data mining tool, namely** association rule mining**, was used to identify strongly associated conditions to a given target condition.**
- **This mining method is able to find**
  - **frequent patterns (condition, sequence, etc.) of occurrence in a database and**
  - **regularities in data such as co-existing conditions**
- **The method also performs causality analysis based on the association rule:**

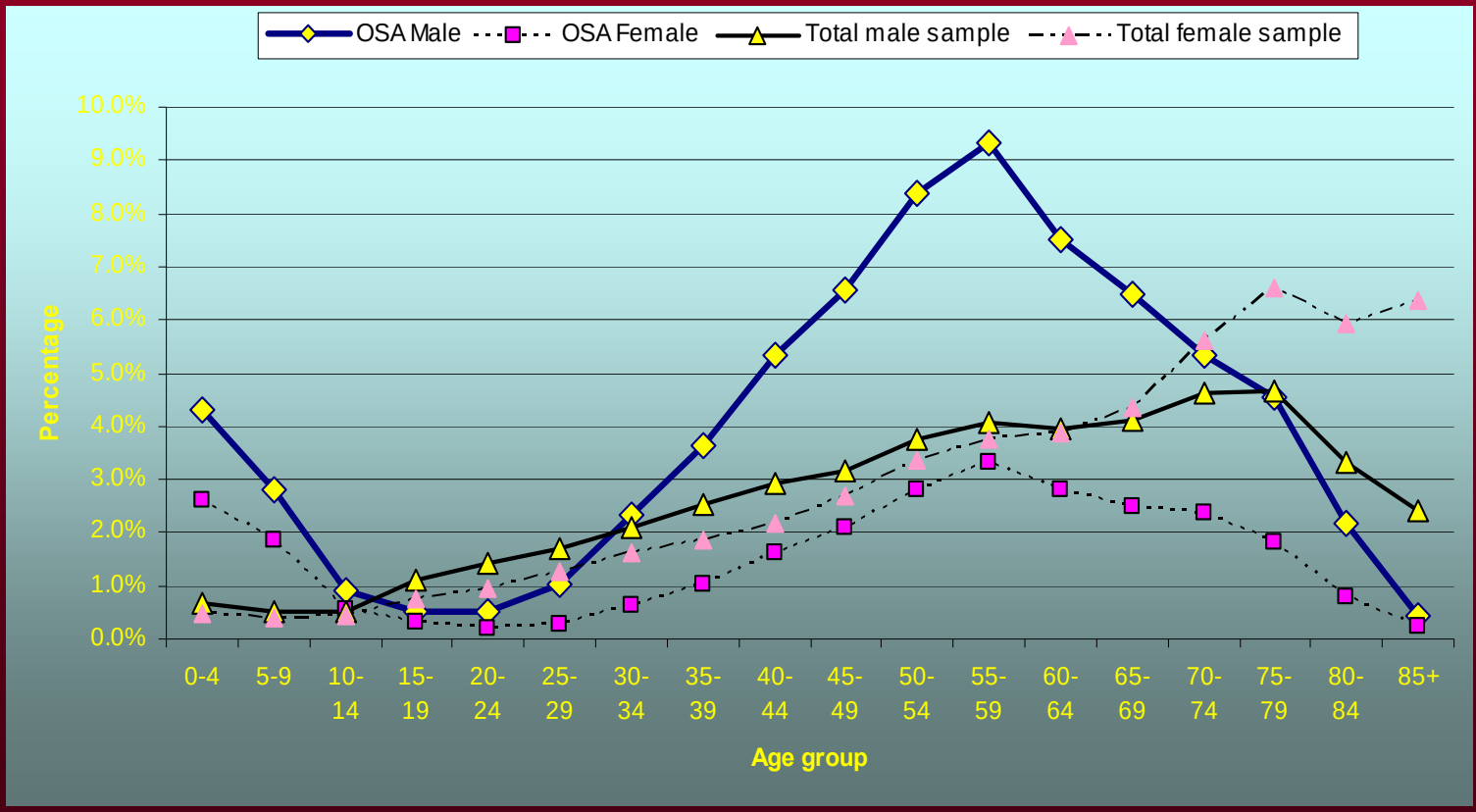
  x→y $X \subset I, Y \subset I$ $x \cap y = \phi$

  (support, confidence)
- **All association rules were searched and ranked without having to specify any minimum threshold values for support and confidence of the association rules.**

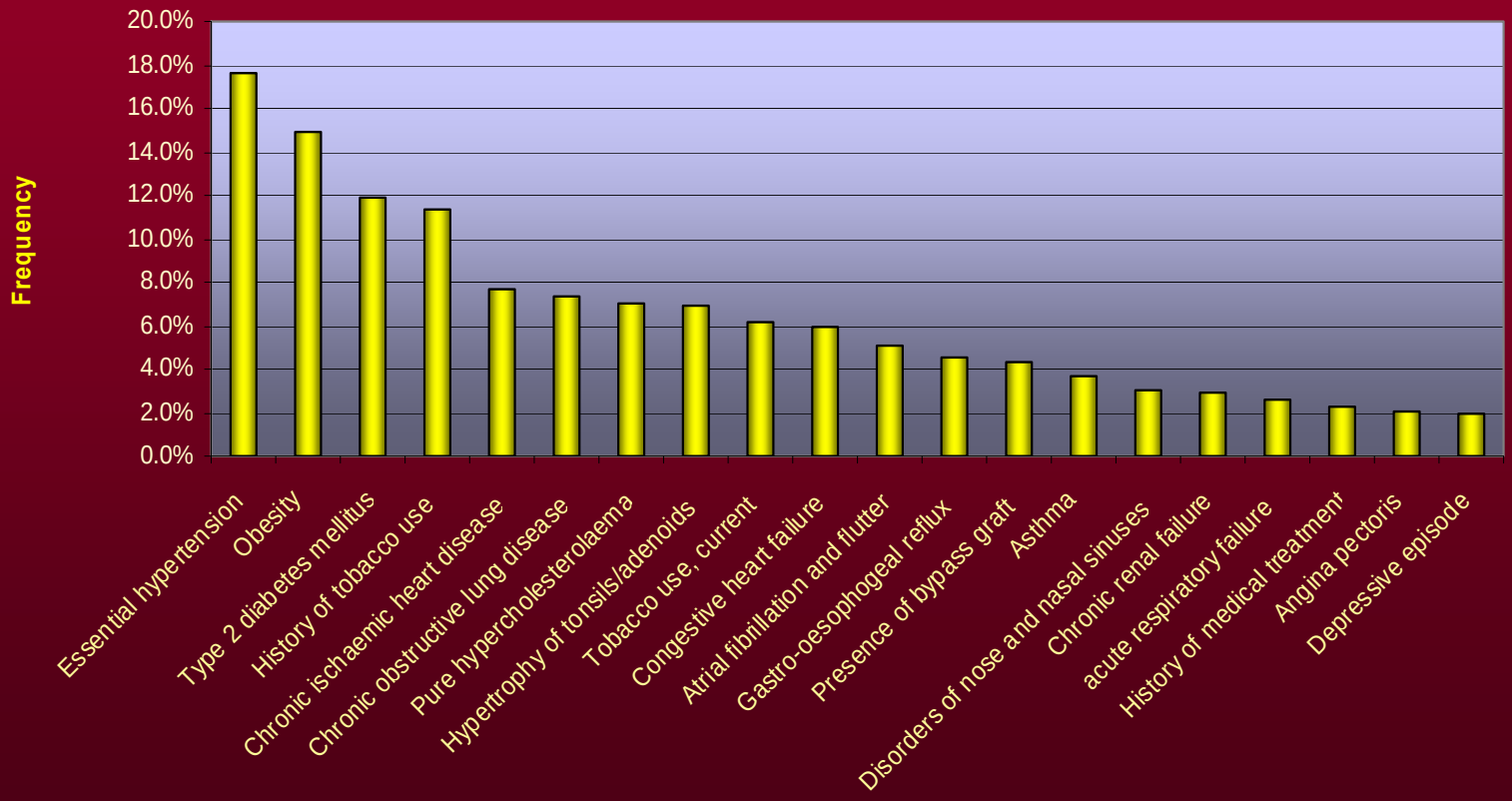
RESULTS

- There were a total of 1,511,078 patient records (47.5% males and 52.5% females) in the dataset
- A total of 60,197 (4% of the total records) had a diagnosis of OSA (72.3% males and 27.8% females)
- A complete comorbid conditions associated with OSA and their patterns were generated.

Age and gender distributions of the total sample and OSA cases

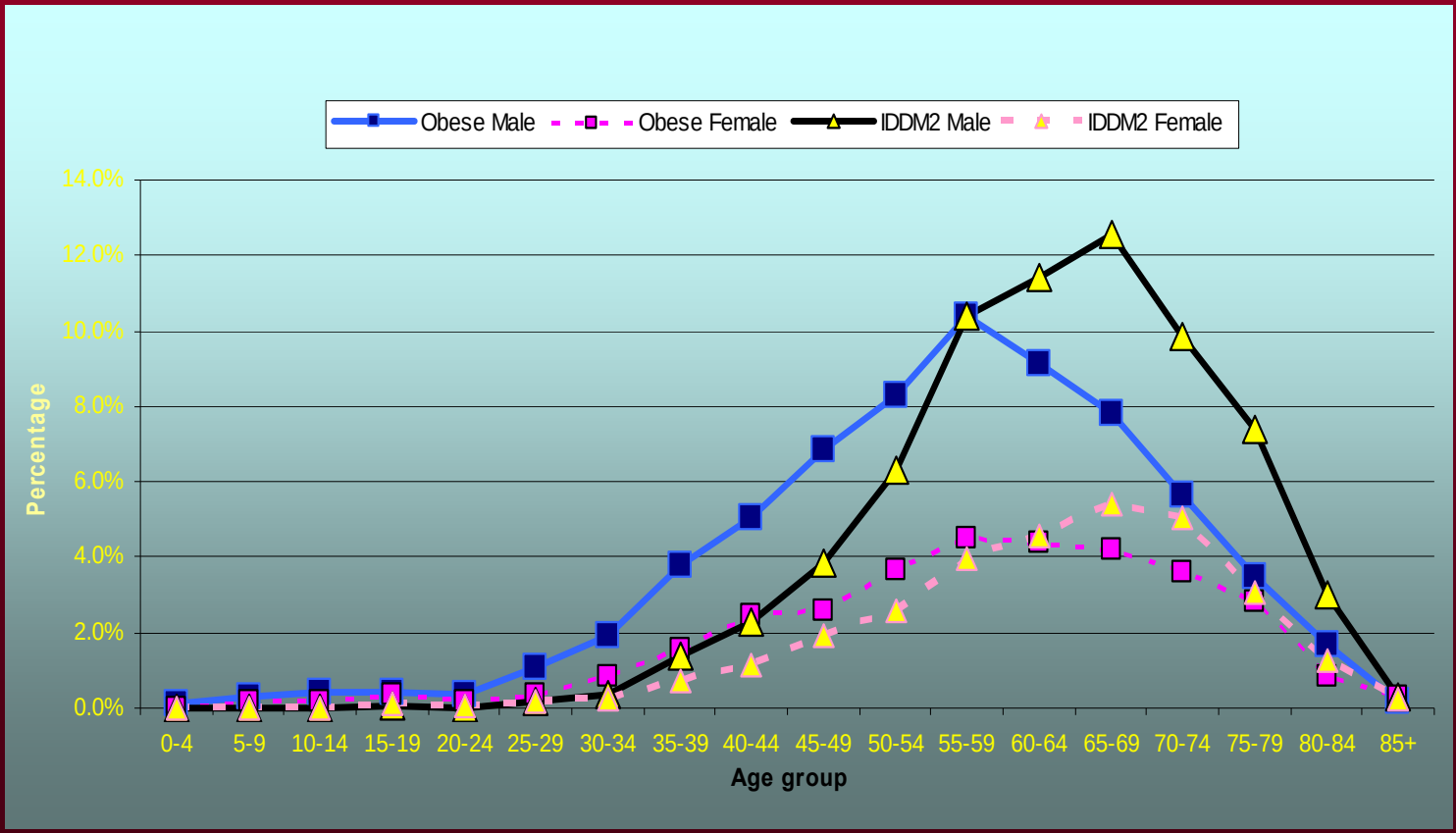


Common comorbid conditions with OSA

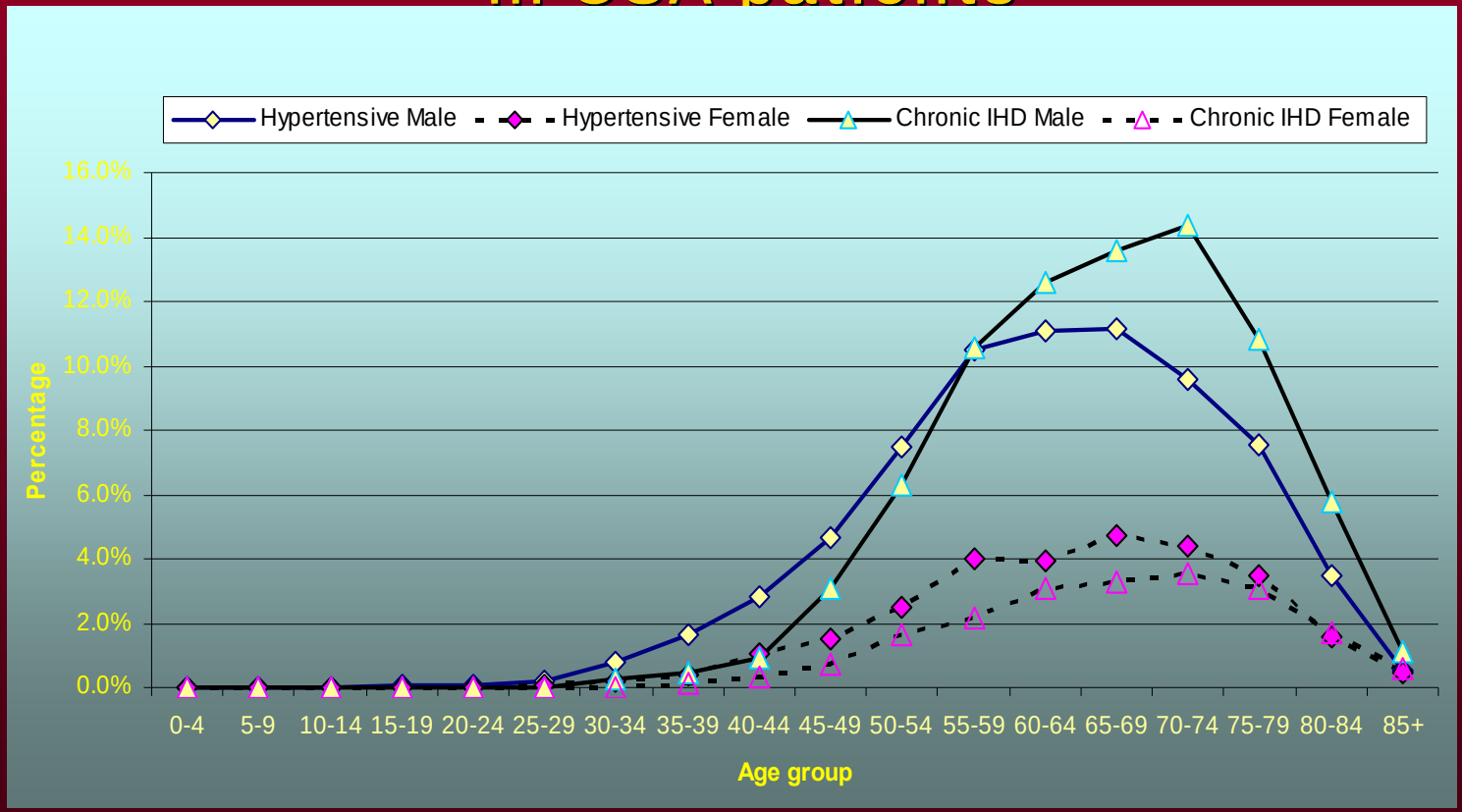


(Note: frequency is the occurrence of a condition of interest against total conditions)

Age and gender distributions of obesity and IDDM2 in OSA patients



Age and gender distributions of hypertension and ischemic heart diseases in OSA patients



DISCUSSION

- This study has for the first time generated a full clinical pattern of comorbid diseases in OSA using a data mining approach.
- It confirms early findings of a higher prevalence in males than in females, obesity as a risk factor, and associated conditions such as diabetes/ metabolic syndrome, and cardiovascular diseases (hypertension, IHD, congestive heart failure, stroke).
- It unveils other conditions that have not been previously reported including atrial fibrillation, asthma, esophageal reflux, chronic renal failure, depression, arthrosis and smoking
- It suggests that data mining, in large data repositories, is a powerful tool in uncovering clinical patterns of a disease with complex comorbidities.

- **References:**
  - Young T, Skatrud J, Peppard PE. Risk factors for obstructive sleep apnea in adults. JAMA 2004;291:2013–2016.
  - Klemettinen M, Manilla H, Ronkainen P, Toivonen H, Verkamo A. Finding interesting rules from large sets of association rules. In: Proceedings of the 3rd International Conference of Information and Knowledge Management. New York: ACM Press, 1994:401–7.

- **Acknowledgement:**
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Data Mining as a Tool of Quality in Obstetrics

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Abstract and objective

There are large amounts of data about patients and their medical condition and evolution, which are stored in electronic databases or simply in archives. These deposits of information contain important nugets which have not been explored. We present our approach in using data mining techniques to investigate the factors associated with care quality and obstetrical risk factors. We also aim at developing suitable models and prediction systems for the two related aspects in obstetrical care.

Keywords:

medical data mining, quality models, obstetrics

Introduction

Following the international trend in health care, the long term strategy of the two Romanian official authorities in the field (the Ministry of Health and the National House for Health Insurance) states that by 2008 there should exist a reliable system for quality assessment in health care and it should serve as a basis for competition on the market. Taking this into consideration, we started a project focused on obstetrical care aiming at identifying the characteristics of our population, so being able to develop a model and a prediction system for this concrete population and environmental context.

Methods

Defining quality measures is not a trivial task and the usual approach is to use a set of measures focused on medical care processes and outcomes [1]. In Romania, we use mainly those available from the DRG system, focused on the outcomes, very limited and difficult to link to the process as they are based on a limited number of 'rate-based' indicators (i.e. occurrence rates of desired or undesired events) [1, 2]. Our approach is to combine pieces of data known as being directly related to quality of obstetrical services (based on criteria like importance as indicators, scientific soundness, and feasibility) [2], and use data mining tools to relate them to other assessments and plans of intervention [3].

Preliminary results and discussion

The work presented in this poster is part of a project aiming at identifying the factors associated with obstetrical outcomes and pre-term risk factors. We began by statistically analyzing reported outcome data from two university hospitals in distant geographic locations of each other, trying to identify patterns of diagnoses (based on the ICD-10 system compulsory in our country). Table 1 presents some raw statistics we obtained, which represented the starting point for further investigations.

Table 1 - Comparison between university Hospital B and university Hospital T (including the limited EHR data set for which we analyzed the pre-term birth risk factors). The ICD-10 codes specified represent the primary DRG reported codes

Year 2006	Hospital B DRG report	Hospital T DRG report	Hospital T EHR data set
No of new born babies	413	2864	211
No of pre-term babies	47 (11.4%)		14 (6.6%)
No of pregnant women (not necessarily distinct cases)	587	4560	211
ICD-10 O80 and O83 vaginal delivery	250 (42.5% of total ob-gyn cases)	2232 (49% of total ob-gyn cases)	157 (74% of deliveries)
ICD-10 - O82.0 elective caesarian delivery	4 (0.7%)	6 (0.1%)	54 (26%)
ICD-10 - O82.1 emergency caesarian section	74 (12.6%)	903 (19.8%)	0
ICD-10 - P03.4 newborn affected by caesarian delivery	40 (10.9% of full-term babies)	263 (9.3%)	22 (11.2% of full-term babies)

The discrepancies between the two hospitals in percent of caesarian section deliveries, as well as between the DRG reported data and the actual data existing in the small internal EHR data set could be related to both the insurance considerations (medical doctors' financial incentives to assign codes for reimbursement purposes combined with little experience in appropriately using the coding) and the patients' preferences or demands (convenience reasons or care for the well-being of the baby). We also tried to calculate some of the proposed performance indices for measuring performance [4, 5].

In parallel, trying to identify the targets for our further efforts in developing models for the obstetrical care outcomes, we focused on the factors associated with spontaneous preterm labour [6, 7, 8]. We have tried a selection of the significant attributes from the EHR database at our university hospital, processing them with Weka 3.4.8, some regressional models with DataFit 7.1.44, and applying a comparative analysis based on the following methods:

M1: a filter type ranking of attributes based on the informational gain (IG) [9];

M2: a filter type ranking of attributes based on the symmetrical uncertainty (SU) [9];

M3: a ranking based on the coefficients obtained by logistic regression (LR); in this case, the higher was the absolute value of a regression coefficient, the higher was the corresponding attribute's relevance;

M4: a ranking method based on the evolutionary multiobjective approach (EMOA) proposed in [10].

Although we have succeeded in identifying only 14 perinatal attributes as contributing to the pre-term delivery risk and the findings mainly confirmed what we already knew from literature or clinical experience [10], the classification results were encouraging (Table 2).

Table 2 - Classification results for attributes subsets selected based on different rankings

Ranks of selected attributes	Correct classification ratio (%)		
	M1(IG), M2(US)	M3 (LR)	M4 (EMOA)
1-14	77.96	77.96	77.96
1-13	78.53	78.53	79.09
1-12	76.27	76.83	77.40
1-11	76.27	77.4	78.53
1-10	78.53	79.09	80.79
1-9	78.53	78.53	80.79
1-8	79.09	80.79	80.22
1-7	79.66	80.22	80.79
1-6	77.96	79.66	81.92
1-5	76.83	81.35	81.92
1-4	78.53	82.48	83.05
1-3	76.83	81.35	82.48
1-2	80.79	81.92	81.92
1	79.09	79.09	79.09

Conclusions

A major problem consisted of the data themselves, which were sparse and incomplete (out of more than 2000 records we started with, we could effectively use only 211 for the pre-term risk model) and in the reported DRG data there were confounding factors in estimating the quality of the perinatal care.

At this stage, we concluded we should reconsider the data collecting methodology as better models require more discriminative clinical information. Despite the difficulties, data mining offers useful tools in this research endeavour.

Acknowledgements

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Data Mining as a Tool of Quality in Obstetrics

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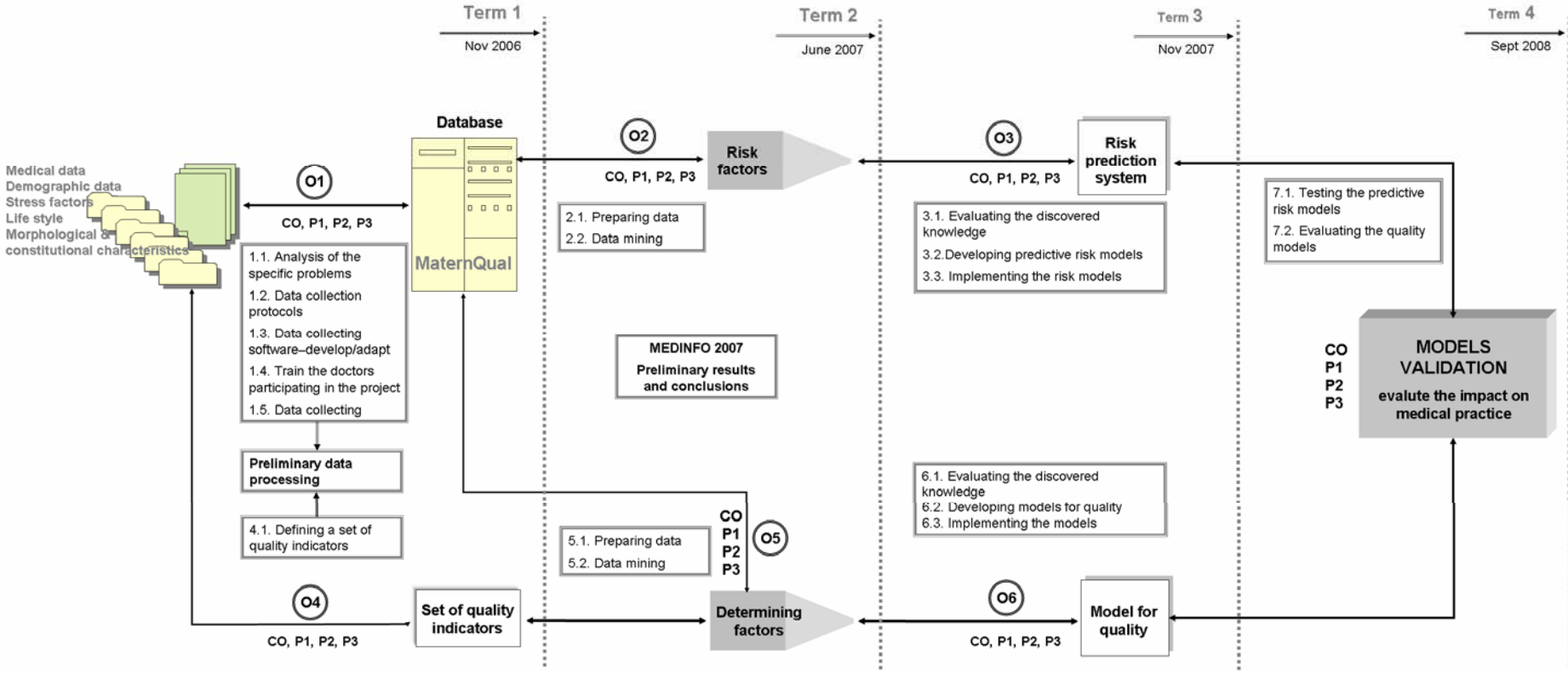
Medinfo 2007
Brisbane

Project MaternQual

- **identifying the factors** associated with
  - obstetrical outcomes
  - pre-term risk factors
- **developing**
  - suitable models
  - prediction systems

for the two related aspects in obstetrical care

2006 - 2008


Term 1
Nov 2006
Term 2
June 2007
Term 3
Nov 2007
Term 4
Sept 2008
Medical data
Demographic data
Stress factors
Life style
Morphological &
constitutional characteristics
O1
CO, P1, P2, P3
Database
MaternQual
1.1. Analysis of the specific problems
1.2. Data collection protocols
1.3. Data collecting software–develop/adapt
1.4. Train the doctors participating in the project
1.5. Data collecting
Preliminary data processing
4.1. Defining a set of quality indicators
O4
CO, P1, P2, P3
Set of quality indicators
O2
CO, P1, P2, P3
Risk factors
2.1. Preparing data
2.2. Data mining
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Preliminary results and conclusions
CO
P1
P2
P3
O5
5.1. Preparing data
5.2. Data mining
Determining factors
O3
CO, P1, P2, P3
Risk prediction system
3.1. Evaluating the discovered knowledge
3.2.Developing predictive risk models
3.3. Implementing the risk models
6.1. Evaluating the discovered knowledge
6.2. Developing models for quality
6.3. Implementing the models
O6
CO, P1, P2, P3
Model for quality
7.1. Testing the predictive risk models
7.2. Evaluating the quality models
CO
P1
P2
P3
MODELS VALIDATION
evalute the impact on medical practice

Specific research questions at this stage

- Are there any patterns apparent in obstetrical DRG code utilisation?
- Could we identify the main factors which determine the obstetrical care outcomes?
- Could we identify the factors associated with the pre-term spontaneous delivery?

Statistical analysis of reported outcome data

- two university hospitals in distant geographic locations of each other
- DRG reported data for each hospital
- EHR data set for Hospital T – more data (demographic, blood chemistry, personal obstetrical history, pregnancy evolution)
- ICD-10 codes reported as primary and secondary diagnostic codes

Comparison between university hospitals B and T

Year 2006	Hospital B DRG report	Hospital T DRG report	Hospital T EHR data set
No of new born babies	413	2864	211
No of pre-term babies	47 (11.4%)		14 (6.6%)
No of pregnant women (not necessarily distinct cases)	587	4560	211
ICD-10 O80 and O83 vaginal delivery	250 (42.5% of total ob-gyn cases)	2232 (49% of total ob-gyn cases)	157 (74% of deliveries)
ICD-10 - O82.0 elective caesarian delivery	4 (0.7%)	6 (0.1%)	54 (26%)
ICD-10 - O82.1 emergency caesarian section	74 (12.6%)	903 (19.8%)	0
ICD-10 - P03.4 newborn affected by caesarian delivery	40 (10.9% of full-term babies)	263 (9.3%)	22 (11.2% of full-term babies)

Newborn babies can be seriously affected by a caesarian delivery

Discrepancy between the DRG reported data and the internal EHR data set

Overall use of ICD-10 obstetrical codes

(mothers & newborns, primary and secondary codes)

- Hospital T – EHR data set

  (211 records after pre-processing)

{{Z391, 269}, {Z392, 265}, {Z390, 255}, {Z370, 254}, { O731, 88}, **{O821, 70}**, {O347, 68}, {Z380, 50}, {P599, 39}, {P025, 26}, {P034, 22}, {O990, 20}, {P128, 19}, {O722, 17}, {O342, 17}, {O713, 16}, {O730, 13}, {O60, 11}, {O700, 10}, {O664, 8}, {P081, 7}, {O321, 7}, {P211, 6}, {P073, 6}, {P030, 6}, {D180, 6}, { P910, 5}……}

Reported O82.1 - emergency caesarian section – 70/211 – 33%

Recorded "elective caesarian delivery" in EHR – 54/211 – 26%

- Hospital B

  (1000 records)

{{Z390, 402}, {Z370, 398}, {Z391, 396}, {Z392, 395}, {P599, 362}, {Z380, 361}, {O731, 361}, {Z300, 357}, {Z480, 350}, {O655, 348}, {O628, 337}, {Z298, 284}, {Z703, 269}, {O838, 258}, {P831, 134}, {O366, 109}, {O335, 107}, {O691, 105}, {O990, 104}, {Z540, 99}, {P121, 91}, {O358, 91}, {O420, 89}, {Z321, 82}, {O260, 79}, {O438, 78}, {P154, 77}, {O998, 77}, **{O821, 74}**, {O224, 74}, {P034, 73}, {O664, 73}, {O60, 73}, {O200, 62}, {O361, 57}, {O800, 55}, {O479, 55}, {O713, 46}, {O365, 46}, {O235, 46}, {P550, 45}, {P073, 45}, {P025, 41}, …..}

Reported O82.1 - emergency caesarian section – 74/100 – 7.4%

Risk factors associated with pre-term birth

Code	Attribute	Code	Attribute
A1	Maternal age	A12	Weight gain during pregnancy
A2	Body Mass Index	A13	*Fundus uterus* - height
A3	Smoking	A14	Gestational age
A4	Parity	A15	Type of birth – vaginal/CSection
A5	No. Pregnancies	A16	Child sex
A6	Hemoglobin level	A17	Child head perimeter
A7	Low/high red cell count	A18	Child weight
A8	Glucose level	A19	Child length
A9	Systolic BP	A20	Apgar score
A10	Diastolic BP	A21	Live/still birth
A11	Abdominal perimeter	A22	*Full-term / Pre-term (class label)*

Comparative analysis

M1: a filter type ranking of attributes based on the informational gain (IG) [9];

M2: a filter type ranking of attributes based on the symmetrical uncertainty (SU) [9];

M3: a ranking based on the coefficients obtained by logistic regression (LR); in this case, the higher was the absolute value of a regression coefficient, the higher was the corresponding attribute's relevance;

M4: a ranking method based on the evolutionary multi-objective approach (EMOA) proposed in [10]

Data processing: Weka 3.4.8; DataFit 7.1.44

Classification results

Rank	M1 (IG)	M2 (US)	M3 (LR)	M4 (EMOA)	
				Attribute	Average rank (stdev)
1	A13	A13	A13	A13	4.1 (2.7)
2	A16	A16	A12	A12	5.8 (2.9)
3	A3	A3	A10	A9	6.4 (3.6)
4	A6	A6	A4	A11	6.4 (4.0)
5	A7	A7	A2	A4	6.6 (4.4)
6	A5	A5	A6	A10	6.9 (3.9)
7	A4	A4	A7	A5	7.5 (4.1)
8	A2	A2	A9	A2	7.97 (4)
9	A11	A11	A16	A7	7.98 (3.1)
10	A1	A1	A8	A6	8.1 (4)
11	A12	A12	A3	A3	8.4 (3.5)
12	A8	A8	A11	A1	8.6 (4.1)
13	A10	A10	A1	A8	9.5 (3.8)
14	A9	A9	A5	A16	10.2 (2.7)

Ranks of selected attributes	Correct classification ratio (%)		
	M1(IG), M2(US)	M3 (LR)	M4 (EMOA)
1-14	77.96	77.96	77.96
1-13	78.53	78.53	79.09
1-12	76.27	76.83	77.40
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1-10	78.53	79.09	80.79
1-9	78.53	78.53	80.79
1-8	79.09	80.79	80.22
1-7	79.66	80.22	80.79
1-6	77.96	79.66	81.92
1-5	76.83	81.35	81.92
1-4	78.53	*82.48*	*83.05*
1-3	76.83	81.35	82.48
1-2	*80.79*	81.92	81.92
1	79.09	79.09	79.09

Conclusions

- major problem – sparse data
- we should reconsider the strategy for data collection

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HISA Ltd Australia

An Evaluation Study of Three Different Classification Methods on Mammogram Images

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Abstract

This study focuses on comparing three different types of classification methods –discriminant analysis, back propagation neural network and support vector machines (SVM) - on a special type of information -numerical data extracted from digitized mammography images-. Data extracted from mammography images show high variations among each other and, have an inhomogeneous nature. Therefore classification of this type of data becomes a challenging task. Neural networks have been known to be successful in analyzing data extracted from mammography images. Various examples of SVM analysis are also applied on mammogram classification in the literature. On the other hand, there are not many studies on discriminant analysis. Furthermore these three methods are not evaluated on the same data set. This study aims to compare and evaluate these methods by using the same data. The output of this work would provide valuable information about the comparative effectiveness of the three different classification methods on mammography image analysis for the researchers.

Keywords:

mammogram, microcalcification, classification,
neural networks, discriminant analysis,
support vector machines, evaluation.

Introduction

It is well known that screening mammography is the best tool available for detecting breast cancer before clinical symptoms appear because it can show changes in the breast up to two years before a patient or physician can feel them [1].

The main abnormality that the radiologists go through to detect breast cancer are the presence of microcalcifications [2]. The detected abnormalities are evaluated by the radiologists. This evaluation includes the decision task of whether the detected masses are malignant or benign by visually inspecting the detected microcalcifications [3].

Since mammograms have a high inhomogeneous nature, the data acquired from them have several drawbacks. First the data may be incomplete, inconsistent and very sensitive. These facts make the classification of this specific type of data a very complex problem.

As a first step of this study a detection application is implemented. The application uses Lee et. al.'s algorithm as the detection algorithm [4]. Using the detection application, selected features of the abnormalities are extracted for the classification.

In this study three different methods will be compared. A statistical method –discriminant analysis- and artificial intelligence methods –back propagation neural network and SVM- are selected for the analysis. The main idea behind this selection is to make a meaningful comparison and evaluation since the methods are based on different theories and mathematical backgrounds. Discriminant analysis is not a widely used method in the literature. On the other hand there are man examples on back propagation neural network classifier. SVM is also another analyzed method for the classification of microcalcification clusters by researchers. Our aim is to determine whether discriminant analysis produce worse results then the other two methods and furthermore determine the best classifier for microcalcification classification.

Finally a research study is accomplished for selecting the most discriminative features for the classification.

Materials and methods

Data

A total number of 117 mammograms were used in this study. Mammograms were acquired from two different sources: 68 mammograms from Cardiology service of Medical School of Hacettepe University and 49 mammograms from the mammographic image analysis society (MIAS) mini-mammographic database [5]. All of these mammograms are visually inspected by a faculty member at the Mammography service of Medical School of Hacettepe University. 117 of the mammograms contain microcalcification clusters where 60 of them are malignant and 57 of them are benign clusters.

The mammograms acquired from Hacettepe University were film mammograms. These mammograms are digitized with 300 dots per inch (DPI) using a Fuji's film scanner. The mammograms taken from the MIAS [5] mini-mammographic database were also digitized with 300 DPI.

All of the digitized mammograms are converted to an 8 bit image (i.e. the mammogram pixel intensities are mapped in to a 0-255 grey level range) before starting the applications since it is easier to work with an 8 bit image.

Detection of the abnormalities

The first step for a proper classification analysis on mammography images, is implementing an effective detection algorithm. In this study, two detection algorithms are developed and evaluated. Lee et. al.'s algorithm is selected as for the detection process since it produced better results. It should be mentioned that this detection algorithm is proven to give good results in many different environments.

The detection system is implemented by using Java-2 platform standard edition, software development kit version 1.4.2 (J2SE v 1.4.2 SDK) taken from Sun Microsystems Inc. [6]. The hardware used is a 1.0 GHz Pentium 3 processor with 256 Mb Read Access Memory (RAM).

The algorithm has 4 main steps: *Gradient Enhancement, Contrast Enhancement, Noise Elimination and Segmentation.*

The output of the segmentation sub-module is the final output of the entire detection system. The microcalcifications are detected satisfactorily by this system. Moreover the shapes of the microcalcifications are preserved which is a must for a microcalcification detection system since the classification is based on the shape and intensity features of the detected calcifications. The result of the detection system is depicted in Figure 1.

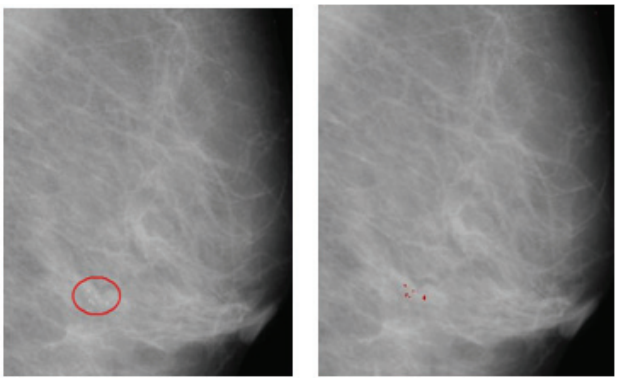

Figure 1 - Original mammogram (left) and segmented mammogram (right) with the detection system

The microcalcifications are marked in a circle in the original view mammogram. The system paints the detected calcifications as depicted in Figure.

The detection system is operated for 153 different mammograms and the detected abnormalities are cropped for the classification analysis. It should be mentioned that the detection results are evaluated by a professional and experienced radiologist and only the successful results (117 samples) are taken for classification.

Classification of the detected abnormalities

After detecting the abnormalities, the radiologists evaluate these results. This evaluation includes the decision task of whether the detected masses are malignant or benign and moreover whether to biopsy the suspicious findings [3].

A false positive diagnosis (i.e. diagnosing a benign tumor as malign) may cause an unnecessary biopsy while a false negative diagnosis (i.e. diagnosing a malign tumor as benign) may lead to cost a human life. .It has been reported that only 15 to 34% of calcifications requiring biopsy are cancerous which indicates a very high False Positive (FP) rate [7].Therefore it is important to correctly identify problematic fields as malignant or benign.

Feature extraction

Feature extraction is a preliminary step for starting classification. It is very important since the selected features will dominate the classification results. In order to define the correct features, the properties of the calcifications that point to breast cancer should be defined. Malignant calcifications are typically very numerous, clustered, small, dot-like or elongated, variable in size, shape and density. Benign calcifications are generally larger, more rounded, smaller in number, more diffusely distributed, and more homogeneous in size and shape [3].

The calcifications are analyzed in two different categories: individual calcifications and clustered calcifications [8]. In a computer aided diagnosis (CAD) system, these two are implemented separately. In other words, it is meaningless to examine only individual calcifications or examine only the groups. Size, shape and radiographic density of the calcifications are the main issues that define the level of malignancy when analyzing individual microcalcifications while their number, orientation, size, position are taken into account when examining microcalcification clusters.

Considering the above definitions about the malignancy indicators the features that point to the breast cancer can be generalized as shown in Table 1 [9].

Table 1

Features relating to descriptions of individual calcification:	**Features relating to the description and the distribution of clustered calcifications:**
Area of calcification	Average distance between calcifications
Average grey level	Orientation of calcifications with respect to its neighbors
Density	Variation of parameters of individual calcifications

Perimeter	Number of calcifications in the cluster
Contrast	Shape of the cluster
Smoothness	Size of the cluster
Approximate horizontal and vertical lengths	Compactness of the cluster
Shape descriptors- compactness, higher moments, Fourier descriptors	Cluster location in the breast
Effective thickness	

Furthermore, additional information can be included in the diagnostic procedure; such as patient history, clinical or demographic data. This study does not include such demographic data but concentrates on microcalcification features only.

Considering the indicators of malignancy described in Table 1,eight different attributes (representing the indicators) are extracted from the regions of interests as follows:

- **Attribute1** is the total number of detected abnormalities in the processed mammogram.
- **Attribute2** is the total area of the detected abnormalities in terms of pixels divided by the total area of the current mammogram.
- **Attribute3** is the mean intensity value of the detected abnormalities divided by the mean intensity value of the mammogram.
- **Attribute4** is the standard deviation of intensity values of the detected abnormalities.
- **Attribute5** is a measure of irregularity of detected abnormalities in shape.
- **Attribute6** is the standard deviation of Attribute 5.
- **Attribute7** is the mean distance between the abnormalities
- **Attribute8** is the standard deviation of the distances between the abnormalities.

Classification

The classification is implemented by extracting the selected features from the detection results. This data set then analyzed in Matlab 6.5 software package for three different classification techniques.

Discriminant analysis

Discriminant analysis is a technique for classifying a set of observations into predefined groups [10]. The classification model is built based on observations, using a set of variables (known as predictors or input variables), for which the groups are known. Discriminant analysis may be used for either measuring the success of classification, given the groups of objects, or assigning objects to one of the groups of objects.

60 of the data will be used for constructing the discriminant formula and the training of the back propagation neural network. And 57 of the data will be used for testing. We have utilized discriminant analysis to classify the mammographic image data.

In this analysis *linear* discriminant analysis and *quadratic* discriminant analysis are used.

For discriminant analysis, we have implemented the test in two different schemes. First we have developed the discriminant function with the training data and then tested it using the test data. “0” value is assigned for benign calcifications and “1” is assigned for malignant calcifications.

When the test data gives a value higher then “0,85” it is accepted in the malignant calcification class. Test values lower then “0,15” is included in the benign calcifications class. This scheme applies for all the three methods implemented in this study.

Before starting the analysis we should define the statistical measures for evaluating the classification methods. “Overall Success Ratio” defines the ratio of the “Total Number of Correct Classifications” to the “Total Number of Observations”. The other descriptive statistics are “Sensitivity” and “Specificity” measures.

Here it should also be mentioned that the same training and testing data which is utilized in discriminant analysis is also used for other classification techniques. The results of the linear discriminant analysis are given in Table 2:

Table 2

Overall Success Rate	Sensitivity	Specificity
84%	0,88	0,80

For quadratic discriminant analysis the results are as follows:

Table 3

Overall Success Rate	Sensitivity	Specificity
82%	0,88	0,76

Linear discriminant analysis gave slightly better results than quadratic analysis for the selected features. However it was expected to gain more benefit from quadratic discriminant analysis since the problem domain is ambiguous and fuzzy in nature.

Neural networks

Neural networks try to solve problems with a structure roughly similar to the neurons in the human brain. McCulloch and Pitts [11] introduced the first neural model. Back Propagation Neural Networks (BPNN) are one of the most common neural network structures, as they are simple and effective, and have a wide variety of application areas.

Neural networks are suitable for applications where only a few decisions are required from a massive amount of data, and also for the applications where a complex nonlinear relation needs to be learned. This property fits with the mammographic data where there is a huge amount of non-linear and fuzzy data which has to be classified into two classes namely benign and malignant.

We started the analysis by utilizing back-propagation neural network. Various back-propagation nets are implemented to get the best results. However due to space constraints we will give the results of the best network structure. The best net structure is determined as a three layered – one input, one hidden and one output- network. Since the data has 8 dimensions there are 8 neurons in the input layer. For this first design 3 neurons for the hidden layer gave the best results. And there is one output neuron. The best results are achieved with 500 epochs of training. The activation function is the tangent function and a standard back-propagation learning algorithm (gradient descent) is utilized. The net is depicted in Figure 2.

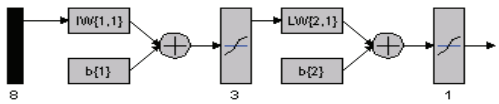

Figure 2 - Back propagation net constructed for mammogram data

The same data set selection with the discriminant analysis is used in the back propagation neural network technique as mentioned earlier. According to this schema the network is trained using 60 pre-selected data. And then the structured scheme is tested with the remaining 57 (27 malign,30benign) data. Below in Figure 3 the results are depicted for 500 epochs which yields the best results among many different trials.

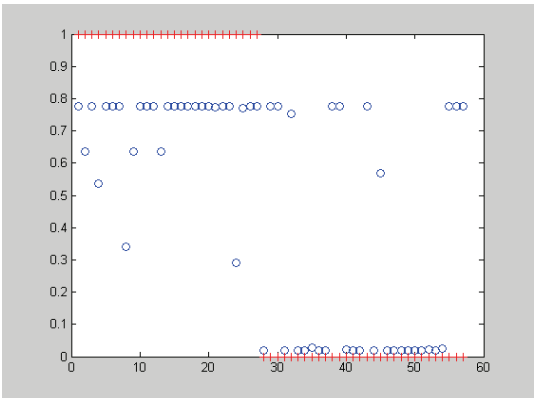

Figure 3 - Test results

The net could not classify 5 samples. The results are shown in Table 4.

Table 4

Overall Success Rate	Sensitivity	Specificity
72%	0,91	0,69

The results of the back propagation neural network can not said to be satisfactory from a clinical point of view. However our main aim is to evaluate this result with the other classification techniques. We can conclude that BPP network is less satisfactory then discriminant analysis.

The less number of epochs resulted in a lower success rate. On the other, when we tried higher number of epochs (i.e. 1000 epochs) the network tends to summarize the data and therefore gives ambiguous results.

Support Vector Machines (SVM)

The attention on this subject is increasing in the last few years. SVMs provide a new approach to the problem of data classification. This approach has relationships with statistical learning theory. SVM is characterized according to its Kernel functin. There are four basic and frequently used kernels. These are:

- linear
- polynomial
- radial basis function (RBF)
- sigmoid

SVM has major differences with comparable approaches such as neural networks: SVM training always finds a global minimum, and their simple geometric interpretation makes further investigation easy. An SVM is largely characterized by the choice of its kernel.

After implementing back-propagation neural networks and discriminant analysis we have analyzed this specific classification problem with SVM. For this analysis, linear SVM and non-linear SVM methods are utilized. Linear SVM uses linear kernel and we utilized polynomial kernel for non-linear SVM in our study. The results of these two methods are discussed below respectively.

Linear SVM results are depicted in Figure 4 and Table 5. In Figure 4, the red pluses represent the original output values, blue circles represent the output values of the test data after toe SVM application and green stars represent the decision values utilized to get the test data output values.

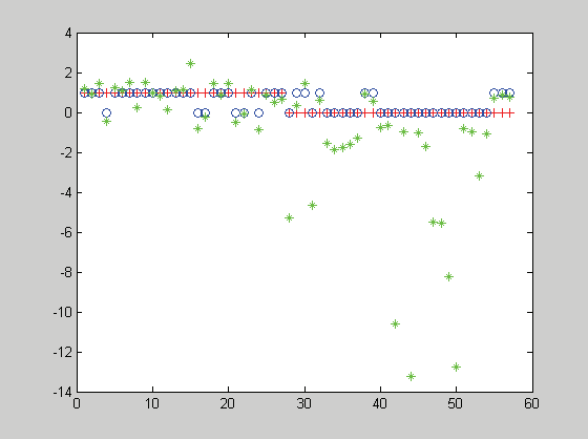

Figure 4 - The linear SVM results

Table 5

Overall Success Rate	Sensitivity	Specificity
75%	0,77	0,73

Linear SVM result in a higher success rate then neural net however the sensitivity and specificity results are not satisfactory. The linear SVM considered being unsuccessful from a clinical point of view.

The non-linear SVM method is implemented finally. We were expecting the most satisfactory results from this method because SVM has a high performance on non-linear and ambiguous data. The results are summarized in Figure 5 and Table 6.

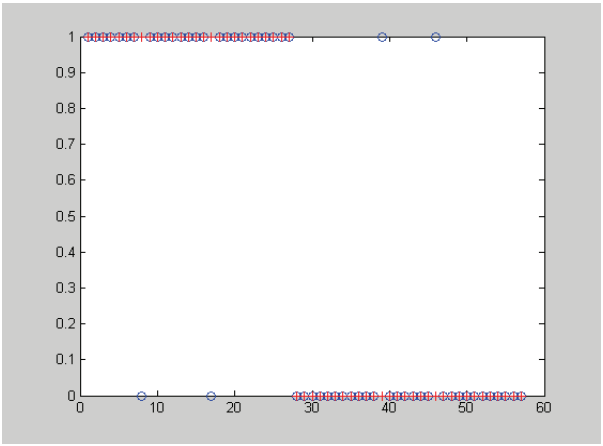

Figure 5 - The results of non-linear SVM

Table 6

Overall Success Rate	Sensitivity	Specificity
93%	0,93	0,93

It is obvious that non-linear SVM is very successful for the classification of mammographic data both from the clinical point of view and respectively to other methods. Only 4 entries are misclassified which is a high satisfactory result.

Discussions and conclusion

Three different classification methods, namely discriminant analysis, back propagation neural networks and support vector machines, are evaluated on a data set that is extracted from mammogram films. Discriminant analysis is not a widely used technique for classifying microcalcifications on mammograms. Using this fact, we comparatively assessed the performance of discriminant analysis method with respect to BPN and SVM techniques on the same training and testing data sets. This study also measures the results of the classifications from a clinical success perspective. In other words, we evaluated the overall success of a method for real life scenarios. Moreover two different detection algorithms are evaluated and the superior one is selected for the detection of microcalcifications. Finally a research study is made to determine the best features for microcalcification classification.

Discriminant analysis produced an overall success rate of 84% which is higher than the BPN success result of 72%. BPN result is also unsatisfactory from a clinical point of view. The most effective method is non-linear SVM for our analysis. Non-linear SVM produced 93% success rate. The sensitivity and specificity measures of SVM are also very satisfactory. SVM is also satisfactory from a clinical usage perspective.

As a result discriminant analysis should be considered during microcalcification classification on mammograms since it produced competent results. The high success of SVM on ambiguous data is again proved after this study.

Acknowledgments

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Analyzing Populations with Visual and Analytical Methods to Identify Family Clustered Diseases

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Abstract

The study of isolated, inbred populations is a promising approach for the identification of disease susceptibility genes. One of the main challenges for geneticists and epidemiologist is to deal with the very complex genealogies of such populations. We present ongoing research on using a visual analytics based approach for the identification of family clustered diseases, risk factors and heritability patterns.

Keywords:

genetic epidemiology, visualization, disease clustering, pedigree

Introduction

The study of familial disease history is the necessary starting point when assessing the extent of genetic components in the etiology of common diseases. The homogeneity of the shared environmental factors and the limited number of recombination events in the DNA make isolated population studies potentially more powerful than general population studies for dissecting complex traits. The limited population dimension often enables to reconstruct very precise genealogies going back to several generations in the past, including hundreds or thousands of individuals. Available genealogical software is mostly focused on a static representation or is able to visualize only sub-pedigrees [1]. Moreover, it does not provide tools for simplifying the visualization of genealogical trees. On the statistical side, existing methods either focus on small family units or require exact calculations that are not computationally feasible.

The principle of "Visual Analytics" (VA) [2] is to combine the outstanding visual capabilities of humans with the power of analytical methods to support the knowledge discovery process. We propose a new approach for the analysis of family histories at a population level based on the concept of VA. Therefore, we (i) developed an effective pedigree drawing, (ii) integrated results in the visualization and (iii) added various tools for supporting the exploratory process.

Methods

Pedigree drawing

For the proper interpretation of pedigree based data, a clear layout is needed for reducing line crossings. Our speed optimized drawing algorithm is based on the 3 phase Sugiyama-heuristic [3]. Furthermore, to reduce line crossings and to facilitate the identification of heritability patterns, we developed a 2.5D visualization, whereby nodes are distributed on two distinct layers according to different criteria (Figure 1).

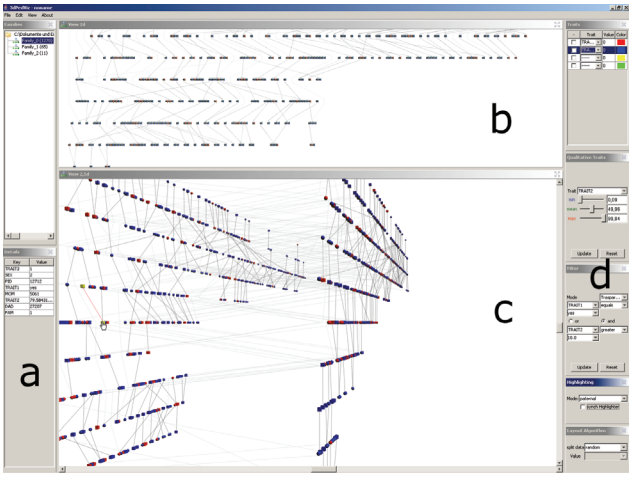

Figure 1 - Prototype PedVizApi: a.) Details on Demand, b.) 2d View c.) 2.5 View, d.) Dynamic Query Interface

Analyzing and visualizing process

The information visualization mantra by Daniel Keim [4] "*Analyse First - Show the Important - Zoom, Filter and Analyse Further - Details on Demand*" was followed.

Analyse first. Initially, various pre-processing steps, such as quantification and normalization, were applied. For the identification of familial disease clusters, different statistical and computational methods are available. Since for this type of analysis the hierarchical structure must be preserved, we integrated the results of the clustering algorithms into the pedigree drawing algorithm.

Show the Important. Depending on the research question, different qualitative and quantitative information is needed and has to be included in the pedigree drawing. Since for family history analysis close relatives are more disease relevant then distant ones, we assigned a transparency value to the connection lines based on the kinship coefficient.

Zoom, filter and re-analyse. The identification of family clustered diseases, risk factors and heritability patterns is an exploratory process. Therefore, we integrated a set of interactive tools, such as dynamic queries.

Details on demand. During the exploratory process additional information is required. On the one hand, static data can be retrieved from a data repository and displayed on demand. On the other hand, on the fly calculated information, such as the connection path between two individuals, is important to identify common risk factors or heritability patterns.

Results

We introduced this novel approach at our institute. Our data consists of the reconstructed genealogy of three isolated valleys, reaching back to the 1600s (50,037 individuals). Health information on 1175 subjects was obtained by means of a screening questionnaire consisting of 960 questions [5].

At this stage of our study, we are especially interested in assessing *which diseases or disease combinations are common and tend to group in families.* Analyses were carried out by three statisticians and four geneticists. Usually, these experts assess the presence of diseases clustering in families using statistical tests and then connecting affected individuals in the pedigree, for each disease of interest. The VA based method was new for them. It starts with an explorative process based on the whole genealogy, whereby the node positions are optimized regarding disease status/cluster, kinship, and line crossings. Based on the following tasks, the differences between the two approaches are highlighted.

Identification of disease clusters

For the subsequent analysis, the probability of familial clustering was estimated [6]. Due the large number of individuals, the exact calculation was not feasible. Moreover, the discovered disease clusters were always limited to small family units. Nonetheless, the VA approach identified clusters at the population level, whereby for the identification of nuclear family disease clusters (parents with less than 3 children) the pedigree must be explored more deeply.

Path between different disease clusters

Using the standard approach was limited to finding common ancestors between different clusters. The process was time-consuming because for every different disease setting paths and sub-pedigrees were reconstructed. With the VA approach, paths between the different clusters could be highlighted during the exploratory process. Moreover, missing and incomplete data were not a problem, because of working with the whole genealogy these parts were inferred by human perception.

Genetics or environment

Analytical methods are able to quantify the contribution of genetic and environmental factors. At the family level this approach is doable; however, at the population level, it becomes time consuming and only a subset of hypotheses can be tested. The VA approach does not quantify exactly the influence of the various factors but, in consideration that this was a screening phase, this is acceptable. All analyses can be performed at a population level, allowing for the exploration of different hypotheses. Missing and uncertain data are balanced partially by the capabilities of the human perception.

Discussion and conclusion

Due the complex structures of isolated population genealogies, classical, analytical methods used in a subsequent visualization setting are only able to identify local and/or single global population clustered diseases. Therefore, the distinction between genetic and environmental factors becomes difficult. Moreover, heritability patterns of rare diseases can only be identified by looking at the whole population in an “error tolerant way”, by exploring different diseases settings.

The VA based approach is capable to perform family history analyses at a population level. Sometimes, the identification of small, single, local disease clusters can be difficult, due to the global optimized representation. However, using the interactive capabilities, the identification of disease clusters and the generation of new hypothesis on the disease etiology are supported in an explorative way.

Integrating the power of the human perception with the VA method provides an appropriated framework for the knowledge discovery process. Nonetheless, experts have to explore findings from different points of view to confirm their robustness and to prevent false positive results.

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Data Mining MEDLINEplus Queries, Circa "9-11"

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Abstract

We examined query logs circa "9-11" from use of MEDLINEplus, a consumer health information website. Our objectives were to determine to what extent consumers' health information interests were stable over time, and to identify and describe anthrax-related health information categories of presumed interest to users during critical time periods following the attack on the World Trade Center. Analyzing health information query logs may identify patterns of consumer usage that can assist health information website developers and sponsors to link consumers to the knowledge they seek and thus, in an epidemic crisis situation, facilitate adoption of self-protective behaviors.

Keywords:

consumer health information, MEDLINEplus, anthrax

Introduction

Surveys of Internet usage show that health information is one of the most cited reasons for searching the internet. That consumers may have problems forming effective queries which can often result in failure to find information sought has been established by the work of Zeng and associates.[1 2 3]

Twenty-two cases of anthrax were confirmed during the anthrax outbreak in the United States which followed the tragedy of September 11, 2001 (see Table 1). Unfortunately, the initial case of anthrax, confirmed on October 4, 2001, was erroneously identified as sporadic and due to a waterborne bacterial source. This false information from high ranking government officials may have undermined the credibility of subsequent reports coming from public health agencies. A consumer survey by Blendon et al[4] noted that during the anthrax outbreak most respondents trusted their own physician *most* for health information. However, information on health information websites was trusted *second-most highly* more so than information from public health agencies, and government officials or television.

How did consumers use health information found on the internet? In a survey by Kittler, Hobbs, Volk, Kreps, and Bates,[5] 58% of those searching online for anthrax-related information reported behavior changes. After searching for health information on the web, consumers physically handled mail differently, and 65% reported adopting self-protective behaviors, such as, washing hands more often.

We examined query logs, over the 4 month period 8/1/2001 – 11/30/2001, from use of MEDLINEplus, a consumer health information website. Our objectives were to determine to what extent consumers' health information interests are stable over time, and to identify and describe anthrax-related health information categories of presumed interest to users during critical time periods following the attack on the World Trade Center. Analyzing health information query logs may identify patterns of consumer usage that can assist health information website developers and sponsors to link consumers to the knowledge they seek and thus facilitate adoption of self-protective behaviors.

Materials and methods

MEDLINEplus query log analyses

In October 1998, the National Library of Medicine (NLM) announced a new resource, MedlinePlus, intended for consumers of health information.[6] When a user submits a query to MEDLINEplus, a program writes data about the query into the log file on the server. The original files we received from NLM consisted of log data for all queries submitted by consumers to the website (www.MedlinePlus.org) on the dates August 1, 2001 through 11/30/2001. Personal identifiers were not included in the log data we received.

We developed a JAVA program to parse the complex query log structure into fields which included: the actual query search terms, and a month, day, year, hour, minute, and seconds timestamp of that submitted query. Parsed files were imported into and analyzed using SAS v. 9.1 for all results reported in this paper.

To identify patterns in usage of consumer search terms over time, we aggregated web access log data into daily intervals to present it in time order. When plotted, time series formats can be visually assessed for patterns of periodicity, seasonality, and outliers.

Unique search queries

By definition, *One* unique or distinct query represents all queries with exactly matching search terms. For example, the exact search terms "diabetes mellitus" might have been

submitted by consumers numerous times and in differing frequencies per day over a selected time period, but would represent only one unique query.

Unique or distinct search terms were identified over the study period. To determine if consumer queries were stable over time, and to estimate to what extent consumer search queries changed over time, we calculated an *Overlap Rate,* which has been previously described and used in the analyses of query log files,[7 8 9] to measure the similarity between query logs on a month to month basis.

Given a series of query log files $L_1, L_2, ..., Ln,$ the *Overlap Rate* is defined as:

$$OR = (L_1 \cap L_2 \cap L_3 \ldots L_n) / (L_1 \cup L_2 \cup L_3 \ldots L_n) \quad (1)$$

Another example, the Overlap Rate for the top 10 unique queries for the month of January when compared with the top 10 unique queries for the month of February would be the number of *common* unique queries in the top 10 from January and February divided by the total number of *all* unique queries in the top 10 from January or February.

Anthrax-related time series plots

Our web access log study period spans the time of the events occurring just before and just after terrorist attacks on the World Trade Center in New York City on September 11, 2001 and the anthrax epidemic that followed. We divided our time series data of all queries containing the word (or search term) anthrax into periods based on possible dates of significance. Please note, our time series graphs represent the actual number of times English search terms containing the word anthrax (anthracis) were used on each day of our study period. Thus, every anthrax-related query is counted as a hit in our time series plot as many times as submitted.

Period 1 begins 8/1/2001 and ends 9/10/2001. Period 2 begins 9/11 and extends through and includes 9/17/2001. Period 3 begins 9/18, the day the first two of four letters containing anthrax spores were postmarked and extends through 10/3/2001. Period 4 begins 10/4/2001. The day the first case of anthrax was confirmed and hit the media and extends through 11/30/2003. Other important dates: October 9, 2001, the date two additional letters with anthrax spores were postmarked, and November 16, 2001, the date the final case of anthrax was confirmed, fall within Period 4. Below is a Centers for Disease Control and Prevention CDC chronology of the outbreak.

Table 1 - Chronology of Anthrax Outbreak (Source Centers for Disease Control and Prevention CDC, Atlanta GA.)

Date(s)	Event(s)
Sept 11	Terrorist attack on World Trade Center, New York, New York
Sept 18	Postmark date of 2 envelopes mailed to news media companies
Sept 22-Oct 2	Symptom onset dates for nine cases of anthrax (2 inhalational)
Oct 4	Anthrax first confirmed and made public
Oct 9	Postmark date of 2 envelopes mailed to government leaders
Oct 14-Oct 26	Symptom onset dates for 13 cases of anthrax (7 inhalational)
Nov 15	Symptom onset date for one *final* case of anthrax (inhalational)

Anthrax multi-word query classifications

Anthrax-related multi-word queries contained the word anthrax or anthracis and at least one other word. These multi-word queries were qualitatively examined and classified into the topics: epidemiology, microbiology, symptoms (lung, skin, other), therapy, vaccine, veterinary, warfare, and other complex queries aided by the use of a keyword search program written to place queries into categories according to matches of words in a query with keywords we used to define a category (see Table 2). The goal of these categorizations was to identify themes or topics that might help us better describe areas of presumed consumer interest. These categorizations were mutually exclusive and exhaustive.

Table 2 - Anthrax-related multi-word query categories and keyword list of some of the words or word fragments (*) used to categorize queries

Category	Keywords
Veterinary	cattle, woolsort*, dog, cat
Vaccine	vaccin*, immun*
Sympt:skin	rash, lesion, cutaneo*
Warfare	bioter*, weapon, postal
Sympt:lung	inhal*, lung, chest
Therapy	cipro, floxacin, penicillin
Microbiology	enzyme, mice, bacteria
Epidemiology	pregnan*, water, outbreak
Sympt:other	intestinal, gastr*, mening*

Table 3 - Anthrax-related queries by search strategy (one-word vs. multi-word) and by period with category breakdowns of multiword queries

Query Type	8/1 - 11/30		P1 8/1 - 9/10		P2 9/11 - 9/17		P3 9/18 - 10/3		P4 10/4 - 11/30	
	Count	%	Count	%	Count	%	Count	%	Count	%
Anthx Queries	15,481	100.0	63	100.0	64	100.0	594	100.0	14,760	100.0
One-Word	11,138	71.9	48	76.2	56	87.5	485	81.6	10,549	71.4
Multi-Word	4,343	28.1	15	23.8	8	12.5	109	18.4	4,211	28.5
Sympt-lung	203	1.3	5	7.9	0	0	5	0.8	193	1.8
Sympt-skin	752	4.9	1	1.6	1	1.6	2	0.3	748	7.1
Sympt-other	390	2.5	0	0	0	0	5	0.8	385	3.6
Vaccine	203	1.3	2	3.2	4	6.3	24	4.0	173	1.6
Therapy	418	2.7	0	0	2	3.1	32	5.3	384	3.6
Warfare	220	1.4	0	0	1	1.6	10	1.9	209	2.0
Microbiology	334	2.2	1	1.6	0	0	10	1.9	323	3.1
Epidemiology	737	4.8	1	1.6	0	0	10	1.9	748	7.1
Veterinary	30	0.2	0	0	0	0	1	0.2	29	0.3
Other	1056	6.8	5	7.9	0	0	10	1.7	1019	9.6

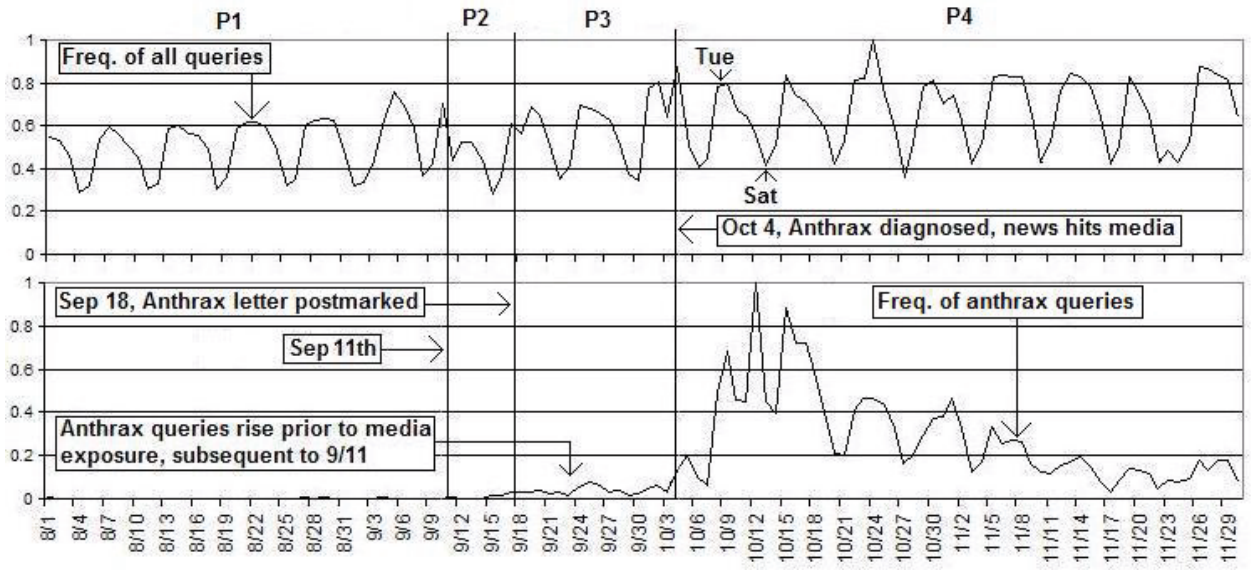

Figure 1 - Top - Normalized graph of all queries showing approximate weekly variation. Bottom - Normalized graph of anthrax-related queries over same time. P1: 8/1-9/10, P2: 9/11-9/17, P3: 9/18-10/3 P4: 10/4-11/30, 2001. Important dates: 9/18 and 10/9 - 2 letters containing anthrax mailed on each date. Nine people become symptomatic between 9/18 and 10/3; thirteen people become symptomatic after 10/4. First case diagnosed 10/4 and hits news the same day. Last anthrax case has symptom onset date 11/16 (CDC)

Results

Over the 121 day study period a *total query volume* of 2,179,571 English queries was submitted to MEDLINEplus; 1,012,542 (46.5%) of these query submissions were of only one word. [Range min: 8,853 queries submitted on 8/4/2001 max: 30,349 on 10/25/2001.] Figure 1 Top presents the normalized aggregated web access log data in daily intervals in time order. As visually depicted and confirmed by counts, queries were submitted approximately according to a *weekly* cycle.

Unique search queries

All submitted queries (regardless of the number of times submitted) or the *total query volume* was 2,179,571; only 634,669 or 29.1% were unique or distinct queries. Mean number of words used in these distinct search terms was 2.23 S.D. 0.14.

Table 4 gives the list of unique queries used 2000 times or more over the 121 day study period and the actual number of times the query was used.

Table 4 - Most commonly used search terms and number of times used

Unique Search Term(s)	Number of Times Used
anthrax	10,958
diabetes	6,093
fibromyalgia	3,549
lupus	3,515
asthma	3,049
multiple sclerosis	2,879
breast cancer	2,516
depression	2,486
cancer	2,392
osteoporosis	2,376
shingles	2,335
hypertension	2,260
alzheimer	2,203
cholesterol	2,138
anemia	2,062
stroke	2,047
arthritis	2,039

Table 5 shows the month-to-month overlap rates for the top 10 and top 100 unique queries of the two adjacent months compared.

Top 10 queries were on average 54% the same month-to-month with a statistically significant 95% Confidence Interval (CI) [34% - 74%].

The top 100 queries were on average 69% the same month-to-month also with a statistically significant 95% Confidence Interval (CI) [53% - 85%].

Table 5 - Month to month overlap rates for top 10 and top 100 unique queries in a month

Months compared	Overlap Rate (OR) Top 10	Overlap Rate (OR) Top 100
Aug. 01 vs. Sep. 01	0.43	0.64
Sep. 01 vs. Oct. 01	0.67	0.70
Oct. 01 vs. Nov. 01	0.54	0.74
Mean OR (S.D.)	0.54 (0.10)	0.69 (0.04)

Anthrax-related time series plots

Over the 121 day study period, 15,481 queries were submitted containing the word anthrax or anthracis; 11,138 of these were just the one-word anthrax or anthracis. Multi-word anthrax queries totaled 4,343 separate (non-unique) query submissions. [Range min: 0 queries submitted on various, but not all, dates between 8/1 and 9/10/2001 max: 885 on 10/13/2001.] Figure 1 Bottom shows a normalized graph of anthrax queries coincident with all queries (including all anthrax queries) on the same timeline.

Anthrax-related unique query classification

Table shows the multi-word anthrax-related query classifications overall and over previously defined periods (see Table 3). Note again, categories are mutually exclusive and that 1056 or 24% of anthrax-related multi-word queries were complex queries on wide-ranging topics and not assignable to the categories selected. Virtually all unassigned queries were submitted during period 4.

Discussion

We analyzed query logs from use of a consumer health information website, MEDLINEplus, over the period August 1, 2001 through November 30, 2001. We found that (for all queries submitted over this time) only about 1 in 3 were unique or distinct. Also, consumers used simple, unsophisticated search strategies; that is, about one-half (46.5%) of consumer queries were of only one-word.

Over our short study period, we determined that consumer health information needs were generally stable and predictable from month to month. With 95% confidence we can say that the top 10 queries would be between 34% - 74% the same month to month and the top 100 queries would be the same between 53% - 85% month to month.

Consumers responded to the events of 9-11 with a presumed interest in information about anthrax using the simple one-word search term for about three quarters of their anthrax-related searches. However, only 127 anthrax-related queries were submitted between 8/1 and 9/18. Once the first case was diagnosed and made public on October 4, 2001, consumers responded with a deluge of "anthrax" queries.

However, between 9/19 and 10/4 before an epidemic was announced, anthrax queries increased to 594. Mounting interest in anthrax, a possible biological warfare agent, following 9-11 might explain this increase, but information on other biological agents such as smallpox was not sought frequently (see Table 4). The predominant interest in anthrax in period 3 seemed to be about therapeutic agents and vaccines or immunization. While in period 4 (after media announcement of first case), the predominant interest was (other) not easily assignable to our selected topics and about cutaneous anthrax or the epidemiology of anthrax.

This study has several limitations. We analyzed queries which are only surrogate measures of actual questions. We could not examine the actual questions users had that led them to submit a query. Also, because of the relatively unsophisticated one word search strategy used for most searches a wide range of information might have been sought which could not be discerned from just that one term.

In conclusion, this study is a descriptive analysis of MEDLINEplus query log data over a 121-day period circa 9-11. In general, consumers used unsophisticated search strategies to access information on a relatively stable body of topics. Sponsors of consumer health information websites may need to provide a broad range of information about a relatively stable number of themes to meet consumer needs.

Also, we conclude that the events of 9-11 sparked an interest in one potential biological warfare agent and this interest was significantly increased once an actual case of anthrax was identified. What else would account for the increase in interest in anthrax between 9/18 and 10/4?

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Towards Identification of Prognostic Subgroups in Rheumatology by of Modeling Expert Knowledge in Knowledge Discovery Procedures

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Abstract

The aim of this study is to examine whether or not heuristic modeling of physicians' expert knowledge can improve standardized data mining methods in prognostic assessments of patients with rheumatoid arthritis (RA). Five consultants in rheumatology were interviewed and their experiences of clinical test values for RA patients, as distinguished from corresponding values for healthy reference populations, were modeled in a knowledge engineering step. The results were used in K-mean-clustering to determine prognostic subgroups. Modeling experts' knowledge was found promising for semi-automatic data mining in the chronic disease setting. Further studies using categorical baseline data and prospective outcome variables are warranted.

Keywords:

knowledge engineering, medical decision making,
knowledge discovery in databases,
clinical decision support systems,
semi-automated data mining, rheumatoid arthritis

Introduction

Chronic diseases constitute a large part of the disease burden in western countries. Early identification of patients with chronic disease at risk of progression is essential, especially when early intervention can induce remission or retard the disease process. Identifying subgroups of patients with a less favorable prognosis at an early stage is therefore both a key clinical and public health priority. A specific type of decision support is assistance with knowledge discovery in databases (KDD) [1]. The aim of this study is to examine whether or not heuristic modeling of physicians' expert knowledge can improve standardized data mining methods in prognostic assessments of patients with RA. The starting point for the heuristic modeling is that the clinical test values for patients with a specific chronic disease differ from those of healthy reference populations.

Materials and methods

The research was performed in three steps. In a knowledge engineering step, physicians' experiences from the clinical use of four variables included in the evaluation of RA patients were elicited. In the second step, these data were analyzed and represented in a model that was implemented in an algorithm for the determination of prognostic groups. For comparison, the same algorithm was also used to develop groups based on the crude data set. In the final step, prognostic group validation, the model was validated by comparing physicians' global assessment of disease activity scores (PGA (scores 0–4, where 0 corresponds to no activity and 4 represents high activity)) for the patient groups identified with and without the model.

The knowledge engineering was based on data from a prospective multi-center study (TIRA) where 320 patients diagnosed with RA were diagnosed early and included during 1996 – 1998 [].The interval-/ratio variables in the database were especially interesting for this study, because they could be used in the standard method of K-mean clustering. The set of variables used here included the erythrocyte sedimentation rate (ESR), C-reactive protein (CRP), the 'number of swollen joints' and the 'number of tender joints'.

To find different subgroups of patients, the method of K-mean clustering was used on crude data, and then with two kinds of transformed data:

- Model A – Using the transformed data.
- Model B – Using the transformed data but with a predefined group of patients with values below the lower limit values (x_0) for both ESR and CRP.

To keep the results on a clinically comprehensive and not too complex level, the number of prognostic subgroups was limited to a maximum of four groups. The case with two subgroups was found trivial. Further cluster analyses were therefore restricted to three and four subgroups.

Results

Determination of prognostic groups

Running K-mean-clustering using three clusters resulted in a 'low value group' (low values for both ESR and CRP), a 'medium value group' (medium values for both ESR and CRP), and a 'high value group' (high values for both ESR and CRP).

Running K-mean-clustering using four clusters made the situation more complex. As in the case of three clusters, a 'low value group' and a 'high value group' appeared. There were also two 'medium value groups'. Despite minor differences in sizes and medium values for the clusters in the different model(s), the results were quite similar in this respect.

Prognostic group validation

The three patient subgroups identified using model B on the basis of ESR and CRP differed significantly with regard to PGA scores (Table 1). In comparison, the analyses based on the crude data identified only significant differences between the two extreme groups. In the case of four clusters, no significant differences were found in the crude data model with regard to PGA. Model A and Model B, however, both allowed the identification of significantly different groups based on ESR and CRP (Model A: 1 significant difference, Model B: 3 significant differences).

Table 1 – Validation of derived models A and B against crude data using physicians' global assessment scores (PGA) as proxy for patient outcome. Mean values (95% confidence interval) are displayed for each cluster (three and four clusters, respectively)

	Crude data		Model A		Model B	
3 Clusters	N	PGA	N	PGA	N	PGA
1	188	1.89 (1.78-2.01)	154	1.84 (1.71-1.96)	59	1.56 (1.37-1.76)
2	70	2.10 (1.93-2.27)	72	2.04 (1.87-2.21)	149	1.99 (1.87-2.11)
3	21	2.33 (1.89-2.77)	53	2.30 (2.08-2.53)	71	2.30 (2.12-2.48)
4 Clusters						
1	171	1.88 (1.76-2.00)	146	1.82 (1.69-1.95)	59	1.56 (1.37-1.76)
2	36	2.19 (1.98-2.41)	31	2.16 (1.95-2.38)	110	2.00 (1.86-2.14)
3	51	2.00 (1.77-2.23)	62	2.05 (1.86-2.23)	58	2.07 (1.87-2.27)
4	21	2.33 (1.89-2.77)	40	2.30 (2.02-2.58)	52	2.31 (2.08-2.54)

Discussion

A knowledge engineering approach where heuristic expert knowledge was used to transform data showed to be more efficient for identifying prognostic subgroups than K-mean clustering of crude data. The resulting subgroups passed the first 'objective gateway,' which means that they differed significantly when using basic statistical criteria for cross-sectional evaluation, compared to the analysis of crude data. The PGA used for evaluation is the variable available in the TIRA database that was the closest proxy to patient outcomes from a clinical point of view. Within this limitation, we found that the model representing physicians' expert knowledge in chronic disease was more efficient in identifying prognostic subgroups than standard procedures based on crude data. Further studies using categorical baseline data and prospective outcome variables are warranted. This effort will be implemented in the Swedish TIRA project using more comprehensive clinical data sets.

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Data Entry Errors in Clinical Research Databases

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Abstract and objective

Human-caused errors occur at all stages of research process. We consider here data entry errors in clinical databases, understood as unintentional mistakes in interpretation or transcription of medical records at the time of data entry, and mistakes resulting from interaction with a computer program. Our experience shows that errors of this type occur commonly The existence, and even the consideration of a possibility of errors of data entry is seldom acknowledged in research practice, despite that they add substantially to the uncertainty about study results and, sometimes, may affect the conclusion of the study. We consider some systematic strategies of database errors reduction.

Keywords:

databases, factual

Methods

To investigate the prevalence of database errors and their characteristics we 1) tested 20 volunteers entering the same data sample, representative of Radiation Oncology databases and 2) used data from a review and consistency checks in a real database of 5500 patients. The volunteer test was performed using proprietary computer software for data entry, which enabled us to capture mistakes, self-corrections, and temporal characteristics of keystrokes. The computer program did not provide the user with a feedback about inconsistent entries, or exceeding allowed ranges for numeric data. However, text data were not allowed in numeric fields and conversely. Test data included 139 records and eight fields: three fields with character data in English text and five fields with numeric data. Between 34 and 100 records were entered per volunteer. A database containing information about 5500 patients was used for estimation of data entry errors. For real database, we considered as an evidence of data entry mistakes the treatment initiation dates and the follow-up date falling on Sunday. To illustrate the significance of database errors we derived two Kaplan-Meier estimates of local control obtained from data interpreted and entered by two physicians from the same medical records of 120 patients.

Results

In data entry experiments, an uncorrected mistake in was made in 0.2%-6.5% of fields entered, depending on the person tested. The average error rate was 2.7%, with S.D. of 2.0%. Type and percent of errors are relatively stable parameters for each person. The actual average distance between errors was significantly less then if we had a uniform distribution of errors. The probability of error in a field was found to depend on nature of the field and relationship of that field with other data. For example in database from 5500 patients Sunday as the day of radiation therapy start was in 0.9% cases, but Sunday as the day of last follow-up visit was in 2.6% cases. For two versions of the data prepared by two physicians, the actuarial local control gave the 69% +/- 6% vs. 61% +/- 6% in 5-year rates. Missing data about local failure is the main source of the survival curves distinction**.**

Conclusions

Database mistakes are a ubiquitous part of the normal research process. As we have demonstrated on Kaplan-Meier estimates of local control, data entry errors may have a substantial impact on study findings and the significance of the results. Different approaches for reduction of data entry errors include proper management of data entry process (including double data entry) and algorithms for detecting inconsistent and out of range entries during time of data entry. Further research is needed to develop algorithms for detecting data entry errors based on temporal characteristics of typing, self-correction of the record, history of the user previous errors, and the style of user typing. A caution should be always exercised during statistical analysis of data and in interpreting study findings. It is possible to propose some methods of database errors reduction, which take into account the statistical properties of the mistakes.

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Automatic Categorization of Google Search Results for Medical Queries using JDI

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National Library of Medicine (NLM), United States

Abstract

The web has become the primary source of medical information for consumers and health professionals. It is quite common for people to "Google" for information related to a medical topic. But the problem remains that as the number of documents increases on the web, the difficulty in quickly locating the best documents increases. Classifying results into meaningful categories helps guide users to the most relevant set of results. Journal Descriptor Indexing (JDI) is a novel approach to fully automatic indexing. In this paper we explore the feasibility of using JDI to organize Google search results for medical queries into meaningful categories.

Keywords:

medical subject headings, information storage and retrieval, internet, classification, MEDLINE, indexing and abstracting

Introduction

It is very common for consumers and health professionals these days to use search engines like Google to look up information related to various medical topics. The number of documents for any given topic on the web is increasing exponentially. Even though search engines such as Google are worthwhile for searching the web, the results typically tend to be of low precision and high recall. Users quickly lose interest, if the relevant results are not in the top 2 or 3 pages. To focus the search, users have to develop a good set of search terms, an often time consuming and challenging process. One approach to help users would be to quickly classify the results into meaningful categories that would allow users to drill down into a category of interest.

In this paper we explore the feasibility of using the Journal Descriptor Indexing (JDI) methodology developed at NLM for automatic categorization of Google search results for medical queries. JDI has been proven effective in characterizing MEDLINE documents. Our experiments explore the feasibility of using JDI on Google documents for categorization.

For this paper we extracted 20 documents for 5 terms from Google using Google's SOAP-based application programmer interface (API) [6]. Of the 5 terms, 3 were medical, one was ambiguous with both medical and non-medical meaning, and the last was inherently non-medical. Three reviewers independently evaluated the quality of the categorization for 3 of the same documents for each of the 5 query terms. Based on the results, this is a promising method for categorizing medical search results from Google.

Materials and methods

Journal Descriptor Indexing (JDI)

The JDI methodology associates JDs with words in titles/ abstracts in a training set of about 435,000 MEDLINE records. Each record "inherits" JDs from the serial record matching the journal title. For example, a MEDLINE record with journal title Journal of Pediatric Surgery inherits the JDs Pediatrics and Surgery from the matching serial record. Each word in the training set can then be described by a JD profile, which is a list of JDs ranked according to the number of co-occurrences between the word and the JDs in the training set.

For example, the first three JDs, with scores in decreasing order, for the word "appendectomy" would be:

1	0.8631	Surgery
2	0.6787	Gastroenterology
3	0.5415	Diagnostic Imaging

Once JD profiles have been computed for each word in the training set, they can be used as the basis for indexing documents. We index a document by averaging the scores for each JD across the words in the document; these averages become the JD scores for the document. We then rank the JDs in decreasing order of these score. That is, we treat the JD profile of a word as a JD vector, and the JD indexing of a document is computed as the centroid of these JD vectors.

For example, the first three JDs, with scores, returned by a MEDLINE title "Appendectomy in children" would be:

1	0.4623	Surgery
2	0.4230	Pediatrics
3	0.3675	Gastroenterology

The Surgery score is the average of the Surgery score for the word "appendectomy" (0.8631) and "children" (0.0614) in the training set. The score for Pediatrics is the average of the Pediatrics score for "appendectomy" (0.1645) and for "children" (0.6815); the score for Gastroenterology is the average of the Gastroenterology

score for "appendectomy" (0.6787) and for "children" (0.0563).

Methodology

We selected 5 terms for this experiment. These are:

Chronic bloody nose, Carotid artery surgery, Dark circles, Ventilator, Cold war

We used Google's SOAP API to make queries to Google's Search Web service. We retrieved the top 20 URLs for each of the 5 documents for a total of 100 documents. These files were then used as input to the JDI tool. The JDI tool created a JD profile consisting of the top 15 JDs for each of the documents.

In order to choose the list of the JDs which best categorizes a given document we developed a set of heuristics. We also assigned confidence levels to each of the categorizations within that set. The following describes the heuristics used in determining the category and the confidence level:

1. If the first JD for a document has a score of less than 0.2, categorize that document as "Undefined". The low score indicates that it is difficult to determine whether the corresponding document contains enough information to allow it to be meaningfully categorized.
2. Pick the top *n* JDs where the difference between the score of the first JD and the rest of JDs is < 0.1.
3. Assign a confidence level to the categorization based on the JD score.

0.1 – 0.2:	Undefined	(U)
0.2 – 0.3:	Weak	(W)
0.3 – 0.4:	Barely	(B)
0.4 – 0.5:	Strong	(S)
> 0.5:	Very Strong	(VS)

Results

Table 1 below summarizes the results of the experiments for each of the documents for each of the 5 query terms.

Table 1 - Summary of categorization results by confidence levels

Query term	VS	S	B	W	U
Chronic Bloody Nose	5%	10%	30%	40%	15%
Carotid Artery Surgery	0	5%	30%	35%	15%
Dark Circles	35%	15%	20%	20%	10%
Ventilator	5%	30%	35%	25%	5%
Cold war	0	0	15%	25%	60%

The results of the experiment show that for those documents that contained high quality medical content, the system categorized them with a very strong (VS) or a strong (S) confidence level as expected. On review, the majority of the documents categorized with a VS or S confidence level appear to have been correctly categorized.

In the case of the term "Cold war", though most documents were high quality, they were non-medical in nature. Our system categorized these documents as Undefined as expected.

Evaluation

For evaluation purposes we randomly selected 3 specific documents for each of the 5 terms. Three reviewers independently reviewed these documents

Table 2 - Summary of reviews by Reviewer

Query Term	Reviewer 1	Reviewer 2	Reviewer 3
Chronic Bloody Nose	100%	100%	100%
Carotid Artery Surgery	67%	33%	100%
Dark Circles	33%	100%	100%
Ventilator	67%	100%	67%
Cold war	100%	100%	100%
Average	**73%**	**87%**	**93%**

Conclusion

In conclusion we found:

1. Based on the results and the evaluations, the use of the JDI methodology may prove a valuable technique for categorizing medical search results from Google.
2. The quality of the categorization may be vastly improved if there were a consistent approach to removing noise from Google documents. (Ads etc.)
3. High quality medical documents (MedlinePlus, Wikipedia) were categorized with a very strong or strong confidence level with high scores. Non-medical documents tended to be categorized as undefined with very low scores.

Future work

We plan to perform the following as part of our future work:

1. We plan to perform additional experiments expanding the number of input terms.
2. We plan to explore the feasibility of using the JDI-based Semantic Type indexing for categorization.

Automatic Categorization of Google Search Results for Medical Queries using JDI

Anantha K. Bangalore, Guy Divita, Susanne Humphrey, Allen Browne, Karen E. Thorn

Introduction

- Consumers and Health care professionals routinely use Google to lookup medical information.
- No. of documents for any given topic is increasing exponentially on the web.
- Users quickly lose interest, if the relevant results are not in the top 2 or 3 pages.
- Quickly classifying the results into meaningful categories would allow users to drill down into a category of interest.
- Explore the feasibility of using Journal Descriptor Indexing (JDI) methodology developed at NLM for automatic categorization of Google search results for medical queries

Journal Descriptor Indexing (JDI)

- Based on NLM's practice of maintaining, in its serials file, a subject index to journal titles using a set of MeSH terms, known as JDs (journal descriptors) corresponding to biomedical specialties
- JDI has proven effective in characterizing MEDLINE documents
- JDI associates JDs with words in titles/abstracts in a training set of about 435,000 MEDLINE records.
- Each record "inherits" JDs from the serial record matching the journal title

Journal Descriptor Indexing (JDI)

- Each word in the training set can then be described by a JD profile, which is a list of JDs ranked according to the number of co-occurrences between the word and the JDs in the training set
- A document is indexed by averaging the scores for each JD across the words in the document; these averages become the JD scores for the document
- The JDs are ranked in decreasing order of these scores. That is, the JD profile of a word is treated as a JD vector, and the JD indexing of a document is computed as the centroid of these JD vectors.

Journal Descriptor Indexing (JDI) (example)

- The first 3 JDs for MEDLINE title “Appendectomy in children”
- Surgery score is the average of the Surgery score for the word "appendectomy" (0.8631) and "children" (0.0614) in the training set. The score for Pediatrics is the average of the Pediatrics score for "appendectomy" (0.1645) and for "children" (0.6815); the score for Gastroenterology is the average of the Gastroenterology score for "appendectomy" (0.6787) and for "children" (0.0563).

1	0.4623	Surgery
2	0.4230	Pediatrics
3	0.3675	Gastroenterology

Methodology

- Extracted 20 documents for 5 terms from Google using Google's SOAP-based application programmer interface (API).
- Of the 5 terms, 3 were medical, one was ambiguous with both medical and non-medical meaning, and the last was inherently non-medical
- The JDI tool created a JD profile consisting of the top 15 JDs for each of the 100 documents
- Developed heuristics to choose the list of JD's which best categorizes a given document
- Multiple JDs required to classify documents containing information about multiple topics.
- Assigned confidence levels to each of the categorizations within that set

Methodology

- If the first JD for a document has a score of less than 0.2, categorize that document as “Undefined”. The low score indicates that it is difficult to determine whether the corresponding document contains enough information to allow it to be meaningfully categorized.
- Pick the top *n* JDs where the difference between the score of the first JD and the rest of JDs is < 0.1.
- Assign a confidence level to the categorization based on the JD score.
- 0.1 – 0.2:Undefined(U) 0.2 – 0.3:Weak(W) 0.3 – 0.4:Barely(B) 0.4 – 0.5:Strong(S) > 0.5:Very strong(VS)
- Three reviewers independently evaluated the quality of the categorization for 3 of the same documents for each of the 5 query terms.

Results

Query term	VS	S	B	W	U
Chronic Bloody Nose	5%	10%	30%	40%	15%
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Dark Circles	35%	15%	20%	20%	10%
Ventilator	5%	30%	35%	25%	5%
Cold war	0	0	15%	25%	60%

Summary of categorization results by confidence levels

Evaluation

Query term	Reviewer 1	Reviewer 2	Reviewer 3
Chronic Bloody Nose	100%	100%	100%
Carotid Artery Surgery	67%	33%	100%
Dark Circles	33%	100%	100%
Ventilator	67%	100%	67%
Cold war	100%	100%	100%
Average	73%	87%	93%

Summary of reviews by Reviewer

Conclusion

- The results show that for those documents that contained high quality medical content, the system categorized them with a very strong (VS) or a strong (S) confidence level as expected.
- Majority of google documents tend to generic in nature, containing information about multiple topics.
- On review, the majority of the documents categorized with a VS or S confidence level appear to have been correctly categorized.
- The quality of the categorization may be vastly improved if there were a consistent approach to removing noise from Google documents. (Ads etc.)
- Non-medical documents tended to be categorized as undefined with very low scores.

Future Work

- Plan to perform additional experiments expanding the number of input terms.
- Plan to explore the feasibility of using the JDI-based Semantic Type indexing for categorization.
- Plan to evaluate whether it is possible to extend our technique for determining the medical or non-medical focus of a document.
- In our experiments we extracted only the first level documents (depth 0) for a given URL. In the future we want to experiment with extracting the second and third level documents for a given site.
- We plan to use the origin of the document (NLM, Wikipedia) in determining the confidence level.

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Representation of Smoking-related Concepts in an Electronic Health Record

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Abstract

Data-driven models, created using the process of knowledge discovery in databases (KDD), can be used to predict characteristics or outcomes of patients, and thus aid decision-making. These models possess the capacity to augment evidence-based decision making related to smoking cessation on the basis of individual patient characteristics. This study (1) assessed the feasibility of a KDD project related to smoking cessation, and (2) mapped strengths and weaknesses in representation of smoking cessation related concepts in a commonly used electronic health record (EHR), EpicCare EMR. A sample of patient records was assayed and mapped to smoking cessation guidelines. Data quality issues related to coded representation of tobacco use were evident. Both strengths and weaknesses in representation of smoking-related concepts were identified. Analysis of free text patient notes may be helpful to adequately describe smoking and smoking cessation in patient records for the purpose of KDD.

Keywords:

Tobacco Use Cessation, decision support systems, clinical, medical records systems, computerized, data analysis, statistical, knowledge discovery in databases

Introduction

Previous work by the principal investigator demonstrated the capability to build predictive models of smoking cessation status from health survey data using the KDD process [1]. However, this capability has not been demonstrated using data from an ambulatory clinical information system. In order to create or augment clinical knowledge models related to smoking cessation using the KDD process, concepts relevant to smoking cessation must be represented by the data. Data quality must be assessed and considered. Moreover, the labor required to pre-process the large amount of data will be great. So, before engaging in a full-scale study, involving large amounts of data, it is prudent to determine the feasibility of using KDD/ data mining to create predictive and descriptive models of smoking cessation using the intended data. The purpose of this study was to determine the feasibility of using data mining methods to create predictive and descriptive models of smoking cessation using data from a primary care clinical information system.

Methods

This study examined data generated by EpicCare EMR (Epic) in a group of community outpatient clinics [2]. A random sample of 3000 electronic records, each corresponding to a single patient coded as a current or former smoker, and seen at a clinic within the past year, was extracted from the enterprise data warehouse. The Epic data dictionary was used to identify tables and attributes within those tables possibly relevant [3]. Each Epic attribute/ variable was assessed for representation of key concepts related to primary care management of smoking cessation, including the assessment of tobacco use/ dependence, tobacco dependence intervention, and relapse prevention. Attributes were manually mapped to concepts extracted from the VA/DoD clinical practice guideline for the management of tobacco use, and the United States Public Health Service (U.S.P.H.S.) Guidelines on Tobacco Use and Dependence. [4, 5]

Results

A series of forty-one individual reports was created, each containing descriptive statistics for each attribute identified as potentially relevant to a KDD study, and/or decode guides. The random sample of 3000 patients coded as current or former smokers, with at least one visit within the past year, was composed of 56% current smokers and 44% former smokers. Table 1 describes the presence and values of attributes used to describe intensity and duration of tobacco use in this sample of Epic records. The number of packs per day for current smokers ranged from 1-31. The most frequently used words in a free text "Tobacco Comment' attribute within the social history table were as follows: age, ago, day, quit, since, smoke, year, yr.

A concept map was generated – a single table mapping individual Epic attributes with smoking-relevant concepts extracted from the clinical practice guidelines and literature review. Table 2 summarizes strengths and weaknesses in representation of smoking cessation related concepts. Prescribed treatments and follow up visits within the system were clearly described in a coded format. However, other information was not

represented: over-the-counter treatments, social support, referrals for external treatment programs, and advice/ counseling offered in the course of a patient encounter.

Table 1 - Attributes describing intensity and duration of tobacco use

	Current User Records (n=1693)	*Former User Records (n=1307)*
"Packs Per Day" data entered	1220	521
"Packs Per Day": Mean (S.D.)	2.54 (3.48)	3.15 (3.69)
"Years": data entered	1012	542
"Years": Mean (S.D.)	15.71 (13.28)	15.18 (12.86)

Table 2 - Strengths and weaknesses in representation of smoking cessation related concepts

Strengths	*Weaknesses*
Prescribed medications	Advice/counseling to quit
ICD9 code "tobacco use disorder" [6]	Educational intervention
Willingness to quit	Self-help materials
Quit date	Referral to external counseling/ treatment programs
Presence and type of tobacco use	Type/ characteristics of program
Arrangement of follow up	OTC nicotine replacement
Demographic information	Social support
Family history	

Discussion

A fundamental description of a smoking habit is its intensity and duration. In the study sample, the records of most current smokers contained data describing intensity and duration of smoking. However, less than half the records of former smokers contained data describing intensity and duration of smoking. Clinicians entering the data appear to be mixing units of measurement, perhaps documenting number of cigarettes vs. number of packs. This interpretation is supported by the words most frequently entered into a "Tobacco Comment" attribute, words commonly used to describe duration. Many clinicians opted to use the free text field to describe intensity and duration of a smoking habit. Similar findings were encountered in other social history table attributes. Interviews with system users reveal that in many clinics, the social history attribute data are entered by medical assistants, not by nurse practitioners and physicians as they interview a patient.

Strengths and weaknesses in concept representation were noted, and may limit the ability of a KDD project to model smoking cessation. However, there are clear strengths in concept representation that could be leveraged to learn more about primary management of smoking cessation/ tobacco dependence (see table 2). Both data quality issues and weaknesses in coded concept representation may be informed by analysis of free text patient note data, not currently stored in the EDW. It is feasible to code smoking–related concepts in EpicCare free text patient notes with natural language processing (NLP). [7]

Conclusion

This feasibility study revealed significant data quality issues in coded social history attributes. These issues included missing data, particularly in the case of former smokers, and misrepresentation of patient characteristics with default attribute values. Unusual values may be related to clinicians using inappropriate units of measurement. The study also revealed key strengths and weaknesses in an ambulatory electronic health record's coded representation of concepts with known relevance to tobacco/ smoking cessation. The weaknesses in data quality and coded concept representation are anticipated to affect a KDD project using only coded data from this repository of ambulatory patient records, but may be ameliorated with analysis of additional data contained in free text patient notes.

Acknowledgements

This study was funded by the University of Utah College of Nursing Research Committee.

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College of Nursing

Representation of Smoking-related Concepts in an Electronic Health Record

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Biomedical Informatics

Purpose/ Aims

(1) Assess the feasibility of a knowledge discovery project related to smoking cessation using warehoused data from a group of outpatient clinics, AND

(2) Map strengths and gaps in the representation of smoking cessation related concepts in a common electronic health record system (EHR), EpicCare EMR.

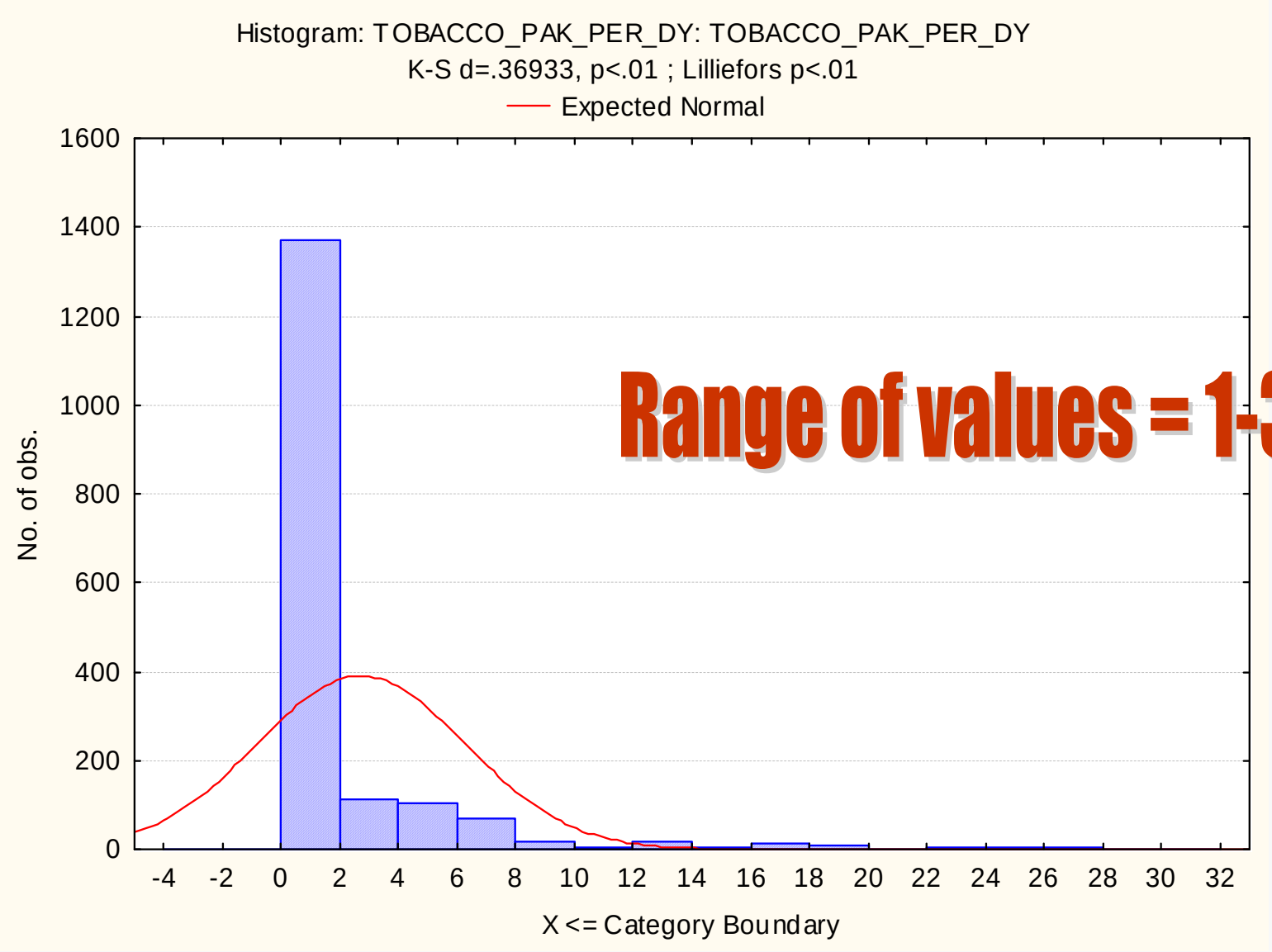
Data

- Source system: EpicCare EMR[4]
- Group of community outpatient clinics in the U.S. intermountain west.
- Data since 2000 (over six years of data).
- Random sample of 3000 electronic records:
  - Patients with a completed social history record
  - Either current or former smoker

Intensity and Duration of Smoking

Tobacco Status	***Current User (n=1693)***	***Former User (n=1307)***
Tobacco Packs Per Day	n=1220	n=521 **39.9%**
Mean (S.D.)	2.54 (3.48)	3.15 (3.69)
Tobacco Years	n=1012	n=542 **41.5%**
Mean (S.D.)	15.71 (13.28)	15.18 (12.86)

Packs Per Day: Distribution



Word frequencies: Tobacco Comment

	Frequency	Number of documents	Stemmed word
age	185	171	age
ago	[illegible]	[illegible]	ago
day	199	196	day
quit	561	[illegible]	quit
since	124	123	sinc
smoke	204	196	smoke
year	157	145	year
yr	178	167	yr

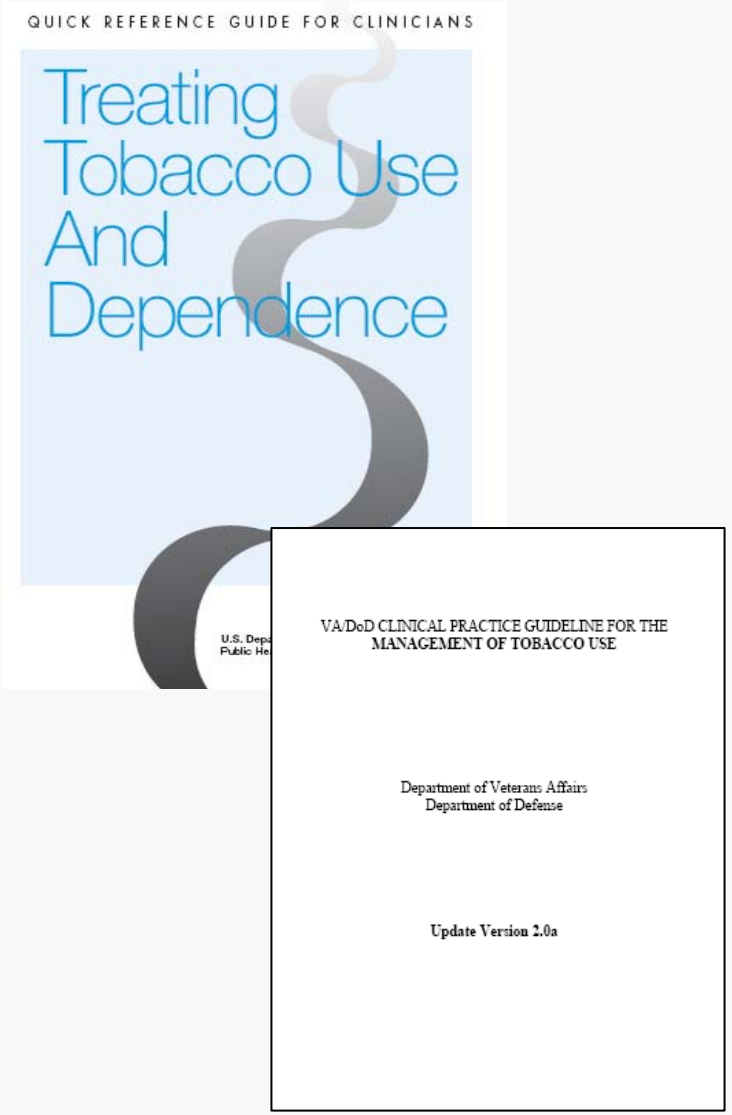
Words used to describe length of time…

Concept Mapping

U.S.P.H.S. Treating Tobacco Use and Dependence[5]

Va/DOD Clinical Practice Guideline for the Management of Tobacco Use[6]

Additional concepts identified in review of the literature[1]



Concept Representation: Strengths

- Prescribed medications
- ICD9 code “tobacco use disorder”[8]
- Willingness to quit
- Quit date
- Presence and type of tobacco use
- Arrangement of follow up
- Demographic information
- Family history/ pedigree

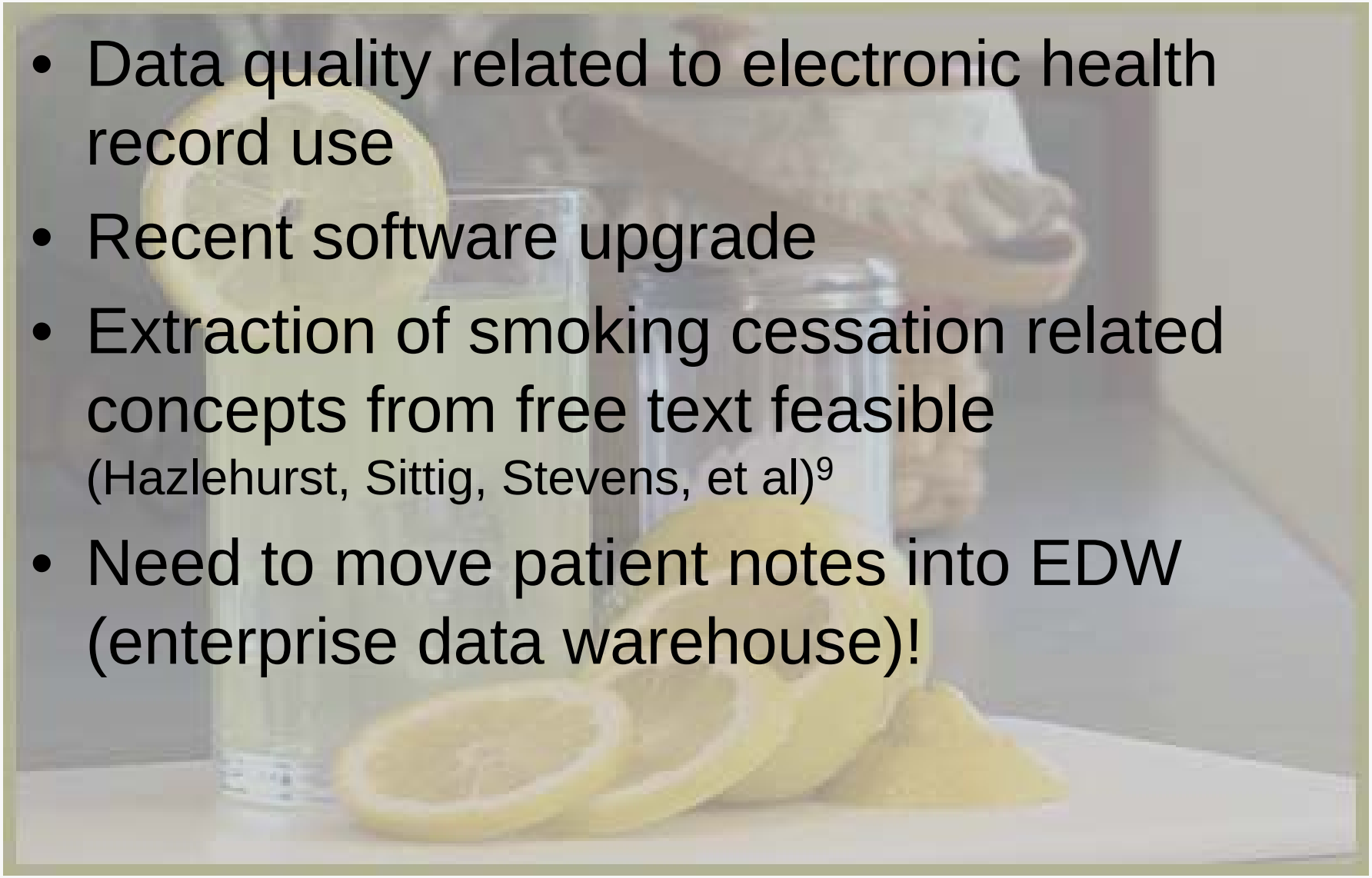
Concept Representation: Gaps

- Advice/counseling to quit
- Educational intervention
- Self-help materials
- Referral to external counseling/ treatment programs
- Type/ characteristics of program
- OTC nicotine replacement
- Social support

Conclusions

- Coded attributes capture some (but not all) concepts relevant to smoking cessation.
- Data assay indicates substantial data quality issues in coded data elements related to smoking cessation.
- Free text patient notes necessary to assess/ describe primary care management of smoking/ tobacco use. (Coded data *not* sufficient).

Discussion



- Data quality related to electronic health record use
- Recent software upgrade
- Extraction of smoking cessation related concepts from free text feasible (Hazlehurst, Sittig, Stevens, et al)[9]
- Need to move patient notes into EDW (enterprise data warehouse)!

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Discharge Summaries can be Diagnosed from Extracted Index Terms by Text Mining

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Abstract

We analyzed electronic discharge summaries by text mining and demonstrated its potential to make an automatical diagnosis and classification. We extracted diagnosis related terminological information by morphological analysis from 4,784 discharge summaries of 14 representative diseases applying vector space model. We calculated the weights of each term for individual diseases and obtained each vector for 14 diseases by tf-idf and entropy methods. The index terms extracted from the discharge summary showed the features of the disease. In comparing tf-idf and entropy methods, the ranking of importance of the terms were different but the extracted terms were approximately the same. When applying these data to new cases, more than 96% of the correct diagnoses could be obtained by both methods. The classification by the clustering showed clear accordance with the code of ICD-9. These results suggest the possibility to classify diseases from medical documents automatically by using the text mining technique.

Keywords:

text mining, discharge summary,
electronic medical record

Introduction

Recently in Japan, the electronic medical record has become popular, and electronic data has been accumulated in great quantities. At Chiba University Hospital, more than 30,000 electronic discharge summaries are stored. We showed the possibility of disease judgement and extraction of the index terms that characterize diseases by applying the vector space model to the discharge summary [1]. In addition, expansion of the target diseases and plural methods of weighting were requested. Therefore we increased the number of target diseases, and added the entropy method to compare. Moreover, we performed cluster analysis by similarity computation, and tried automatic classification of the disease.

Methods

Discharge Ssmmary

The full text computerization of the discharge summary began at Chiba University Hospital in 1999. A total of 36,335 summaries were registered in four years by May, 2003. Free text which described the history of the present illness was used for analysis in this research. All the cases have been extracted from representative diseases that consisted of more than 100 cases individually. These diseases were selected from diverse fields (Table 1). Subsequently, we selected 4,784 discharge summaries from 14 diseases.

Morphological analysis

Morphological analysis that resolves the character string to the element like a noun, an adjective, and a particle, etc. is necessary for the analysis of a Japanese natural sentence. In this research, we used the "ChaSen" that was developed as a morphological analysis system [2]. The PHYXAM dictionary was used as a medical technical dictionary [3].

Vector space model

We calculated the weights of each term for every disease and obtained each vector for 14 diseases by the vector space model [4]. In this research, we compared two weighting methods (tf-idf and entropy methods).

Tf-idf method

In tf-idf method, weight *ij* is shown by *ij=(lij×gi)/nj*. *lij* is the local weight, and a big value is given to the index term that appears frequently in the document. *gi* is global weight, and a big value is given to the term that appears only in a specific document. *nj* is a document normalization coefficient to which removes the influence by the length of documents.

$$\alpha_{ij} = \frac{l_{ij} g_i}{n_j}$$

tf $l_{ij} = log(1 + f_{ij})$ idf $g_i = log(\frac{n}{n_i})$

$n_j = \sqrt{\sum_{i=1}^{m} (l_{ij} g_i)^2}$

f_{ij} ··· Frequency of term w_i in disease d_j
n ··· Total number of the diseases in discharge summary
n_i ··· Number of the diseases which include the term w_i

Entropy method

Entropy decreases when each event occurs in equal probability. The value of *Hi*/log is close to 1 when the index

term appeared in each document at an equal probability, therefore, the following expressions can be used as global weight of an index term.

$$g_i = 1 - H_i = 1 + \frac{1}{\log n} \sum_{j=1}^{n} \frac{f_{ij}}{F_i} \log \frac{f_{ij}}{F_i}$$

Disease judgment

We testify to the diseases from a discharge summary based on the calculated vector of the 14 diseases. First of all, we selected 10 cases of discharge summaries from 14 diseases that were not used to make the vectors, in total 140 cases as test cases. Next, similarity computation between the test case and each of the14 diseases were calculated by inner products. When the disease showed the highest similarity computation corresponding to the correct diagnosis, it was set to "matched".

Cluster analysis

We substituted similarity between the diseases for the distance of the Euclidean square, and performed the cluster analysis by the furthest neighbor method.

Results

Extraction of the index term

8,375 index terms have been extracted from the discharge summary set which is composed of 4,783 cases. Table 2 shows the result of permuting the extracted index term of each disease in order of weight. It seems that the index term characterizing each disease was extracted from among the terms actually used in the hospital. No significant difference was found about medical validity observed in both methods. The correlation coefficient of the weight of all the index terms between both methods indicated a very high value (0.95).

Disease judgment

As shown in Table 3, 137 cases were correctly diagnosed out of 140 cases (98%) by entropy methods and 135 cases (96%) by tf-idf method. There were no significant differences between both methods. All the cases misjudged here were those with ancillary diagnosis and computer selected a complication as a main diagnosis.

Cluster analysis of 14 diseases

The results of the classification by clustering were almost the same order of the code system of ICD-9, and showed good accordance from a medical viewpoint.

Discussion

We identified diseases even though we expanded the number of diseases. Furthermore, we experimentally analyzed the discharge summaries of other hospitals, and we could identify the diseases as well as the summaries at our hospital (Data not shown). We believe that this technique is universal when target diseases and facilities expand in the future, and the universal vector data is obtained. In comparing the methods of calculating weights, the difference was seen in the order, however extracted terms and phrases were almost the same between the tf-idf method and the entropy method. Furthermore, clear superiority was not observed about medical validity between both methods. In identifying diseases, there were no significant differences.

The research on the medical technical term using the vector space model is performed. We analyzed the documents in Japanese, however, similar results can be expected in English, because we only used the index terms and their weighting for analysis from the characteristics of language. Takemura et al. are experimenting with the automatic diagnosis of the diseases from text mining of the radiograph report [5]. Text mining seems to be applied to all medical documents in the future.

[1]

Table 1 - 14 diseases and number of case

Disease	organ	ICD-9	Case
gastric cancer	GI tract	151	524
hepatoma	liver	155	483
lung cancer	respiratory	162	687
mammary cancer	mamma	174	363
prostatic carcinoma	genital organ	185	340
renal carcinoma	renal	189	158
malignant lymphoma	hematology	202	153
diabetes Mellitus	endocrine	250	293
schizophrenia	psychiatric	295	104
cataract	eye	366	777
angina	circulatory	413	467
asthma	allergy	493	114
scar contracture	skin	709	133
osteoarthritis	motor organ	715	188

Table 2 - Top 5 list of index term order by severity (abstract)

	gastric cancer		hepatoma		Angina	
	tf-idf	entropy	Tf-idf	entropy	tf-idf	entropy
1					(exertional chest pain)	
2						
3					(acetyl-choline)	
4					(Q wave)	(chest pain)
5	(total gas-trectomy)	(gastric cancer)	Angio -CT			(nitro)

Table 3 - Judgment result of each disease

disease	ICD-9	tf-idf	entropy
gastric cancer	151	9	9
Hepatoma	155	10	10
lung cancer	162	10	10
Mammary cancer	174	9	10
prostatic carcinoma	185	10	10
renal carcinoma	189	9	9
Malignant lymphoma	202	10	10
Diabetes Mellitus	250	9	9
Schizophrenia	295	10	10
Cataract	366	10	10
Angina	413	10	10
Asthma	493	10	10
scar contracture	709	9	10
Osteoarthritis	715	10	10
Accuracy		96%	98%

Conclusion

We extracted the index terms that characterize diseases, and by using them identified more than 96% out of 140 discharge summaries. There were no significant differences between the tf-idf method and the entropy method. The classification by the clustering showed good accordance with the code of ICD-9.

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Discharge Summaries can be diagnosed from extracted index terms by text mining

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Abstract

- Abstract
  - We analyzed electronic discharge summaries by text mining and demonstrated its potential to make an automatical diagnosis and classification. We extracted diagnosis related terminological information by morphological analysis from 4,784 discharge summaries of 14 representative diseases applying vector space model. We calculated the weights of each term for individual diseases and obtained each vector for 14 diseases by tf-idf and entropy methods. The index terms extracted from the discharge summary showed the features of the disease. In comparing tf-idf and entropy methods, the ranking of importance of the terms were different but the extracted terms were approximately the same. When applying these data to new cases, more than 96% of the correct diagnoses could be obtained by both methods. The classification by the clustering showed clear accordance with the code of ICD-9. These results suggest the possibility to classify diseases from medical documents automatically by using the text mining technique.

- Keywords:
  - Text mining, Discharge summary, Electronic medical record.

Introduction

- Recently in Japan, the electronic medical record has become popular, and electronic data has been accumulated in great quantities. At Chiba University Hospital, more than 30,000 electronic discharge summaries are stored. We showed the possibility of disease judgement and extraction of the index terms that characterize diseases by applying the vector space model to the discharge summary in Medinfo 2004 [1].
- In addition, expansion of the target diseases and plural methods of weighting were requested. Therefore we increased the number of target diseases, and added the entropy method to compare.
- Moreover, we performed cluster analysis by similarity computation, and tried automatic classification of the disease.

Materials

- The full text computerization of the discharge summary began at Chiba University Hospital in 1999. A total of 36,335 summaries were registered in four years by May, 2003.
- All the cases have been extracted from representative diseases which consisted of more than 100 cases individually. These diseases were selected from diverse fields of medicine such as gastric cancer in gastrointestinal disease (Table 1). Subsequently, we selected 4,784 discharge summaries from 14 diseases.

Table 1. 14 diseases and number of case

Disease	organ	ICD-9	Case
gastric cancer	GI tract	151	524
Hepatoma	liver	155	483
lung cancer	respiratory	162	687
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Cataract	eye	366	777
Angina	circulatory	413	467
Asthma	allergy	493	114
scar contracture	skin	709	133
osteoarthritis	motor organ	715	188

Methods

1. **Obtained vector for discharge summary**

   We extracted diagnosis related terminological information from 4,784 discharge summaries by morphological analysis that resolves the character string to the element like a noun, an adjective, and a particle, etc. is necessary for the analysis of a Japanese natural sentence.
   We used the “ChaSen” that was developed as a morphological analysis system [2]
   The PHYXAM dictionary was used as a medical technical dictionary [3],
   We calculated the weights of each term for individual diseases and obtained each vector for 14 diseases by tf-idf and entropy methods.

2. **Disease judgment**

   We testify to the diseases from a discharge summary based on the calculated vector of the 14 diseases. First of all, we selected 10 cases of discharge summaries from 14 diseases, in total 140 cases as test cases. These summaries were not used to make the vectors according to disease.
   Next, similarity computation between the test case and each of the 14 diseases were calculated by inner products, and visualized by the radar chart. When the disease showed the highest similarity computation corresponding to the correct diagnosis, it was set to "matched".

3. **Cluster analysis**

   We substituted similarity between the diseases for the distance of the Euclidean square, and performed the cluster analysis by the furthest neighbor method.

Vector space model

- We calculated the weights of each term for every disease and obtained each vector for 14 diseases by the vector space model. The vector space model is a technique widely used in the field of information retrieval, which changes the characteristic of the document into the multidimensional vector. [4] In this research, we compared two weighting method (tf-idf and entropy methods).

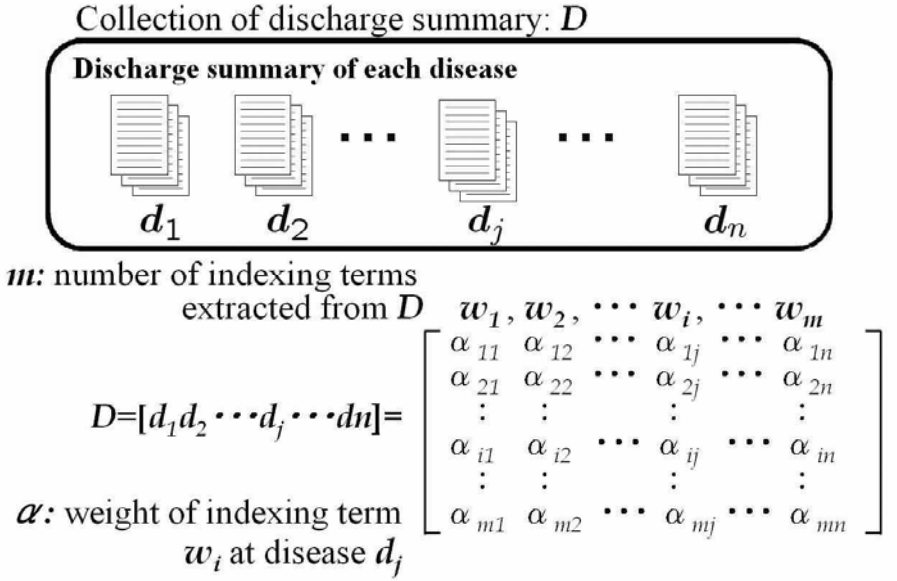

Figure 1- Vector space model

The total targeted discharge summary set is assumed to be D, and discharge summary sets of each disease are assumed to be $d1, d2, \cdots, dj, \cdots, dn$. Next, the m pieces of index term extracted from D are assumed to be $w1, w2, \cdots, wi, \cdots, wm$. Weight of index term wi in the discharge summary dj is assumed to be αij. As a result, the discharge summary dj is expressible by the vector that consisted of the m pieces of element α, and defined this as the discharge summary vector of disease j.

Weight of the index term

- tf-idf method
  - In tf-idf method, weight α_{ij} is shown by $\alpha_{ij}=(l_{ij} * g_i)/n_j$.
  - l_{ij} is the local weight, and a big value is given to the index term that appears frequently in the document. g_i is global weight, and a big value is given to the term that appears only in a specific document. n_j is a document normalization coefficient to which removes the influence by the length of documents.

$$\alpha_{ij} = \frac{l_{ij} g_i}{n_j}$$

tf $$l_{ij} = log(1 + f_{ij})$$

idf $$g_i = log(\frac{n}{n_i})$$

$$n_j = \sqrt{\sum_{i=1}^{m} (l_{ij} g_i)^2}$$

f_{ij} ・・・ Frequency of term w_i in disease d_j
n ・・・ Total number of the diseases in discharge summary
n_i ・・・ Number of the diseases which include the term w_i

- Entropy method
  - Entropy decreases when each event occurs in equal probability. The value of H_i/log is close to 1 when the index term appeared in each document at an equal probability, while it closes to 0 when it appeared only in limited documents. Therefore, the following expressions can be used as global weight of an index term w_i.

$$g_i = 1 - H_i = 1 + \frac{1}{\log n} \sum_{j=1}^{n} \frac{f_{ij}}{F_i} \log \frac{f_{ij}}{F_i}$$

Results: Extraction of the index term

- We extracted 8,375 index terms from the discharge summary set D which is composed of 4,783 cases. The summaries of 14 diseases were vectorized by using the weight of the index term. Table 2 shows the result of permuting the extracted index term of each disease in order of weight. It seems that the index term characterizing each disease was extracted from among the terms actually used in the hospital. tf-idf method and entropy method were compared in each disease. No significant difference was found about medical validity observed in both methods. The correlation coefficient of the weight of all the index terms between both methods indicated a very high value (0.95).

Table 2. Top 10 list of index term order by severity (abstract)

	gastric cancer		hepatoma		Angina	
	tf-idf	**entropy**	**tf-idf**	**entropy**	**tf-idf**	**entropy**
1	IIc	EMR	PEI	HCC	労作時胸痛 (exertional chest pain)	CAG
2	IIa	IIc	CTA	PEI	aVf	PTCA
3	laser	GS	LpTAI	TAE	アセチルコリン(acetyl-choline)	LAD
4	por	GFS	TAI	TAI	Q波 (Q wave)	胸痛(chest pain)
5	胃全摘術(total gastrectomy)	胃癌 (gastric cancer)	Angio-CT	DyCT	RCA	ニトロ(nitro)
6	MDL	胃体(body of stomach)	RHA	RFA	hypokinesis	RCA
7	EMRC	group	lipiodol	CTAP	不安定狭心症(unstable angitis)	LVG
8	CY	幽門 (pylorus)	staining	CTA	絞扼感 constriction	aVf
9	LapMR	小弯(lesser curvature)	PVTT	LpTAI	NTG	舌下 (hypoglottis)
10	Billroth	IIa	RFA	AFP	Extremities	胸部圧迫感 (chest constriction)

Results: Disease judgment

- As shown in Table 3, 137 cases were correctly diagnosed out of 140 cases (98%) by entropy methods and 135 cases (96%) by tf-idf method. There were no significant differences between both methods. All the cases misjudged here were those with ancillary diagnosis and computer selected a complication as a main diagnosis.

Table 3. Judgment result of each disease

disease	ICD-9	tf-idf	entropy
gastric cancer	151	9	9
Hepatoma	155	10	10
lung cancer	162	10	10
Mammary cancer	174	9	10
prostatic carcinoma	185	10	10
renal carcinoma	189	9	9
Malignant lymphoma	202	10	10
Diabetes Mellitus	250	9	9
Schizophrenia	295	10	10
Cataract	366	10	10
Angina	413	10	10
Asthma	493	10	10
scar contracture	709	9	10
Osteoarthritis	715	10	10
Accuracy	709	96%	98%

Results: Cluster analysis of 14 diseases

- We performed cluster analysis from similarity computations between 14 calculated diseases by the nearest-neighborhood method, and visualized it by the dendrogram. According to these results, three diseases became complicated such as diabetes, angina, and cataracts and malignant tumors such as stomach carcinomas and liver carcinomas were established in the small groups.

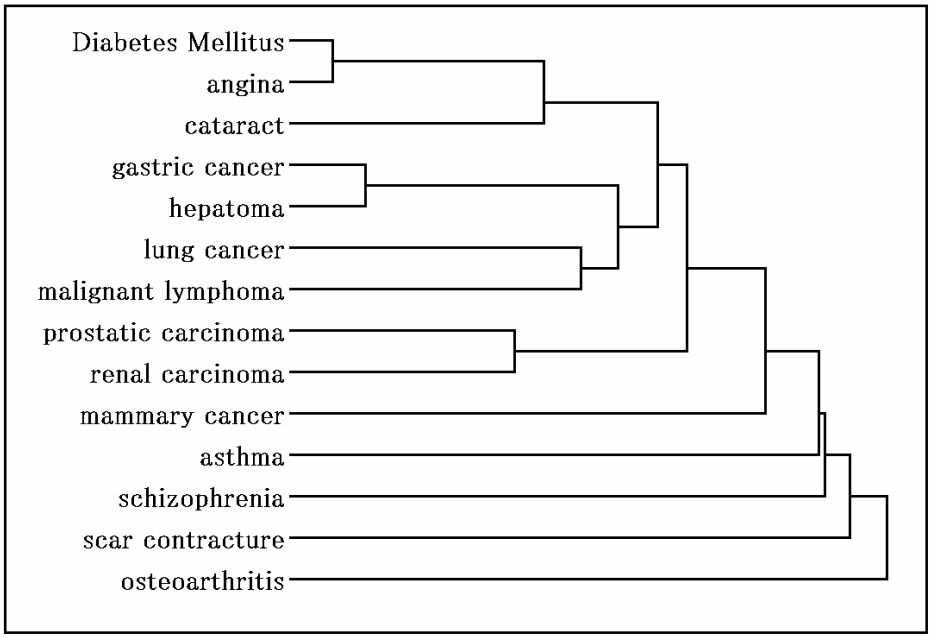

Figure 3- Cluster analysis of 14 diseases

The group that was the furthest from others was osteoarthritis. The results of the classification by clustering were almost the same order of the code system of ICD-9, and showed good accordance from a medical viewpoint.

Discussion & Conclusion

- **Discussion**

  We showed the extraction of the linguistic information and by using it we made a diagnosis of the discharge summary by the vector space model, in Medinfo 2004. [1] However, the some questions arose. Firstly it happens to work only in the combination of specific diseases and did not function when other kinds of diseases were added, such as circulatory diseases. Secondly, since there are various techniques for weighting the index terms, therefore it would be more effective than the tf-idf method.

  We identified diseases even though we expanded the number of diseases. Furthermore, we experimentally analyzed the discharge summaries of other hospitals, and we could identify the diseases as well as the summaries at our hospital. (Data not shown) We believe that this technique is universal when target diseases and facilities expand in the future, and the universal vector data is obtained. In comparing the methods of calculating weights, extracted terms and phrases were almost the same between the tf-idf method and the entropy method. In identifying diseases, there were no significant differences. Furthermore, clear superiority was not observed about medical validity between both methods.

  The research on the medical technical term using the vector space model is performed. We analyzed the documents in Japanese, however, similar results can be expected in English, because we only used the index terms and their weighting for analysis from the characteristics of language. Takemura et al. are experimenting with the automatic diagnosis of the diseases from text mining of the radiograph report [5] and Iwahashi et al. are also researching automatic classification of an incident report [6]. Text mining seems to be applied to all medical documents in the future.

- **Conclusion**

  We extracted the index terms that characterize diseases, and by using them identified more than 96% out of 140 discharge summaries. There were no significant differences between the tf-idf method and the entropy method. The classification by the clustering showed good accordance with the code of ICD-9.

  By collecting discharge summaries in many facilities, we can obtain universal vectors, characteristics for every disease and analysis through for electronic medical records by textmining, therefore we can expect to discover new medical knowledge.

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A Text Mining Approach to Explain What Being Actively Engaged in Life Means

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Abstract

This paper shows the findings and analysis of a national survey data on 'Active Ageing'. We examine the applicants responses on "what being actively engaged in life means to you?" with the text mining approach. The analysis shows that the 'Family', 'Friend' and 'Activity' were the most important concepts appearing across all age groups and both genders.

Keywords:

text mining, data mining, active ageing

Introduction

It is widely accepted that many first world countries are experiencing extended life expectancies and reduced fertility rates, which is resulting in an ageing population. A definition of active ageing is "the process of optimizing opportunities for physical, social, and mental well-being throughout life in order to extend healthy life expectancy [2]. The Australian Active Ageing (Triple A) study at the Queensland University of Technology (QUT) has conducted a national-wide postal survey to collect the responses of older people on a wide range of questions related to 'work', 'learning', 'social', 'spiritual', 'emotional', 'health and home', 'life events' and 'demographics'. The survey also included an open-ended question that the applicants responded to was "Briefly describe what being actively engaged in life means to you?". The purpose of this paper is to present the findings and analysis of the open-ended question in the survey using the text mining techniques [1]. This paper attempts to gain a better understanding of the impact of aging upon older Australians' engagement in society and their sense of well being. The findings and analysis are based on the responses from 2645 (45% response rate) participants over the age of 50 years residing across Australia.

Method: text mining

Text mining extracts the important concepts and emerging themes from the collection of text sources using computation linguistics, machine learning and information science methods [1,3]. We utilize the Leximancer text mining application [3] to extract relationships from the text data. It is based on the bayesian theory using the words which make up a sentence to predict the concepts being discussed. Each *term* appearing in the text data is analyzed to form a *concept* and then many concepts are put together to form a *theme* based on the co-occurrence of terms and concepts in the text.

Data: The Triple A study data includes responses of 2645 members of a large Australia wide seniors organization on a wide range of questions related to their life. The survey includes 178 questions grouped into 8 sections covering the life aspects of social, health and home, emotional etc and an open-ended question. The sample included a reasonable balance of gender (57% female) and state representation (NSW: 32%, Vic: 24% and Qld: 20%). The respondents were quite comfortable financially, well educated and majority were living with a companion, in their own home in a metropolitan area.

Table 1 - Categorization by age and gender

Grouping	Category	Qty
All comments		1964
Grouped by age	55-64	1252
	65-74	474
	75 & over	238
Grouped by gender	Male	870
	Female	1094
Males grouped by age	55-64	523
	65-74	230
	75 & over	117
Females grouped by age	55-64	729
	65-74	244
	75 & over	121

Process: Preprocessing such as (1) removal of surveys (instances) that did not have sufficient information of age, gender etc, (2) application of spelling and grammar checking function in Excel in order to locate and correct the misspell words, incorrect abbreviations and slang, and (3) stop word removal and stemming were performed. The data file was then arranged and split into categories of both Age and Gender that allowed us to thoroughly compare and contrast the different combinations of categories (Table1).

Results and discussion

Comparison by age groups

Age group 55 – 64: The most significant concept and theme is 'Family'. 'Life' and 'Active' are next in the level of frequency. There is an integral relationship between 'family' and 'time' as well as having close ties with the 'enjoy' entity. 'Work' is considered a significant concept ranking highly for both males and females. 'Work' and 'Active' aspects comes to the fore in Males whereas 'Health' and 'Social' aspects are more frequent in the Females. This may indicate that Males place a greater importance in physically active aspects while Females signal social themes as figuring in their perception of active ageing.

Age group 65 – 74: This age group shows that they consider an active life to being engaged in it, living a full life, having a life with purpose and friendship in terms such as visit, involvement and participation. In this age group, males considered 'work' a more important concept than females. Both males and females emphasize on Family. However the terms that form the 'Family' concept in both groups differ. The females were concerned with interaction with emphasis on meeting, touching, visiting, whereas the males, although the terms indicate a need to be interactive, are less personal. Their terms include social, involved, community, and activities. Although it is a subtle difference, it could possibly indicate that for males, family is also a source of activity or social events. Whereas with the females, it could be perceived as a more emotional connection as opposed to as a source of activities or social connectivity.

Age group 75+: Ageing is perceived as having a close association with family and friends and maintaining an engagement in life through activities with these people. The concept of 'health' emerges as a significant concept, more highly ranked by the males than the females. This differs from the prior age groups indicating that this group may be considering health issues more frequently in relation to active ageing.

A very interesting difference that appears between male and female of this age group is the 'enjoy' concept. Female associate enjoy with life concept. However, male segregate the enjoy concept from either of family or active concept. Male population subtly emphasizes more on 'active' concept in comparison to female. Male population being actively means being involved with people. The female population seems to relate being actively with being involved with their loved ones, friends and social groups such as church.

Comparison by gender

All Females: Ageing is perceived as having a close association with family and friends and enjoying the activities with these people. Ageing is also perceived as being active in life through the time based work activities.

All Male: Ageing is perceived as being active in life and spending time with family and friends.

The most significant difference between the results of the males and females, are that where the females population were concentrated around 'Life', 'Family' and 'Friends', the male population seems to include a wider range of concepts including 'Active' and 'Work' as heavily weighted.

Using the whole population

To understand the behavior of the whole population including various age groups and all gender, we grouped the respondents according to the way they reflect active ageing using the clustering method [4]. This method also utilizes the computation linguistics to analyses the terms that mainly form a theme and consequently puts them into the same group. All respondents are grouped into 6 clusters. Following is the detail of each cluster including the few top-most terms due to which the respondents were put together in same group along with number of similar respondents in that cluster according to the written response.

Cluster 1: people, thing, good, new, health (1073)

Cluster 2: friend, social, work, child, grandchild (736)

Cluster 3: physical, mental, good, health, activity (175)

Cluster 4: mental, physical, happy, independent, family (136)

Cluster 5: help, other, helping, helping others (99)

Cluster 6: body, mind, help, good (89)

Cluster 1 is the biggest cluster in the dataset, which gives a general description for the meaning of active aging. The concepts covered are as follows: learning new things and skills, maintain good health, dealing with other people etc. Cluster 2 focuses more on the aspect of personal life, involves the family life, the friendship and the attitude to society. These respondents would like to enjoy with their family, look after their grandchild, stay with their friends, participate in social event and contribute to the society. Respondents in cluster 3 realize good health (mental and physical both) is the basis for happy life and are willing to participate in activities according to their health status. Cluster 4 respondents find the mental and physical health along with the family surroundings as key aspects for active ageing. People in cluster 5 wish to find out their personal values by helping others, in the aspect of daily life or whatever and wherever others need. The responders in cluster 6 wish to be interactive with other people to make their body and mind active as well as help the others.

These clusters show the various characteristic that each group of common respondents have. Further drilling to each group will identify more common concepts and themes.

Conclusion

A strong common themes across all groups, male, female and age groups were that 'Family', 'Friends' and 'Activities'. The younger age group considers 'Work' an important variable in active ageing, and this drops off to be important for only males in the next group, and is not ranked in the 75 and older group. Within the eldest group however, 'Health' emerges as an important concept, and given that this group is in a minority in the population as a whole, could explain that lack of representation overall of health concerns. These trends seem to indicate that the respondents are considering factors that are relevant to them in the immediate timeframe when responding to the question without consideration toward their future. There are various areas where these results may have impact and warrant some consideration such as future planning for government funding of community activities.

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A Text Mining Approach to Explain What Being Actively Engaged in Life Means

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Introduction

- It is widely accepted that many first world countries are experiencing extended life expectancies and reduced fertility rates, which is resulting in an ageing population.
  - A definition of active ageing is “the process of optimizing opportunities for physical, social, and mental well-being throughout life in order to extend healthy life expectancy.
- The Australian Active Ageing (Triple A) study at the Queensland University of Technology (QUT) has conducted a national-wide postal survey to collect the responses of older people on a wide range of questions related to ‘work’, ‘learning’, ‘social’, ‘spiritual’, ‘emotional’, ‘health and home’, ‘life events’ and ‘demographics’.
- The survey also included an open-ended question that the applicants responded to was “Briefly describe what being actively engaged in life means to you?”.
- The purpose of this paper is to present the findings and analysis of the open-ended question in the survey using the text mining techniques.
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- We utilize the Leximancer text mining application [3] to extract relationships from the text data.
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  - Each *term* appearing in the text data is analyzed to form a *concept* and then many concepts are put together to form a *theme* based on the co-occurrence of terms and concepts in the text.

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- The Triple A study data includes responses of 2645 members (45% response rate) of a large Australia wide seniors organization on a wide range of questions related to their life.
- The survey includes 178 questions grouped into 8 sections covering the life aspects of social, health and home, emotional etc and an open-ended question.
- The sample included a reasonable balance of gender (57% female) and state representation (NSW: 32%, Vic: 24% and Qld: 20%).
- The respondents were quite comfortable financially, well educated and majority were living with a companion, in their own home in a metropolitan area.

Process

- Preprocessing steps were performed.
  - (1) removal of surveys (instances) that did not have sufficient information of age, gender etc,
  - (2) application of spelling and grammar checking function in Excel in order to locate and correct the misspell words, incorrect abbreviations and slang,
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- The data file was then arranged and split into categories of both Age and Gender that allowed us to thoroughly compare and contrast the different combinations of categories.

Combinations of categories for analysis

Grouping	Category	Qty
All comments		1964
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Comparison by Age Groups

Age group 55 – 64

- The most significant concept and theme is ‘Family’.
- ‘Life’ and ‘Active’ are next in the level of frequency.
- There is an integral relationship between ‘family’ and ‘time’ as well as having close ties with the ‘enjoy’ entity.
- ‘Work’ is considered a significant concept ranking highly for both males and females.
- ‘Work’ and ‘Active’ aspects comes to the fore in Males whereas ‘Health’ and ‘Social’ aspects are more frequent in the Females.
- This may indicate that Males place a greater importance in physically active aspects while Females signal social themes as figuring in their perception of active ageing.

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- This age group shows that they consider an active life to being engaged in it, living a full life, having a life with purpose and friendship in terms such as visit, involvement and participation.
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- Both males and females emphasize on Family. However the terms that form the ‘Family’ concept in both groups differ.
  - The females were concerned with interaction with emphasis on meeting, touching, visiting, whereas the males, although the terms indicate a need to be interactive, are less personal.
  - Their terms include social, involved, community, and activities.
  - Although it is a subtle difference, it could possibly indicate that for males, family is also a source of activity or social events.
  - Whereas with females, it could be perceived as a more emotional connection as opposed to as a source of activities or social connectivity.

Comparison by Age Groups

Age group 74+

- Ageing is perceived as having a close association with family and friends and maintaining an engagement in life through activities with these people.
- The concept of ‘health’ emerges as a significant concept, more highly ranked by the males than the females.
  - This differs from the prior age groups indicating that this group may be considering health issues more frequently in relation to active ageing.
- A very interesting difference that appears between male and female of this age group is the ‘enjoy’ concept.
  - Female associate enjoy with life concept.
  - However, male segregate the enjoy concept from either of family or active concept.
  - Male population subtly emphasizes more on ‘active’ concept in comparison to female.
  - Male population being actively means being involved with people.
  - The female population seems to relate being actively with being involved with their loved ones, friends and social groups such as church.

Comparison by Gender

- All Females:
  - Ageing is perceived as having a close association with family and friends and enjoying the activities with these people.
  - Ageing is also perceived as being active in life through the time based work activities.
- All Male:
  - Ageing is perceived as being active in life and spending time with family and friends.
- The most significant difference between the results of the males and females, are that where the females population were concentrated around ‘Life’, ‘Family’ and ‘Friends’, the male population seems to include a wider range of concepts including ‘Active’ and ‘Work’ as heavily weighted.

Summary

- A strong common themes across all groups, male, female and age groups were that ‘Family’, ‘Friends’ and ‘Activities’.
- The younger age group considers ‘Work’ an important variable in active ageing, and this drops off to be important for only males in the next group, and is not ranked in the 75 and older group.
- Within the eldest group however, ‘Health’ emerges as an important concept, and given that this group is in a minority in the population as a whole, could explain that lack of representation overall of health concerns.
- These trends seem to indicate that the respondents are considering factors that are relevant to them in the immediate timeframe when responding to the question without consideration toward their future.
- There are various areas where these results may have impact and warrant some consideration such as future planning for government funding of community activities.

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Numerical Assessment of Blood Trauma in BiVentricular Assist Device (BVAD)

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Abstract and objective

A CFD assessment of shear induced hemolysis in the early design phase of artificial prosthetics may decrease time and costs of development. Among the cardiac assist devices available, the BVAD has attracted worldwide interest because patients who received a left ventricular assist device (LVAD) have extended lives. However, some of them develop right heart failure syndrome, and these patients required a right ventricular assist device (RVAD). In this paper, a numerical analysis was performed to predict the share stresses which may allow possible blood trauma analysis in BVAD.

Keywords:

CFD, BVAD, blood trauma, Hemolysis

Introduction

Ventricular assist devices (VADs) have become widely used in bridging to heart transplantation, bridging to recovery, or destination therapy. However there is still insufficient understanding of fluid mechanics related issues in the clearance gap of the BVAD. The design nature of the pump requires sufficient washout in the clearance between the impeller and the stationary pump housing inner surface. In this paper, a numerical analysis was performed to predict the share stresses in the clearance regions of the BVAD.

Methods

The BVAD (Fig 1) is under development at the Queensland University of Technology in Brisbane, Australia.

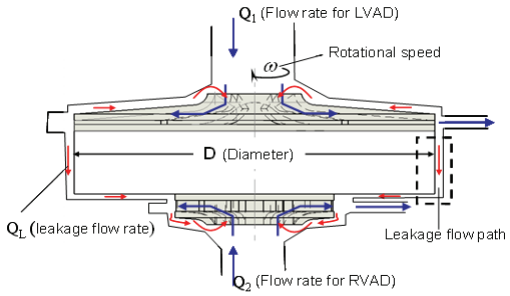

Figure 1 - The schematic drawing of the BVAD

The shear stress in blood is comprised of molecule viscosity stress and Reynolds stress components. A scalar stress value can be obtained according to Bludszuweit's stress formula[1]:

$$\sigma = \left[\frac{1}{6}\sum(\sigma_{ii} - \sigma_{jj})^2 + \sum\sigma_{ij}^2\right]^{\frac{1}{2}} \quad (1)$$

where σ is the scalar stress (pa) and σ_{ij} is the stress tensor. In order to predict the blood damage, it is necessary to define a threshold shear stress value leading to blood cell damage.

Results

Figure 2 shows the results of 2,200 rpm on the stress distribution. The maximum scalar stress value reached in the back region is 245 N/m2. The threshold levels of 500 Pa have been reported as the design condition in the development of centrifugal blood pump for exposure times of 0.1 s. [2]. Therefore, exposing the blood cells to such levels of fluid stress will not likely result in blood trauma based on these computational results.

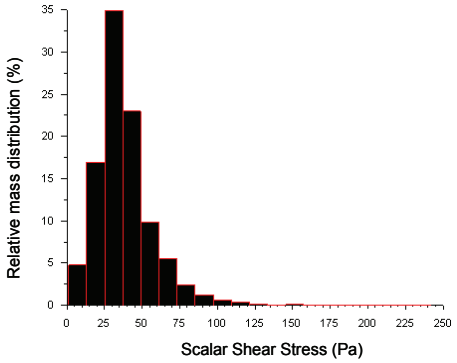

Figure 2 - Mass weighted distribution of scalar shear stress in clearance gap

In future studies, the CFD predictions will be compared quantitatively to data that are being obtained using PIV measurements.

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Advantages of Computer-based Approaches to Clinical Guidelines: the Case of the GLARE Approach

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Abstract

Computer-based approaches to clinical guidelines are gaining an increasing relevance within the medical community. We discuss the specific advantages of adopting the GLARE system

Introduction and background

Clinical guidelines are a means for specifying the "best" clinical procedures and for standardizing them. Several computer-based approaches have been introduced to overcome the gap between clinical guidelines as provided by standardization committees and their applicability in the clinical practice [1]. GLARE (Guideline Acquisition, Representation and Execution) is a system which has been built from 1997 in cooperation with Az. Osp. S. Giovanni Battista, Turin, Italy [2]. It is a domain-independent system to acquire, represent and execute clinical guidelines, which has been tested on several guidelines, including asthma, cardiac diseases, ischemic stroke.

Methods

GLARE has a three level architecture. At the highest level, it offers a high-level and easy-to-use interface to physicians. At the intermediate level, it has an acquisition module, to enter a new guideline, and an execution engine, to instantiate a guideline on a patient. At the lower level, it interacts with a DBMS to store clinical guidelines and to interact with patient records.

Results

The adoption of the GLARE system provides several main advantages. As regards the acquisition phase:

1. It provides a high-level graphical interface to introduce clinical guidelines by drawing graphs and filling slots
2. It provides automatic facilities to check the correctness of guidelines, including (i) a terminological check and a check on the correctness of the values of attributes, (ii) a check on the "logical" well-formedness of the graph (e.g., only decision actions may have more than one exiting arc), (iii) a check of the consistency of the temporal constraints in the guideline, based on the adoption of advanced Artificial Intelligence techniques [3]. Moreover, (iv) GLARE is integrated with the SPIN model-checker, to automatically check several kind of properties (e.g., the presence of a therapy with specific properties for a given patient).
3. It provides a module to contextualize a general guideline considering the local availability of resources

As regards the execution phase:

1. It interacts with the Patient DB, so that patients' data are automatically retrieved from it whenever needed
2. It adopts advanced Decision Theory techniques to assist physicians' decision making ("what if" analysis)
3. It checks whether the execution on a given patient is correct, in the sense that the actions in the guidelines are executed, and the temporal constraints in it are respected [3];
4. It provides a schedule of the set of actions to be executed in a given temporal window (e.g., in the next two days)

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Knowledge Discovery Based on the Identification of Relationships Among Medical Concepts by Clustering Candidate Descriptors

Shizuka Yamazaki[a], Mariko Iwasawa[b], Shin-ichi Nakayama[b], Natsuo Onodera[b], and Yusuke Tanigawara[a]

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[b] *Graduate School of Library, Information and Media Studies, University of Tsukuba, Japan*

Abstract

The discovery of hidden connections within the medical literature could give new and plausible knowledge. This study proposes and examines a new methodology for hypothesis generation and knowledge discovery using cluster analysis. We obtained a knowledge overview from a network of medical concepts by clustering candidate descriptors.

Keywords:

cluster analysis, information storage and retrieval, medical subject headings

Introduction

It is important to obtain knowledge on relationships between various phenomena observed in clinical practice. All relationships are not always direct connections, however. The identification of relationships among medical concepts from the literature database could show such indirect connections.

Methods

Don R. Swanson, in his the ABC model, showed that unknown relationships between a chemical substance (A) and a disease (C) could be found by identifying a concept (B) that connects A and C in the literature (Figure 1) [1]. Closed and one-directional open discovery processes were reported by Marc Weeber et al. [2]. Most prior works used ranking based on term frequency. Such methodology may bring on only a part of the concepts. For effective discovery of useful relationships, we propose grouping candidate descriptors by means of hierarchical clustering. Three types of discovery processes were examined experimentally. In the closed process (a), the B terms were MeSH terms that co-occurred in the document sets A and C: these B terms were grouped into several clusters. In the one-directional open process (b), the B terms were MeSH terms in the set C: these B terms were grouped and the B terms in each group were used to extract set A from MEDLINE: the A terms were also grouped. In the two-directional open process (c), the A and C terms were MeSH terms in the set B: those terms were grouped. In each process, the stop list of MeSH terms used was similar to that applied in Swanson's method [3]. These processes were applied in an attempt to identify relationships between fish oil and Raynaud's disease from MEDLINE documents as an experimental test of Swanson's hypothesis. Additionally, we searched for particular terms with the relevant subheading: C-term(s)/th [therapy] - B-terms(s)/de [drug effect] - A-term(s)/tu [therapeutic use] OR A-term(s)/pd [pharmacology].

Results

In our experiment (a), 56 documents on "Raynaud Disease/th" and 40 on "Fish Oils/tu OR Fish Oils/pd" from 1983 to 1985 in MEDLINE had 29 co-occurring MeSH terms, included 7 B-terms/de. For example, "Platelet Aggregation/de" and "Blood Viscosity/de" were found among the MeSH terms (Figure 2). When we did not use subheadings in searching for documents, the document sets increased in size to 511 hits for "Raynaud Disease" and 262 for "Fish Oils", but the number of co-occurring terms was the same and the resulting knowledge overview was similar. In our experiment (b), MeSH terms appearing in 56 "Raynaud Disease/th" documents were clustered, which generated 5 groups of B terms (Figure 3). One of the groups of B terms facilitated the discovery of documents on Fish Oil. In addition, we got the relationships between Raynaud's disease and the serotonin reuptake inhibitor Fluoxetine, and also the calcium channel blocker Felodipine, Nisoldipine, Isradipine. In our experiment (c), the relationships between fish oil and variant angina pectoris were obtained (Figure 4).

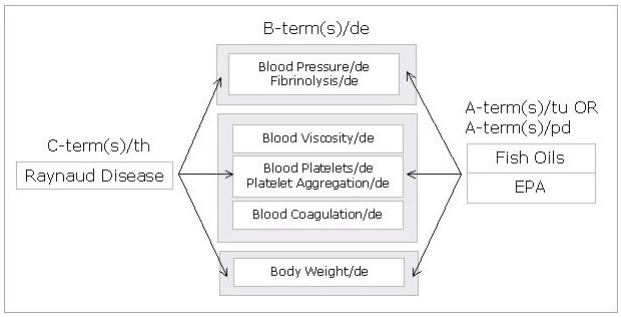

Figure 2 - Closed discovery process

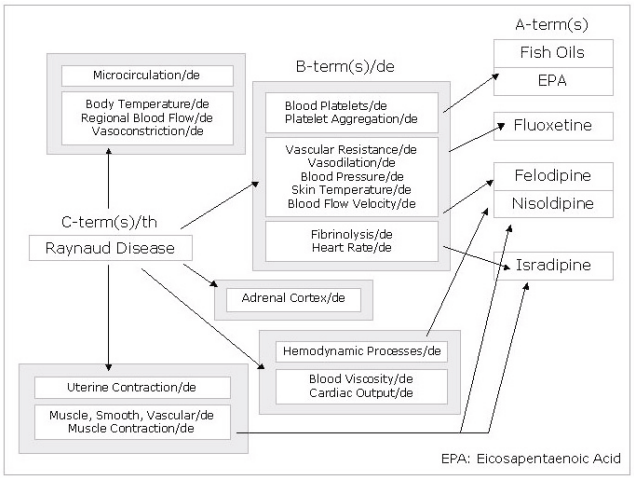

Figure 3 - One-directional open discovery process

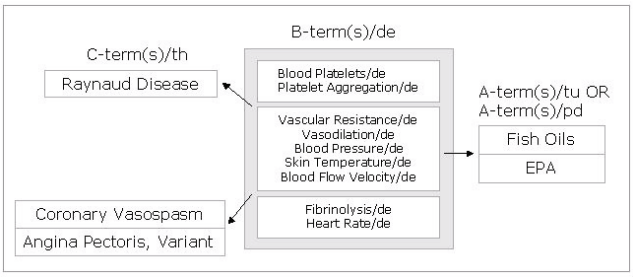

Figure 4 - Two-directional open discovery process

Conclusion

By grouping candidate descriptors using cluster analysis, we succeeded in detecting invisible connections between medical concepts. It is important to obtain knowledge on relationships between various phenomena observed in clinical practice. All relationships are not always direct connections, however. Our new methodology was effective in identifying hidden connections between medical concepts. The resulting knowledge overview could be helpful in clinical practice.

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[1] Swanson DR. Fish oil, Raynaud's syndrome, and undiscovered public knowledge. Perspectives in Biology and Medicine. 1986. 30(1), 7-18.

[2] Weeber M, Klein H, de Jong-van den Berg LTW, and Vos R. Using concepts in literature-based discovery: Simulating Swanson's Raynaud-fish oil and migraine-magnesium discoveries. Journal of the American Society for Information Science and Technology. 2001: 52(7), 548-557.

[3] Swanson DR. Smalheiser NR. Torvik VI, Ranking indirect connections in literature-based discovery: The role of medical subject headings. Journal of the American Society for Information Science and Technology. 2006: 57(11), 1427-1439.

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Knowledge Discovery Based on the Identification of Relationships Among Medical Concepts by Clustering Candidate Descriptors

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Introduction

- The discovery of hidden connections within the medical literature could give new and plausible knowledge.

Objective

- This study proposes and examines a new methodology for hypothesis generation and knowledge discovery using cluster analysis.

Methods

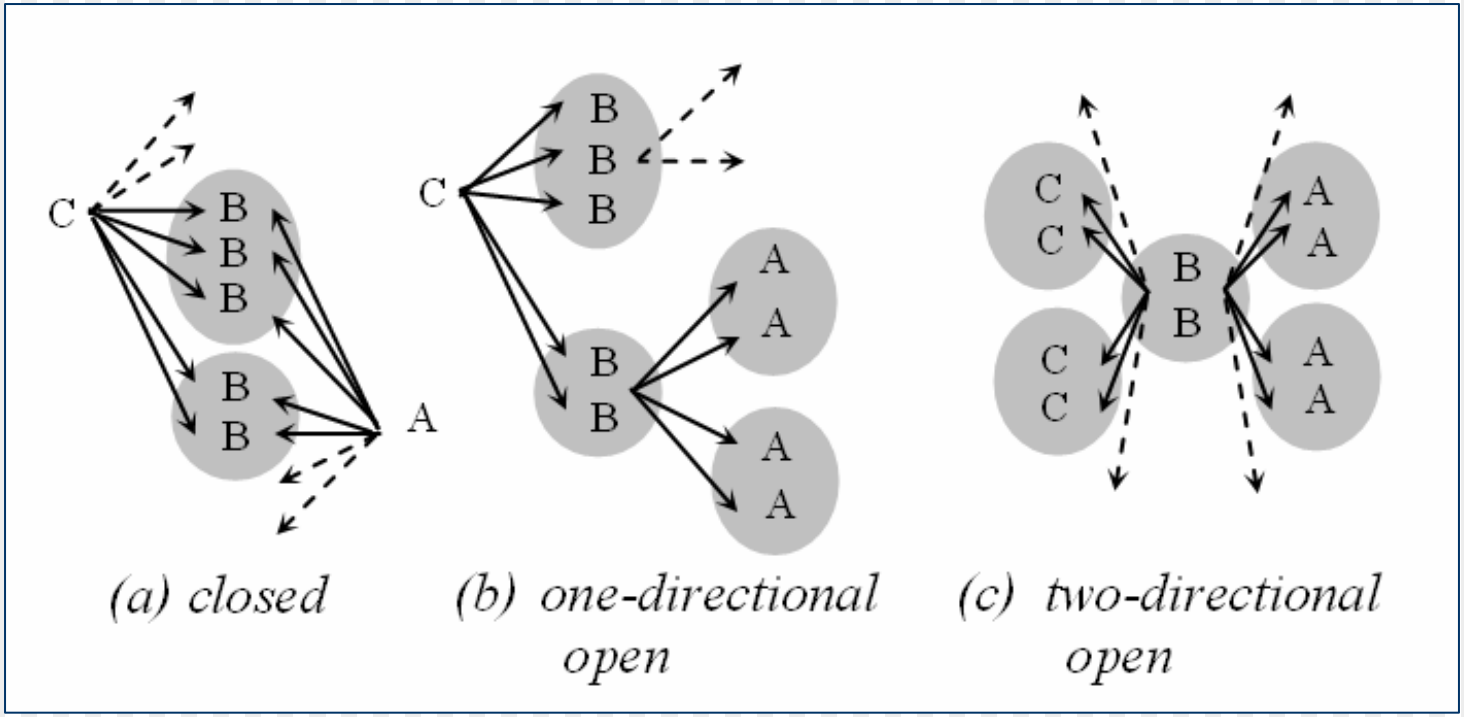
Background

- Don R. Swanson (1986), in his the ABC model, showed that unknown relationships between a chemical substance (A) and a disease (C) could be found by identifying a concept (B) that connects A and C in the literature .
- Closed and one-directional open discovery processes were reported by Marc Weeber et al. (2001).
- Most prior works used ranking based on term frequency. Such methodology may bring on only a part of the concepts.

We propose grouping candidate MeSH terms by means of hierarchical clustering for obtain knowledge overview.

Methods

Discovery process



We constructed the term-document matrix for clustering candidate MeSH terms.

Methods

(a) Closed discovery process

The B terms were MeSH terms that co-occurred in the document sets A and C.

i. Creating document sets A and C (B-terms collection)
ii. B-terms grouping

(b) One-directional open discovery process

The B terms were MeSH terms in the set C. These B terms were grouped and the B terms in each group were used to extract set A from MEDLINE.

i. Creating document set C (B-terms collection)
ii. B-terms grouping
iii. Creating document set A (A-terms collection)
iv. A-terms grouping

(c) Two-directional open discovery process

The A and C terms were MeSH terms in the set B

i. Creating document set B (A-terms, C-terms collection)
ii. A-terms, C-terms grouping

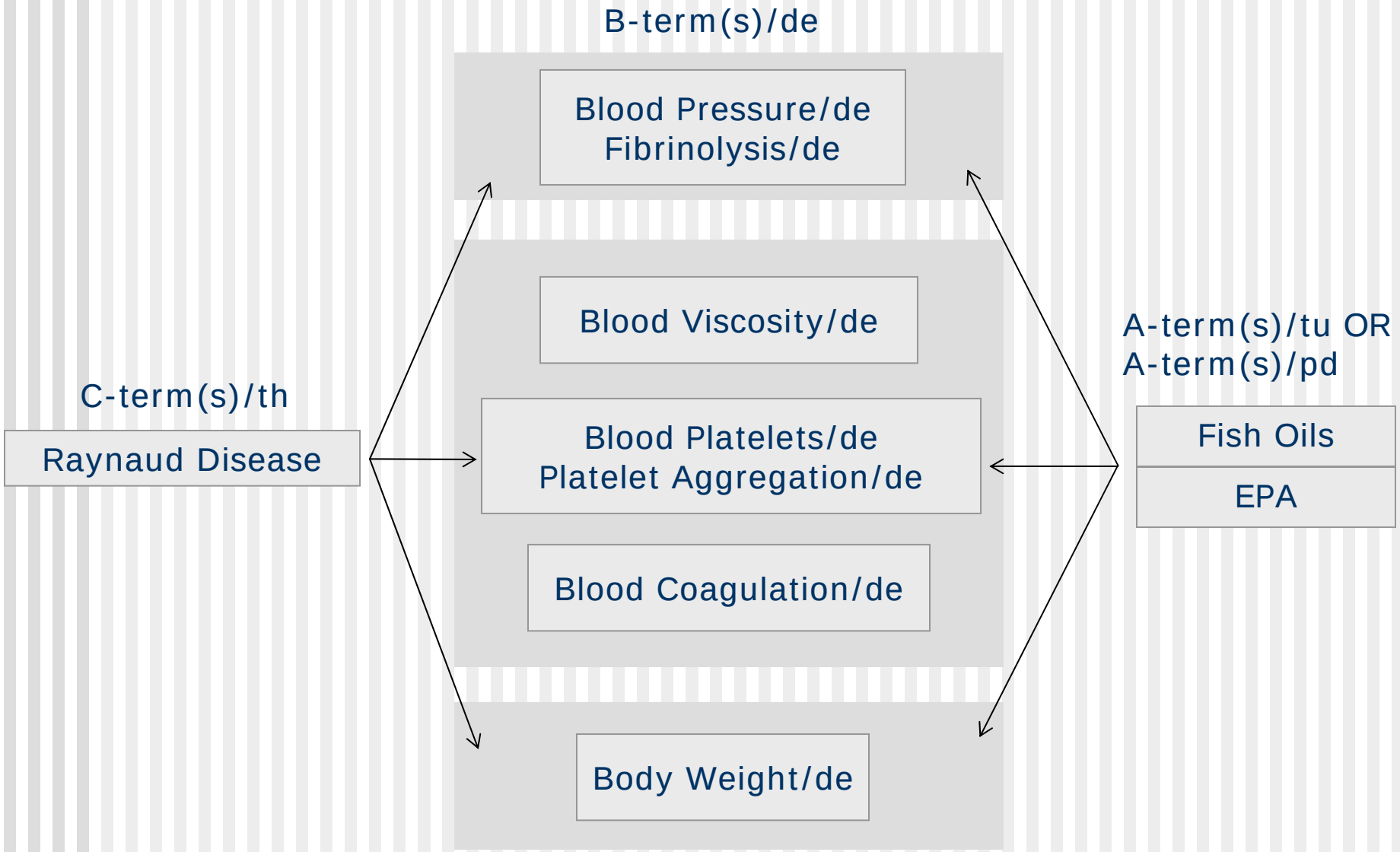
Methods

- We searched for particular terms with the relevant subheading:

C-term(s)/th [therapy]
- B-term(s)/de [drug effect]
  - A-term(s)/tu [therapeutic use] OR A-term(s)/pd [pharmacology].

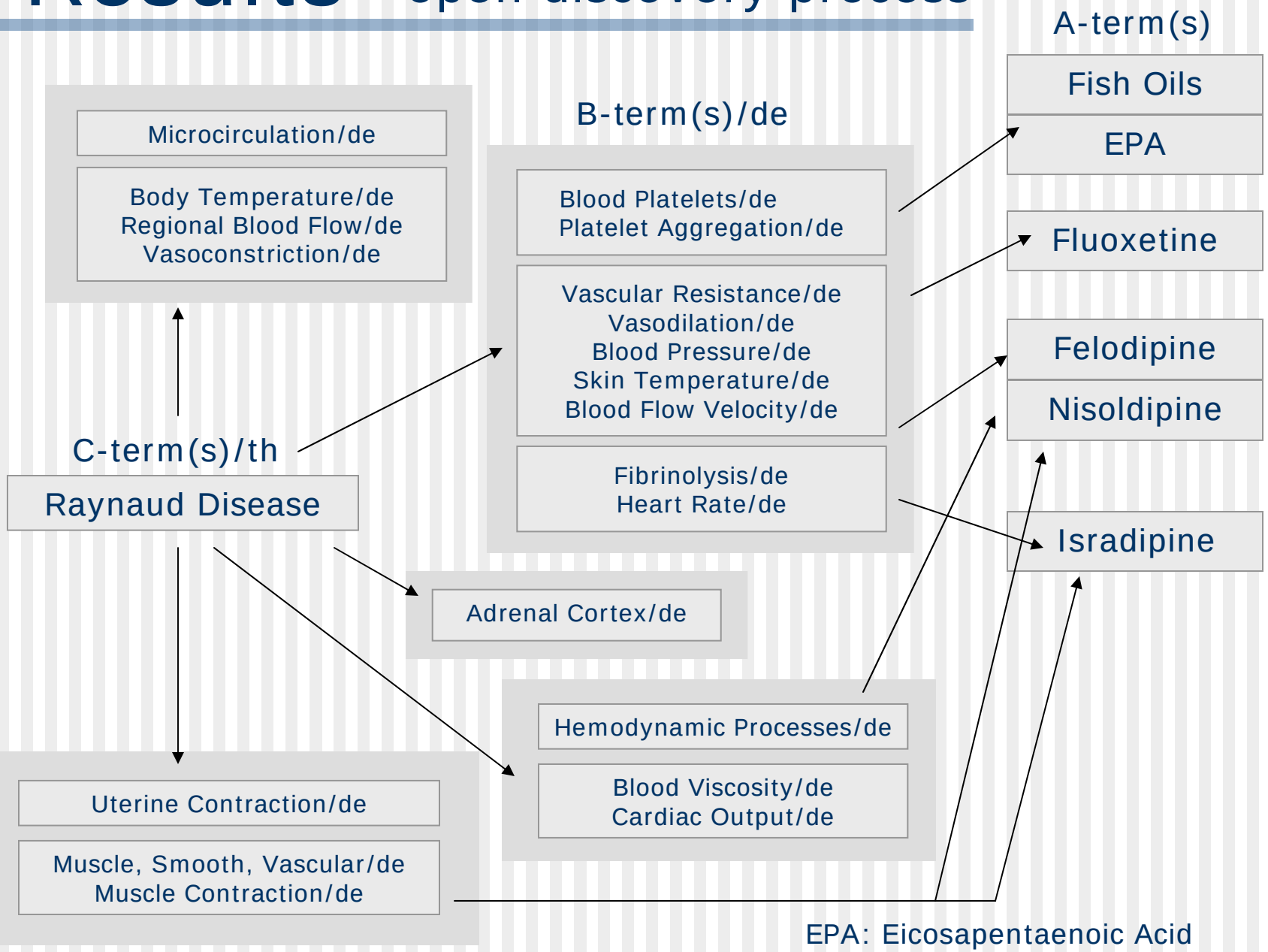
- In each process, the stop list of MeSH terms used was similar to that applied in Swanson's method (2006).
- Our discovery processes were applied in an attempt to identify relationships between fish oil and Raynaud's disease from MEDLINE documents as an experimental test of Swanson's hypothesis.
  Database: PubMed http://www.ncbi.nlm.nih.gov/PubMed/
  ("1983/01/01"[PDAT] : "1985/12/31"[PDAT])

Results Closed discovery process



Results

One-directional open discovery process



EPA: Eicosapentaenoic Acid

Results

One-directional open discovery process

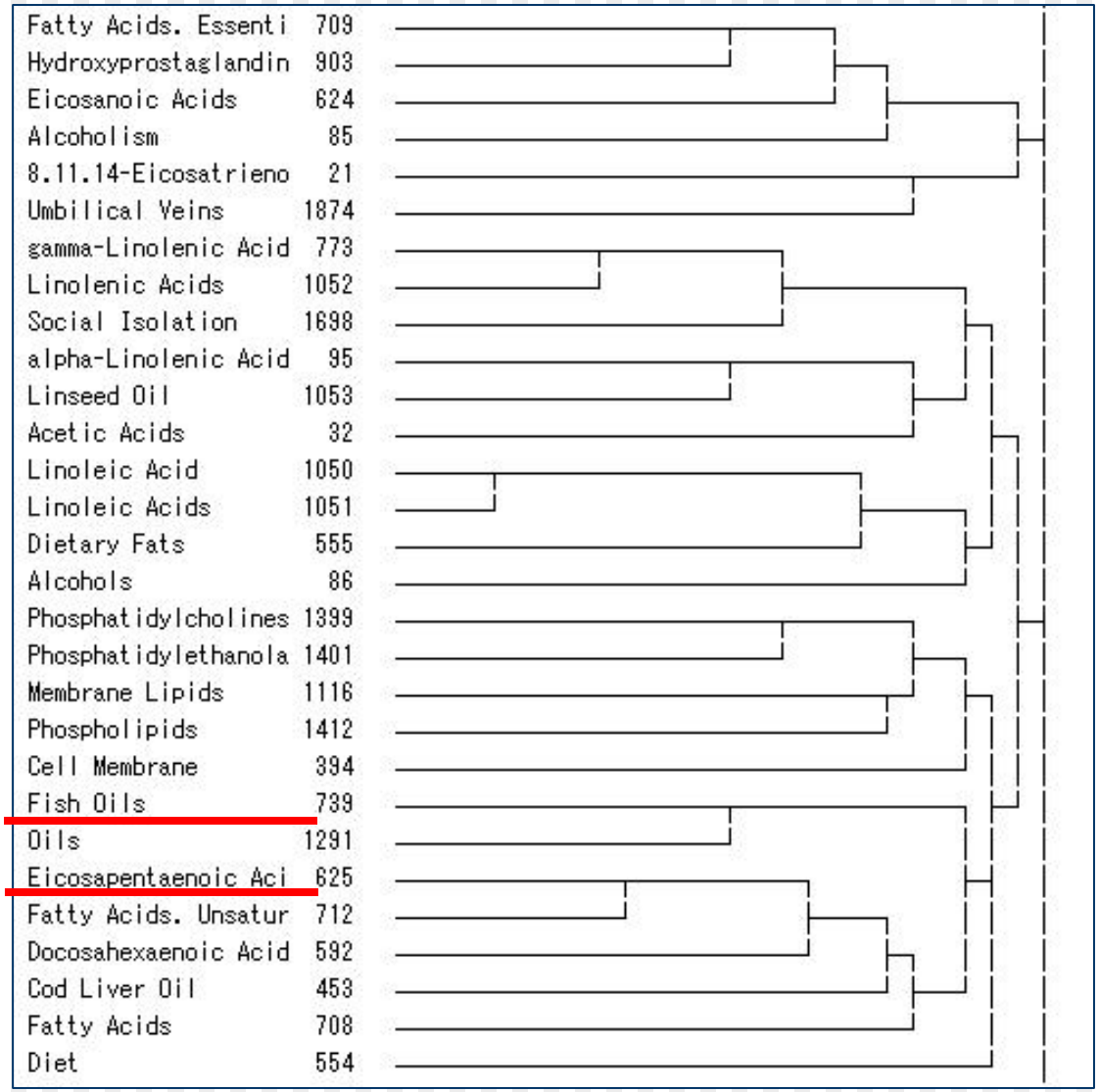
B-term(s)/de

- Blood Platelets/de
  Platelet Aggregation/de
- Vascular Resistance/de
  Vasodilation/de
  Blood Pressure/de
  Skin Temperature/de
  Blood Flow Velocity/de
- Fibrinolysis/de
  Heart Rate/de

↓

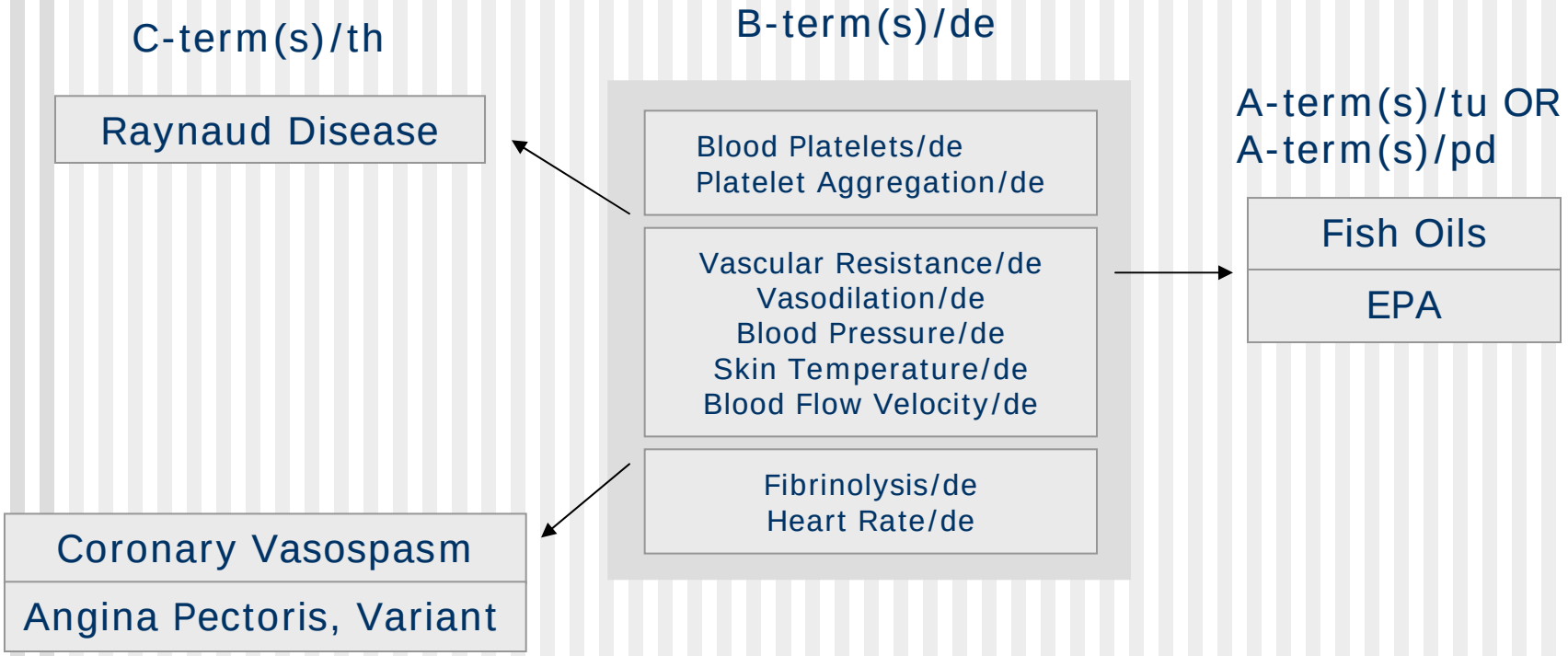
A-term(s)

- Fish Oils
- EPA



Results

Two-directional open discovery process



Discussion and conclusion

- By grouping candidate descriptors using cluster analysis, we succeeded in detecting invisible connections between medical concepts.
- It is important to obtain knowledge on relationships between various phenomena observed in clinical practice. All relationships are not always direct connections, however.
  Our new methodology was effective in identifying hidden connections between medical concepts.
- The resulting knowledge overview could be helpful in clinical practice.

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[1]Swanson DR. Fish oil, Raynaud's syndrome, and undiscov-ered public knowledge. Perspectives in Biology and Medi-cine. 1986. 30(1), 7-18.

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Developing the Knowledge Base for Health Informatics: from the Otley Think-tank to the IMIA Strategic Plan

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Abstract

The original aims of the Otley (UK) 'Education Steps' think-tank meeting were to explore the evidence base for and theoretical constructs underpinning health informatics. From these, the aim was to identify and explore the educational issues and implications, including the need for, and so content of, different levels of education in health informatics. This work has become part of a larger research project that is being jointly funded by the International Medical Informatics Association (IMIA) and the British Computer Society Health Informatics Forum (BCSHIF). This paper explores the methods used, and the initial results, from the first two phases of the project. The research process used in the 2005 Otley think tank workshop (Phase 1) are explored in detail, and illustrative examples of the outcomes are provided. The methods being used in Phase 2 are discussed, together with plans for validation of the outputs by the wider international community. The outputs of the project will now help to define the knowledge core at the centre of IMIA's Strategic Plan.

Keywords:

medical informatics, information science, knowledge, review literature

Introduction

Researchers based in CHIRAD, the Centre for Health Informatics Research and Development (an Academic Institutional Member of IMIA, the International Medical Informatics Association, and the first Institutional Member of the European Federation for Medical Informatics, EFMI), have been attempting to build a mapping of the discipline of health informatics. The *Education Steps* think-tank meeting (March 2005 in Otley, UK) was the first stage of this project, which was initiated and originally funded by the Health Informatics Forum of the British Computer Society (BCSHIF) and conducted by CHIRAD. The original primary aim was to explore the theoretical constructs underpinning health informatics, and from this, identify and investigate the educational issues. The further aims were to consider the evidence base of health informatics, and examine the existence of, or need for, and so content of, different levels of education in health informatics. Following considerable reflection by the CHIRAD research term and BCSHIF on the initial outputs of the Otley meeting, [1,2] and taking into account the development of the IMIA Strategic Plan, [3] it became apparent that this work could form part of a larger project that could benefit many sectors of the international health informatics community.

A second phase of research, now jointly funded by BCSHIF and IMIA, is contributing to the development of an international mapping of the discipline of health informatics, using a triangulation of expert opinion, document analysis and literature review. It is intended that this will contribute to the development of the knowledge core of IMIA's Strategic Plan.

This paper addresses the context of the phases of the project; the educational framework selected for the first phase; the approaches used for conducting the Otley workshop; and a summary of the discussions and opinions of the participants. Finally, it presents the approaches being used in the current work (phase 2) that builds on the outputs of the Otley meeting, together with some initial results and emerging issues for the future development of the project.

Background to and context of the Otley meeting

In the UK health informatics community there has been a growing concern about the pre-dominant modules/competencies approach, with work-based, skills-oriented delivery of health informatics education. While it was recognised that this work had a valuable role to play, it seemed, to some people, to be resulting in a 'lowest common denominator' approach that did not provide an atmosphere for the higher level scientific and theoretical development of the discipline of health informatics. Indeed, it could be argued that the approach potentially threatened an atmosphere in which one could nurture the exploration of the higher level scientific discussions.

The CHIRAD research team and BCS HIF recognised that there existed, from developments over the previous 5-10 years, and primarily funded through the former NHS Information Authority (NHSIA), much good work relating to skills and competency frameworks for health informatics. As this area had been well rehearsed, it was not the inten-

tion of the project to revisit this work (but to take cognisance of it) . It was also not the aim of the project to seek to define health informatics or explore the most appropriate name for the field (i.e., health, medical or biomedical informatics). Rather, the intention was, through essentially a mapping exercise that drew on the experience and views of health informatics experts, to examine the core components of the discipline by collating the scientific elements of the subjects and thematic areas within the domain.

It could be argued that much of the work envisaged within the project had already been undertaken, within the UK and internationally. In the UK, the NHS Information Authority had developed check lists of competencies for a wide range of staff, focused largely on IT skills but including issues such as security, confidentiality, data quality etc. which were considered vital or useful for different staff groups. These approaches formed a large part of the UK Department of Health's human resource strategy, and provided the basis for Professional Qualifications in IM&T. The adoption of the European Computer Driving Licence as the minimum standard in IT skills for NHS staff has perpetuated the competency driven approach.

The participants in the Otley workshop saw several important possible uses of the outcomes of the think-tank, including:

1. trying to answer the question of whether health informatics exists as an identifiable academic subject domain;
2. assisting in the maturing of the identity of the health informatics profession;
3. bringing together education and training elements of health informatics; and
4. contributing to the academic rigour of the United Kingdom Council for Health Informatics Professions (UKCHIP - www.ukchip.org) framework.

Why use Bloom's taxonomy?

The cognitive domain of Bloom's taxonomy [5] was used as a theoretical framework within which to situate discussions. As CHIRAD's research team has a strong academic background, and many years' experience in delivering education, designing curricula, and research and publication, they felt that the project needed an appropriate academic context. Bloom's taxonomy is well known from health, medical and nursing curricula, and provides a hierarchical framework for categorising levels of abstraction for objectives within educational settings, and maps well against other academic levels, e.g. progression from undergraduate to postgraduate levels.

Bloom identified three domains of educational activity: the cognitive, relating to knowledge and mental skills, the affective, relating to attitude, feelings and emotions, and the psychomotor, relating to manual or physical skills. Bloom's cognitive domain recognises six levels of educational objectives, from the lowest, knowledge, through comprehension, application, analysis, synthesis, to evaluation, the highest level. The intention was that participants in the workshop would collate the conceptual basis of health informatics to elucidate the elements that could be categorised as knowledge, comprehension, application, analysis, synthesis and evaluation.

In preparation for the workshop, we asked participants to familiarise themselves with documents such as the IMIA Scientific Content Map [4] and any other similar documents to which they had access. We asked, in particular, that participants should bring with them either the module descriptions from any health informatics programme that they were involved with, which should include the aims and objectives or learning outcomes, and indicative content; or a list of the models, theories and laws, constructs and concepts that framed their understanding of the discipline of health informatics.

The Otley workshop: the ducks and ponds metaphor

The Otley meeting was an intensive 24-hour residential think-tank, with workshop format and comprising small group and plenary discussions. It brought together 25 international health informatics experts, from varioushealth informatics groups, including BCS Health Informatics Forum, BCS Health Informatics Specialist Groups, ASSIST (The Association of ICT Professionals in Health and Social Care) and IMIA. Most of the participants were from the UK, whilst others came from other European countries, Australia, South Africa and the USA.

The workshop aimed to capture all the elements of the discipline of health informatics, and also the broad themes or subject areas into which these elements might be grouped. The metaphor of 'ducks' (for the individual elements) and 'ponds' (for the broad themes of the framework) was felt to be an appropriate way of helping participants to visualise the tasks they would be undertaking. The six levels of the cognitive domain of Bloom's taxonomy were used to form the basis of the grouping of the 'ducks' within the 'ponds', and it was felt that they might contribute to understanding the development of the curriculum at different academic levels.

Participants in the Otley meeting were asked to identify 'ducks' (health informatics elements), but at the same time, to think 'what does a duck look like?' This meant that in describing them, there was a need to include an active verb from one of Bloom's cognitive levels, plus a generic principle. It was also felt that we would need to identify as many 'ducks' as possible, that is, capture the fullest size of

the 'flock of ducks' (total numbers). The CHIRAD team acted as facilitators in encouraging the discussion groups to pursue this challenging exercise, as there existed the risk of discussion focusing on a few examples if different participants had differing views on the nature or importance of particular 'ducks'; however, we also felt that the breadth of experience of participants would help in capturing a large number of different 'ducks'. The broad themes (ponds) were also identified. Within small groups, participants identified the main subject areas (ponds) from their own lists, curricula or knowledge and experience. Participants identified elements (ducks) of subject areas within small groups. Participants finally assigned each duck to a subject area and, if possible, to a level from Bloom's cognitive domain.

The first set of 'ducks' and 'ponds'

With 'ducks' and 'ponds' representing respectively the finer elements of the discipline and the broad themes within which those elements could be clustered, a first set of outputs comprise 221 'ducks' in total, grouped into 13 'ponds'.

Table 1 – Sample from Otley workshop

Theme ('pond')	Element ('duck')
Health Informatics standards	Assess quality of draft message design process standard
	Assess utility of a clinical interface
	Clinical coding systems
	Describes Technical Infrastructures
	Design of specific clinical message
	Explains the needs for technical standards
Health and social care – care processes	Apply telehealth solutions to the elderly population
	Describe systems currently used by clinicians to gather clinical information
	Evaluates how Health Informatics affects outcomes
	Knows the method of primary to secondary to tertiary care referral and the flows of information

An example of the current level of detail of one 'pond' and set of 'ducks' is given in Table 1. The ponds varied in size, with the smallest containing 6 ducks and the largest 37, although it was already recognised by participants that the largest pond would likely be divided following further discussions.

The 13 ponds are currently named as follows (although the names may change as a result of ongoing discussions):

- Health and social care - care processes;
- Health (care) records;
- Health informatics standards;
- Computer Science for Health Informatics (ICT for Health);
- Health and Social care Industry;
- Knowledge Domains & Knowledge Discovery;
- Legal & Ethical;
- People in organisations;
- Politics and policy;
- Terminology, classification and grouping;
- Toolkit (systems);
- Uses of clinical information; and
- Uses of informatics to support clinical healthcare governance.

The full set of outcomes can be found through the CHIRAD website on the Education Steps project website at:

http://www.differance-engine.net/educationsteps/documents/otley2005outputs.htm

Validating and disseminating the Otley outputs

The first lists resulted from a time-limited discussion among a relatively small group, albeit of nationally and internationally recognised experts. All participants recognised the provisional nature of the lists and the need for further reflection and refinement, which was envisaged as being conducted through international discussions in the later phases of the project, to generate a widely accepted list of ducks and ponds. The Otley participants were invited to comment on the list, and to propose amendments, through a mixture of individual commentary and online group discussions. There was a general feeling that the set of 'ducks' and 'ponds' that had been developed and agreed was not complete, and that others would emerge. There was a general consensus on the first listing, but it had been evident in the discussions that some people felt that what had been identified as 'ponds' might, as a result of further discussion and reflection, be seen to be simply 'ducks'.

In attempts to validate the outputs of the Otley workshop, in March 2006, a further 24 hour workshop was held in Belfast, which focused specifically on refining the technical and computing themes developed at Otley. This resulted in some success, as it included several of the Otley participants, and provided the time for immersion in the discussions. The outputs from Otley have been used to help formulate an undergraduate biomedical informatics degree programme. [6]

Reflections on the process and outputs

The question naturally arising from any project with seemingly limited outputs is 'would we do the same again, and in the same way?' Bringing together a group of 25 health informatics experts, from a range of practical and theoretical backgrounds, with a wide range of special interests, and collectively with in excess of 500 years experience in health informatics, and asking them to explore, and possibly challenge, the fundamental basis of their discipline, was always going to be a potentially risky undertaking. It is a tribute to the professionalism and enthusiasm for their areas of expertise that the participants at the Otley meeting engaged in the process so enthusiastically and that they felt that the beginnings of something useful resulted from the time and effort. The overall structure of the workshop was felt to work well,with the greatest complaint being the lack of time devoted to each stage of the process, and in particular to some of the discussions and sessions when there was an attempt to reach consensus where several disparate views clearly existed. The level of knowledge displayed by participants, the passionate defences of their views, and the enthusiasm displayed at all stages of the workshop clearly showed that we had the right types and mix of people involved. That we have had no-one significantly disclaiming the outputs indicates that some form of valuable output has been achieved.

Participants in the Otley meeting found that, although the metaphor had limits and could be stretched in many ways, it was a useful way of starting to think about what are the essential broad themes ('ponds') within health informatics as a discipline, and what are the essential finer-grained components ('ducks'). As the project evolves, the metaphor may become less useful. As might be expected from experts with strongly-held views and coming from a wide range of practical and theoretical backgrounds and interests, the discussions were wide-ranging. It was quickly acknowledged that the scope of the task was huge and that we could only make a small start. The attempt to focus on the cognitive domain of the discipline, and to break free of the constraints of thinking only about psychomotor skills and competencies, caused problems for some participants. Yet it is remarkable that, even within a short period of intense discussion, we managed to make some progress towards agreement on some of the broad themes.

Contributing to IMIA's Strategic Plan

Work on the development of IMIA's Strategic Plan, 'Towards IMIA2015' [3] was formally launched by incoming President Nancy Lorenzi at Medinfo2004, with the aim of having a final version ready for IMIA's endorsement at Medinfo2007. The core vision and conceptual framework for the IMIA Strategic Plan place knowledge at the core of IMIA's activities, and has lead to a realisation of the need to update the 2001 IMIA Scientific Content Map. Building on, in part, the Otley outputs, a second phase of work is being jointly funded by IMIA and BCSHIF to develop the knowledge core for IMIA, and the wider international health informatics community.

Phase 2 methods and pilot results

In Phase 1, the Otley workshop, a group of health informatics experts was asked to identify the elements of the discipline of health informatics. For Phase 2, the published and peer-reviewed literature is taken to be a valid proxy for such expertise. A literature analysis examining the emerging themes and high level descriptors is being undertaken, using document and discourse analysis software and methods. This is based in an analysis of available electronic literature, and will additionally use established and novel indexing and analysis techniques. The method is acknowledged to be similar to that used by Lorenzi to develop the original IMIA Scientific Map, but makes use of materials and methods not available at that time.

The research team is seeking to collect all the electronically available health informatics literature, i.e. in CD-ROM format and available via the Internet. This includes conference proceedings (e.g. Medinfo, AMIA, MIE), as well as journal articles and textbooks. To date, we have a corpus approaching 7,000 articles, items and chapters, most of which are in PDF format and comprise a total of 2GB of files. We are still seeking additional material, although expect that a saturation point will be reached in respect of identifying themes from only a small portion of this corpus.

Several searching and indexing methods have been used to determine the size of the available corpus of literature, and as a pilot test for the analysis methods being employed. An online search in August 2006 using Google Scholar, for example, returned 92,800 citations using the term 'medical informatics', 80,600 using 'health informatics' and 42,500 using 'clinical informatics. Using the Reference Manager 11 software to undertake online searches of PubMed returned 6,249 papers when using the term 'medical informatics', 3,611 using 'health informatics and 1,785 using 'clinical informatics'.

The corpus of articles collected so far is stored on a network hard drive and we have used several indexing tools to index the articles and then search them using a subset of the Otley outputs as a pilot analysis. Google Desktop, Copernic and ASK, as commonly available tools have been used. Table 2 illustrates some of the similarities and differences encountered in using the same search terms in different engines and algorithms. This work is ongoing, and is expected to be completed in early 2007, although several issues are already emerging. There will be a need for the research team to replicate and validate some of the indexing and searching, as different search algorithms are yielding differing results. The contextual nature (i.e., using

Bloom's taxonomy) of the Otley outputs may not match well to the more restricted searching allowed by some of the algorithms. Use of keywords in many publications depends on author selection as opposed to a consistent approach, and is causing some issues in indexing, and different 'in vogue' terms in different places and times seem to be skewing some of the results of the literature searches. All of these issues are important factors that we will be a an analysing as the current research phase unfolds.

The whole project seeks to use a triangulation of research methods (literature review, document analysis, and expert opinion) to obtain different perspectives on the issue of mapping the discipline if health informatics, and with the expectation that the different views will provide some congruence. Once the literature analysis has been completed, the results will be made available for discussion and refinement to the international health informatics community. A consensus conference will be held, to explore the commonalities and differences between the Otley outputs with the document analysis. An international advisory board of health informatics experts, especially including those who have undertaken work in health informatics education and aspects of defining the discipline, is advising on the methods being used and facilitating access to the source materials.

Conclusions

From an initially small scale project, a first set of elements was developed to contribute to a mapping of the cognitive elements of the discipline of health informatics. This work is now contributing to a larger international project, jointly funded and co-ordinated by IMIA and BCSHIF, that will contribute to the knowledge core of IMIA's Strategic Plan. As the results of the current phase of the research emerge, the CHIRAD, BCSHIF and IMIA research team will be inviting members of the international health informatics community to contribute to their refinement and validation, and so be involved in developing a commonly shared – but dynamically evolving – map of the discipline of health informatics.

Acknowledgments

The first phase of the project was funded by the British Computer Society Health Informatics Forum (BCSHIF). Phase 2 is jointly funded by BCSHIF and the International Medical Informatics Association (IMIA).

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Table 2 – Examples from phase 2 indexing

Average	ASK	Copernic	Google Desktop	Element
814.67	735	1003	706	Health informatics standards
1306.67	1225	1486	1209	Standards
42.00	29	67	30	Terminology, classification and grouping
941.67	928	1031	866	Terminology
1140.67	1119	1334	969	Classification
188.33	140	258	167	Grouping
805.00	787	921	707	Healthcare records
1388.33	1327	1631	1207	Health care records

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Using GLIF and GLEE to Facilitate Knowledge Management in Development of Clinical Decision Support Systems

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Abstract

Effective knowledge management is a critical challenge to development of clinical decision support systems (CDSSs). We have been using the GuideLine Interchange Format (GLIF) and the Guideline Execution Engine (GLEE) to facilitate knowledge modeling, adaptation, and validation for CDSSs that address a variety of healthcare problems. Based on a review of case studies, we synthesized three major functions of GLIF and GLEE during this process: (1) improving communication between CDSS developers and domain experts, (2) facilitating fast prototyping of CDSSs, and (3) providing multi-stage system validation. We argue that development of CDSSs should start from analyses of user needs and identification of knowledge sources, followed by an evolving process with multiple rounds of conceptualization, encoding, simulation, and evaluation. Our review has shown that GLIF and GLEE can be used effectively to facilitate this process.

Keywords:

clinical decision support systems, knowledge management, practice guidelines, GLIF, GLEE

Introduction

Development of clinical decision support systems (CDSSs) needs effective translation of domain knowledge and their adaptation to specific application environments. We have been using the GuideLine Interchange Format (GLIF) and the Guideline Execution Engine (GLEE) as tools to facilitate knowledge management for a variety of healthcare problems. In this paper, we review our experience of using GLIF and GLEE for knowledge modeling, adaptation, and validation, focusing on analyses of their specific functions and examinations of the overall process.

Methods

Our analyses included two aspects: (1) the specific functions provided by GLIF and GLEE in development of CDSSs, and (2) the overall process to use GLIF and GLEE for CDSS development. The examinations were based on data of specific case studies drawn from finished or ongoing projects. These data were then integrated and synthesized along the two dimensions of function and process. A variety of healthcare problems have been addressed by these case studies, including childhood immunization, cough management, influenza vaccination, hyperkalemia screening, diabetic foot care, post-CABG recovery, depression screening, and tobacco cessation.

Results

Functions of GLIF and GLEE in development of CDSSs

Improving communication between CDSS developers and domain experts

Improving communication between CDSS developers and domain experts is one of the most challenging issues in development of CDSSs. Effective communication between CDSS developers and domain experts is especially important when decisions need to be made to extract and to translate specific pieces of domain knowledge from their original sources, to organize knowledge in well-defined structures, and to identify the potential points in healthcare processes where interventions can be delivered in appropriate formats. The GLIF model provides a conceptual-level representation of healthcare processes using a flowchart-like graphical presentation. This level of representation and visualization has been used intensively in development process to exchange ideas between CDSS developers and domain experts. Paper-based flowcharts have also been used widely for conceptualization purposes, but typically with various problems from computational prospective. In contrast, the flowchart-like algorithm in GLIF is supported by the underlying computational model. Thus, once the conceptual-level algorithm is developed, it can be directly used for computational purposes. An important aspect in development of an algorithm is its testing through the stand-alone user interface of GLEE, which can simulate the execution of specific patient cases through particular paths of the algorithm. These features of GLIF and GLEE can significantly improve the effectiveness and efficiency of communication when presenting the encoded knowledge base to domain experts and seeking their feedback.

Fast prototyping for knowledge modeling and adaptation

Development of CDSSs is an evolving process that typically requires multiple rounds of knowledge encoding, modification, and validation. During this process, fast prototyping of a knowledge base can significantly improve the efficiency of development. With the three-level representation of GLIF (the conceptual flowchart, the computation model, and the interface for integration and implementation) and the simulation function of GLEE, their combination as a tool set provides a unique and powerful testing environment for CDSS development such that the knowledge base of a CDSS can be prototyped without the need to be fully integrated with the final applications. The ability to create such prototypes and test them quickly was essential to the iterative and interactive process of CDSS development.

Facilitating multi-stage system validation

System validation is a critical step in CDSS development. Since development of CDSSs requires significant investment of resources, identifying system errors in early stages of development is important. The combination of GLIF and GLEE provides a unique chance to discover potential problems earlier and thus to prevent/reduce expensive errors in later stages. Specifically, the conceptual level flowchart-like algorithm of GLIF has been used widely to facilitate communication between CDSS developers and domain experts, which can significantly improve mutual understanding on organization of medical knowledge and their adaptation to local practices and settings at an early stage of development. In addition, the simulation function of GLEE that can be used to examine the execution path of an individual patient case provides an added value for validation, as this approach can be easily understood by clinicians. Finally, the batch execution mode of GLEE can be used to process large-scale simulation data that can be further analyzed with powerful statistical methods for formal evaluation.

Overall process of using GLIF and GLEE to facilitate knowledge management in development of CDSSs

Based on the findings documented or reported in case studies, we summarize an overall process to use GLIF and GLEE for development of CDSSs. This process consists of 12 steps: (1) identifying clinical needs of a system; (2) identifying knowledge sources; (3) initializing communications (first round) or reviewing results (later rounds) with domain experts to conceptualize or to modify system functions; (4) defining specific clinical tasks, decisions, and care processes along with the patient data required to perform the tasks and to make the decisions; (5) working with domain experts to identify potential points of interventions in care processes; (6) encoding an algorithm to conceptualize the clinical tasks, decisions, and processes; (7) encoding the specifications at computational levels; (8) performing simulations on individual patient cases; (9) performing simulations in a larger scale for formal analyses; (10) designing appropriate interventions at specific points of care processes and integrating system components; (11) deploying system and evaluating its actual use; and (12) maintaining system. It is important to note that development of CDSSs is an evolving process. It typically requires multiple rounds of conceptualization, encoding, simulation, and evaluation for successful development of a system.

Discussions

We identified three major functions and a twelve-step process of using GLIF and GLEE to facilitate knowledge management for CDSS development. Compared with other research, our unique contribution is to focus on facilitating communication between CDSS developers and domain experts. Based on many years' experience in development of CDSSs, we observed that it is unnecessary or infeasible to translate each and every piece of information from the original paper sources into a CDSS. The medical knowledge behind the useful features of a CDSS is typically a combination of small pieces of information from multiple origins. Thus, we have been moving toward an approach to starting from analyses of clinical needs and identifying the knowledge sources that can support these needs. The subsequent steps of conceptualization, encoding, simulation, and evaluation all serve for this original goal. We believe it is more promising to develop CDSSs with such clearly-defined, user-required, and focused objectives. This approach is also consistent with the theory of user-centered system design that has been widely reported in human-computer interaction research.

There are a few limitations of our studies. First, most of our experience up to now is only to use GLIF and GLEE for knowledge modeling. The actual integration of knowledge base with real world applications will introduce many further challenges. Steps 11 and 12 of the overall process summarized in the result section thus need to be further examined, refined, and reported. Second, we only focus on CDSSs that deliver patient-specific recommendations, while delivering of generic (vs. patient-specific) information in the right context can also generate significant positive impacts. In this scenario, a document model or a hybrid model can play an important role, which is what GLIF and GLEE lack of. Finally, GLIF is not a comprehensive process model. For example, it does not support quantitative temporal modeling, and it is not based on formal logic. Thus, it might not be the best choice to use GLIF for applications with such requirements.

Conclusion

GLIF and GLEE can be used as a set of tools in CDSS development to improve communication between CDSS developers and domain experts, to facilitate fast prototyping of CDSSs, and to provide multi-stage system validation. These functions are embedded within an evolving process with multiple rounds of conceptualization, encoding, simulation, and evaluation. Future studies are required to investigate the use of GLIF and GLEE in deployment of CDSSs.

Acknowledgments

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Updating a Computerised Clinical Observation Entry Form According to the Pattern of its Previous use and to the Evolution of Medical Knowledge

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Abstract

In order to update a semi-structured medical observation entry form, we studied previously completed forms, revealing physicians' actual needs in clinical settings, and guidelines, reflecting the evolution of medical knowledge. Statistical analysis of completed forms pointed to items almost never used by clinicians and some of them were removed from the form. Terminological analysis of free text answers in previously completed forms and of guidelines revealed concepts relevant for clinical practice. Accordingly, some new items were added in the structured part of the form.

Keywords:

computerised medical records systems,
medical history taking, user-computer interface,
natural language processing

Introduction

Computerised and structured data entry forms can improve the reliability, availability and reuse of clinical data for patient care (including decision support), medical audit, activity coding and clinical research [1,2]. Once an entry form has been modelled, maintenance issues arise with the evolution of medical knowledge and practice.

Natural language processing (NLP) of free-text records has already been used to design or improve clinical data entry forms [3,4]. We present an extended approach, relying on statistical analysis of previously completed forms and terminological analysis of free text answers and clinical guidelines. This procedure has been applied to a computerized clinical record form used since 1975 for hypertension management [5,6].

Material and methods

We analysed 5109 completed entry forms from a single hypertension unit (year 2005), including 176 optional questions, with either structured (Boolean, checklist, numeric) or free-text answers. When a question or a predefined answer was used less than 50 times, its deletion was considered. This threshold, approximately 1% of the analysed forms, was arbitrary chosen as a compromise between signal (identification of items seldom used that should be deleted because they are indeed useless) and noise (identification of items seldom used that should not be deleted because they are nonetheless useful).

In order to find recurrent clinical concepts in free text answers, we used the NLP tools SYNTEX and UPÉRY to perform their terminological analysis [7]. When a concept appeared more than 50 times in the corpus, we discussed the inclusion of a corresponding item in the form. For example, the concept of sleep apnoea syndrome appeared about 80 times in the corpus. It was subsequently added as a predefined answer to the pre-existing checklist question "Respiratory disorders?" in the form. We also separately analysed eight hypertension guidelines. Each new clinical concept found in guidelines was considered for inclusion in the form, regardless of its occurrence rate.

A staff of four senior clinicians took the final decisions to remove old items or add new ones. Besides the statistical and terminological results, they took other factors into account, like the value of the data for medical decision making or clinical research. The physicians explicitly favoured objective questions with reproducible answers. However, in order to restrain the drive toward excessive structuring, they also considered the burden of data entry during the patient visit and the drawbacks of an inflexible, excessively structured, clinical record [8].

Results

Among the 176 questions, 19 were completed less than 50 times and 16 of them were deleted. Among the 203 predefined answers to the 39 checklist questions, 78 were ticked less than 50 times and 47 of them were deleted. Physicians judged the remaining items too important to be deleted.

Terminological analysis of free text answers (respectively guidelines) yielded 103 (respectively 95) concepts not found in the structured part of the entry form. Thirty-two of these concepts were common to both sources. Accord-

ingly, items were added in the form: eight numeric and four free-text questions; six checklist questions and 28 associated answers; and four new answers for pre-existing checklist questions.

The conclusion of the visit was previously recorded in a single free-text question. Some of the new questions contributed to structure a more standardised and informative closing. Four checklist questions on hypertension aetiology, pattern, severity and complications now allow stating the characteristics of the patient's disease. They are followed by a question on the specific blood pressure goals and two checklist questions about the prescribed lifestyle changes and treatment modifications. Additional closing thoughts and decisions can still be recorded in the free-text question.

Discussion

The presented approach allowed us to update a long-standing medical record form. Statistical analysis guarantees that no frequently used item is removed during the process. Terminological analysis of free-text answers and guidelines, critically appraised by senior clinicians, guarantees the pertinence of the new items for patient care, audit and/or clinical research.

Terminological analysis of free-text answers is always possible but will indicate recurrent concepts only if clinical cases exhibit some homogeneity. The approach relies on guidelines to reflect the state of current medical knowledge, but could also use less formal review articles. However, guidelines and review articles only pertain to well circumscribed clinical domains. In all these regards, the context of hypertension management was ideal, since it is limited, highly repetitive and well standardised. To which extent and with which results our approach can be generalized to other clinical settings remains to be investigated, especially for broad specialities like internal or emergency medicine.

Another shortcoming of our approach is that we only involved senior clinicians with an extensive experience of the data entry form. Inputs from naive users would have been helpful to identify ambiguous or vague items and eventually improve their content or phrasing.

Conclusion

Our approach allowed us to revise content and organisation of a medical record form, relying on the analysis of its previous use (reflecting clinicians' actual needs in practice) and on the analysis of recent clinical guidelines (reflecting the evolution of medical knowledge). It should be possible to reproduce this approach in other clinical domains, if they are specialised enough to be covered by guidelines and for free text answers of entry forms to show some recurrent patterns.

Acknowledgements

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Updating a computerised clinical observation entry form according to the pattern of its previous use and to the evolution of medical knowledge

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Structured data entry Benefits

Improves data reliability, availability and reusability for:

- Patient care
- Audit
- Activity coding
- Clinical research
- Teaching

Structured data entry
Costs

- Needs a sound clinical information model
- Requires dedicated hardware and software
- Changes users' habits:
  - Data entry by physicians (typing skills)
  - Templates may be too close-ended
  - ➔ Disrupts the patient – physician relationship
- Must be maintained

Structured data entry Maintenance

- Correction of initial modelling errors
- Adaptation to contextual changes:
  - Patients recruitment
  - Clinical circumstances
  - Medical knowledge and practice

Purpose

To update a computerized record form used in a hypertension clinic, considering:

1- the physicians needs in actual practice, as ascertained by their use of the record

2- the evolution of medical knowledge, as synthesized in guidelines

Material

1- A computerized clinical record form used for hypertension management since 1975

- 5.109 forms completed in year 2005
- 176 optional questions, either date, numeric, Boolean, checklist or free-text
- Free-text answers from year 2005 make a 350.000 words corpus

2- Eight guidelines for hypertension management, making a 56.000 words corpus

Methods

1- Statistical analysis of the answer rate of each question and of the use of each predefined answers in checklists during year 2005

- ➔ Seldom used questions / answers are candidates for deletion

2- Terminological analysis of the two text corpora (free-text answers and guidelines)

- ➔ Recurrent or new clinical concepts are candidates for inclusion as structured items

Statistical results

- 19/176 questions were completed less than 50 times in 2005 and 16 were deleted
- 78/203 predefined answers for 39 checklist questions were ticked less than 50 times in 2005 and 47 were deleted
- Questions and predefined answers of significant value for patient care or clinical research were not deleted, even if seldom used

Terminological results

- 166 clinical concepts not already found as structured items in the form were identified:
  - 103 occurred more than 50 times in free text answers
  - 95 were extracted from guidelines
  - 32 were common to both sources

- These concepts lead to 50 new items the form:
  - 8 numeric and 4 free text questions
  - 6 checklist questions with 28 associated answers
  - 4 new answers for pre-existing checklist questions

Strengths of the approach

- It relies on empirical data providing clues for changes, which are critically appraised for validation by senior clinicians
- Analysis of previously filled forms reflects the clinicians' actual needs in practice
- Analysis of guidelines reflects the evolution of medical knowledge

Limits of the approach

- It suits well hypertension management, which is highly repetitive and standardized. To which extent and with which results it can be adapted to other settings must be investigated.

- It does not address the issue of vague or ambiguous question labels, which are also amenable to improvements. In this regard, inputs from naïve users should be helpful.

Acknowledgements
Didier Bourigault provided the results of terminological analyses with Syntex and Upéry. This work benefits from a grant of the AP-HP and from a subsidy of the French Society for Hypertension.

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Open Platform for A Longitudinal Study in Dental Implant

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Abstract

With aesthetical and functional aspects, dental implant is regarded as mostly effective treatment to restore missing teeth. Accordingly, a longitudinal study on the implant is important for both patients and dentists. However, because of the limitation in collecting cases and records, the studies concentrate on only one or few considerable variables. As an effort to solve these problems, we suggest an open platform model to facilitate longitudinal studies in dental implant. It unburdens researchers to collect, share, assess and utilize the related research and reported cases.

Keywords:

dental implants, dental research, information networks, methodology

Introduction

Despite of a short history, dental implant is considered as mostly effective treatment to restore missing teeth. With aesthetical and functional aspects, it is becoming more popular [1][2]. Accordingly, a longitudinal study on the implant is important to help a dentist choose a suitable operational option prior to therapy or manage patient's subsequent events such as a side effect and a failure. However, pinpointing factors of a success and a failure of dental implant is not simply determined because they are either very salient or monotonous. It is also a toilsome study that involves periodic observations of similar cases over long periods of time. Given the requirement for evaluating pre-examinations, treatments and re-call checks, the efforts become much weighted.

As an effort to solve these problems in a dental implant study, we propose an open platform for a longitudinal study to mitigate researchers' burden to collect, share, assess, and utilize the related research and reported cases. Our initiative, inspired by current paradigm to Web 2.0 [3], is in the pursuit of achieving a collaborative intelligence among dental implant researchers and practitioners. We also expect that the concept of an open platform provides solutions to the prolonged problem of the longitudinal study through massive data acquisition, broad ranging collection of cases, and identifying the repetition of the same cases.

Design of the open platform

The proposed open platform is primarily designed to effectively support a longitudinal study of a researcher. We are also objective to solve the problems which even appear at upper level studies. Before, describing the design of the platform, let us list general steps of the conventional studies.

(1) *Identification of a problem and modeling of a hypothesis from one's intuition or survey*: For example, a dentist observed a particular situation from his patients. The dentist constructed a hypothesis about causal relationship describing the situation.

(2) *Background research for a given problem*: To examine any previous work and refutation, the doctor searched MEDLINE and other online medical literature databases.

(3) *Collection of data*: The doctor decided to test the hypothesis by collecting the related data. He can gather the data, e.g., cases and surgical records, from direct hand contacts or some paper works published in conferences and journals.

(4) *Assessment of data quality*: To decrease a risk of bias, a series of data are classified through his own assessment.

(5) *Extracting data according to required form*: He makes an electronic data extraction form to format and to list extracted data into the forms.

(6) *Data synthesis*: From formatted data, he can identify whole connection between considerable valuables.

(7) *Result Interpretation*: Standardization and formalization are performed on the causal relationship identified from the study.

These series of steps require hard works and are sometimes even painful. It is mainly because of the difficulties of data collection, data extraction, and assessment of data quality. By employing the notion of the current web 2.0 and a collaborative intelligence, the platform will mitigate researchers' burden for these steps.

Functionalities of the platform

With postulated desiderata of the open platform for supporting efficient and effective longitudinal studies, the open platform offers functionalities described here.

- *Store & Categorization*: As a basic function, the platform stores and categorizes received data such as surgical reports, summarized records and performed research.
- *Search*: A researcher can easily find out a particular report, record and study through the platform. By a search with single and multiple factors, the platform should enable controversies to be easily caught.
- *Relatives*: A researcher can speculate the specific research and records related to a given problem. Based on the corresponding complications, research are summarized and shown.
- *Import/Export*: A researcher can import/export needed data. To be used in various applications, the data are formatted with an interoperable electronic document like XML and RDF (Resource Description Framework).
- *Collaborative assessment*: A researcher can appraise the study and record whether it is archived by an explicit evaluation method or methodology. The assessment is archived collaboratively to avoid unreliable data.
- *Extraction*: For his/her own research, a researcher can extract and sample specified data from the platform. It is able through an optional selection provided in a user interface.
- *Statistical view*: Statistical difference of selected data and variation of particular field are observed. It provides an overlook on the interested relation.

These functionalities unburden a large part of the steps for the study. For instance, a research can get an inspiration or a problem from the platform by seeking controversial arguments. He also can look for related research topics and results from it, then he can obtain data for the study from it, and so on.

Conceptual view of the system

The figure 2 shows a conceptual view of the system. In the platform, the main users can be divided into two groups; individual clinicians and research groups. Through the platform, individual clinicians can import their case reports for the qualification of their skill or reporting methods. The simple search of a case and an expectation using the case are other benefits individual clinicians can take. The other part of involver is serious research groups. To possess the every benefit of the platform, they may use total functionalities of the platform including a 'Relative', 'Collaborative assessment' and 'Extraction'.

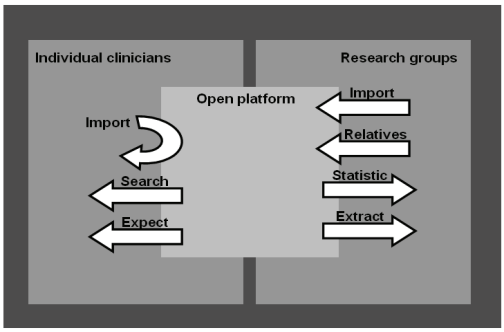

Figure 2 – Conceptual view of the open platform

Conclusion and discussion

We proposed an open platform for a longitudinal study in dental implant. By encourging involvment of positive participants, we expect the platform relieves the burdens to collect, share, assess, and utilize the research and cases for the study. We also have some concerns on keeping it as a sound platform. The first one is from a worry about unreliable and inaccurate data. Even the system employs collaborative assessments for evaluation; it is still remaining problems because of the user with mischief and unseriousness. Another problem is a free-riding of users. If every user wants to get something but to give anything, it will make a trouble in maintenance of the platform. These problems remain as significant challenges to develop a sound system.

Acknowledgments

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Open platform for A Longitudinal Study in Dental Implant

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- Proposing Open platform for A Longitudinal Study in Dental Implant
  - To mitigate researchers' burden to collect, share, assess, and utilize the related research and reported cases
  - Inspired by current paradigm to Web 2.0 and collaborative intelligence
  - Providing solutions to the prolonged problem of the longitudinal study through massive **data acquisition**, broad ranging collection of cases, and **identifying the repetition** of the same cases.

- Dental implant
  - Effective treatment to restore missing teeth
  - With aesthetical and functional aspects
- Longitudinal study
  - Help a dentist choose a suitable operational option prior to therapy or manage patient's subsequent events

Related Works

- Medical knowledge sharing and positive web sites
  - GenBank: www.ncbi.nlm.nih.gov/Genbank
    - Sharing DNA and amino acid sequence and protein structure data by depositing them publicly available web databases
  - Telemakus
    - A tool to facilitate analyzing, displaying, and summarizing research reports across a domain: it provides three component
  - Delicious (http://del.icio.us)
    - Social book-marking service enabling its users to keep and share their tags and to discover new sites on the Web
- Longitudinal upper level studies
  - Problems
    - Data acquisition is rarely possible to come up with a decisive conclusion,
    - Data from papers are sometimes considerably convergent toward a particular conclusion.
    - A kind of positive effect tends to be published more often than those that do not; it is called 'Publication bias'

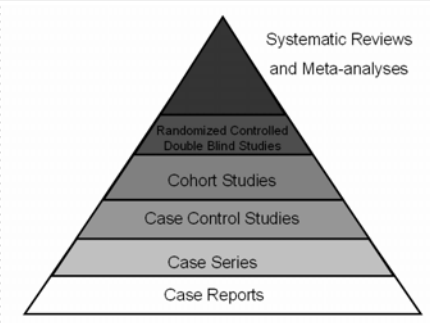

Figure 1 – Upper part of the Evidence Pyramid

Conventional steps for Longitudinal study

- **(1) *Identification of a problem and modeling of a hypothesis from one's intuition or survey*:** For example, a dentist observed a soft tissue inflammation of his patient who did not quit smoking even right after an implant treatment. The dentist constructed a hypothesis that there is a causal relationship between smoking and soft tissue inflammation.
- **(2) *Background research for a given problem*:** To examine any previous work and refutation, the doctor searched MEDLINE and other online medical literature databases. Then, he became aware of the problem that is not completely solved yet.
- **(3) *Collection of data*:** The doctor decided to test the hypothesis by collecting the related data concerning smoking, smoking amount, a condition of soft tisuue after surgery, and etc. He can gather the data, e.g., cases and surgical records, from direct hand contacts or some paper works published in conferences and journals.
- **(4) *Assessment of data quality*:** To decrease a risk of bias, a series of data are classified through his own assessment. The classification is to establish whether the data meet the inclusion criteria or not. The other criterion is whether the data measured through a right examination.
- **(5) *Extracting data according to required form*:** He makes an electronic data extraction form. Required data, for example, demographic data, implant sites, number and type, and RSTV, are extracted independently of what data extraction forms are used.
- **(6) *Data synthesis*:** From formatted data, he can identify whole connection between smoking and soft tissue inflammations.
- **(7) *Result Interpretation*:** Standardization and formalization are performed on the causal relationship identified from the study.

Design of the Open Platform - Desiderata

- The platform must be based on a collaborative intelligence widely opened to everybody. It should incite the collaborative works of researchers and research organization through the web. It also should also provide several beneficial functionalities to encourage independent researchers and get diverse cases from them.
- The platform must have efficient functions for the research. It should support most steps of a study for longitudinal analysis.
- The platform must be cost effective. Even there are diverse shapes in research information or actual data, the platform should process the data transparently to the user.
- The platform must be a richly connected network of data to enable a variety of studies. It enables researchers to identify, relate and compare research and data from multiple perspectives.
- The platform must help a researcher easily find controversial arguments according to the supported evidence. For instance, some researchers argue that mercury has lethal to patient's health while others have the other end of extreme insisting there is no evidence. Researchers can easily catch this controversial through the platform.
- The platform must be easy to use. It includes various digital record forms and interfaces for longitudinal study. Through the form and interface, it must be simple to enter, search, and access to data stored in it.

Design of the Open Platform - Functionalities

- ***Store & Categorization***: As a basic function, the platform stores and categorizes received data such as surgical reports, summarized records and performed research. A researcher can also continuously update the corresponding data.
- ***Search***: A researcher can easily find out a particular report, record and study through the platform. By a search with single and multiple factors, the platform should enable controversies to be easily caught.
- ***Relatives***: A researcher can speculate the specific research and records related to a given problem. Based on the corresponding complications, research are summarized and shown.
- ***Import/Export***: A researcher can import/export needed data. To be used in various applications, the data are formatted with an interoperable electronic document like XML and RDF (Resource Description Framework).
- ***Collaborative assessment***: A researcher can appraise the study and record whether it is archived by an explicit evaluation method or methodology. The assessment is archived collaboratively to avoid unreliable data. For example, by the collaborative assessment, a study exploiting a perio-test for bone quality measurement can be regarded as a more reliable research than a simple 4-degree leveling.
- ***Extraction***: For his/her own research, a researcher can extract and sample specified data from the platform. It is able through an optional selection provided in a user interface.
- ***Statistical view***: Statistical difference of selected data and variation of particular field are observed. It provides an overlook on the interested relation.

A Longitudinal Study with Proposed platform

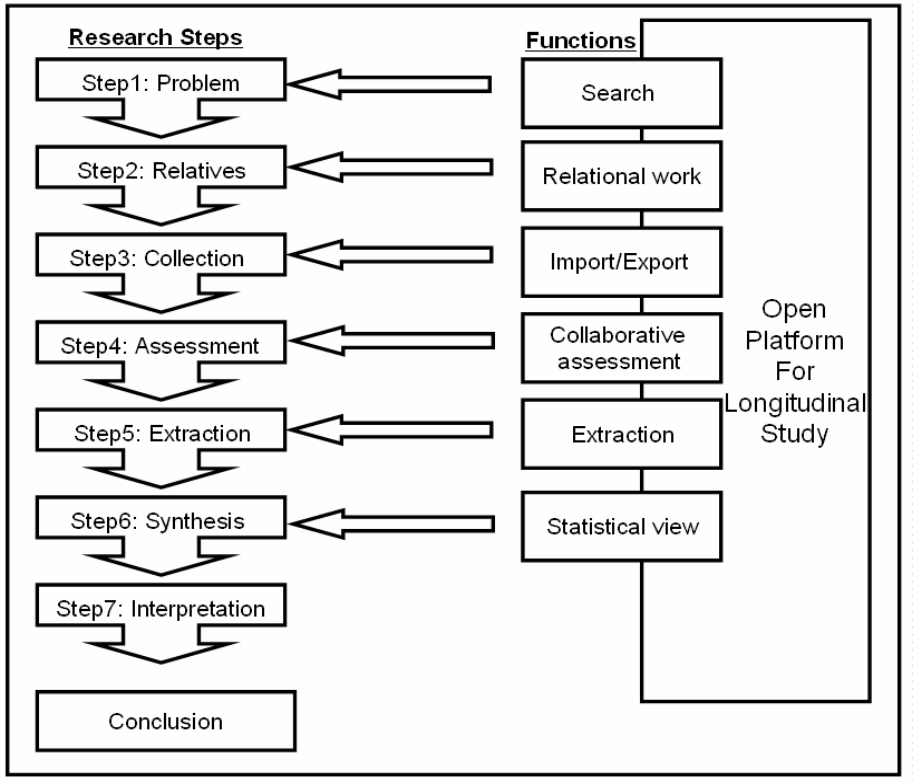

Figure 2 –Revised Scenario

Design of the Open Platform - Sorts of Data

- *Table 1 – Data Record Format for a Research*

Research	Record data	
Title	Year of Publish	
	Authors or Performers	
	Publisher	
	Related Complications	
	Linkage to Data	
	Summary of Data	Criteria for inclusion
		Reported Outcomes
		Methods of Evaluation
		Time interval

- *Table 2 – Classification of Data for Dental Implant study*

Pre-Operative Examination	Treatment & Operative Record	Post-Operative Evaluation & Maintenance
Demographic Variables	Choice of treatment	Maintenance and Follow-Up Protocol
Health Status Variables	Anatomic Variables related to operative sites	Evaluation of Patient's comfort and satisfaction
Social/ Psychological/Financial Variables	Implant-specific Variables	Periodontal Evaluation of soft tissue health around implants
Dental variables related to Oral exam	Abutment-specific Variables	Radiographic Evaluation of implant fixture
Prognosis for remaining dentition	Prostheses Variables	Complication Assessment of implant prosthesis
Operator Variables		

Conceptual view of the system

- Individual clinicians
  - Import their case reports for the qualification of their skill or reporting methods
  - Search of a case and an expectation using the case
- Research groups
  - Possess the every benefit of the platform
  - Use total functionalities of the platform including a ‘Relative’, ‘Collaborative assessment’ and ‘Extraction’.

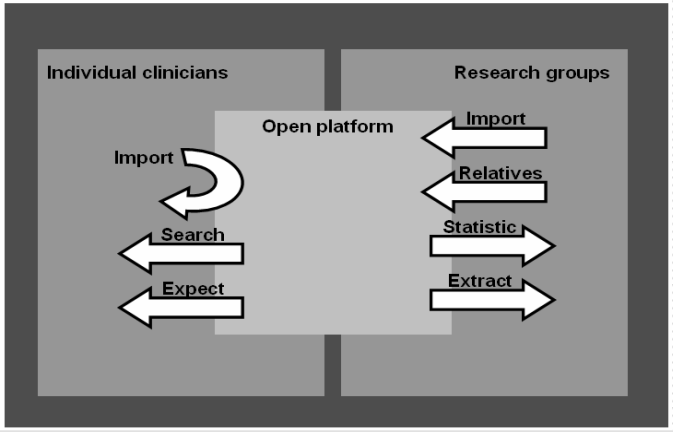

Figure 3 – Conceptual view of the open platform

Conclusion and Discussion

- We expect the platform relieves the burdens to collect, share, assess, and utilize the research and cases for the study.

- Empowering the upper level longitudinal studies at three kind of view.
  - Massive acquisition of data will lead and support decisive conclusions.
  - The broad ranging collection of records and data can be easily used for a refutation to a conclusion unevenly supported by positive pieces of results.
  - Identifying the repetition of same cases will prevent publication bias.

- Expected problems
  - Unreliable and inaccurate data
    - Problems because of the user with mischief and un-seriousness.
  - Free-riding of users.
    - Tangible benefits or compensations should be offered

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Structure and Functional Overview of a Web Based Knowledge Management Tool in Healthcare Organizations

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Abstract

In this poster we present the development and the evaluation of a Web-based knowledge management tool for healthcare organizations. We make clear the necessity for the existence of a knowledge management system and we analyze all the functions of the tool we have developed. The evaluation of the system is achieved through the examination of a sample of users according their satisfaction from the tool. Finally, we report the evaluation results, the conclusions and the future work which we have to do for the improvement of our system.

Keywords:

Healthcare Informatics, Knowledge Management, Healthcare Organizations

Introduction

The healthcare organizations face a lot of challenges, because of the changes that take place in the structures and the more general frame of health systems. Increased costs, economic restrictions, bigger emphasis in the medical responsibility and transparency, changes in the education, enormous developments in the biomedical research, new collaborations in the area of health, are the main factors that influence the effectiveness of healthcare organizations. At the same time, with the above factors, a new difficulty in the work of clinicians is added in our days, which tends to become a permanent characteristic of a healthcare environment. The healthcare professionals are called continuously to absorb information on new drugs, new illnesses, new clinical processes and biomedical techniques, governmental directives, warnings on negative effects of medicines and new scientific discoveries in the medicine. It is almost impossible for a doctor to absorb completely and to apply rightly the new knowledge, which is included in big volume of texts that he receives daily. He is allocated to dedicate concrete effort and small period of time for this procedure. Also, each doctor has specific capabilities of memorizing and retracting information. Similarly, a nurse should be able to think and to act using his own judgment, through the big volume of information that he gets from various sources. There are the doctor's commands, the patient's demands, the patient family's needs, new nursing activities and simultaneous demands from various departments of the healthcare organization [2]. So, the area of healthcare requires precise, complete and comprehensive data for efficient clinical practice, effective clinical management, control, education and research.

These data should be provided in a healthcare organization with the help of a Knowledge Management system, which will be managed and organized by specialized healthcare professionals. In this paper we present and evaluate a Knowledge Management Tool which provides the capability for integrated and effective Knowledge Management in a Healthcare Organization.

Materials and methods

System analysis and development

In order for a doctor or a nurse to be capable to face all these above challenges, able to be fully informed, to cover his cognitive voids and to apply the new knowledge with the most effective way at the appropriate time, it requires that he has the capability for access in qualitative information and knowledge. This is feasible through a Knowledge Management environment, which gives the capability in each healthcare professional who is seeking knowledge inside or outside the limits of his organization, acquiring and storing this knowledge, organizing and categorizing it in corresponding categories of data. Furthermore, through this environment, the healthcare professionals can recover easily the knowledge of the organization whenever they want, can communicate with professionals who are related with it, and finally, be able to share the knowledge with other users of the system [1].We present a Web based system which integrates the above operations.

The application is built on Windows Advanced Server 2000 with the object-oriented programming framework ASP.net, which is one of the elements of .NET Platform and is used for building powerful Web Applications. It is based on Web Standards and practices, fully supports existing Internet technologies and provides an easy and dynamic Web User Interface. As development Database was chosen SQL Server 2000, which is a common and reliable well known database but the application itself could be build on any other relational database [3].

The capabilities of this system, succinctly, are determined in the followings:

- It has been built on a relational database which has the appropriate infrastructure to storage data of various departments and operations of a healthcare organization.
- The knowledge can be in various formats. Each element of knowledge that exists in the application is called 'object'.
- The knowledge can be stored in a central server via the interface of the application. Each object can be available to the public for time interval that its owner wishes.
- There is a User Profile, which contains personal data, studies, scientific interests etc. After each action from a user, his profile is updated automatically according to his fields of knowledge.
- The objects of knowledge have been organized and classified according the thematic unit and the scientific field that they concern, aiming at the easy search and retrieval of knowledge by the user.
- There is search capability for knowledge within all the knowledge base and users of the system. The search results are categorized in objects, individuals, localities of knowledge and other relative categories. For this aim, meta-data are used, which are collected by the application every time a user interacts with it.
- The tool we present emphasizes equally on the technical aspect of knowledge (storage and organization of knowledge) and on its distribution between the users (personal contact of users).
- The application can be connected with the database of any other applications of the healthcare organization for retrieving information

Tool evaluation and results

Our purpose was to evaluate the effectiveness and usefulness of the application. The application was installed in the Faculty of Nursing (National and Kapodistrian University of Athens) in order for its operation to be tested. The system was tested and evaluated by a representative sample of users, undergraduate and postgraduate students. For the evaluation procedure, we used specific scenarios and questionnaires according to user's satisfaction and the effectiveness of the tool. The questionnaires and scenarios are based on standard questionnaires such as QUIS (Questionnaire for User Satisfaction), SUMI (Software Usability Measurement Inventory), WAMMI (Website Analysis and Measurement Inventory), CSUQ (Computer System Usability Questionnaire), ASQ (After Scenario Questionnaire) and other well known questionnaires and they have been improved and adapted to the special characteristics of a Knowledge Management system. Some of the basic criteria we used for the evaluation are the following [2]: *Speed*, *Flexibility in use, Flexibility in data source,. Ease to use, Interactivity, Accuracy, Efficiency, Control, Search engine facility, Traceability and activity links*. The evaluation results has been collected and analyzed and they will be presented in the MedInfo2007 Conference.

Conclusions and future perspectives

Through the presentation of the tool we have developed and its evaluation, we intend to define with concrete way the practical usefulness of such systems in the daily practice of healthcare professionals. Our main future work is to complete the evaluation of the application in a real clinical environment such as a hospital. Also, the next step in the research on the field of Knowledge Management in healthcare has to do with the complete incorporation and integration of a KM tool with the potentials of the technology of intranets, electronic medical records, document management, visualization tools, collaborative tools and data mining tools in order to provide more personalized Knowledge Management and capabilities for creating new Knowledge [4]. A research on the development of Knowledge Management systems leads to the awareness for the creation of conditions, which can help healthcare professionals to face most efficiently the problems that are related with the knowledge and the information in the field of healthcare.

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Structure and functional overview of a Knowledge Management Environment In Healthcare Organizations

Charalampos Balis, John Mantas

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National and Kapodistrian University of Athens, Greece

Introduction

The healthcare organizations face a lot of challenges:

- Increased costs
- Economic restrictions
- Bigger emphasis on medical responsibility and transparency
- Changes in education
- Enormous developments in biomedical research
- Initiatives that focus in the distribution of knowledge

All the above factors influence the effectiveness of healthcare organizations and lead to the increased need for changes

The current situation

Healthcare professionals are called continuously to absorb information on:

- new drugs
- new illnesses
- new clinical processes and biomedical techniques
- EU and state directives or guidelines
- warnings on negative effects of medicines
- new scientific discoveries in medicine
- big volume of information from various sources
- patient's demands for quality treatment and better healthcare services

They are obliged to dedicate concrete effort and small period of time for the above procedure. Also, each doctor has specific capabilities of memorizing and retracting information.

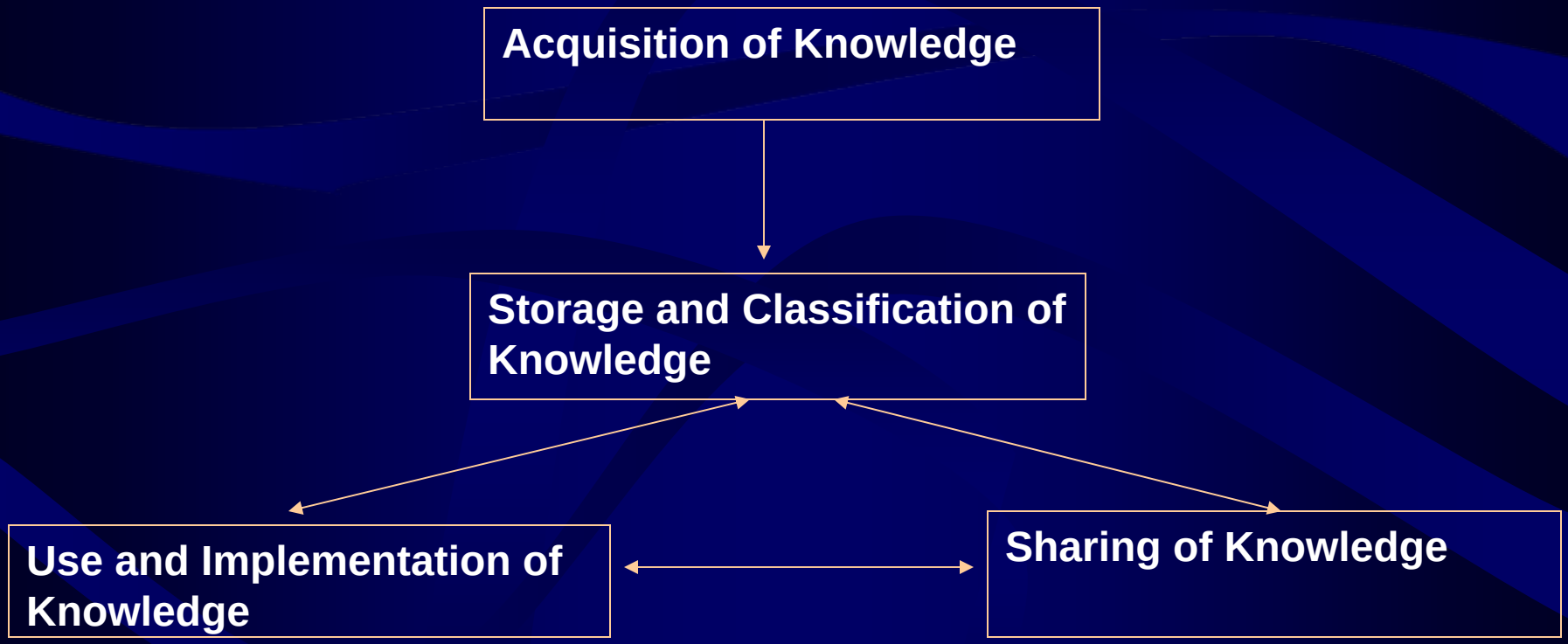
Related Technologies

- Methods and tools for supporting the dissemination of new discoveries and treatments via the Internet
- Document and workflow management applications
- Collaboration systems and communication tools
- Development and use of modern medical terminology and classification

These technologies, however, are not Knowledge Management applications, because each one of them emphasizes in a particular operation.

Our proposal

Basic processes of the Knowledge Management tool that we propose

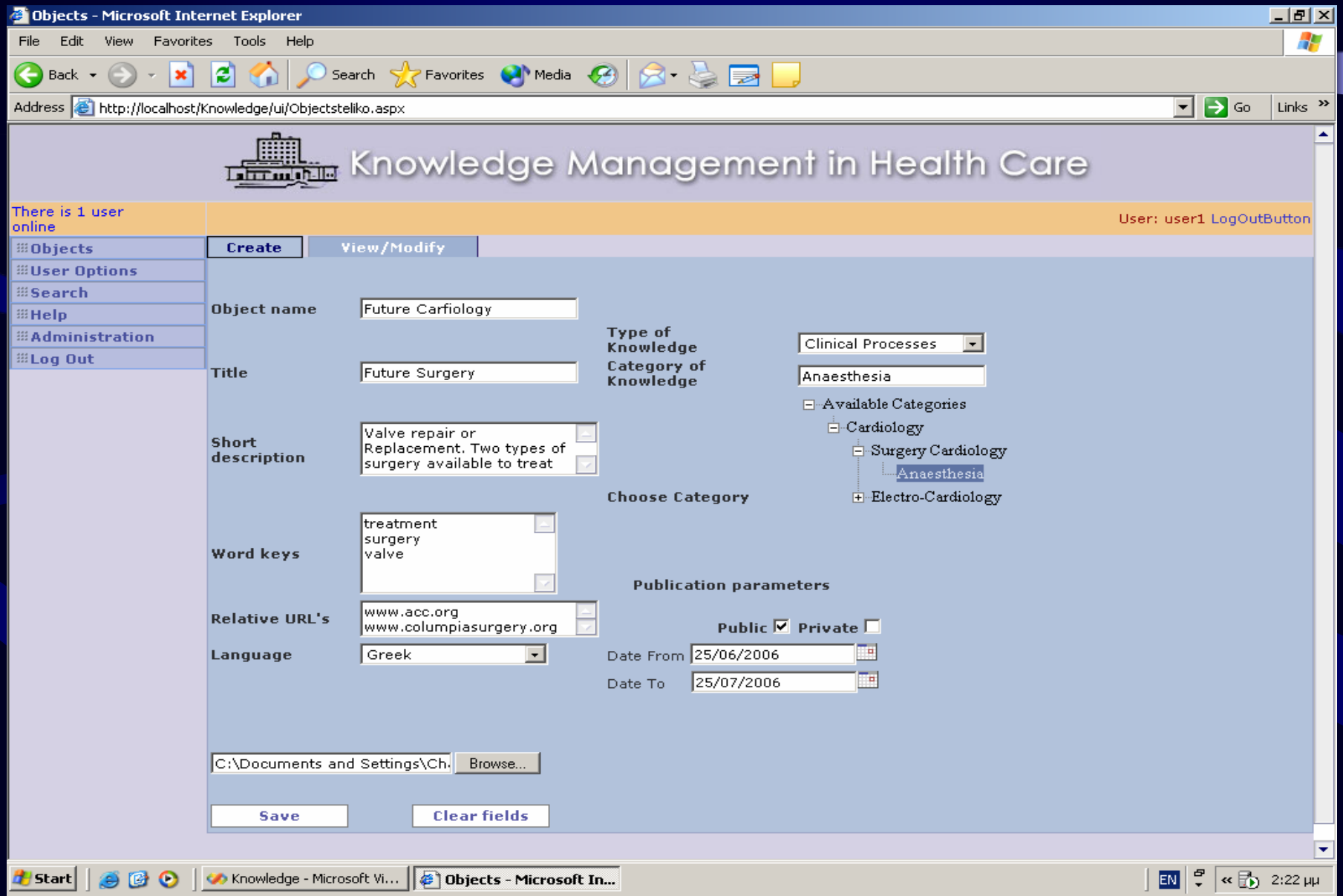


Functions of the application

1. Knowledge (Objects) can be stored in various format: documents, spreadsheets, pictures, video, sound, text etc.
2. The Objects are stored in a central Database server via the interface of the application
3. Knowledge is organized and classified in Types and Categories of Knowledge according to the thematic unit and the scientific field that it concerns
4. User Profile: contains personal data, studies, scientific interests etc. Each user can create and update his own profile. After each action from a user, his profile is updated automatically according to his fields of knowledge
5. Search objects and people through various ways
6. Search results are categorized in objects, individuals, localities of knowledge and other relative categories within the category of search.

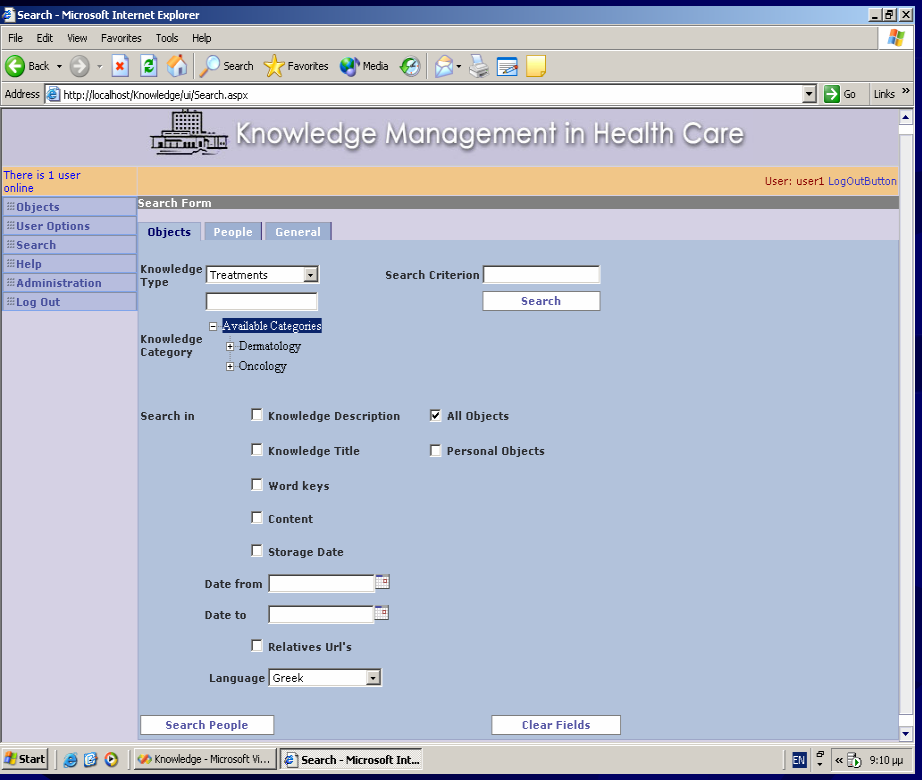
Development of the tool

Storing and classifying objects

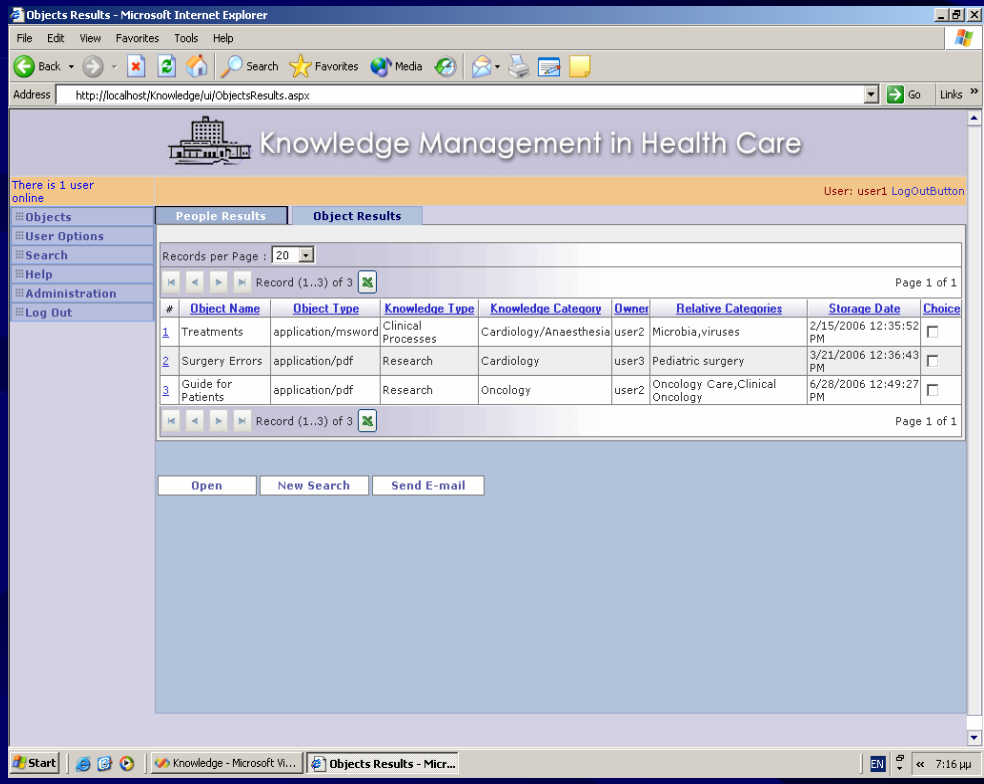


Development of the tool

Search Screen



Search Results for objects



Evaluation

- The application was installed in the Faculty of Nursing (National and Kapodistrian University of Athens). The system was tested and evaluated by a representative sample of users, undergraduate and postgraduate students.
- Questionnaires and scenarios :

  QUIS (Questionnaire for User Satisfaction), SUMI (Software Usability Measurement Inventory), WAMMI (Website Analysis and Measurement Inventory), CSUQ (Computer System Usability Questionnaire), ASQ (After Scenario Questionnaire) and other well known questionnaires.

Evaluation Criteria

- *Speed*
- *Flexibility in use*
- *Flexibility in data sources*
- *Ease to use*
- *Accuracy*
- *Interactivity*
- *Efficiency*
- *Control*
- *Search engine facility*
- *Traceability*

Conclusions and Future Perspectives

The main conclusion is:

- The existence of a Knowledge Management system in every modern healthcare organization is imperative

Future work :

- To install the application in a real clinical environment

- Focus on the complete incorporation and Integration with:
  - OLAP tools
  - document management
  - visualization tools
  - collaborative tools
  - data mining tools

in order to provide more personalized Knowledge Management and capabilities for creating new Knowledge

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Use of the Vector Space Model for Expansion of Medical Queries

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[2]*University for Health Sciences, Medical Informatics and Technology, Innsbruck - Austria*

Abstract and objective

We present an application of the Vector Space Model in connection with Medical Thesauri. The general idea is to use the Vector Space Model for a weighted expansion of medical queries. The application is based on the standardized ontology format OWL and – as first step – the concerning MeSH thesaurus. This includes an more generic approach than others. The application is implemented as prototyp web-service.

Keywords:

internet, information retrieval, Vector space model , MeSH

Introduction

Information Retrieval (IR) has become an important practice for millions of people in nearly every area. Especially in the area of Health Information Retrieval there is a lack of tools which support customers (patients, citizens) to find relevant and satisfying information. Most systems are based on full-text search. One example is Apache Lucene [1]. If you formulate a query you often get a lot of non relevant results because the system doesn't use any semantic relations. Another approach is used by Zeng et al [9]. With this tool the user is supported by a Query Assistant which assists the user to formulate his\her query.

This work focuses on the application of the vector space model on medical domain knowledge. Additionally to full-text search techniques the semantic relations between terms from a given domain should be considered. A simple and very common form of Information Retrieval is the Boolean model [2, 3]. This model is binary in other words documents are considered depending upon the presence or absence of the query term. Further, the queries are build by combining terms with Boolean operators (AND, OR, NOT). This model does not use weighting of terms. In this paper individual weighting of terms shall be reached with a variant of the vector space model [4, 5, 15]. The semantic relation between each search term shall become extracted with the Main Headings from the medical thesaurus "Medical Subject Headings" (MeSH) [6] which was published by the National Library of Medicine. With input from the desired search term an acyclic graph (represented by an n x n adjacent matrix) including all related terms (from the thesaurus) is generated. Furthermore the distance to each received term is calculated from the matrix by using the Floyd-Warshall Algorithm [7]. Finally, the calculation of the similarity between the search term and the existing documents is done regarding the vector space model.

Methods

The following components are used and form the base for this work:

- Medical Subject Headings (MeSH) thesaurus [6]
- Using vector space model for medical domain knowledge [8]
- Web Services, Apache Web Services [10,11]
- RDF/OWL [12,13]
- Converting Thesauri to RDF/OWL [14]

Based on [8] we develop a tool which makes a weighted query-expansion based on MeSH terms available via a web service.

Results

The results are implemented as web-service based on the vector space model using state of the art technologies. As the software will be realized as a web service it will be available on a server and can be used by a client from each arbitrary location through the Standard Internet Protocol (HTTP). The medical thesaurus MeSH is used as domain knowledge, as already stated above. MeSH is mainly used to index and to search for articles in large databases (e.g.: MEDLINE/PubMED). However this thesaurus is only available in a proprietary XML format. To be compatible with the semantic web standard format RDF(S) the MeSH thesaurus shall be used in RDF/OWL format. A description for converting thesauri to RDF/OWL is available at [14].

If a user is searching for information in a distinct subject area, conventional full-text based search engines often deliver a lot of non relevant responses. With this work it will be much easier for a user to find similar documents, related to his request, in a defined document pool. The user submits a suited search term (MeSH term) to the system and gets as a result the documents which will be most similar to the given search term. The calculation of the similar documents is done with the additional received Main

Headings from the MeSH thesaurus on the bases of the vector space model in combination with the Floyd-Warshall Algorithm.

Conclusion

By using domain knowledge in a standardized format in the future it is possible to use other medical knowledge domains like ICD-10 or SNOMED for searching similar documents. But it is important that these domains are also available in the same standardized format. In any case Information Retrieval will be much easier with this web service and vector space model based tool. Especially in the health Information Retrieval area customers will profit from this approach that take as a first step the MeSH thesaurus as a knowledge domain.

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If a user is searching for information in a distinct subject area, conventional full-text based search engines often deliver a lot of non relevant responses. With this work it will be much easier for a user to find similar documents, related to his request, in a defined document pool. The user submits a suited search term (MeSH term) to the system and gets as a result the documents which will be most similar to the given search term. The calculation of the similar documents is done with the additional received Main

Headings from the MeSH thesaurus on the bases of the vector space model in combination with the Floyd-Warshall Algorithm.

Conclusion

By using domain knowledge in a standardized format in the future it is possible to use other medical knowledge domains like ICD-10 or SNOMED for searching similar documents. But it is important that these domains are also available in the same standardized format. In any case Information Retrieval will be much easier with this web service and vector space model based tool. Especially in the health Information Retrieval area customers will profit from this approach that take as a first step the MeSH thesaurus as a knowledge domain.

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Description of Implementation of Clinical Decision Support Alert in Response to a Case Report of a Preventable Adverse Drug Event

Andrew C. Seger [a,c], Tejal K. Gandhi [a,c], Saverio M. Maviglia [b], Tonya M. Hongsermier [b], Eileen Yoshida [b], Teal K. Petaja [b], John F. Nolan [b], David W. Bates [a,c]

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Abstract and objective

While Clinical Decision Support Systems (CDSS) can be developed as a large group of rules- based advice occasionally, cases of preventable adverse drug events come to the attention from various pathways, both through clinical and policy activities. At Partners HealthCare Systems, there is a centralized knowledge management structure that allows for clinicians to present information to a Medical Knowledge Committee (MKC) in a structured way so that any information can be properly vetted. A case of a fatality due to the administration of 2 medications concurrently and the understanding that key decision support components were not available to the prescribing clinicians, drove us to implement this advice in both our acute care and ambulatory clinical systems.

Keywords:

decision support systems, clinical, medical informatics, medication errors, drug interactions

Introduction

Clinical Decision Support Systems (CDSS) can assist clinicians in the proper use of medications[1]. While the large majority on clinical situations can be addressed with CDSS there are potentially some situations that occur in clinical care that require addition of clinical knowledge to CDSS. We describe a case that came to a team member in his work as a reviewer for a newsletter and while attending a pharmacy board meeting. Utilizing this information, a team approach to vetting this case information into our current CDSS architecture to ensure that all clinicians who write medication orders will receive this intervention alert.

Methods

We became aware of a case of a patient who received azathioprine prescribed in ambulatory setting, was admitted to a hospital and ordered for 6-mercaptopurine (the metabolic product of azathioprine) and discharged on both medications. The patient developed myelosupression, sepsis and died. Utilizing this knowledge, the case was presented to the Medical Knowledge Committee. The MKC oversees the knowledge base for the drug-drug interaction alerting across all platforms at Partners Healthcare Systems, an integrated delivery network. An interruptive alert, but not one that is a hard stop was developed and rolled out to all applications utilizing drug-drug interaction alerting.

Results

The utilization of a case of a preventable adverse drug event to develop a single piece of clinical knowledge can be a way to increase the quality and safety of care provided in both the acute and ambulatory care settings. Clinical and informatics professionals can utilize case reports to supplement clinical knowledge at their local sites. A team approach is essential to ensure that the alert is implemented in a structured way.

1 Rochon PA, Field TS, Bates DW et al CMAJ 174(1):52-4

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BRIGHAM AND WOMEN'S HOSPITAL

DESCRIPTION OF THE IMPLEMENTATION OF A CLINICAL DECISION SUPPORT ALERT IN RESPONSE TO A CASE REPORT OF A PREVENTABLE ADVERSE DRUG EVENT

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Division of General Medicine & Primary Care

Brigham & Women's Hospital

Information Systems

Partners HeatlhCare System

MedInfo 2007 August 20-24, 2007

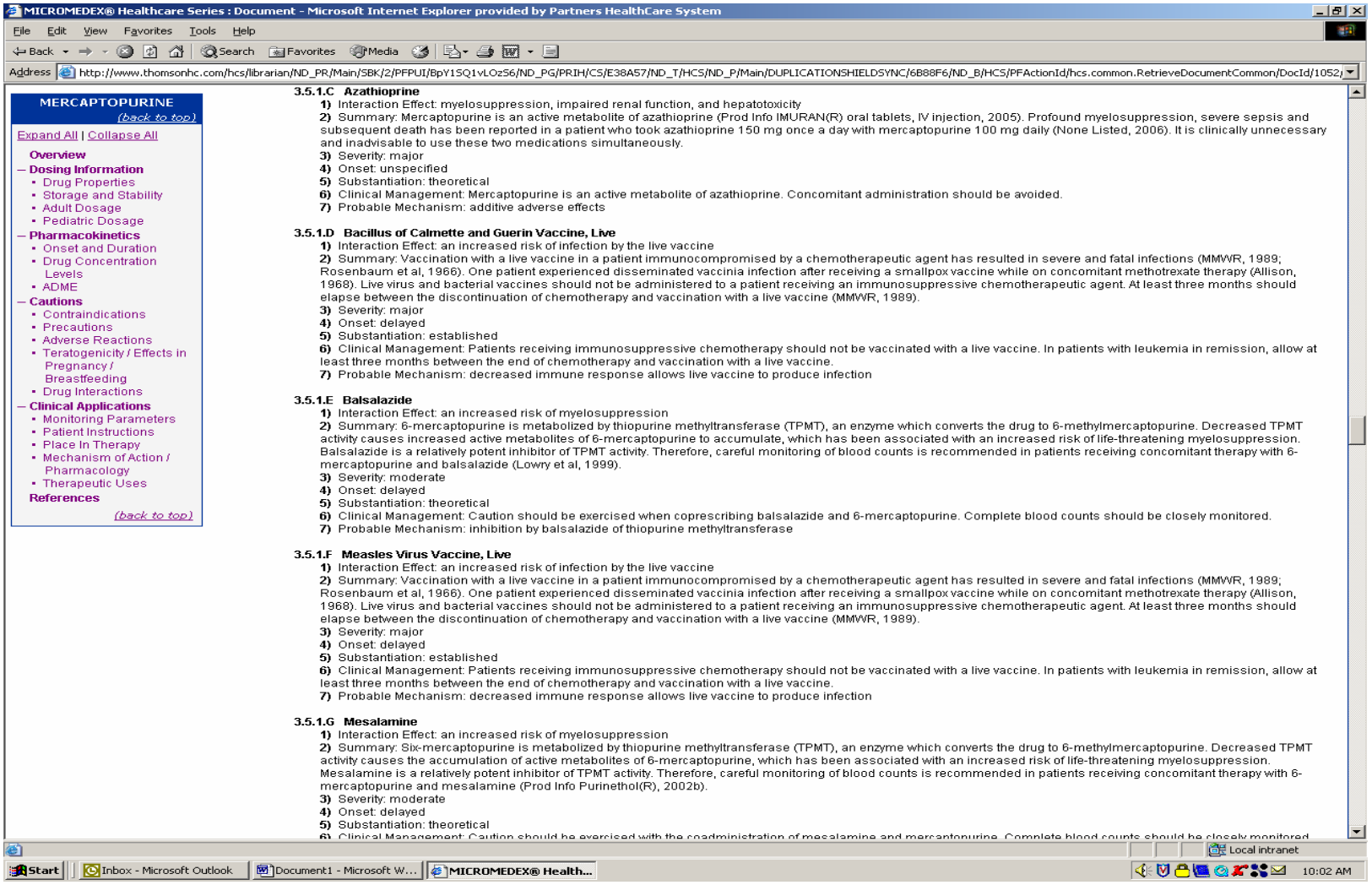
Objective

- Clinical Decision Support Systems
- Case Report of Medication Error
- Editor of Newsletter
- Attended Board of Pharmacy meeting
- Case of death due to sepsis
- Patient prescribed known interacting drugs
- Utilize this information to create an alert

Introduction

- Clinical Decision Support Systems (CDSS)
- Azathioprine/6-mercaptorpurine (the metabolic product of azathioprine)
- Listed in Micromedex® as both a DDI and therapeutic duplication
- How do we integrate this piece of knowledge into CDSS
- Medical Knowledge Committee (MKC)

6-Mercaptopurine/Azathioprine DDI



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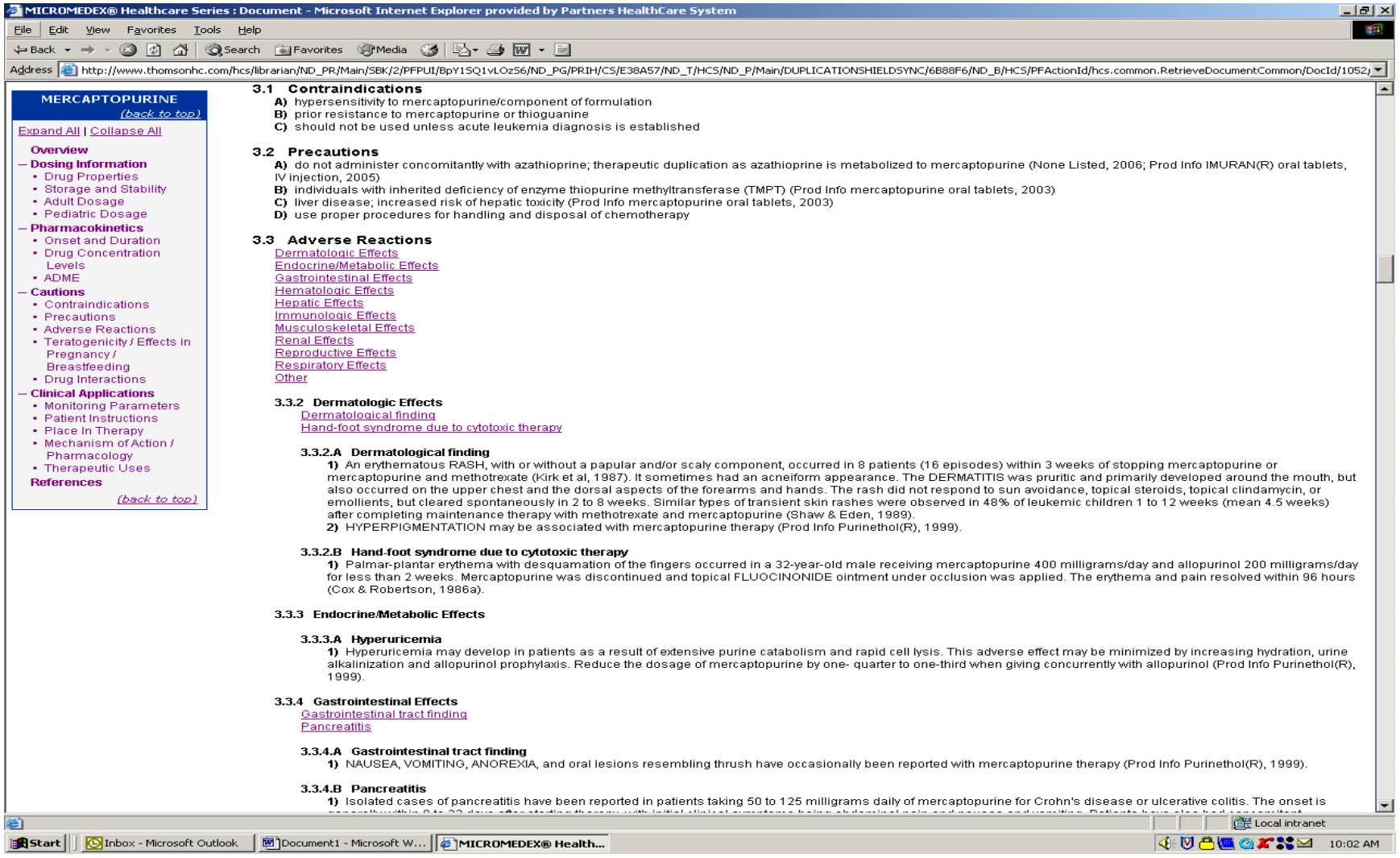
Therapeutic Duplication

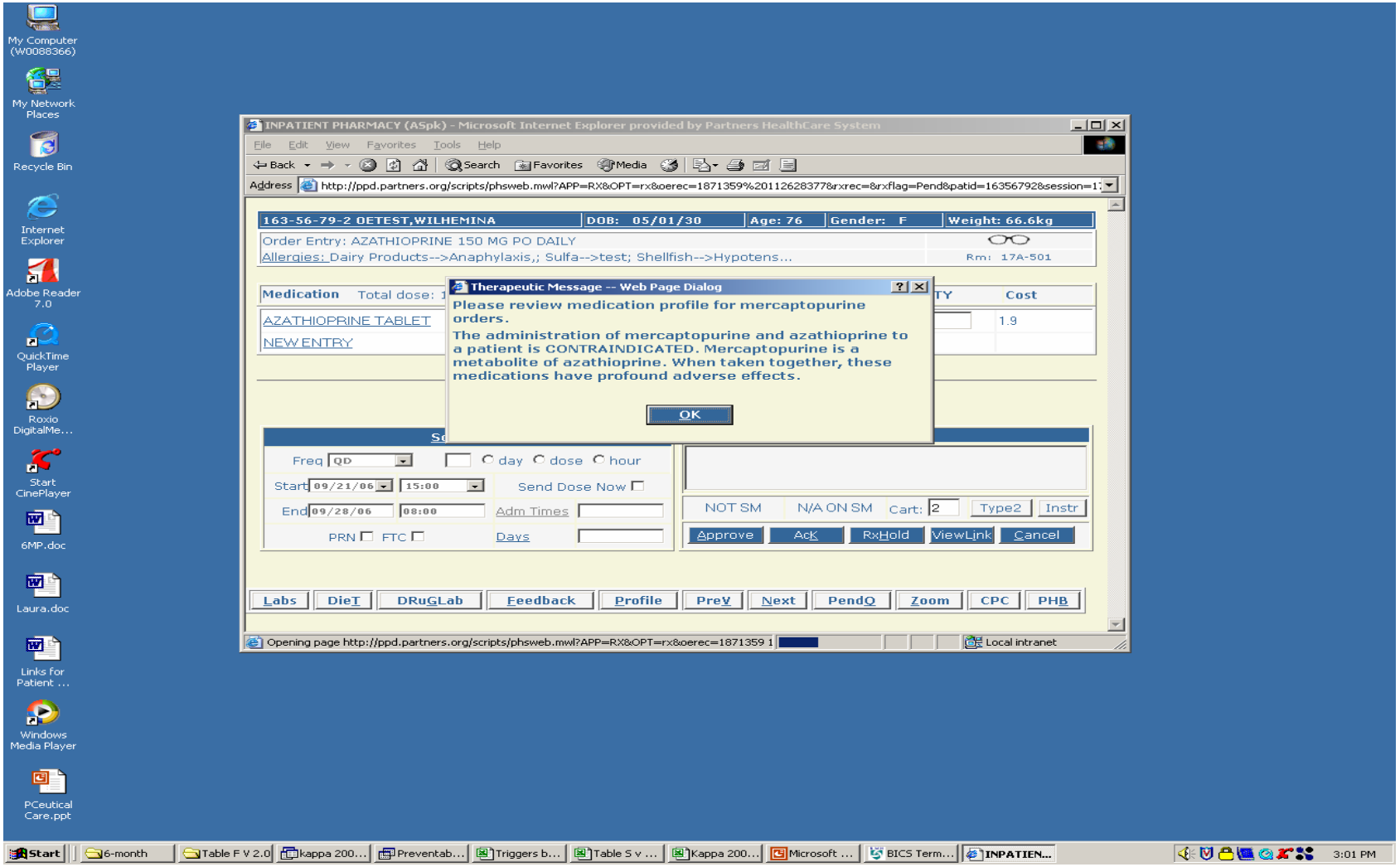


BRIGHAM AND WOMEN'S HOSPITAL

Methods

- Present information to MKC
- MKC's Medical Director is concerned that others will try to utilize exception to propose therapeutic duplications as inclusion in DDI knowledge base
- Utilization of TD will allow only outpatient clinicians to see alert
- Inpatient pharmacists are the ONLY one alerted in CPOE

Pharmacy OE/Pre-Implementation



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Results

- After discussion with Medical Director of MKC, present information to full MKC
- The concerns of Medical Director of MKC also presented at meeting
- These are taken into account in conjunction with presented material
- Decision is made to include in DDIs as benefits outweigh risk

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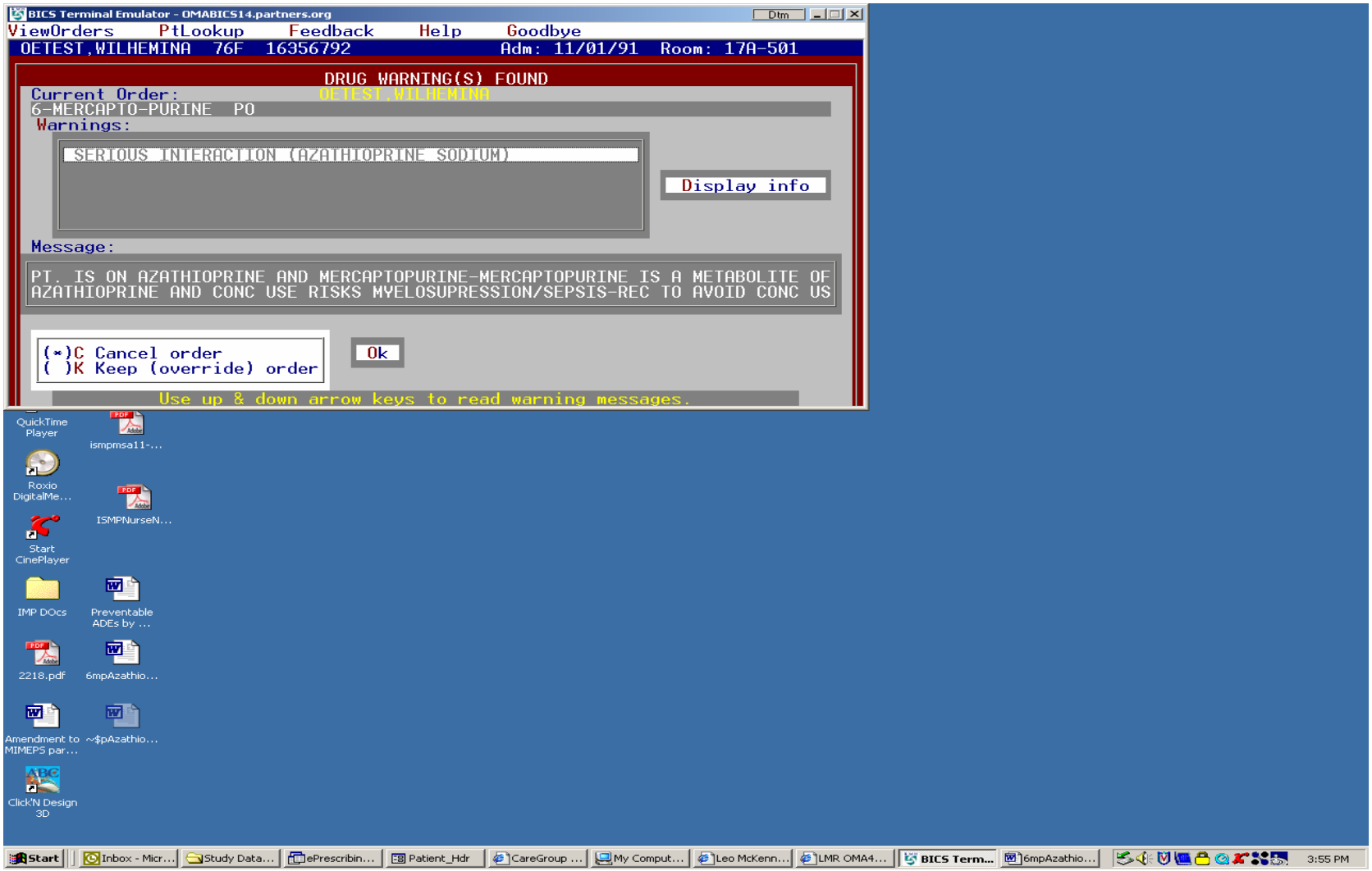
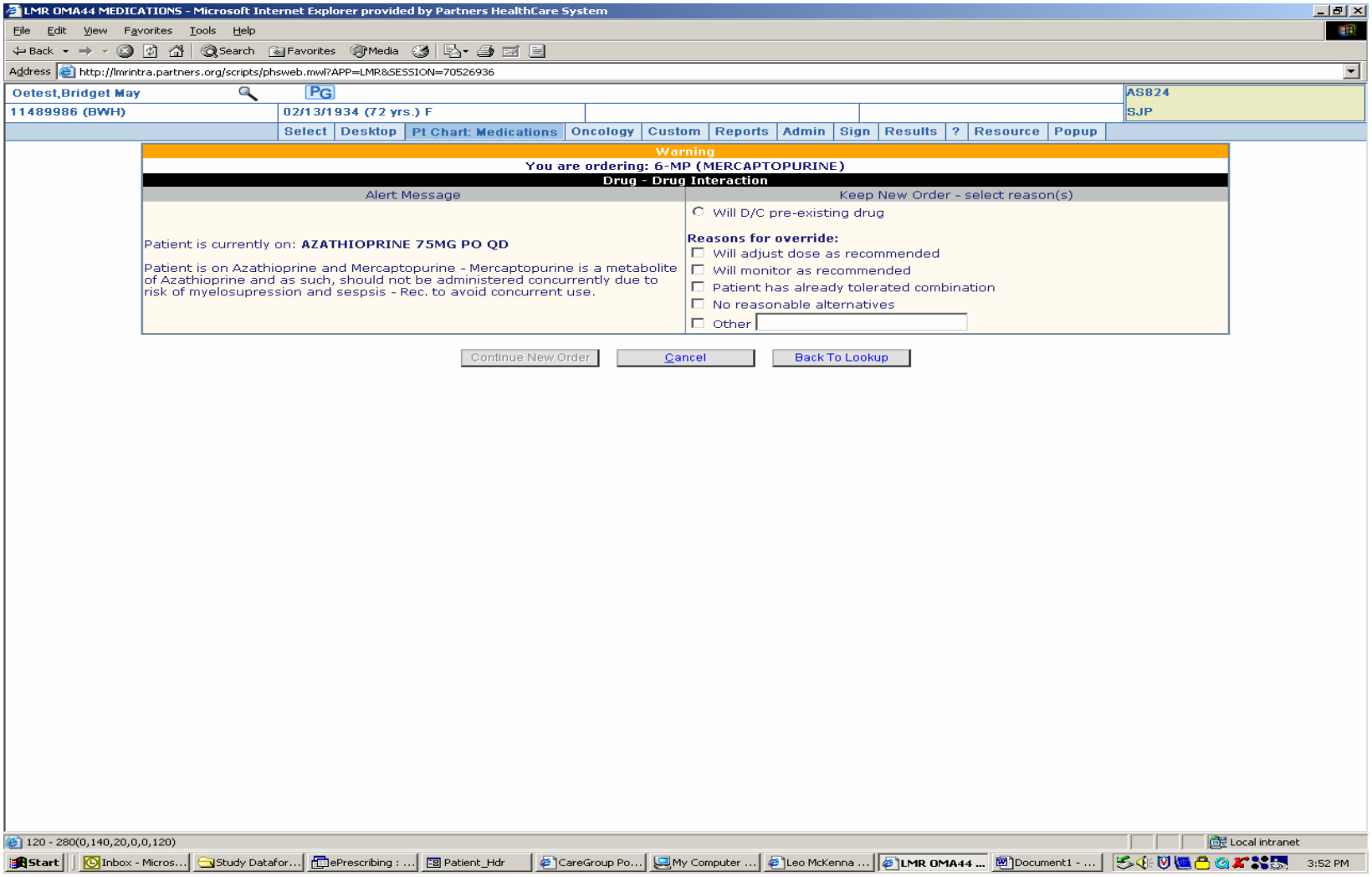
Screen Shot CPOE Inpatient/Post Implementation



BRIGHAM AND WOMEN'S HOSPITAL

Screen Shot Outpatient/Post Implementation



BRIGHAM AND WOMEN'S HOSPITAL

Conclusion

- Utilization of medication error data can enhance CDSS
- Information must be presented in a logical, concise form
- Utilization of team concept ensures all issues are vetted and contributes to a more robust knowledge structure

An Ethnographic Focus for the Study of Information Needs in the Emergency Center of the Hospital Italiano de Buenos Aires

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Acronyms

- **IN**: Information Need
- **PIN**: Possible Information Need
- **EC**: Emergency Center
- **HIBA**: Italian Hospital of Buenos Aires
- **EHR**: Electronic Health Record

Rationale

Why to study Information Needs?

- The HIBA is designing an EHR integrated with decision support tools for the EC
- It is a challenge to create decisions tools useful to and used by physicians
  - Developers must have accurate models of end users
    - What information the physycians use while they are caring for patients?
    - How much information do they need?
    - What kinds of information do they need?

It is necessary to identify the IN of the physicians

Problems for studying INs

Published studies of physicians' information needs have reported widely disparate results, with quantitative estimates of information need that vary by several orders of magnitude (Gorman)

Why?

➔ The method for eliciting requirements

➔ The definition of INs

Problems for studying INs

- **The method for eliciting requirements**
  - →Oral/written user reports
    - Nobody know/realizes his own practices
    - To report IN is a signal of professional incompetence
      - ➔ **Incomplete and incorrect identified INs**
      - ➔ **Out of the context of the daily work**

- **The definition of IN**
  - →Neither explicit nor univocal definition of IN
    - By type of information (Patient data; Population statistics; Medical knowledge; Logistic information; Social influences)
    - By the intention of search (Unrecognized needs; Recognized needs; Pursued needs)
      - ➔ **Identification depends on the point of view of the researcher**

The ethnographic approach

- **Based in direct observation of the scenarios**
- **Applied by Forsythe to elicit requirements in medical settings**

  →It allows...

  - **to identify any kind of physician's doubts**
  - **to understand the interrelationship between the requirement and the work flows**

Background

Forsythe's definition of IN

"Conscious expressions (verbal or non-verbal) of a desire for more information by one or more people"

⟶Any type of message that implies a desire for information is registered, independently of the nature of the information wanted

⟶The researcher registers the expressions he considered an IN

- ➔ **It is more feasible to identify verbal messages**
- ➔ **It depends on the researcher**

Objectives of the study

- To identify Information Needs of physycians in the EC of the HIBA...
  - Embodied in the daily work of the emergency setting
  - Independently of the type of information
  - Based on the perspectives of the stakeholders

Methodology

Definition of the object of study

Given the complexity of those involved in the information system for the EC, to decide whether an expression constitutes an IN or not will depend on the perspectives of the person faced with this question

Possible Information Need: the registry of a verbal or gestural single message considered by the researcher a lack of information

Information Need: PIN validated by the stakeholders as an information necessity within the EC

Methodology

Design of the study: Qualitative research

1) Eliciting PINs:

→Participant observation

- Carried out by observers of different professional formations (doctors, nurses and sociologists) that accompany the emergentologists and the residents during their daily work

2) Defining INs:

→Focus groups

- The PIN list will be discussed in focal groups with the interested parties and those responsible for the design of the EHR for the EC

Methodology
Methods

1) Participant observation

- 1 hour observation in the EC, in different moments of the day and the week, during at least 1 month and until saturation of the analysis. The registry (including messages and context) will be recorded manually after the observation and discussed within the research team for identification of the PINs

2) Focus groups

- Homogeneous groups of 5 to 6 of residents, emergentologysts, developers, medical IT specialists, hospital administrators. The previously identified PINs will be exposed for the group discusion. Textual registries will be analyzed and the Information Needs defined by each stakeholder will be identified

Acknowledge:
To the Emergency Department physicians and nurses

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Abstract

The development of informatics resources which meet the Information Needs (IN) of those who use them is an important challenge for the developers, and demands a profound knowledge of those needs. At the same time IN vary according to setting and the kind of work to be carried out. Classically, users' IN are clarified by asking the users direct questions but this type of evaluation brings with it an under-reporting of IN. The ethnographic investigation method allows an analysis of the IN of users in their workplace, and offers an understanding of those needs in the context in which they arise. Our purpose is to identify the IN of the physicians who work in the Emergency Center of a University Hospital, using the ethnographic method. The preliminary results of the investigation show that both the work dynamic of the Emergency Center and the context of emergency make it difficult to recognize physicians' IN , but following the methodology proposed by Diane Forsythe, we think it possible to achieve informatics developments which answer the real needs of the users.

Keywords:

information management, anthropology, cultural, needs assessment; emergency medical services

Introduction

In their daily practice, professionals systematically search for and use information of varying kinds. Clinical Decision Support Systems integrated with an electronic health record (EHR), have been proposed as one of the ways in which professionals can access the information they need in the different contexts of their professional life. However, it is difficult to develop systems which respond to the need for information in the process of decision making and in accordance with the requirements of their professional practice [1] To identify those requirements, common sense tells us that it should be sufficient to ask the users what they need, and in fact the majority of developments in information systems use this method [1-3]. However, the information that people give in response to direct questions leads to an under-registering of information needs [4]. Self-reporting tends to be incomplete and at times even incorrect [5].

The problematic of studying information needs (IN) is even more complex, in part because there is no explicit definition of the term "information needs" and a wide range of phenomena has been investigated under the rubric of Information Needs [6]. The majority of publications that we have found until now make reference to academic information [5].

Ethnography is a method of anthropological investigation which allows us to understand the context of the nature of knowledge; that is to say how it is personally experienced and used by each one of those who work in different cultural and organizational contexts [7]. Seen from this perspective the concept of IN is not restricted only to academic doubts, but rather to an absence of information that could interfere with the workflow. Studies based on ethnographic methods have revealed a greater diversity and quantity of information needs than those based solely on self-reporting [1, 8].

The Italian Hospital of Buenos Aires (HIBA) is a tertiary care, teaching and research hospital. Since 1998 a full-scale Health Information System has gradually been implemented. At this stage we are beginning the design of an electronic medical record for the Emergency Center (EC) and defining users' IN.

In the literature that we have found up until now, the information needs which are described are, in the majority of cases, related to the ambulatory area. We have found no literature making reference to what happens in the context of an EC. And no work of this nature has been carried out in Latin America.

The present study proposes to identify the Information Needs of doctors in the context of their daily work in the EC of the HIBA, using ethnographic methodology, decide which of these messages can be considered IN for the final users and to classify the IN according to the possibility of developing decision making support systems based on them.

The definition of the object of study

Forsythe propose to study "conscious expressions (verbal or non-verbal) of a desire for more information by one or more people and distinguish them from information deficits, which may or may not be conscious: only expressed

and therefore conscious information needs were recorded". In the Preliminary Results, we present the modifications that we propose in order to study the concept of IN.

Materials and methods

Qualitative investigation based on ethnographic methodology by means of participating observation. The observation and registration will be carried out by observers of different professional formations (doctors, nurses, sociologists) who will accompany the attending doctors in the EC, and will register the expressions of IN without prejudging the nature of or the occasion for the doubts. They will also register the context in which each IN is produced. This will allow these expressions to be validated by those who express the IN, whose observations and reflections will be incorporated in the register as part of the same process of analysis. Another investigator will provide an initial list of Possible Information Needs (PIN) for use in the joint discussions of the observers.

The PIN list will be discussed in focal groups with the interested parties and those responsible for the design of the EHR for the EC, to decide which of these possible needs are recognized by the doctors as true information needs and analyze which of these needs could be met by an informatics system. After this stage, we will have the views of the different parties involved on the role which the system should play, enriched by the contextual experience of practice in the EC.

Preliminary results

Following the definition proposed by Forsythe, IN is a wish or intention, which may or may not be made effective, in order to seek some type of datum. Methodologically this approach implies identifying questions and doubts, and interpreting them as IN. Therefore, any type of message that implies a desire for information is registered, independent of the nature of the information wanted, be it strictly clinical, academic, and administrative or of any other kind which may arise. Once the observer has identified and registered these expressions, he should interpret which of them could imply a potential search for information.

The EC presents characteristics different from those for which Forsythe's definition of IN proved both adequate and productive (morning rounds of residents who discussed a case with a hierarchical superior around the bed of a patient). The ambit of the EC is highly dynamic, and guided by the principle of economy of words and gestures. Accordingly, verbal interactions are few and brief and the observer must base his registers on gestures, proximity and space, all signs which, from a semiotic point of view, are little codified and whose meaning is indecipherable if they do not have a verbal anchorage which gives them meaning.

On the other hand, the professionals of the EC, unlike the residents who wait for the morning round to express their doubts, are little disposed to recognize that they have any significant doubts. We believe that the No-doubt condition would be, in our context, in some way related to the professional workplace of these doctors.

Both suppositions were corroborated by the preliminary observations which we carried out (n=20; words= 18.411; hours 11; persons observed=18; observers= 4), this led us to the conclusion that participant observation would allow us to identify, from verbal and gestural interactions, textual fragments which we could consider "Possible Information Needs". However, the ratification of these textual fragments as IN, given the complexity of those involved in the development and use of an information system for the EC, it should not be interpretative; for the answer – deciding whether an expression constitutes an IN or not – will depend on the perspective and the interests of the person faced with this question.

Methodologically, this implies the need for different view at the issue to decide which of these messages can be considered as IN, from the perspectives of the different people involved in the definition of what are and what are not IN. Finally, we propose that the PIN be validated by those parties involved in order to be considered true IN.

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The present study proposes to identify the Information Needs of doctors in the context of their daily work in the EC of the HIBA, using ethnographic methodology, decide which of these messages can be considered IN for the final users and to classify the IN according to the possibility of developing decision making support systems based on them.

The definition of the object of study

Forsythe propose to study "conscious expressions (verbal or non-verbal) of a desire for more information by one or more people and distinguish them from information deficits, which may or may not be conscious: only expressed

and therefore conscious information needs were recorded". In the Preliminary Results, we present the modifications that we propose in order to study the concept of IN.

Materials and methods

Qualitative investigation based on ethnographic methodology by means of participating observation. The observation and registration will be carried out by observers of different professional formations (doctors, nurses, sociologists) who will accompany the attending doctors in the EC, and will register the expressions of IN without prejudging the nature of or the occasion for the doubts. They will also register the context in which each IN is produced. This will allow these expressions to be validated by those who express the IN, whose observations and reflections will be incorporated in the register as part of the same process of analysis. Another investigator will provide an initial list of Possible Information Needs (PIN) for use in the joint discussions of the observers.

The PIN list will be discussed in focal groups with the interested parties and those responsible for the design of the EHR for the EC, to decide which of these possible needs are recognized by the doctors as true information needs and analyze which of these needs could be met by an informatics system. After this stage, we will have the views of the different parties involved on the role which the system should play, enriched by the contextual experience of practice in the EC.

Preliminary results

Following the definition proposed by Forsythe, IN is a wish or intention, which may or may not be made effective, in order to seek some type of datum. Methodologically this approach implies identifying questions and doubts, and interpreting them as IN. Therefore, any type of message that implies a desire for information is registered, independent of the nature of the information wanted, be it strictly clinical, academic, and administrative or of any other kind which may arise. Once the observer has identified and registered these expressions, he should interpret which of them could imply a potential search for information.

The EC presents characteristics different from those for which Forsythe's definition of IN proved both adequate and productive (morning rounds of residents who discussed a case with a hierarchical superior around the bed of a patient). The ambit of the EC is highly dynamic, and guided by the principle of economy of words and gestures. Accordingly, verbal interactions are few and brief and the observer must base his registers on gestures, proximity and space, all signs which, from a semiotic point of view, are little codified and whose meaning is indecipherable if they do not have a verbal anchorage which gives them meaning.

On the other hand, the professionals of the EC, unlike the residents who wait for the morning round to express their doubts, are little disposed to recognize that they have any significant doubts. We believe that the No-doubt condition would be, in our context, in some way related to the professional workplace of these doctors.

Both suppositions were corroborated by the preliminary observations which we carried out (n=20; words= 18.411; hours 11; persons observed=18; observers= 4), this led us to the conclusion that participant observation would allow us to identify, from verbal and gestural interactions, textual fragments which we could consider "Possible Information Needs". However, the ratification of these textual fragments as IN, given the complexity of those involved in the development and use of an information system for the EC, it should not be interpretative; for the answer – deciding whether an expression constitutes an IN or not – will depend on the perspective and the interests of the person faced with this question.

Methodologically, this implies the need for different view at the issue to decide which of these messages can be considered as IN, from the perspectives of the different people involved in the definition of what are and what are not IN. Finally, we propose that the PIN be validated by those parties involved in order to be considered true IN.

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Cross-Scale Mapping of Gene Expression to Neuroimaging Datasets via Semantic Decomposition

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[b] *Center for Biomedical Informatics, Department of Medicine, University of Chicago, Chicago, IL, USA*
[d] *Department of Psychological and Brain Sciences, Dartmouth College, Hanover, NH, USA*

Abstract

A labor-intensive step towards heterogeneous neuroscience data interoperability is the development of compatible metadata models that formally describe entities, attributes and the relationships between them in the underlying data. An alternative and complementary approach is proposed that uses Natural Language Processing (NLP) and a knowledge-based phenotype organizer system (PhenOS) to link terms to underlying data from each database, and then maps these terms using SNOMED CT®, a comprehensive Description-Logic (DL) ontology that describes anatomies across biological scales and morphologies related to disease. (See http://phenos.bsd.uchicago.edu/public/supplement-1-medinfo2007.doc for supplemental information.) A prototype was developed using sample datasets from the fMRI Data Center, Gene Expression Omnibus (GEO) at NCBI and Neuronames that allowed for complex and loosely-defined queries such as "List all disorders with a finding site of brain region X, and then find the closest references to these disorders (identical or subtypes) in all participating databases." The utility of this system in increasing interoperability between databases in domains as diverse as neuroimaging and gene expression, albeit on a semantic level, is discussed.

Keywords:

computational ontologies, phenotypes,
database interoperability, Mediated Schema, SNOMED

Introduction

Increasingly, there is an understanding that well-managed, comprehensive databases and their interoperability will be necessary for important further advancement in neuroscience (1). In contrast to the reliance on and advancements of informatics in other biosciences, such as molecular biology and genomics, or which data is primarily text-based, the tremendous complexity of neuroscience data is a major impediment in consistent informatics integration and implementation (2). One promising approach has been to use Ontologies employing Description Logic (DL), such as those that have been introduced into biomedical domains, as a flexible and powerful way to capture and classify biological concepts and potentially be used for making inferences from biological data (3-5). A major challenge to the use of DL ontologies in mediating between diverse databases is the differences in concepts and terms used to describe the underlying data in each database (6). This has been addressed by the development of automated methods for the lexical mapping of terminologies and medical vocabularies onto a major medical DL ontology used to link disparate information systems, typically the UMLS (7-9), but also SNOMED as was recently done for ontology-based query of tissue microarray data (10). The current effort differs from the abovementioned approaches because we are mapping very distinct datasets (that may not share many concepts) to SNOMED, which allows for the use of both hierarchical relationships and semantic decomposition between the anatomies and morphologies related to a disease to find relevant relationships across scales of biology. In effect, the proposed approach is also more effectively utilizing a 'reference model' of disease, such as that contained in SNOMED.

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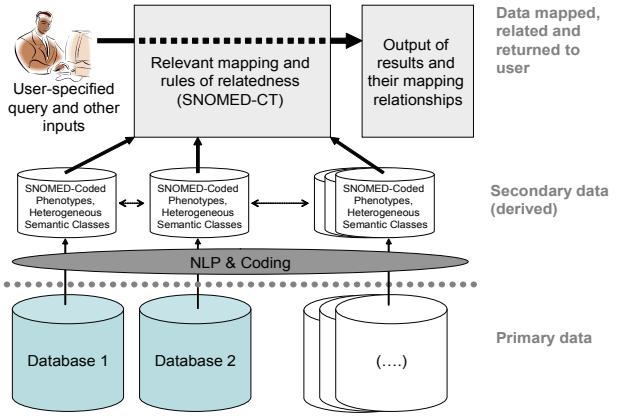

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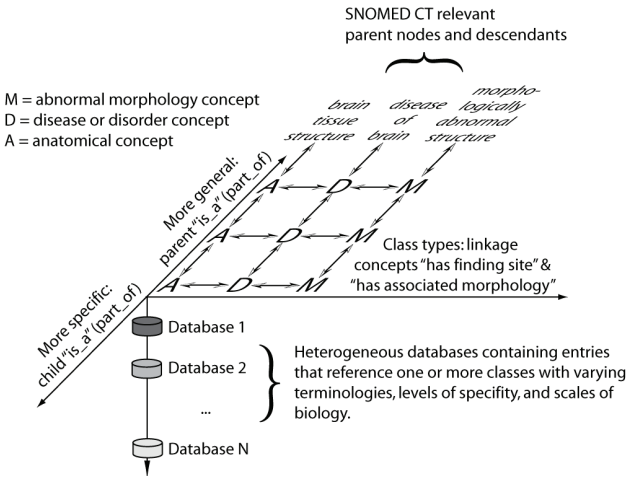
Materials and methods

(Details in *Supplement*, obtained at the URL supplied in the abstract.) The current method (outlined in **Figure 1**) employed four general steps: 1) conceptualization of the general query model **(Figure 2)**, that defines the traversable paths (hierarchical relationships and semantic switches) used in mapping relationships between terms contained in each database 2) mapping of database terms to SNOMED via NLP and coding 3) mapping rules of relatedness (according to the general query model) and 4) query construction and implementation. Mapping of database terms to SNOMED was conducted using PhenOS, a knowledge-based phenotype organizer system (14), which was also used in assigning phenotypic context to Gene Ontology Annotations (15). **Figure 3** depicts a query model path that was traversed in answering an example query, and **Figure 4** depicts the semantic mapping for one result of the example query.



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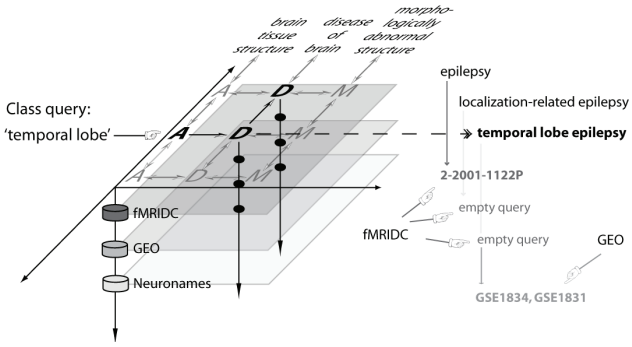

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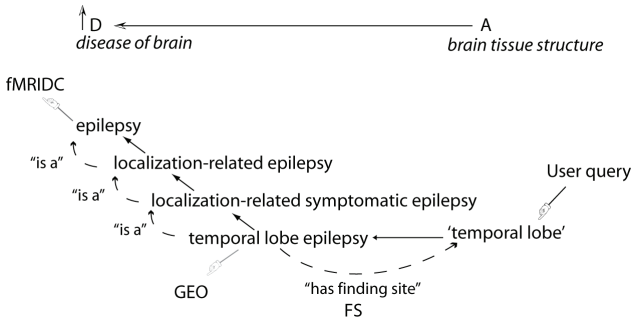

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5,497 unique pair-wise mappings were generated for seven types of relationships between each of the datasets: 1) **Identity -** terms are identical or similar between one dataset and another 2) **Subsuming** – terms in the one dataset subsume terms in the second 3) **Subsumed** – terms in one dataset are subsumed by terms in the second 4) **A,MD** - terms in one dataset are either an Anatomical Structure or Abnormal Morphology and terms in the second dataset are Diseases that subsume diseases that have as finding site or associated morphology the term in the first dataset 5) **A,MD** - terms in one dataset are either an Anatomical Structure or Abnormal Morphology and terms in the second dataset are Diseases that are subsumed by diseases that have as finding site or associated morphology the term in the first dataset 6) **DA,M** - terms in one dataset are Diseases and terms in the second dataset are either an Anatomical Structure or Abnormal Morphology that subsume finding sites or associated morphologies of terms in the first dataset 7) **DA,M** - terms in one dataset are Diseases and terms in the second dataset are either an Anatomical Structure or Abnormal Morphology that are subsumed by finding sites or associated morphologies of terms in the first dataset. Table 1 (see *Supplement*) shows the number of mappings for each relationship between each pair of datasets.

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(Details in *Supplement*.) The current work presents a novel method for query implementation that makes use of the modeling in SNOMED to decompose semantic information allowing for mapping between anatomies or morphologies related to disease. This allows for the mapping of heterogeneous data with different biological scales, such as arrays and imaging, because the decomposition of a diagnosis or disease to its cell type, anatomical and/or morphological component allows for the spanning of more biological scales than the diagnosis would alone.

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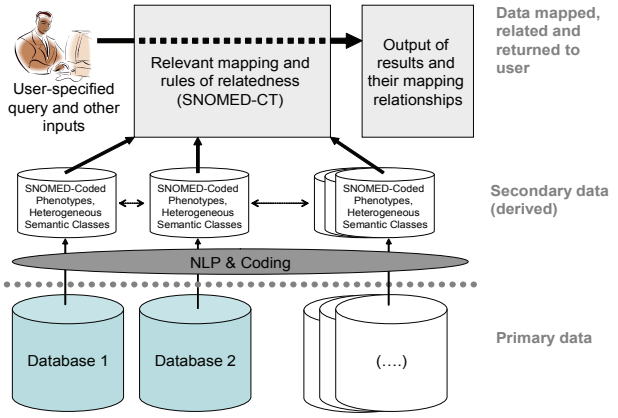

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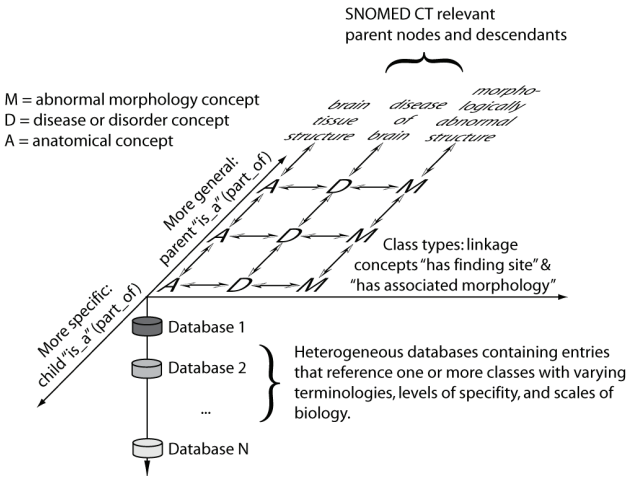

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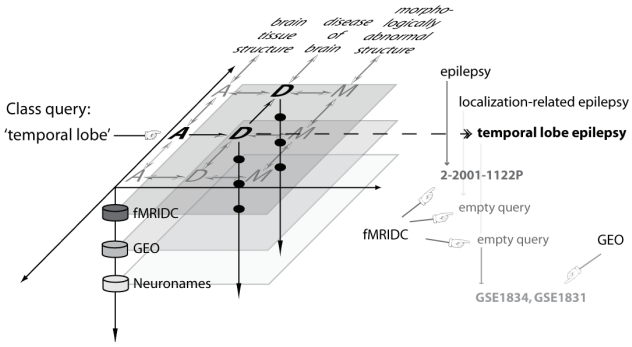

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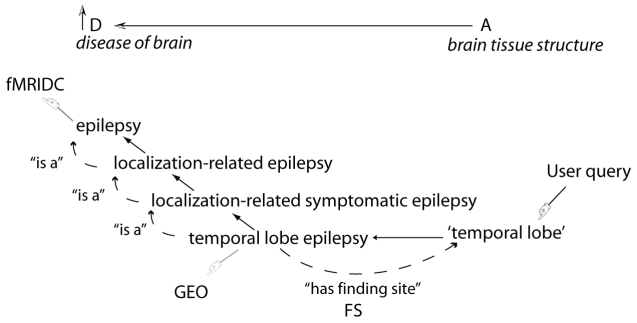

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A Semantic Web Based Framework for Modeling Clinical Practice Guidelines to Develop Clinical Decision Support Systems

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Abstract

In this paper we present a Semantic Web based framework for the computerization and execution of Clinical Practice Guidelines via a Clinical Decision Support System (CDSS). Our framework involves multiple ontologies to represent different CPG, domain and patient knowledge. We have developed a tool to specify the CPG's decision logic as decision-rules that are executed via a proof-engine to derive patient specific recommendations. We provide a justification tree of the reasoning process to explain to the user the CPG-mediated recommendations suggested by the CDSS.

Keywords:

Clinical Practice Guidelines, knowledge management, Decision Support System, Semantic Web, ontologies

Introduction

Clinical Practice Guidelines (CPG) are systematically developed disease-specific recommendations to assist clinical decision-making in accordance with the best evidence [1]. However, the uptake of CPG is rather minimal in actual healthcare settings due to a range of behavioral, operational and technical issues. Indeed, CPG can be more effectively used if they are computerized and incorporated within Clinical Decision Support Systems (CDSS) that are available at the point-of-care[2].

In our work, we take a knowledge management approach to computerize CPG and develop a CPG-based CDSS. We apply the Semantic Web framework [3] to (i) Computerize a CPG by semantically representing disease-specific knowledge inherent within a CPG, whilst specifying the relationships and interactions between the key CPG elements to realize a functional and executable CPG plan; (ii) Transform the decision logic inherent within a CPG into executable logic-based decision rules; (iii) Execute the computerized CPG based on patient information, in order to provide CPG-mediated, patient-specific recommendations; and (iv) Justify the CDSS's recommendations by providing CPG-based explanations. The Semantic Web purports the semantic modeling and markup of knowledge, its properties and its relations using well-defined semantics such as formal definitions of terms, ontological definitions of domain concepts and resources. The semantically modeled knowledge can then be operationalized via proof engines employing logic-based reasoning methods to infer 'trusted' solutions.

In this paper we present a Semantic Web based framework for developing CDSS. The key elements of our framework are (a) modeling the CPG knowledge and (b) executing the CPG knowledge. To model the entire working environment and knowledge essential to derive a CPG-based recommendation, we developed three unique ontologies as follows: (i) A CPG Ontology that models the computerized structure of the CPG. We model the CPG using the Guideline Element Model (GEM) [4] structure, and therefore our CPG ontology is based on the GEM DTD; (ii) A Domain Ontology, in OWL, that models the CPG's medical knowledge; and (iii) A Patient Ontology that models the patient in terms of various health information. We used Protégé [5] to develop all the ontologies.

Our CDSS is divided into two main modules, namely CPG Encoding Module and CPG Rule Authoring and Execution Module. The CPG Encoding Module is used to encode the text-based CPG into the CPG ontology and to annotate the decision variables and logic structures inherent within the CPG. Both the CPG Ontology and the Domain Ontology are used for CPG encoding. The CPG Rule Authoring and Execution Module is used to define the decision logic rules in a CPG and to execute them based on patient data. A novel feature of our CPG Execution Module is that it provides an automated justification trace of inferred recommendations. Figure 1 shows the architecture of our Semantic Web based CDSS.

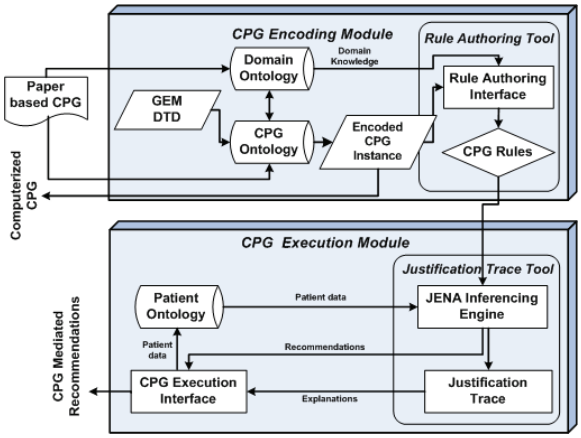

Figure 1- System Design of our CDSS

CPG Encoding Module

The CPG encoding module comprises two components: (a) a CPG representation formalism to convert the paper-based CPG into an electronic format; (b) a CPG ontology to model the structure of the CPG; and (c) a patient ontology to describe the characteristics of a patient. The *CPG Ontology* is based on the GEM DTD [4]. The *Patient Ontology* mirrors an Electronic Patient Record (EPR) and models a patient in terms of various health information and patient clinical situations.

CPG Rule Authoring and Execution Module

The CPG Rule Authoring and Execution module is designed to capture the CPG's clinical decision making logic in terms of logical rules—the logical rules were executed by a reasoning engine to derive CPG-based recommendations given a patient health record. To achieve the above functionality, we built three sub-modules namely, Rule Authoring Sub-Module, Execution Sub-Module and Justification Trace Sub-Module.

Rule Authoring Sub-Module uses the GEM encoded CPG to allow the user to identify the logical constructs within the CPG and define them as CPG (decision logic) rules using our CPG Rule Syntax. Upon completion of the rule authoring process, we apply a rule transformation algorithm to transform the CPG rules into the JENA syntax so that they can be executed the Execution Sub-Module that leverages the JENA inference engine [6].

Execution Sub-Module invokes the JENA inference engine to execute a CPG in order to infer recommendations based on patient profiles. We model instances from the Domain Ontology, CPG Ontology and Patient Ontology as RDF graphs, which serve as the knowledge base for JENA. JENA inference engine uses both the knowledge base and the CPG rule-set in a backward reasoning mode to infer CPG-mediated recommendations based on the given knowledge.

Justification Trace Sub-Module generates a justification trace of the rule execution to assist medical practitioners in understanding the logic behind the inferred recommendations. The justification derivation includes the linear representation of premises (facts) under which the JENA rules are satisfied and the conclusions based on those rules. The justification trace initiates with a derived patient recommendation (derived facts) from the JENA model (knowledge base) and generates facts which served as premises for deriving the patient recommendation, recursively.

The working of our CPG Authoring and Execution Module involves the following sequence of actions: (a) Input a text-based CPG and loads its pre-defined Domain Ontology and the Patient Ontology; (b) Encode the CPG in terms of the CPG Ontology and the Domain Ontology; (c) Specify the CPG (decision) rules. The CPG rules are transformed to JENA rule syntax and passed to the JENA reasoning system; (d) Execute the CPG based on a given patient instance to infer CPG-mediated recommendations; and (e) Justify the inferred recommendations through a justification tree.

Concluding remarks

The Semantic Web provides an interesting framework both for modeling and executing a CPG. Our Semantic Web based approach for CDSS development features the integration of multiple ontologies—we integrated two ontologies, each representing the form and function of a CPG—i.e. the *Domain Ontology* describing the CPG function and the *CPG Ontology* representing the CPG structure. We presented an intuitive CPG rule syntax that medical practitioners can use to write clinical decision rules from the CPG. We internally transformed the CPG rules into a complex rule syntax so that they can be executed via a inferencing engine to infer CPG based recommendations for a specific patient. Using our CDSS development approach we have developed two CDSS—i.e. (a) Breast Cancer Follow-up and (b) Imaging radiation protection—each based on a specific CPG.

The use of CPG in a CDSS not only provides an evidence based knowledge-base, but it relives CDSS developers from the perennial knowledge engineering problem. By design, CPG entail a decision logic that is structured in an algorithmic format that can be used to generate explicit symbolic clinical decision-support rules to suggest CPG-guided clinical recommendations. The knowledge management paradigm of the Semantic Web extends a logic-based framework to semantically model medical knowledge to provide a variety of knowledge-mediated services. Our CDSS approach is quite generic and can be extended to other medical problems.

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A Semantic Web Based Framework for Modeling Clinical Practice Guidelines to Develop Clinical Decision Support Systems

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Abstract

In this paper we present a Semantic Web based framework for the computerization and execution of Clinical Practice Guidelines via a Clinical Decision Support System (CDSS). Our framework involves multiple ontologies to represent different CPG, domain and patient knowledge. We have developed a tool to specify the CPG's decision logic as decision-rules that are executed via a proof-engine to derive patient specific recommendations. We provide a justification tree of the reasoning process to explain to the user the CPG-mediated recommendations suggested by the CDSS.

Keywords:

Clinical Practice Guidelines, knowledge management, Decision Support System, Semantic Web, ontologies

Introduction

Clinical Practice Guidelines (CPG) are systematically developed disease-specific recommendations to assist clinical decision-making in accordance with the best evidence [1]. However, the uptake of CPG is rather minimal in actual healthcare settings due to a range of behavioral, operational and technical issues. Indeed, CPG can be more effectively used if they are computerized and incorporated within Clinical Decision Support Systems (CDSS) that are available at the point-of-care[2].

In our work, we take a knowledge management approach to computerize CPG and develop a CPG-based CDSS. We apply the Semantic Web framework [3] to (i) Computerize a CPG by semantically representing disease-specific knowledge inherent within a CPG, whilst specifying the relationships and interactions between the key CPG elements to realize a functional and executable CPG plan; (ii) Transform the decision logic inherent within a CPG into executable logic-based decision rules; (iii) Execute the computerized CPG based on patient information, in order to provide CPG-mediated, patient-specific recommendations; and (iv) Justify the CDSS's recommendations by providing CPG-based explanations. The Semantic Web purports the semantic modeling and markup of knowledge, its properties and its relations using well-defined semantics such as formal definitions of terms, ontological definitions of domain concepts and resources. The semantically modeled knowledge can then be operationalized via proof engines employing logic-based reasoning methods to infer 'trusted' solutions.

In this paper we present a Semantic Web based framework for developing CDSS. The key elements of our framework are (a) modeling the CPG knowledge and (b) executing the CPG knowledge. To model the entire working environment and knowledge essential to derive a CPG-based recommendation, we developed three unique ontologies as follows: (i) A CPG Ontology that models the computerized structure of the CPG. We model the CPG using the Guideline Element Model (GEM) [4] structure, and therefore our CPG ontology is based on the GEM DTD; (ii) A Domain Ontology, in OWL, that models the CPG's medical knowledge; and (iii) A Patient Ontology that models the patient in terms of various health information. We used Protégé [5] to develop all the ontologies.

Our CDSS is divided into two main modules, namely CPG Encoding Module and CPG Rule Authoring and Execution Module. The CPG Encoding Module is used to encode the text-based CPG into the CPG ontology and to annotate the decision variables and logic structures inherent within the CPG. Both the CPG Ontology and the Domain Ontology are used for CPG encoding. The CPG Rule Authoring and Execution Module is used to define the decision logic rules in a CPG and to execute them based on patient data. A novel feature of our CPG Execution Module is that it provides an automated justification trace of inferred recommendations. Figure 1 shows the architecture of our Semantic Web based CDSS.

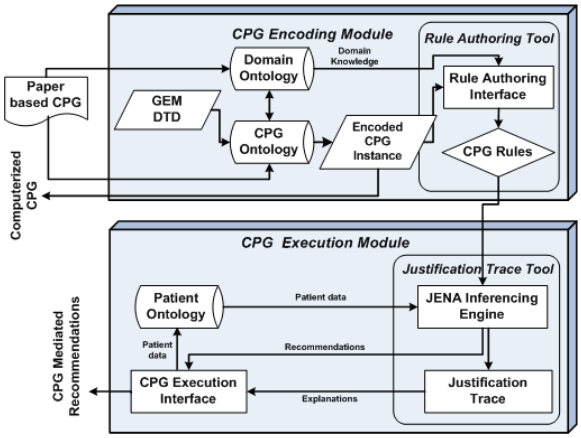

Figure 1- System Design of our CDSS

CPG Encoding Module

The CPG encoding module comprises two components: (a) a CPG representation formalism to convert the paper-based CPG into an electronic format; (b) a CPG ontology to model the structure of the CPG; and (c) a patient ontology to describe the characteristics of a patient. The *CPG Ontology* is based on the GEM DTD [4]. The *Patient Ontology* mirrors an Electronic Patient Record (EPR) and models a patient in terms of various health information and patient clinical situations.

CPG Rule Authoring and Execution Module

The CPG Rule Authoring and Execution module is designed to capture the CPG's clinical decision making logic in terms of logical rules—the logical rules were executed by a reasoning engine to derive CPG-based recommendations given a patient health record. To achieve the above functionality, we built three sub-modules namely, Rule Authoring Sub-Module, Execution Sub-Module and Justification Trace Sub-Module.

Rule Authoring Sub-Module uses the GEM encoded CPG to allow the user to identify the logical constructs within the CPG and define them as CPG (decision logic) rules using our CPG Rule Syntax. Upon completion of the rule authoring process, we apply a rule transformation algorithm to transform the CPG rules into the JENA syntax so that they can be executed the Execution Sub-Module that leverages the JENA inference engine [6].

Execution Sub-Module invokes the JENA inference engine to execute a CPG in order to infer recommendations based on patient profiles. We model instances from the Domain Ontology, CPG Ontology and Patient Ontology as RDF graphs, which serve as the knowledge base for JENA. JENA inference engine uses both the knowledge base and the CPG rule-set in a backward reasoning mode to infer CPG-mediated recommendations based on the given knowledge.

Justification Trace Sub-Module generates a justification trace of the rule execution to assist medical practitioners in understanding the logic behind the inferred recommendations. The justification derivation includes the linear representation of premises (facts) under which the JENA rules are satisfied and the conclusions based on those rules. The justification trace initiates with a derived patient recommendation (derived facts) from the JENA model (knowledge base) and generates facts which served as premises for deriving the patient recommendation, recursively.

The working of our CPG Authoring and Execution Module involves the following sequence of actions: (a) Input a text-based CPG and loads its pre-defined Domain Ontology and the Patient Ontology; (b) Encode the CPG in terms of the CPG Ontology and the Domain Ontology; (c) Specify the CPG (decision) rules. The CPG rules are transformed to JENA rule syntax and passed to the JENA reasoning system; (d) Execute the CPG based on a given patient instance to infer CPG-mediated recommendations; and (e) Justify the inferred recommendations through a justification tree.

Concluding remarks

The Semantic Web provides an interesting framework both for modeling and executing a CPG. Our Semantic Web based approach for CDSS development features the integration of multiple ontologies—we integrated two ontologies, each representing the form and function of a CPG—i.e. the *Domain Ontology* describing the CPG function and the *CPG Ontology* representing the CPG structure. We presented an intuitive CPG rule syntax that medical practitioners can use to write clinical decision rules from the CPG. We internally transformed the CPG rules into a complex rule syntax so that they can be executed via a inferencing engine to infer CPG based recommendations for a specific patient. Using our CDSS development approach we have developed two CDSS—i.e. (a) Breast Cancer Follow-up and (b) Imaging radiation protection—each based on a specific CPG.

The use of CPG in a CDSS not only provides an evidence based knowledge-base, but it relives CDSS developers from the perennial knowledge engineering problem. By design, CPG entail a decision logic that is structured in an algorithmic format that can be used to generate explicit symbolic clinical decision-support rules to suggest CPG-guided clinical recommendations. The knowledge management paradigm of the Semantic Web extends a logic-based framework to semantically model medical knowledge to provide a variety of knowledge-mediated services. Our CDSS approach is quite generic and can be extended to other medical problems.

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Using GLIF and GLEE to Facilitate Knowledge Management in Development of Clinical Decision Support Systems

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Abstract

Effective knowledge management is a critical challenge to development of clinical decision support systems (CDSSs). We have been using the GuideLine Interchange Format (GLIF) and the Guideline Execution Engine (GLEE) to facilitate knowledge modeling, adaptation, and validation for CDSSs that address a variety of healthcare problems. Based on a review of case studies, we synthesized three major functions of GLIF and GLEE during this process: (1) improving communication between CDSS developers and domain experts, (2) facilitating fast prototyping of CDSSs, and (3) providing multi-stage system validation. We argue that development of CDSSs should start from analyses of user needs and identification of knowledge sources, followed by an evolving process with multiple rounds of conceptualization, encoding, simulation, and evaluation. Our review has shown that GLIF and GLEE can be used effectively to facilitate this process.

Keywords:

clinical decision support systems,
knowledge management, practice guidelines,
GLIF, GLEE

Introduction

Development of clinical decision support systems (CDSSs) needs effective translation of domain knowledge and their adaptation to specific application environments. We have been using the GuideLine Interchange Format (GLIF) and the Guideline Execution Engine (GLEE) as tools to facilitate knowledge management for a variety of healthcare problems. In this paper, we review our experience of using GLIF and GLEE for knowledge modeling, adaptation, and validation, focusing on analyses of their specific functions and examinations of the overall process.

Methods

Our analyses included two aspects: (1) the specific functions provided by GLIF and GLEE in development of CDSSs, and (2) the overall process to use GLIF and GLEE for CDSS development. The examinations were based on data of specific case studies drawn from finished or ongoing projects. These data were then integrated and synthesized along the two dimensions of function and process. A variety of healthcare problems have been addressed by these case studies, including childhood immunization, cough management, influenza vaccination, hyperkalemia screening, diabetic foot care, post-CABG recovery, depression screening, and tobacco cessation.

Results

Functions of GLIF and GLEE in development of CDSSs

Improving communication between CDSS developers and domain experts

Improving communication between CDSS developers and domain experts is one of the most challenging issues in development of CDSSs. Effective communication between CDSS developers and domain experts is especially important when decisions need to be made to extract and to translate specific pieces of domain knowledge from their original sources, to organize knowledge in well-defined structures, and to identify the potential points in healthcare processes where interventions can be delivered in appropriate formats. The GLIF model provides a conceptual-level representation of healthcare processes using a flowchart-like graphical presentation. This level of representation and visualization has been used intensively in development process to exchange ideas between CDSS developers and domain experts. Paper-based flowcharts have also been used widely for conceptualization purposes, but typically with various problems from computational prospective. In contrast, the flowchart-like algorithm in GLIF is supported by the underlying computational model. Thus, once the conceptual-level algorithm is developed, it can be directly used for computational purposes. An important aspect in development of an algorithm is its testing through the stand-alone user interface of GLEE, which can simulate the execution of specific patient cases through particular paths of the algorithm. These features of GLIF and GLEE can significantly improve the effectiveness and efficiency of communication when presenting the encoded knowledge base to domain experts and seeking their feedback.

Fast prototyping for knowledge modeling and adaptation

Development of CDSSs is an evolving process that typically requires multiple rounds of knowledge encoding, modification, and validation. During this process, fast prototyping of a knowledge base can significantly improve the efficiency of development. With the three-level representation of GLIF (the conceptual flowchart, the computation model, and the interface for integration and implementation) and the simulation function of GLEE, their combination as a tool set provides a unique and powerful testing environment for CDSS development such that the knowledge base of a CDSS can be prototyped without the need to be fully integrated with the final applications. The ability to create such prototypes and test them quickly was essential to the iterative and interactive process of CDSS development.

Facilitating multi-stage system validation

System validation is a critical step in CDSS development. Since development of CDSSs requires significant investment of resources, identifying system errors in early stages of development is important. The combination of GLIF and GLEE provides a unique chance to discover potential problems earlier and thus to prevent/reduce expensive errors in later stages. Specifically, the conceptual level flowchart-like algorithm of GLIF has been used widely to facilitate communication between CDSS developers and domain experts, which can significantly improve mutual understanding on organization of medical knowledge and their adaptation to local practices and settings at an early stage of development. In addition, the simulation function of GLEE that can be used to examine the execution path of an individual patient case provides an added value for validation, as this approach can be easily understood by clinicians. Finally, the batch execution mode of GLEE can be used to process large-scale simulation data that can be further analyzed with powerful statistical methods for formal evaluation.

Overall process of ssing GLIF and GLEE to facilitate knowledge management in development of CDSSs

Based on the findings documented or reported in case studies, we summarize an overall process to use GLIF and GLEE for development of CDSSs. This process consists of 12 steps: (1) identifying clinical needs of a system; (2) identifying knowledge sources; (3) initializing communications (first round) or reviewing results (later rounds) with domain experts to conceptualize or to modify system functions; (4) defining specific clinical tasks, decisions, and care processes along with the patient data required to perform the tasks and to make the decisions; (5) working with domain experts to identify potential points of interventions in care processes; (6) encoding an algorithm to conceptualize the clinical tasks, decisions, and processes; (7) encoding the specifications at computational levels; (8) performing simulations on individual patient cases; (9) performing simulations in a larger scale for formal analyses; (10) designing appropriate interventions at specific points of care processes and integrating system components; (11) deploying system and evaluating its actual use; and (12) maintaining system. It is important to note that development of CDSSs is an evolving process. It typically requires multiple rounds of conceptualization, encoding, simulation, and evaluation for successful development of a system.

Discussions

We identified three major functions and a twelve-step process of using GLIF and GLEE to facilitate knowledge management for CDSS development. Compared with other research, our unique contribution is to focus on facilitating communication between CDSS developers and domain experts. Based on many years' experience in development of CDSSs, we observed that it is unnecessary or infeasible to translate each and every piece of information from the original paper sources into a CDSS. The medical knowledge behind the useful features of a CDSS is typically a combination of small pieces of information from multiple origins. Thus, we have been moving toward an approach to starting from analyses of clinical needs and identifying the knowledge sources that can support these needs. The subsequent steps of conceptualization, encoding, simulation, and evaluation all serve for this original goal. We believe it is more promising to develop CDSSs with such clearly-defined, user-required, and focused objectives. This approach is also consistent with the theory of user-centered system design that has been widely reported in human-computer interaction research.

There are a few limitations of our studies. First, most of our experience up to now is only to use GLIF and GLEE for knowledge modeling. The actual integration of knowledge base with real world applications will introduce many further challenges. Steps 11 and 12 of the overall process summarized in the result section thus need to be further examined, refined, and reported. Second, we only focus on CDSSs that deliver patient-specific recommendations, while delivering of generic (vs. patient-specific) information in the right context can also generate significant positive impacts. In this scenario, a document model or a hybrid model can play an important role, which is what GLIF and GLEE lack of. Finally, GLIF is not a comprehensive process model. For example, it does not support quantitative temporal modeling, and it is not based on formal logic. Thus, it might not be the best choice to use GLIF for applications with such requirements.

Conclusion

GLIF and GLEE can be used as a set of tools in CDSS development to improve communication between CDSS developers and domain experts, to facilitate fast prototyping of CDSSs, and to provide multi-stage system validation. These functions are embedded within an evolving process with multiple rounds of conceptualization, encoding, simulation, and evaluation. Future studies are required to investigate the use of GLIF and GLEE in deployment of CDSSs.

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Tooth Positional Ontology Represented in OWL

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Abstract

In the practice of dentistry, few biomedical ontologies exist that support dentists' decisions or meet their clinical needs. Unlike other medical domains, a dental concept requires specific identification in terms of position. In order to assist with dentists' clinical tasks, we created a tooth ontology in Web Ontology Language (OWL) with embedded spatial relations. In this paper, we share our experiences in building and maintaining this tooth ontology.

Keywords:

tooth ontology, OWL, biomedical ontology

Introduction

Representing knowledge in a medical domain is advantageous for supporting decisions based on clinical judgment and reusing patient information for clinical research or quality assessment. An ontology provides a way to compile medical knowledge in a reusable, sharable, machine-understandable way. In medicine, research on biomedical ontologies is a response to the need of handling large volumes of patient data in a more comprehensible and effective way [1].

Although the current ontologies are designed to minimize ambiguities and redundancy, none of these ontologies have been used in dentistry. The main reason for generally accepted mereological relations, such as **part-of** and its inverse **has-part**, are complex in *classes* between material and nonmaterial entities, parthood over time, parthood and spatial location, and parthood between occurrents [2]. Ontologies built in a given domain must be foundational and robust with regard to interpretation, to prevent human-dependent semantic bias.

We do not argue that **part-of** and **has-part** are the most important roles in a biomedical ontology, but we must address the necessity of identifying more specific spatial relations. A more detailed expression may be needed to define the positional relationships among the anatomical structures in the oral and maxillofacial region, compared to other body structures.

Materials and methods

Each adult human has 32 teeth distributed evenly, with eight teeth in each quadrant: the central incisor, lateral incisor, canine, first premolar, second premolar, first molar, second molar, and wisdom tooth. Incisors and canines are front teeth that are essential to one's appearance. Premolars and molars are located in the back of the oral cavity and play an important role in chewing and digesting food. In other words, we can divide teeth into two categories: anterior (front) teeth and posterior (back) teeth.

There are four central incisors, which are classified by position as left, right, upper, and lower. When we refer to a tooth as a *Central_Incisor*, we do not know which is being indicated. To identify whether a specific tooth is positioned on the left or right, three different dental notation systems are commonly used: the universal numbering system, the Palmer Notation Method, and the two-digit World Dental Federation (FDI) notation. In this paper, we adopt the two-digit FDI notation, which is also known as the ISO-3950 notation. We insert this notation in the *ToothNumber* class.

There are three different relations connecting a physical entity to the positional quality. These properties take their ranges with their positional quale from the *Positional_Value_Partition,* which has six leaf subclasses: *Anterior, Posterior, Right, Left, Upper*, and *Lower.* The value of **hasAP_Position** is either *Anterior* or *Posterior*, the value of **hasRL_Position** is either *Right* or *Left*, and the value of **hasUL_Position** is either *Upper* or *Lower.*

In order to use the *Anterior* class as the only representation of "Anterior" value, we made **hasAP_Position** as a functional property with the restricted domain such as *Anterior* and *Posterior*. A functional property is a property that every individual to which the property applies has at most one image along the relation [3].

The class *ToothNumber* has 32 subclasses, which have the three properties listed above: **hasAP_Position, hasRL_Position,** and **hasUL_Position**.

To build and share our ontology more consistently and unambiguously, we adopted formal relationships in biomedical ontologies [4]. Since we can select symmetry as a characteristic of **co-adjacent_to** in OWL, we use it as a

vehicle to connect neighbors. For example, *W11,* one of the subclasses of *ToothNumber,* is a neighbor to *W12* and *W21*.

We defined *AnteriorTooth* that has only the **hasAP_Position** property linking to the class *Anterior* using a closure axiom [5]. Similarly, we made the classes *PosteriorTooth, LeftTooth, RightTooth, UpperTooth,* and *LowerTooth*, for the purpose of identifying position.

We can infer a class as part of another class based on this definition, which is strength of description logic. The following shows the results after classification.

Results

Given the definition of our tooth position ontology written in OWL, we expect that any tooth located anteriorly to be in the appropriate subclass of the *AnteriorTooth* class. **has_Position** relations tie the positional concept to all relevant classes. There is no inconsistency. From this result, we easily recognize which the *ToothNumber* class is in a subsumptive relation to the class *AnteriorTooth.*

Discussion

In light of the above results, we can observe the arbitrary classification of the classes *ToothName* and *ToothNumber* into the expected positional classes depending on the user's intention (*e.g., AnteriorTooth, LowerTooth*). This positional concept of teeth helps to build a dental decision support system that lets the computer know where a tooth is positioned [6].

In addition, one can modularize the other tooth-related concepts such as dental materials and dental treatments using our pre-defined positional ontology, so that the maintainability, reusability, and interoperability are easy to obtain. They are crucial features in ontology development written with OWL.

Smith et al. [4] showed that consensus was recently reached concerning the foundational relationships in biomedical ontologies. However, the real application of temporal relations has a weakness in weaving binary ontological plots with OWL. Interestingly, the temporal concept requires more than two arity, which is impossible in OWL. Although there are several approaches to enable OWL with n-arity relations, we cannot find a formal methodology to incorporate temporal concept to our ontology within OWL. Because of that, we just employ spatial relations of the several proposed relations of *Smith et al.* [4] into our tooth positional ontology written with OWL. Above practice, the application of temporal relations leaves some issues unanswered, even though temporal perspective can be a fundamental role in dentistry in order to define a missing tooth and a milk tooth sufficiently.

Conclusion

This paper shows how spatial relations are specified using a special property (**has_Position**). Well designed properties help the ontology engineer to grasp clear definitions and usage. Here, the powerful interdependent concept classification in OWL-DL allows us to build our modularized ontology.

Identifying the position of a tooth is crucial in a dental ontology since ontology users must identify a specific tooth in order to make a correct decision. For example, a tooth colored restoration should be used for a decayed anterior tooth. The main limitation of our approach is due to simplification, for which well-designed relations in OWL-DL are still necessary.

Acknowledgments

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Affiliation of a Resource Type to a MeSH Term in a Quality-Controlled Health Gateway

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Introduction

Among several quality-controlled health gateways, CISMeF ([French] acronym for Catalog and Index of French Language Health Resources on the Internet) was designed to catalog and index the most important and quality-controlled sources of institutional health information in French in order to allow end-users to search them quickly and precisely (N=14,714). CISMeF is manually indexed by a team of four indexers, which are medical librarians and systematically checked by the chief information scientist (the "super-indexer"). Its URLs are http://www.chu-rouen.fr/cismef or http://www.cismef.org.

CISMeF uses two standard tools for organizing information: the MeSH thesaurus and several metadata element sets, in particular the Dublin Core metadata format (URL:http://www.dublincore.org). The use of specific metainformation is crucial in order to improve the recall and precision of internet searches As proposed by Hoelzer et coll., CISMeF uses XML and RDF to meet these requirements.

The heterogeneity of Internet health resources led the CISMeF team to enhance the MeSH thesaurus with the introduction of two new concepts, respectively resource types (RT) and metaterms (MT). CISMeF resource types (RT) are an extension of the publication types of MEDLINE. As defined by the Dublin Core Metadata Initiative (URL: http://www.dublincore.org/documents/dcmi-terms/), a RT is used to categorize the nature or genre of the content of the resource. MeSH (term/subheading) pairs describe the topic of the resource. RT is one of the fifteen Dublin Core repeatable and optional elements.

However, the MeSH thesaurus was originally intended to index scientific articles for the MEDLINE database. In order to customize it to the broader field of health Internet resources, we have been developing several enhancements to the MeSH since 2000, including the generalization of Major/Minor weights to RT and MT.

The goal of this article is to describe and to evaluate another new enhancement of the CISMeF terminology: affiliation of a RT to a MeSH term or to a MeSH (term/subheading) pair. The main idea is to obtain a new affiliation concept [MeSH (term/subheading)\CISMeF RT] constituting a triplet, in order to be more precise during the manual indexing process and therefore during the information retrieval process. Affiliation of a RT is similar conceptually to the affiliation of SH, taking into account the respective definitions of a RT and a SH (see above).

Materials and methods

Background

Compared to the publication types of MEDLINE, the CISMeF RTs are more diverse, with specific RTs dedicated to electronic health resources, such as *association, patient information, community networks*, or *clinical guidelines*. For example, in the case of a clinical guideline about carbon monoxide intoxication, 'carbon monoxide poisoning' is the MeSH term and 'clinical guidelines' is the resource type. CISMeF RTs are organized similarly to MeSH terms and subheadings, in a hierarchical structure with subsumption relationships (allowing the explode property) and a maximum of five-level depth. The MEDLINE publication types were mainly a flat list till 2005 (see URL: http://www.nlm.nih.gov/mesh/pubtypes2005.html). Since 2006, MEDLINE publication types has also a hierarchical structure. The overall number of resources types in December 2006 is 257.

Nonetheless, this list is largely inspired by the MeSH thesaurus as 187 RTs (76%) are deliberately ambiguous because they are also MeSH terms (e.g. magnetic resonance imaging). The objective of this ambiguity is to maximize the recall then the search answers (which means the Doc'CISMeF search ORes the answers for the MeSH term and the answers for the RT) when the request contains this kind of ambiguous term. Furthermore, to be as close to a standard as possible, 28 RTs (11%) are also MEDLINE publication types (e.g. technical

Affiliation

In April 2004, the creation of medical image types led us to propose a refinement of the CISMeF terminology and thus a refinement of manual indexing procedures: for a number of specific RTs, mainly images types but not exclusively (e.g. *multiple choice quiz* also applies here),

we proposed to affiliate a RT to a MeSH term or to a MeSH (term/subheading) pair. Thus we can obtain a [MeSH (term/subheading)\CISMeF RT] triplet, where the backslash character '\' represents the RT affiliation (the slash character / represents in MEDLINE the affiliation of subheading to a term). This approach can be viewed as an extension of the affiliation of a subheading to a MeSH term. Since April 2004, all the CISMeF resources indexed with an image RT (N=1288 out of 14,714; 8.8%) have been reviewed by the five CISMeF medical librarians to check the need of any affiliation of a RT.

Evaluation

To evaluate the precision of the affiliation of RTs, we have selected the 15 diseases from the C and F MeSH trees which are the most frequently used for the indexing in the CISMeF catalogue. For the RT, we have chosen the top level hierarchy "image" because it is the most used RT for affiliation. For each MeSH term, two requests were performed: one request with floating RT (MeSH term AND image) and one request with affiliated RT (MeSH term\image). We compared the precision of the affiliation of RTs with the affiliation of subheadings in the same catalogue. We have used the most frequently employed subheading in the CISMeF catalogue: therapy (N=4,267, 29.0% of the catalogue).

Results

The number of resources with at least one affiliation of a RT is 412 (2.8%) in the overall CISMeF catalogue. This figure is significantly lower than the number of resources with at least one affiliation of a SH (N= 8,110; 55.1%; p<0.0001; Mac Nemar's test). A significant difference was also present in the evaluated sample (see Table 1) between the number of resources with at least one affiliation of a RT vs. the number of resources with at least one affiliation of a SH (39/2,019 (1.9%) vs. 1,001/2,019 (49.6%); p<0.0001; Mac Nemar's test). The number of resources with at least one affiliation of a RT (and of a SH) in the last 500 resources included in CISMeF is higher when compared to the overall catalogue. (173/500; 34.6% for RT vs. 415/500; 83.0% for SH). Nonetheless, in the sample of the last 500 resources included in CISMeF, there is still a significant difference between the number of resources with at least one affiliation of a RT vs. the number of resources with at least one affiliation of a SH (p <0.0001; Mac Nemar's test).

Furthermore, the average use of RTs per resource is also significantly lower than the average use of SHs in the overall CISMeF catalogue (1.95 vs. 4.47, p <0.0001; paired Student's T test). This result is correlated by the significant difference between the number of resources with the floating RT image (Request: MeSH term AND image) vs. the number of resources with the floating subheading therapy (Request: MeSH term AND therapy) in the evaluated sample: 344 (17.0%; 344/2,019) vs. 1,368 (67.8%; 1,368/2,019) (p <0.0001; Mac Nemar's test). In the evaluated sample, to measure the precision of the affiliation of RTs, we compared the number of resources affiliated with at least one RT of the RT tree "image" vs. the number of resources with a floating RT image (Request: MeSH term AND RT image). The ratio is 39/344 (11.3%). Therefore, in our sample, a request with an affiliated RT is nine times more precise than the equivalent request with a floating RT.

Then, to measure the precision of the affiliation of SHs, we compared the number of resources affiliated with the SH "therapy" vs. the number of resources with the floating SH "therapy" (Request: MeSH term AND SH therapy). The ratio was 1,001/1,368 (73.2%). In our sample this means that a request with an affiliated SH is only 1.3 times more precise than the equivalent request with the floating SH. The possibility to affiliate RTs has been implemented in the Doc'CISMeF search engine in every search mode (Simple, Advanced, Boolean, and Step by Step). Nonetheless, by default, this improvement will not modify the information retrieval process in the Doc'CISMeF search engine (URL: http://doccismef.chu-rouen.fr), in the Simple Search mode. As described in , this information retrieval process is based by default on implicit query processing and the algorithm is based on maximizing the recall. Implicit query processing means that the end-user does not interact with the system to improve the quality of the information retrieval. In that case, the search engine tries to maximize the mapping of the end-user's request to the CISMeF terminology. This CISMeF mapping algorithm has similarities with PubMed's Automatic Term Mapping.

For example, an ambiguous query such as "Diagnosis of choledocholithiasis with ultrasonography", will be transformed into the following Boolean query in order to provide the user with the wider range of documents likely to meet their needs, using MeSH terms, floating SHs and floating RTs: "diagnosis AND choledocholithiasis AND ultrasonography". Nonetheless, a trained user may use the affiliation of RTs (combined or not with the affiliation of SH) to obtain a more precise retrieval process. In the last example, the user may enter the triplet "(choledocholithiasis/diagnosis)\ultrasonography" to be as precise as possible if s/he is searching for an image of ultrasonography to diagnose choledocholithiasis.

To lead CISMeF users to use this refinement among others enhancements of the CISMeF terminology, two training sessions are organized on a monthly basis by the CISMeF team, targeting mainly medical students, as well as librarians and health professionals. How to use the affiliation of

RT will part of the training session as it is already the case for affiliation of a subheading.

Conclusion

Affiliation of a RT to a MeSH (term/subheading) to create a triplet allows a better precision of the information retrieval in a quality controlled health gateway

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Applying AI Model-Checking Techniques to Clinical Guidelines

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Abstract

We describe the advantages of extending computer-based approaches to clinical guidelines with the facilities provided by model-checkers developed by the AI community.

Introduction and background

Clinical guidelines represent the current understanding of the best clinical practice, and constitute an important area of research in Artificial Intelligence (AI) in medicine. Several computer-based approaches have been introduced to automatically manage clinical guidelines. GLARE (Guideline Acquisition, Representation and Execution) is a prototypical system which has been built from 1997 under the leadership of physicians of Az. Osp. S. Giovanni Battista, Turin, Italy [1]. It is a domain-independent system to acquire, represent and execute clinical guidelines, which has been tested on several guidelines, including asthma, cardiac diseases, ischemic stroke.

Recently, in AI, the *model-checking* techniques have gained an important role. They are widely used, e.g., for agent verification. In this work, we extend GLARE to explore the advantages of applying such techniques to clinical guidelines.

Methods

In order to enhance GLARE with model-checking facilities, we provided a loosely-coupled integration of GLARE with the model-checker SPIN [2]. Roughly speaking, we have devised a tool to map clinical guidelines acquired by the GLARE system into the Promela language, which is the language used by SPIN. Promela allows a high level model of a distributed system to be defined in an extended pseudo-C code, including synchronization primitives and message exchange primitives. Once we have the translation of GLARE's guidelines in Promela code, we can use SPIN as a general-purpose engine to prove any property that can be expressed in the temporal logic LTL. In fact, SPIN automatically translates each process defined in the Promela code into a finite automaton representing the global state space of the system, and the global behaviour of the system is obtained by computing an asynchronous interleaving product of automata. The property which has to be verified on the system is passed to the verifier through an interface, which maps it into a temporal formula, as required by SPIN. SPIN automatically converts the negation of the temporal formula into an automaton and computes its synchronous product with the system global state space. If the language of the resulting automaton is empty then the property is true on all the possible execution of the system (otherwise the verifier provides a counterexample for the property).

Results

The methodology above provides a way of providing GLARE with the possibility of automatically checking several types of properties concerning guidelines. Specifically, we have identified four different classes of properties:

i) **Properties concerning a guideline "per se"**. One can check if the guideline contains a path of actions satisfying a given set of conditions (e.g., a path including actions X, Y and Z, or a path nor requiring a given laboratory test, or a path requiring only a given set of resources, and so on);

ii) **Properties of a guideline in a given context.** Specific contexts may impose limitations on executable actions, related, e.g., to the lack of resources (e.g., laboratory instruments). The consequences of such limitations may be automatically checked using the model checker. For instance, the model checker can prove whether there is or not a therapy for a patient affected by a given disease, in the case a specific set of resources is available (not available).

iii) **Properties of a guideline when applied to a specific patient.** Provided that the model checker has in input all the data in the patient record, the feasibility of a given action or path of actions on the patient can be proved.

iv) **Integrated proofs.** Since SPIN is flexible and task-independent, any combination of the above types of proofs is feasible. E.g., one may ask whether, given a patient with a specific disease and set of symptoms, and given a specific set of resources, there is a path in the guideline which applies to the patient and satisfies a given set of properties.

Acknowledgements

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Development of a Specialist Medical Vocabulary for Radiation Oncology

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Abstract

Controlled specialist medical vocabularies (SMV) include some terms used in Radiation Oncology (RO), although no objective specification of the specialist medical terms used in RO has been published.

We are developing a Specialist Medical Vocabulary for Radiation Oncology (SMV-RO) using an objective and systematic method of discovery of data elements. The importance of any data element to radiation oncologists is judged according to the criterion that it was included in a report deemed worthy of publication in the RO literature.

From a defined period, 97 articles were retrieved. Analysis of 80 articles found 622 individual data elements and 2392 instances of use. Infrequent data elements comprised the majority of individual data elements (54%), and frequently used data elements were a minority (27 individual data elements with 10 or more instances of use). However these 10 data elements comprised 49.5% of the total data elements found.

Keywords:

vocabulary, controlled, radiation oncology, clinical,
specialist medical vocabulary,
oncology information system

Introduction

Radiation oncologists are medical specialists who treat cancer patients with high energy x-rays and work with software designed to minimize human error in the delivery of radiation to patients which also includes an electronic medical record module (the OIS-EMR).

Specialist Medical Vocabularies (SMV) list standardized terms devoid of relationships [1], but are the first step in defining ontologies. Any SMV should undergo frequent review to addressing inadequacies [2] as clinically unused SMVs appear to decay over periods of only 4-5 years [3].

Clinical data in a SMV format informs clinical decision making [4] and clinical outcomes, but must be stored in matching data structures in the OIS-EMR. This will enable successful data retrieval with its standardized meaning intact, which is a requirement for successful implementation of a national electronic health record (EHR) which derives its information for patient interaction.

The oncology data is a small proportion of a patient's EHR. A SMV for Radiation Oncology (SMV-RO) has not been developed, although there is some overlap with general terminologies (MeSH thesaurus, SNOMED), and specific collections (NCI's Common Data Elements dictionary for oncology trials [5]).

Research aims

We aim to document the SMV used in the domain of RO.

Research methodology

The SMV-RO should be determined by systematic extraction of terms from a corpus of text which is carefully sampled to be maximally representative.

The corpus that informs the practice and knowledge of RO is the published literature. The importance and relevance of the data sets used in the literature is determined by its acceptance for publication after peer review.

Content analysis can analyze and classify written communications in conjunction with domain specific knowledge. A methodology of "*text deconstruction*" was developed and applied by a radiation oncologist (AAM) to find and list the data elements used in a report's description of data collection, measurement and analysis. Aggregation of these data elements formed the SMV-RO. The initial manual analysis establishes a gold standard within a well defined corpus of the literature, against which to later compare automated tools.

A focused PubMed search was undertaken for articles describing the use of radiotherapy in the month of February 2006 (search "Major MeSH Heading [Radiotherapy] AND 2006/02[pdat]"). Other specialist RO journals, general oncology journals and general medical journals were also surveyed.

Results

The data collection and analysis for the first 97 articles are presented, which revealed 622 data elements used in the analysis or description of study groups. Seventeen articles did not include patient data and were excluded.

A total of 2392 instances of data element were catalogued (mean of 3.8 instances/data element). The data elements were unevenly distributed as is seen in Table 1.

Table 1 - Distribution of data elements

Frequency of occurrence	Individual data elements (count)	Total number of occurrences (sum)	% of data elements (count)	% of occurrences (sum)
5n1	523	886	84.1	37.0
10n6	44	331	7.1	13.8
15n11	25	308	4.0	12.9
20n16	9	163	1.4	6.8
25n21	3	69	0.5	2.9
30n26	6	168	1.0	7.0
35n31	3	100	0.5	4.2
40n36	5	187	0.8	7.8
45n41	2	83	0.3	3.5
50n46	2	97	0.3	4.1
55n51	0	0	0.0	0.0
60n56	0	0	0.0	0.0
Total	622	2392	100	100

The commonest data elements used include: Diagnosis (n=65), Date of Birth (n=50), Histology (n=47), Surgery Decision (n=42), Radiotherapy Decision (n=41), and Date of Death (n=38). Data elements seen once were commonest (345 occurrences), but while one to five occurrences produced 37% of the total elements found, the remaining 15.9% of data elements produced 64% of the total elements found.

Inferred data elements were common. The most frequent inferred data element is the date of event which has preeminence in the analysis of outcome in oncology reports.

Data elements were categorized into physical and temporal separations within the oncology treatment and management process as shown in Table 2.

Table 2 - Distribution of data elements within the Corpus

	Individual data elements	Total frequency of	Entries per data element (mean)
PATIENT	305	1044	3.4
Disease	240	764	3.2
Diagnosis	35	429	12.3
THERAPY	258	1232	4.8
Surgery	15	151	10.1
Radiotherapy	111	453	4.1
Drugs	20	106	5.3
Chemotherapy	71	335	4.7
Other Therapy	1	2	2
OUTCOMES	60	181	3.0
Recurrence	14	99	7.1
Response	8	37	4.6
Patient Milieu	**341**	**576**	**1.7**

Many data elements defined the tumour's characteristics (e.g., oncogenes expressed). The 'Patient Milieu' group comprises patient assessments of anatomy (imaging), physiology (blood tests), psychology (Quality of Life items), and clinical status (signs & symptoms) undertaken initially, while on treatment and after treatment, and constituted 54.8% of the total, and were used infrequently (mean 1.69 entries/data element).

Discussion

Assessments form a very large part of this SMV, although the usage frequency is low. The correlation of biological factors with clinical outcome may improve cancer therapy and indicates that authors should itemize their data sets (data elements and choices) to permit similar data collection. Other departments should be able to include new assessments into the OIS-EMR to permit medical staff to assess and record data in identical formats for later analysis. The Common Data Elements approach of the NCI is a relevant example and easily reviewed for potential terms [5].

The lack of relationships between terms within this specialist medical vocabulary were apparent. The data elements discovered always related to an event related to a patient, a patient's diagnosis, or the patient's treatment for their diagnosis. When the vocabulary is used to define an ontology and OIS-EMR, the storage of these terms should allow for reconstruction of the relationships present at collection. For example, an assessment of an entity such as depression could be measured as a psychological factor as well as part of a Quality of Life Assessment, an eligibility factor for an intervention, or a biological factor modifying the response to therapy, a prognostic factor predicting outcome, or an outcome of therapy.

To cover the complete range of assessment terms is impossible by the method we have used. The dynamic nature of oncological knowledge argues for the establishment of a modern data set with periodic updates [8], ideally through the submission of data sets by the authors of the published reports as part of the submission for publication.

Conclusion

While the vocabulary is a starting point that has successfully demonstrated that specified terms used in Radiation Oncology can be derived from the Radiation Oncology literature, further work remains to reflect the complexity of this vocabulary by the inclusion of concepts and relationships, in particular any ontology must explicitly quantify the time of measurement [6]. Future work should map this vocabulary into other systematic nomenclatures (SNOMED, DICOM, and ultimately the UMLS), as well

as seek software methods to automate discovery of new terms.

The nature of many terms already discovered argues that the OIS-EMR should possess an assessment tool that can assign assessments to the correct setting, that are scalable to include many data elements that are used infrequently and are able to be drawn from established nomenclatures.

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Development of a Specialist Medical Vocabulary For Radiation Oncology

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Specialist Medical Vocabulary For Radiation Oncology

- Radiation Oncologists (RO)
  - medical doctors
  - cancer specialists
  - all use radiation to treat cancer conditions
- Oncology Information Systems (OIS)
  - verifies & records radiation machine use
  - also has attached Electronic Medical Record
    - » The 'OIS-EMR'
- Electronic Health Record (EHR) perspective
  - our data needs to be represented
  - our information will be transferred
  - our meaning needs to be preserved

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Specialist Medical Vocabulary For Radiation Oncology

- Informatics requirements
  - Limited subspecialty area
    - Affects 25-30% of population
  - Specific data needs
    - Date-specific events
      - Necessary for reporting
    - Decisions based on a defined finite dataset
      - » DIAGNOSIS*
      - » STAGING
      - Informs discrete treatment decision
      - Produces idiosyncratic therapy sequences
    - Focused on Outcomes
      - Measured side effects of therapy & control of disease
      - Informs prognostication & therapy choices

* Most medical specialties start with a Problem or Complaint

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Specialist Medical Vocabulary For Radiation Oncology

- The "competent" OIS-EMR
  - should be based on representation of medical knowledge of Radiation Oncologists
    - Vocabulary (the right words)
    - Nomenclature (the right connections)
    - Ontology (the right framework)
  - all should be seen in ERD construction of databases

- BUT …. no vocabulary has been defined!

  - **Problem: Just ask the 'experts', or find an objective text source/corpus for Vocabulary?**
  - **Solution: objective source for Vocabulary is better**
  - Later: Is this Vocabulary embedded in existing Nomenclatures? Is a new Ontology required?

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Specialist Medical Vocabulary For Radiation Oncology

- There is an objective corpus of text
  - the RO literature
    - Read by all ROs
    - Reviewed by many ROs
    - introduces and propagates new concepts
    - Publication defines the contained data as ‘important’
  - Define time period
    - Content analysis
      - “text deconstruction”
        - » find data elements used in literature construction
        - » list according to workflow
        - » Domain-specific knowledge required

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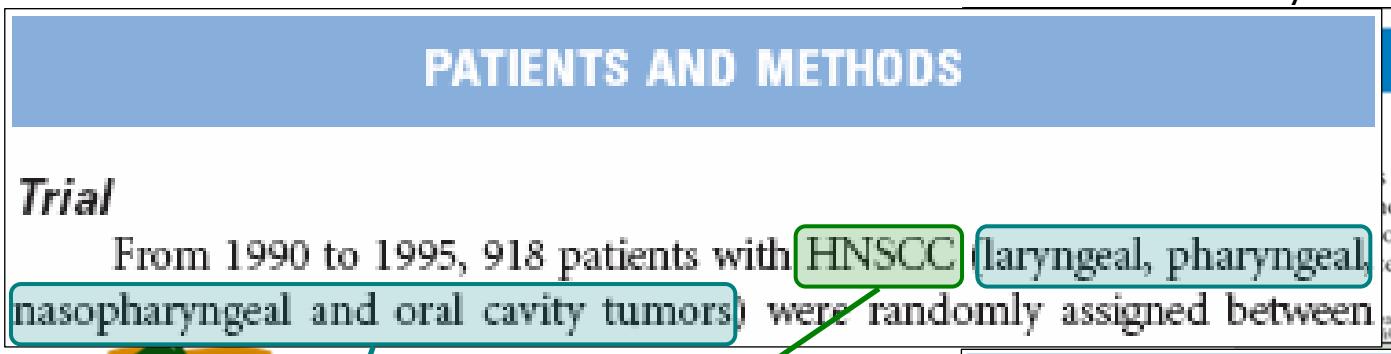
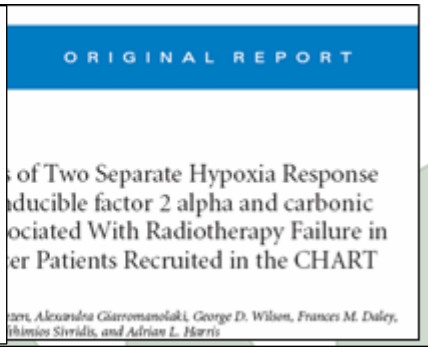
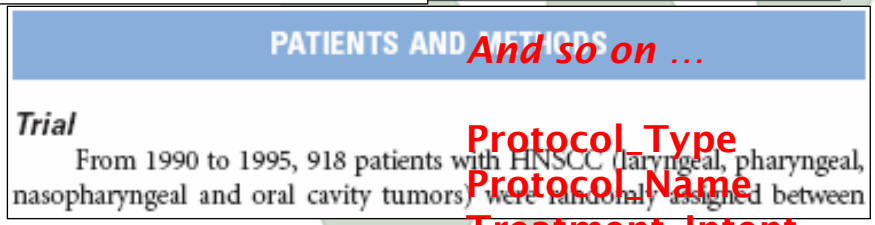
Specialist Medical Vocabulary For Radiation Oncology

text deconstruction 1.Select article 2.Read 3.Analyse text 4.collate







And so on …

Protocol_Type
Protocol_Name
Treatment_Intent
Therapy_Modality
Modality_Intent
Total_Radiation_Dose
Dose_Per_Fraction
RT_Start_Date
RT_End_Date …..

Deconstruct & categorize

- Diagnosis
- Diagnosis_classification

Categorized Data Elements

- Diagnosis
- Site
- Morphology

all classified in ICD-10
e.g. larynx – C32
"Head & Neck squamous cell carcinoma"

- CANCER SITE category
- CANCER MORPHOLOGY type

Histology confirmation

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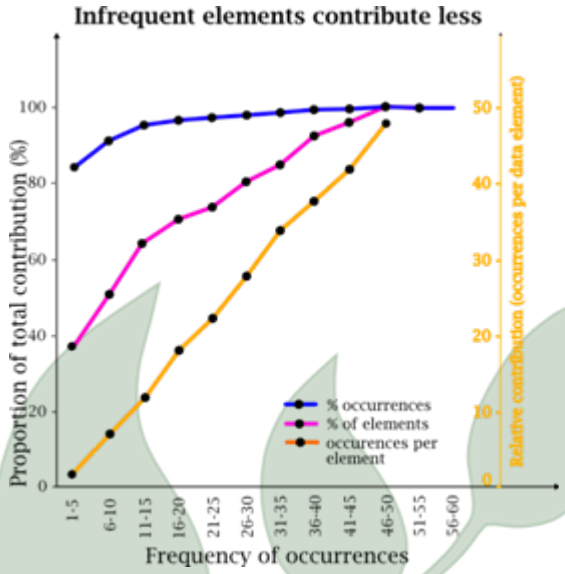
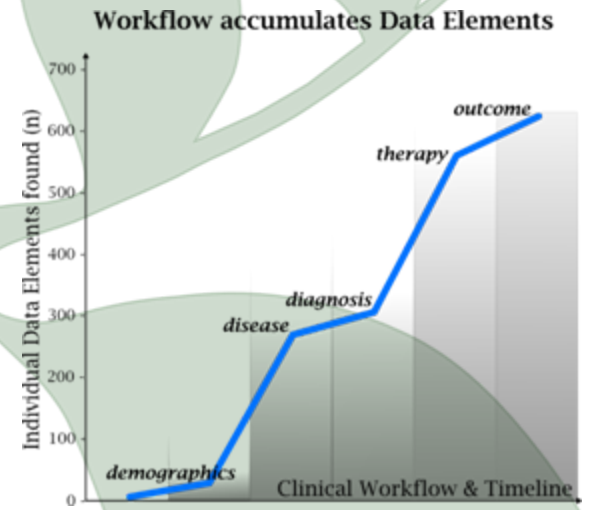
Specialist Medical Vocabulary For Radiation Oncology

- Content Analysis
  - 97 articles accessed
    - 17 unsuitable (no patient data)
  - 622 data elements found
  - 2392 occurrences of data elements found
    - many infrequent elements
      - Minor contribution to occurrences
    - few frequent elements
      - Major contribution to occurrences
  - Data elements describing patient ("Patient Milieu")
    - 54.8% of data elements
    - 1.69 per element (mean)
  - Data element accumulation is a continuous process





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Specialist Medical Vocabulary For Radiation Oncology

Conclusions

- This specialist medical vocabulary (SMV) defined manually from the literature can act as a gold standard for later automated efforts
- The SMV of clinical notes should be compared
- The SMV should be mapped to 'standard' nomenclatures and ontologies (e.g., SNOMED-CT)
- OIS-EMRs should be constructed to hold this SMV, and respect their relationships, and allow units to reproduce the same data collection as reported in the literature
  - Reports submitted for publication might be more useful if they listed the data elements used

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Specialist Medical Vocabulary For Radiation Oncology

- Further Work
  - discover SMV used in clinical notes/letters
  - map SMV into SNOMED-CT, DICOM-RT & UMLS
  - integrate into medical ontologies

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Development of hypertension management ontology for a guideline-based clinical decision support system

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Introduction_1

- In Korea, the Government leads an Electronic Medical Record (EMR) system development for the 152 public health centers, and this is planned to be expanded to a national Electronic Health Record (EHR) system.

- As a part of this project, a study on the development of clinical decision support system (CDSS) is currently being undertaken.

Introduction_2

- This study is one step in the construction of a guideline-based CDSS that will be used for hypertension management in public care settings
- A development of domain ontology is an essential part in representing knowledge in a computerized method, but it is also important for the reuse of knowledge in the interesting domain area.
- For the sharing of medical knowledge nationwide, a knowledge management method such as ontology is the main issue from the point of view of CDSS.

Materials and Methods_1

- This ontology is primarily based on the concepts extracted from 12 published hypertension guidelines, including JNC 7.

- The hypertension management ontology provides formal definitions, relationships and usage of various concepts relevant to patients with hypertension.

Materials and Methods_2

- Concepts were defined at the modeling stage, and defined concepts were classified according to semantic category.
- Relations and attributes of concepts were defined, and the Protégé 3.1.1 environment was used.
- Because the development of ontology is an iterative process, the modification and reconstruction will be continuous during the process of guideline encoding.

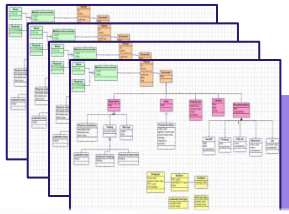
Research Process

370 concept

Collection & Classification of Concept based on JNC7

50 Rules

Collection of Term, Concept, …

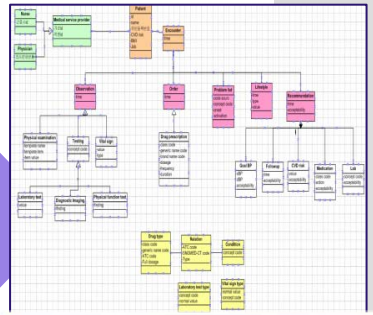


Brain storming

Specification

Conceptualization

Formalization

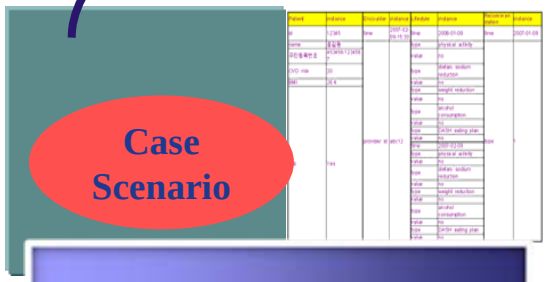


Verification of Ontology

Definition of Concept

Reference Terminology (UMLS)

Mapping to Concept, Instance, …



Case Scenario

Mapping to Ontology

CiEHR
Center for Interoperable EHR

Results_1

- In our ontology prototype, about 300 concepts relevant to hypertension management were defined.

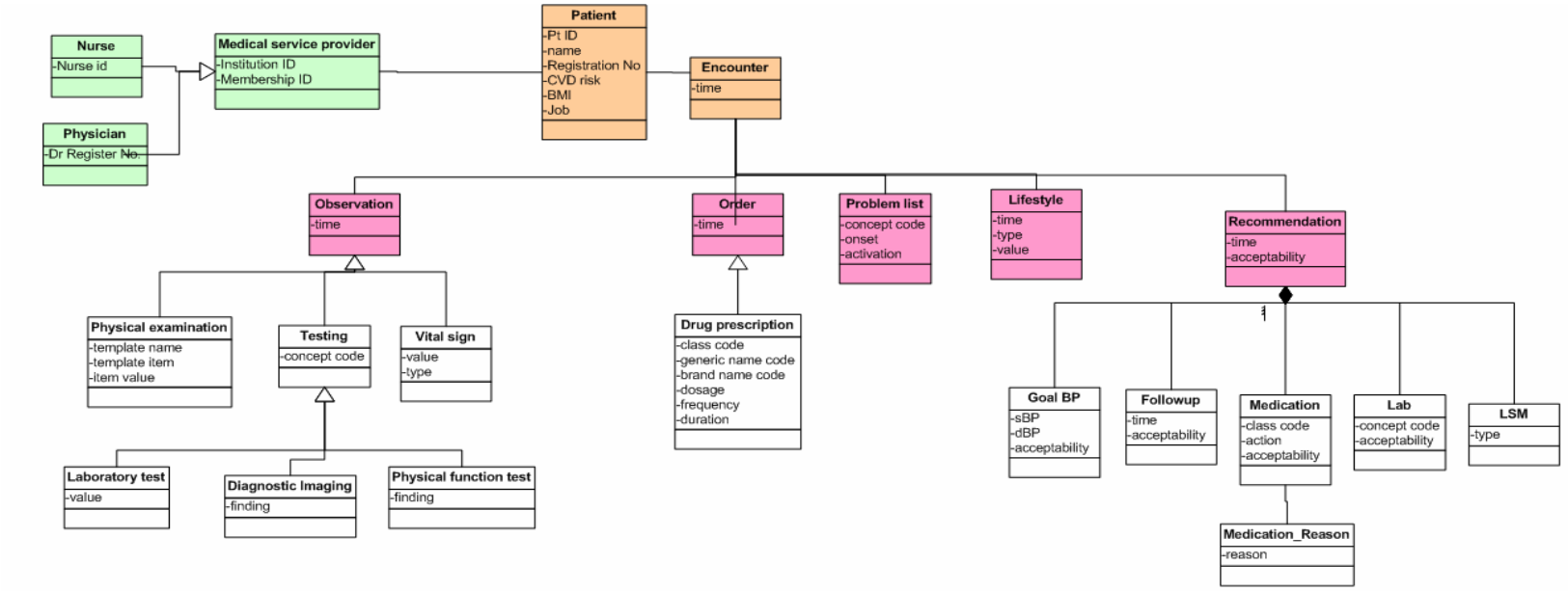
- A medication prescription, laboratory test, physical examination and other related conditions were included in the related concepts.

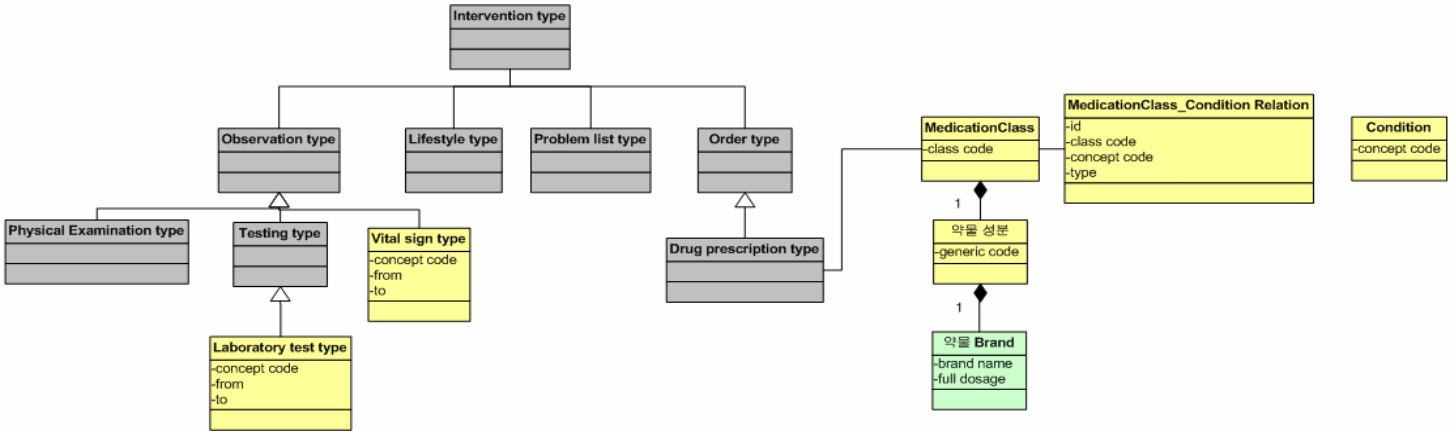
Results_2

- Based on all of this, high-level classes were defined as the main axis.

- Each class included subordinate concepts of is-a relation. After that, attributes of concepts were defined.

Domain ontology for Hypertension management





Conclusion

- Through this approach, the creation of a tool for the purpose of acquiring particular domain knowledge is expected to be easier.

- Furthermore, it is believed that the ontology of hypertension management for a guideline-based clinical decision support system will contribute to the sharing and deploying of knowledge and to the dissemination of standardized clinical guidelines through the reuse of this knowledge

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❖ Acknowledgments

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Development of Hypertension Management Ontology for a Guideline-based Clinical Decision Support System

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Abstract

For the development of a guideline-based hypertension management system, ontology was adapted as a method for enabling me to represent and to reuse the domain guideline knowledge consistently. Based on 12 of the published guidelines, including the 7th report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of high blood pressure (JNC 7), concepts extracted from the guidelines on the hypertension management and relations between concepts were identified. This ontology includes 11 high-level classes and covers over 300 low-level concepts, and it also defines instances of each concept. This work will help to create a tool for acquiring more specific hypertension knowledge and will contribute to representing, managing and sharing knowledge logic. It will also be used in the further development of hypertension guidelines.

Keywords:

ontology, hypertension management,
computerizing clinical guideline,
knowledge representation

Introduction

In Korea, the Government leads an Electronic Medical Record (EMR) system development for the 152 public health centers, and this is planned to be expanded to a national Electronic Health Record (EHR) system. As a part of this project, a study on the development of clinical decision support system (CDSS) is currently being undertaken. This study is one step in the construction of a guideline-based CDSS that will be used for hypertension management in public care settings. A development of domain ontology is an essential part in representing knowledge in a computerized method, but it is also important for the reuse of knowledge in the interesting domain area.

For the sharing of medical knowledge nationwide, a knowledge management method such as ontology is the main issue from the point of view of CDSS. Ontology has often been used to formalize a shared understanding of a domain, and it enables software applications and humans to share and reuse knowledge consistently.

Materials and methods

This ontology is primarily based on the concepts extracted from 12 published hypertension guidelines, including JNC 7. The hypertension management ontology provides formal definitions, relationships and usage of various concepts relevant to patients with hypertension. Concepts were defined at the modeling stage, and defined concepts were classified according to semantic category. Relations and attributes of concepts were defined, and the Protégé 3.1.1 environment was used. Because the development of ontology is an iterative process, the modification and reconstruction will be continuous during the process of guideline encoding.

Results

In our ontology prototype, about 300 concepts relevant to hypertension management were defined. A medication prescription, laboratory test, physical examination and other related conditions were included in the related concepts. Based on all of this, high-level classes which contained medication, clinical finding, laboratory test, patient education, problem, patient case, event, rule, therapeutic adjustment, temporal predicate and eligibility criteria were defined as the main axis. Each class included subordinate concepts of is-a relation. After that, attributes of concepts were defined.

Conclusion

Through this approach, the creation of a tool for the purpose of acquiring particular domain knowledge is expected to be easier. Furthermore, it is believed that the ontology of hypertension management for a guideline-based clinical decision support system will contribute to the sharing and deploying of knowledge and to the dissemination of standardized clinical guidelines through the reuse of this knowledge

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Poseacle: An Ontological Infrastructure for Managing Clinical Archetypes in Semantic Web Environments

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Abstract

There are currently different standards for representing and exchanging EHR information among different systems. In advanced EHR approaches, clinical information is represented by means of archetypes. Most of these approaches use ADL to specify archetypes. In this paper, an alternative representation in OWL is presented. The OWL representation has some advantages such as its formal condition, its suitability for sharing and reuse, and the possibility of reasoning over OWL content. This new representation allow for managing clinical information in Semantic Web settings.

Keywords:

Medical Informatics, Information Management, Electronic Healthcare Records, Semantic Web

Introduction

The lifelong clinical information of any person supported by electronic means configures his Electronic Health Record (EHR). As pointed out in [3], EHR systems must support life-long EHR, be technology and data format independent, facilitate sharing of EHRs via interoperability at data and knowledge levels, integrate with any/ multiple terminologies, support for clinical data structures and prioritize the patient / clinician interaction. Nowadays, there are different advanced standards and architectures [3] for representing and communicating electronic healthcare records, such as HL7 [8], OpenEHR [6] and the CEN ENV13606 [7]. Each standard defines its own information models and manages the information in a particular way. This implies that clinical information systems of different clinical organizations might differ in how electronic healthcare records are managed. Current advanced EHR standards make use of the dual model architecture approach [1]. This architecture is based on the meta-modelling of healthcare records, based on two basic principles. First, two conceptual levels are distinguished: (1) reference model, and (2) archetypes. This work is focused on the latter level. Archetypes are typically represented by using the Archetype Definition Language (ADL), which is a formal language for expressing archetypes, which are constraint-based models of domain content. However, ADL document are syntactic rather that semantic. In this paper, an alternative semantic representation, based on the Ontology Web Language (OWL) [5], which is the W3C recommendation for exchanging semantic content on the web, is proposed.

Methods

Tim Berners-Lee [2] defined the Semantic Web as an extension of the current Web, in which information is given well-defined meaning, better enabling computers and people to work in cooperation. Amongst the different available Semantic Web technologies, ontologies are considered a basic technology to promote semantic interoperability between independent and heterogeneous systems. An ontology represents a common, shareable and reusable view of a particular application domain, and they give meaning to information structures that are exchanged by information systems. In practical settings, ontologies have become widely used due to the advantages they have: reusability and shareability (see for instance [4]). The "de facto" standard language for representing ontologies is the Ontology Web Language(OWL), which can formally describe the semantics of classes and properties used in Web contents. In order to represent archetypes in OWL, a semantic interpretation of the archetype level has to be performed.

Apart from their different nature, the parsing and processing of information is also different in ADL and OWL. When parsing an ADL document, the result is an Archetype Object. This object contains the lists of codes, names of terms, constraints and so on. All the elements of these lists are strings so that the relations between the different elements must be explicitly searched for. In this sense, mistakes are more likely to be committed when defining an ADL document. Moreover, the processing of OWL content does both the parsing of the OWL and the capture of consistent clinical information, whereas ADL parsing does only obtain the information without guaranteeing the consistency of the clinical information. In fact, it does not perform any analysis related to clinical information contained in the archetype.

Results

The first step was to analyze the representation of clinical archetypes, so a semantic interpretation might be performed. Figure 1 shows the result of the semantic interpretation of clinical archetypes to produce an ontological representation suitable for being modeled in OWL. The top part of Figure 1 shows the ontological representation of the definition of an archetype and their links with issues such as translations, terms, audit information or terminologies. This part is common for any EHR architecture. The lower part of the figure contains some architecture specific items, such as the clinical data structures and data types. This OWL modeling brings all the information concerning a particular term together (code, name, binding, translations, constraints) so that a particular information item can be accessed and analyzed in its context.

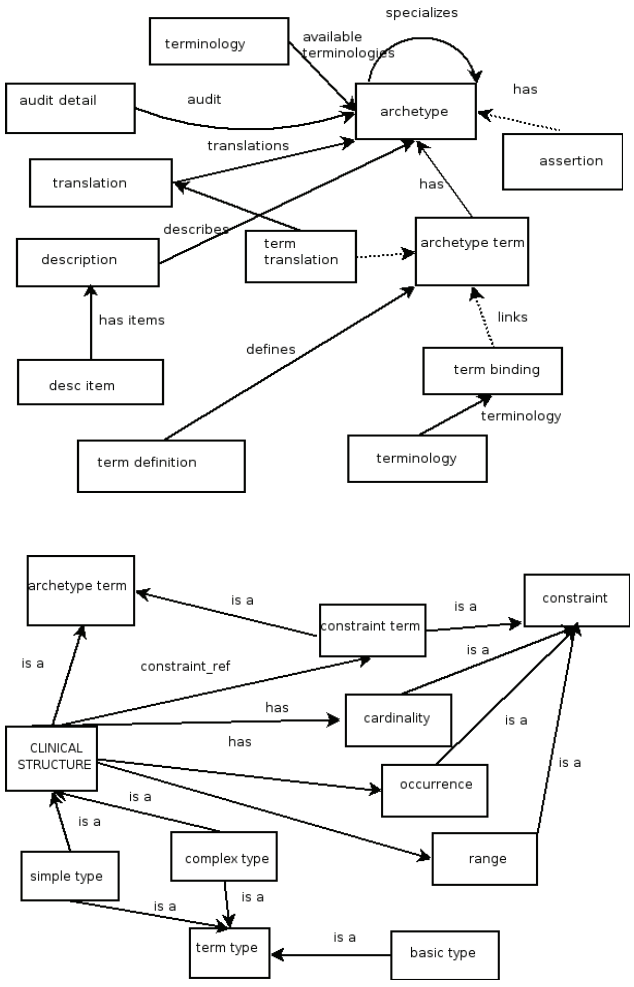

Figure 1 - Ontological representation of the semantic interpretation of clinical archetypes

Through this research work, the POSEACLE set of ontologies has been developed, providing a semantic web-oriented representation of clinical archetypes. Amongst the available EHR standards, our work has been focused on CEN ENV13606 and OpenEHR. By following the archetype approach shown in Figure 1, a set of OWL ontologies for the standards have been developed. These ontologies are available at http://klt.inf.um.es/~poseacle.

Different clinical archetypes for both CEN and OpenEHR have been manually built for clinical concepts such as measurements for Cholesterol, Creatinine, Coagulation or Blood Pressure. These archetypes can be found at the referred web portal. To simplify the use of the ontologies, an OWL archetype template is also available; then, the user only needs to instantiate the ontology to define the archetype.

Discussion and conclusions

In this work, a Semantic Web-oriented ontological modeling of clinical archetypes has been presented. This approach is based on semantic technologies rather than syntactic ones such as ADL, so that more efficient knowledge management mechanisms can be developed. As a result of this work, different ontologies have been obtained to represent archetype models for CEN and OpenEHR. Hence, the ontologies developed can also be used by Semantic Web applications in the health domain. These ontologies can be used as a starting point for defining a framework for the consecution of semantic interoperability across clinical information systems.

Acknowledgments

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[8] http://www.hl7.org

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LinkEHR: A Tool for Standarization and Integration of Legacy Clinical Data

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Abstract

It is just a matter of time that standard based information systems for medicine become completely necessary. However, the system migration can turn to a huge loss of information if the pre-standard subsystems are not integrated on the electronic health records (EHR) system. LinkEHR aims to help integrating those pre-standard subsystems into the main EHR system providing at the same time a terminology binding and semantic improvement of the information. Using archetypes known as "integration archetypes" let us to map data sources to standard based EHR information systems.

Keywords:

standardization, systems tntegration,
Electronic Health Record

Introduction

During years, the lack of a standard on Electronic Health Records (EHR) has become one of the main issues on communication and interoperability of medical systems. Nowadays, obtaining a complete patient medical record still turns into a great effort on manual integration of the distributed systems among the organization. To solve this, organizations like European Committee for Standardization (CEN), OpenEHR or HL7 are providing new standards for EHR. CEN and OpenEHR are based on a dual model methodology that makes use of archetypes to manage the separation between information and knowledge [1].

However, although new standard based systems will have a standardized reference model making systems interoperable, it is not acceptable to lose current patient medical records. There is a need for a tool that helps to integrate those non-standard EHR in some way into the new information system. LinkEHR is a multi reference model tool that gives solution to this problem allowing the creation of standard-based archetypes offering mapping capabilities on data sources.

LinkEHR Features

- Multi reference model: LinkEHR is able to handle different reference models in order to guide the archetype's definition process. The importation of a new reference models is done by analyzing the XML Schema Definition (XSD) of the imported reference model. LinkEHR currently fully supports CEN and OpenEHR standards. In fact, LinkEHR is the first archetype editor for CEN EN13606.
- Data source mapping: One of LinkEHR's main features is the capability to define mappings between archetypes and data sources. The only requirement data source must fit is to be representable as XML (such as relational data bases or XML documents). The mapping syntax allows the definition of some useful transformation functions between data sources and archetypes. Mappings are stored with the textual representation of the archetype (ADL [2]) as an extension of it. These are the so called "integration archetypes".
- Semantic validation: The creation of archetypes in LinkEHR is fully guided by the reference model and parent archetype (if it exists). LinkEHR assures that the new archetypes satisfies both the constraints stated in the reference model entity being archetype and the archetype being specialized.(subsumption operation compliance [3]).

Conclusion

Standards-based EHR are undoubtedly the future on information systems development. LinkEHR will allow health institutions to integrate existing medical records into the new systems providing a fully semantic view of stored data.

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A Physician's Decision-making Oriented Model of Cancer Chemotherapy toward Computer-assisted Chemotherapy Planning and Alerting System

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Abstract

Objective: *For the development of computer-assisted chemotherapy planning system, we present a chemotherapy planning model emphasizing on decision-making process and associated heuristic knowledge.* ***Methods:*** *We analyzed the information structure of chemotherapy regimens based on the requirements that we set. i) Creating a chemotherapy planning model emphasizing on physician's decision-making process. ii) Building up expressions to reason about particular knowledge associated with each decision-making process.* ***Results:*** *We developed a model consisting of three kinds of sub-models: an entity model of chemotherapy regimen, a process model of chemotherapy work-flow, and a model of expression language to represent decision criteria. For experiment and evaluation of the model, we implemented a prototype system.* ***Conclusions:*** *We developed a model for chemotherapy planning, which emphasize on physician's decision-making. Through the implementation of the prototype system, our model seems promising because it seems to reflect the knowledge of chemotherapy correctly.*

Keywords:

knowledge representation, decision support system, chemotherapy

Methods

We analyzed the information structure of chemotherapy regimens [1] and divided it according to the role. Also, we clarified typical scenes of decision-making in chemotherapy work-flow through discussing with physicians. To document our results of requirement analysis, we applied the Unified Modeling Language [2]. For experiment and evaluation, we developed a prototype system of computer-assisted chemotherapy planning and alerting system based on the proposed model.

Results

Classification of chemotherapy knowledge

We classified the knowledge of chemotherapy into three categories. 1) Entities of chemotherapy. 2) Process of chemotherapy work-flow. 3) Heuristic knowledge for a physician to intervene in a chemotherapy schedule. Then, we developed sub models for each category: an entity model of chemotherapy, a process model of chemotherapy work-flow, and a model of expression language to represent decision criteria.

Entity model of chemotherapy

Figure 1 shows an entity model of chemotherapy. *Therapy cycle* class consists of *Chemotherapy drug* class that has a standard dosage, a dosage rate, a maximum dosage, and an administration specification as attributes. An administration schedule is conducted by the *Date allocation* class and the administration specification.

Recommendations, which consist of combination of a specific patient status and a therapy action, are important for decision-making of a physician. *Pretreatment evaluation* is carried out at the time of beginning of chemotherapy, therapy cycle, and daily administration. When a patient status doesn't meet each criterion, discontinuance of chemotherapy or therapy cycle is recommended. *Dosage modification* represents a recommendation of modification of a drug dosage according to a patient status.

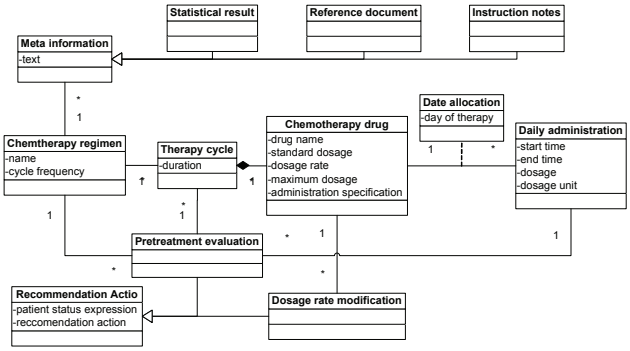


Figure 1 - The entity model of chemotherapy regimen

Process model of chemotherapy work-flow

Whole chemotherapy work-flow consists of repetition of a therapy cycle, and a therapy cycle consists of repetition of a daily administration. There are four kinds of decision-making process in those repetitions, *Pretreatment evaluation of chemotherapy, Pretreatment evaluation of therapy*

cycle, Pretreatment evaluation of daily administration, and *Dosage modification of chemotherapy drug.* Figure 2 shows a perspective of a work-flow of chemotherapy.

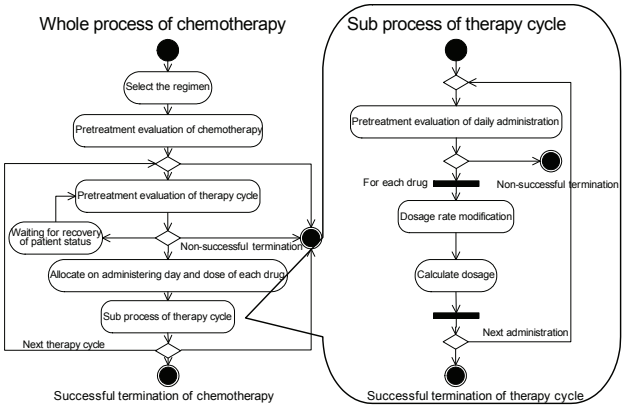
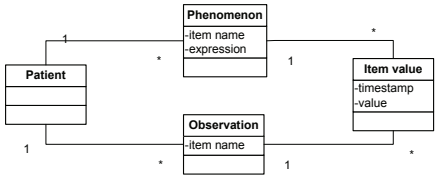


Figure 2- Perspective of a work-flow of chemotherapy

Model of expression language to represent decision criteria

To construct decision criteria by building up expressions to reason about a particular status of a patient, we defined a data model of a patient and a model of rule expression language including decision criteria (Figure 3). Here, decisions about patient status often depend on the past data as well as on the current data. Therefore, the effective time of the data has to be specified as *Time Context* in our model.



(1) Observation("creatinine") .greaterThan(2.0, "mg")

(2) Phenomenon : NCI-CTC Leukocytes grade:
IF Observation ("leukocyte").greaterThan(4000, "ul")
THEN Phenomenon("Leukocytes grade").setItemValue(0)
IF Observation ("leukocyte").lessOrEqual (4000, "ul")
AND Observation ("leukocyte").greaterThan(3000, "ul")
THEN Phenomenon("Leukocytes grade").setItemValue(1)
...
(3) Dose Modification of Doxorubicin: Time context: 14days
IF Phenomenon("Leukocytes grade").greaterThan(3)
THEN Decrease Doxorubicin to 50% dose

Figure 3 - Data model of patient and examples of heuristic rule expression. (1) "Serum creatinine is greater than 2.0mg" (2) Definition of Phenomenon "NCI-CTC Leukocytes grade" decision criteria. (3) Decision criteria of dosage modification of doxorubicin

Implementation of a prototype system

For the experiment of the proposed models, we developed a prototype system for chemotherapy planning and alerting. The entity model and the rule expression language were combined into structured chemotherapy regimen and became knowledge base of the prototype system. An overview of the system architecture is shown in Figure 4. There are two functions in the system. 1) Providing decision support for a physician to create an administration schedule. In each decision-making process such as pretreatment evaluation and dosage modification, system evaluates a decision criterion according to a patient status. 2) Providing real-time notification for the physician. When the dosage should be modified according to additional patient data, the system sends a recommendation message to the physician.

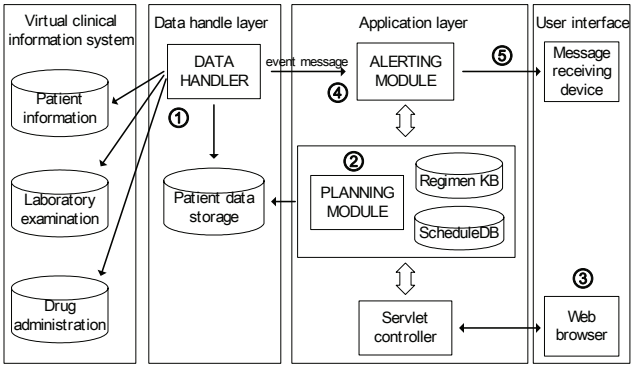


Figure 4 - 1) Different kinds of patient data are collected and unified into data storage. 2) PLANNING MODULE provides an administration schedule while evaluating recommendation criteria. 3) A physician can operate planning module to create an administration schedule. 4) ALERTING MODULE is evoked by DATA HANDLER and evaluates a drug dosage, cooperating with planning module. 5) When the drug dosage should be modified, alerting module sends a recommendation massage to the physician

Conclusion

We presented a model for chemotherapy planning consisting of three kinds of sub-models: the entity model of chemotherapy regimen, the process model of chemotherapy work-flow, and the model of expression language to represent decision criteria. Using this model, we implemented a prototype system for supporting chemotherapy planning and alerting. Our model seems promising because it seems to reflect the knowledge of chemotherapy correctly.

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A Physician's Decision-making Oriented Model of Cancer Chemotherapy toward Computer-assisted Chemotherapy Planning and Alerting System.

Yoshimasa Kawazoe [1] , Toru Endo [2] , Yutaka Mitsuishi [2] , Kengo Miyo [3], Kazuhiko Ohe [1]

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Objective

- **Developing a computer-assisted cancer chemotherapy planning and alerting system.**
  - To prevent iatrogenic injury.
  - To improve patient safety and quality of care.

For that purpose…

- **Presenting a model of chemotherapy planning.**
  - Emphasizing physician's decision-making process.
  - Representing associated heuristic knowledge.

Methods

- **Analyzing**
  - Analyze an information structure of chemotherapy regimens [1] and categorize it.
  - Clarify typical scenes of decision-making through discussing with physicians.
- **Representing**
  - Document out our models using Unified Modeling Language [2].
- **Developing**
  - Develop a prototype system based on the proposed models.

Results

- **Classified and expressed the knowledge of chemotherapy into three categories.**

  a. Entities of chemotherapy.

     Entity model of chemotherapy.

  b. Process of chemotherapy work-flow.

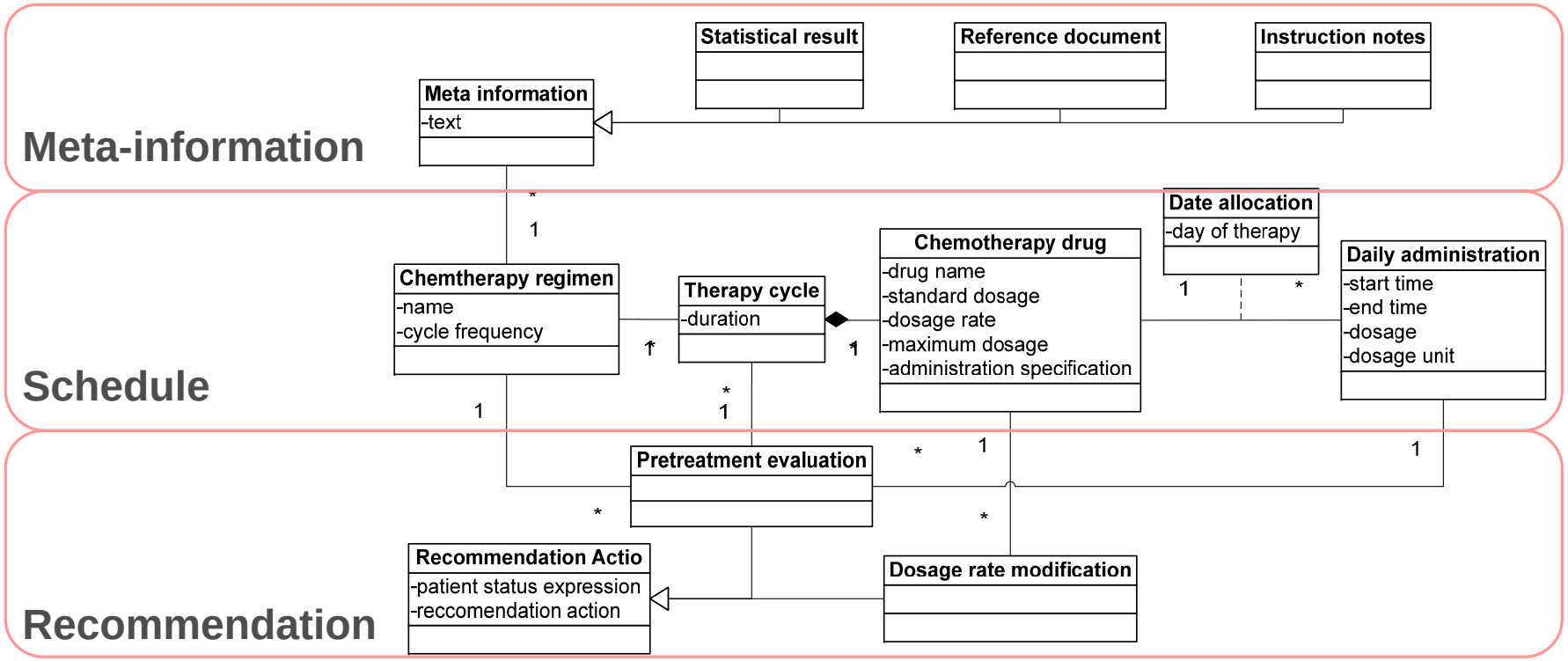
     Process model of chemotherapy work-flow.

  c. Heuristic knowledge to intervene in a chemotherapy planning.

     Model of expression language to represent decision criteria and therapy actions.

Results - a. Entity model

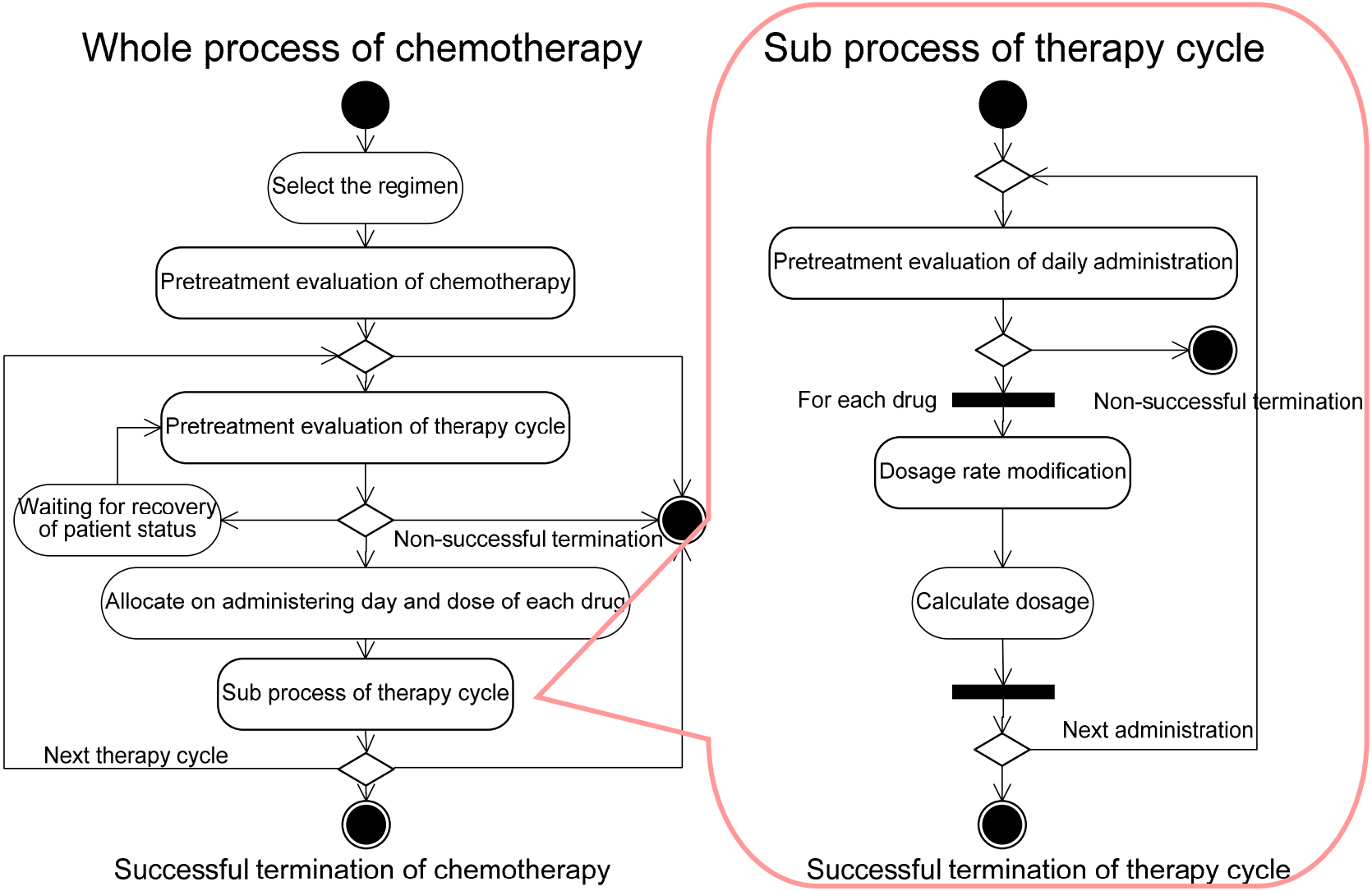
- Administration schedule of chemotherapy drug.
- Recommendation criteria of therapy actions.
- Meta-information about chemotherapy.



Results - b. Process model 1

- **Whole chemotherapy process consists of repetition of a therapy cycle.**
- **Therapy cycle consists of repetition of a daily administration.**
- **Four kinds of scenes of decision-making in those repetitions.**
  - Pretreatment evaluation of chemotherapy.
  - Pretreatment evaluation of therapy cycle.
  - Pretreatment evaluation of daily administration.
  - Dosage modification of chemotherapy drug.

Results - b. Process model 2



Results - c. Expression language

- **Recommendation criteria of therapy actions.**
  - Represented as a rule expression including classes of *Observation* and *Phenomenon*.
  - Expiration date of patient data has to be specified as *Time Context* for automated data retrieval.

Dosage Modification of Doxorubicin in CHOP

Time context: 14days

IF Phenomenon(“Leukocytes_grade”).greaterThan(3)

THEN Decrease Doxorubicin to 50% dose

Results - Knowledge base

- **Structured chemotherapy regimen.**
  - An Entity model and a model of expression language are combined.

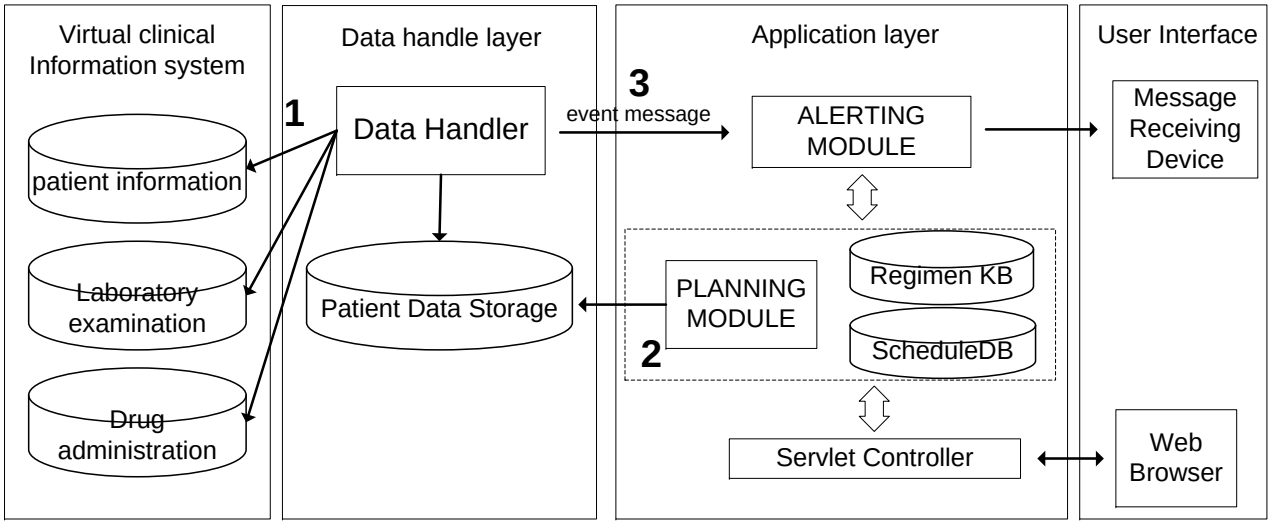
Example of a structured chemotherapy regimen of “CHOP”

```
<regimen name="CHOP" code="001" cycle_frequency="5">
  <therapy_cycle duration="21">
    <pretreatment_evaluation time_context=”14" unit=”day”>
      <lhs_expression> phenomenon(NCICTC_Leukocytes_Grade).greaterThan(3) </lhs_expression>
      <rhs_expression> Recommend beginning at the cycle to be postponed </rhs_expression>
    </pretreatment_evaluation>
    <chemotherapy_drug name="vincristine" standard_dosage="1.4" max_dosage=”2.0” dosage_unit=”mg”>
      <date_allocation> 1 </date_allocation>
      <administration_method route=”iv”>
        <division unit=”min”>60</division>
      </administration_method>
      <dosage_modification time_context=”14" unit=”day”>
        <lhs_expression> phenomenon (NCICTC_Leukocytes_Grade).greaterThan(2) </lhs_expression>
        <rhs_expression> Recommend reduce to 80% dose </rhs_expression>
    .....
```

Results - Prototype system

- **Two types of applications.**
  - **Planning module** provides a chemotherapy schedule while evaluating recommendation criteria.
  - **Alerting module** provides a notification message.

Overview of the prototype system architecture



1. Retrieve patient data from virtual clinical information system.
2. Reason about chemotherapy schedule according to the patient status.
3. Send an event message to alerting module.

Conclusion

- **We have presented the model of chemotherapy planning.**
  - Entity model of chemotherapy.
  - Process model of chemotherapy work-flow.
  - Model of expression language to represent the decision criteria and therapy action.
- **Through the implementation of the prototype system,**
  - Enables the system to support physicians appropriately in the chemotherapy work-flow.
  - Seems to be useful for preventing physicians from overlooking the information about patient.

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Design of an Ontology on Cerebral Aneurysms: Representing the Conceptual Space of the @neurIST Project

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Introduction: @neurIST

- The aim of the European project @neurIST (2006-2009)[1] is the provision of an integrated information structure related to intracranial aneurysms and subarachnoid hemorrhage. The expected benefit for clinicians and scientists includes the support of diagnosis and treatment planning, particularly with regard to aneurysm rupture risk, and an easier access to knowledge in the field, provided by a set of elaborate software tools and platforms.

Disease ontology

- A controlled vocabulary (e.g. an ontology) intends
  - To define a common vocabulary: using textual definitions, hierarchies, relations
  - To make domain assumptions explicit
  - Agreement on meaning

- Task according to DoW: “An ontology binding together the different levels of description of the disease intracranial aneurysm (e.g. from a clinicians or a geneticist’s view) and different sources of information (e.g. literature, clinical databases, image databases).”
  - Intended application contexts: text mining, semantic data mediation

„All relevant entity types …“

- Conceptual space of the project:
  - Clinical Medicine
  - Molecular Biology
  - Epidemiology
  - Simulation
  - Disease
  - Risk factor
- Classification of entities like…
  - Patient
  - Hypertensive Disease
  - Severe Headache
  - Sudden Onset
  - Intracranial Aneurysm
  - Aneurysm Rupture
  - Middle cerebral artery
  - Excessive Coffee Consumption
  - High Risk
  - Mortality
  - Shear stress

Materials and Methods

- Tools
  - Protégé ontology editor
  - OWL DL, Reasoner
- Reference ontologies and terminologies
  - Upper Level: DOLCE
  - Anatomical entity types: Foundational model of anatomy (FMA)
  - Links to Unified Medical Language System (UMLS), SWISSProt, Entrezgene
- Sources of relevant entity types (concepts)
  - clinical databases and information models (CRIM)
  - literature (high frequency domain specific terms extracted from abstracts)
  - domain experts
  - the UMLS metathesaurus and
  - open source databases (e.g. in the molecular biology field)

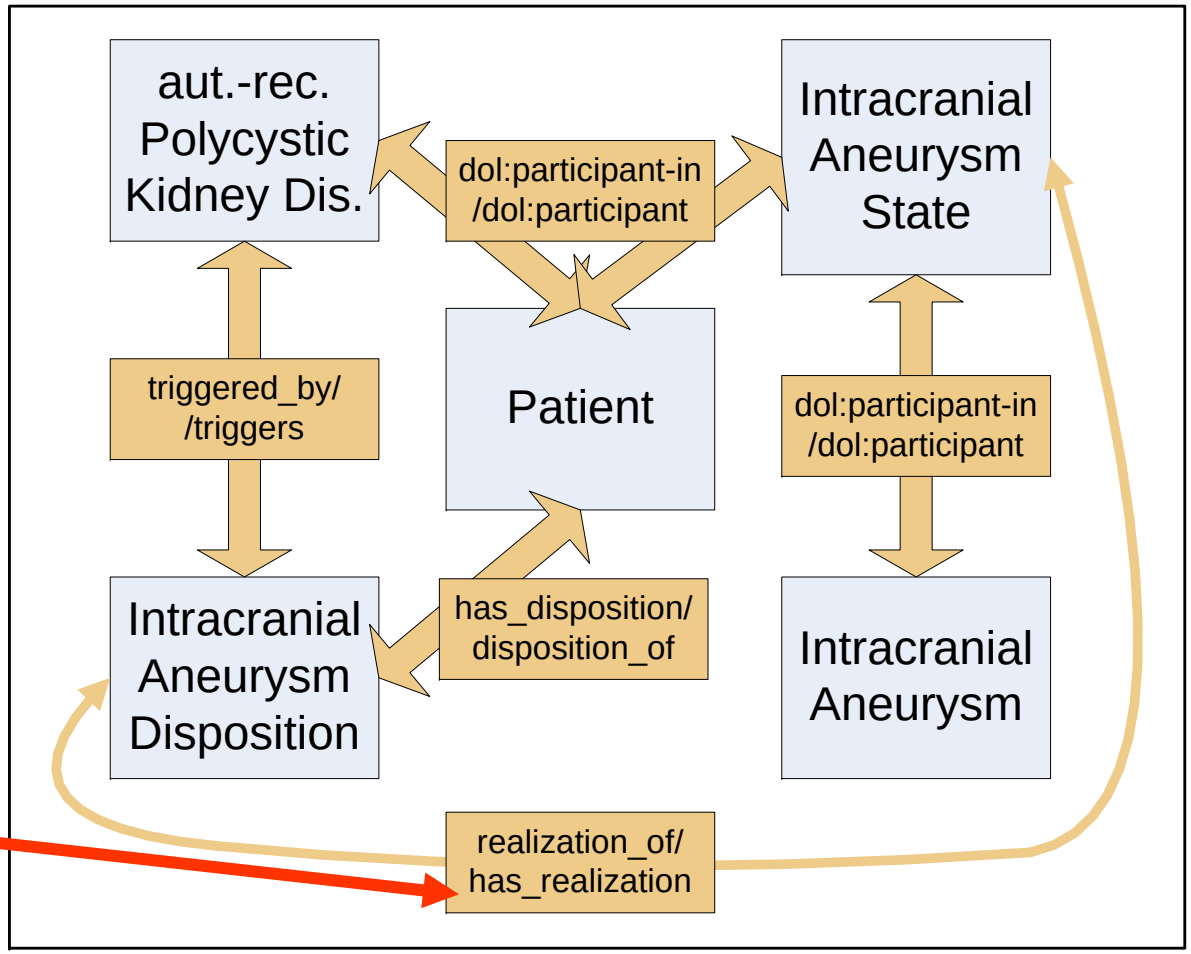
Ontology Design

- Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) [2] as the basic onto-logical framework (DOLCE-Lite)
- Top-Level ”Particular” subdivided in terms of:
  - Endurants (including object- and substance-like entities, e.g. “Internal Carotid Artery”, “Blood”)
  - Perdurants (event- and state-like entities, e.g. “Angioplasty”, “Hypertensive Disease”)
  - Qualitys (individual attributes, e.g. “Blood Pressure”, “Sex”) and
  - Abstracts (mainly conceptual “regions” for structuring attributes – “values”, e.g. “Male” as a possible value for the quality “Sex”)

Results

- Coverage
  - 2000 entity types, which mostly belong to the realm of clinical medicine, throughout classified according to DOLCE top level categories
  - 86 properties (relations, e.g. part-of, participates-in)
  - Mapping to Unified Medical Language System in 51%
- Model of the conceptual space
  - see next slide for an exemplary model of a possible clinical situation in the project:
  - a “patient”, for example, participates in a disease (“Intracranial aneurysm state” which is the pathologic state of bearing an aneurysm), an “intracranial aneurysm (which is an anatomical abnormality) participates, too. The patient suffers from polycystic kidney disease; a fact which according to epidemiological knowledge leads to an increased probability for aneurysm development (i.e “triggers” the disposition to develop an aneurysm).
- Usability supported by:
  - “Particular in Context”: additional hierarchy for the representation of entity types in certain application-related contexts of human knowledge, including the possibility to extract ontology subtrees according to user’s needs, for example for text mining purposes
  - synonym database provides lexical information
  - Web Browser provides easy access to ontology content

Model - Example for a view on Intracranial Aneurysm: @neurIST ontology view on the disease



- Associated Probability

The @neurIST Ontology

Taxonomy

- __Arbitrary_Sum
- Non_Physical_Endurant
- Physical_Endurant
  - Amount_of_Matter
  - Physical_Object
    - Anatomical_Space
      - Subarachnoid_Space
      - Subdural_Space
    - Manufactured_Object
    - Material_Anatomical_Structure
      - Anatomical_Abnormality
      - Biological_Macromolecule
        - Protein
        - Structural_Gene
      - Embryonic_Structure
      - Fully_Formed_Anatomical_Structure
        - Cardinal_Body_Part
        - Cell
        - Cell_Part
        - Organ
        - Organ_Part
        - Organ_System
        - Organ_System_Subdivision
    - Organism
    - Population_Group

Cell | Change Entity | Search Entity

UMLS Identifier (CID)

C0007634

Definition

"The basic structural and functional unit of all organisms. Includes the plasma membrane and any external encapsulating structures such as the cell wall and cell envelope" [GO:curators] (Gene Ontology). "Anatomical structure that consists of cytoplasm surrounded by a plasma membrane, with or without the cell nucleus; together with other cells and intercellular matrix, it constitutes tissues. Examples: lymphocyte, fibroblast, erythrocyte, neuron" (Digital Anatomist)

Restrictions [to be done]

Lexical Information

Pref. Term	Synonym	Language	Source
1	Zelle	de	UMLS
1	cell	en	UMLS
0	normal cell	en	UMLS
1	cellula	la	UMLS
1	celula	sp	UMLS

Version Info

Different views on entities

- Representation of entity types in certain application-related contexts of human knowledge:
  - Clinical
  - Epidemiological
  - Biomolecular
  - Simulation
  - Risk Factor

- Classification of “Tobacco Smoking”?
  - “Tobacco Smoking” is a consumption habit.
  - What was discovered later:
    - “Tobacco Smoking” has a certain influence on the state of the human body
    - “Tobacco Smoking” is associated with certain pathological states (diseases)
    - “Tobacco Smoking” causes certain pathological states (diseases)

- “Tobacco Smoking” is a risk factor for aneurysm rupture” <=> View on a consumption habit as “risk factor” – in epidemiological and clinical context!

Conclusion

- The @neurIST ontology provides a structured representation of the conceptual space using DOLCE:
  - the use of the DOLCE upper level categories facilitated a classification of the @neurIST entity types in the difficult field of clinical terminology with its often vaguely defined vocabulary
  - substantial coverage of the @neurIST conceptual space is already achieved
- The ontology is currently used for text mining purposes
  - application for semantic mediation discussed

Acknowledgements

- This work was generated in the framework of the @neurIST Integrated Project, which is co-financed by the European Commission through the contract no. IST-027703.(http://www.aneurist.org).

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Design of an Ontology on Cerebral Aneurysms: Representing the Conceptual Space of the @neurIST Project

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Abstract

Ontologies are designed to represent knowledge, and to support the semantic interoperability among heterogeneous, distributed sources (e.g. databases or web sites) by providing machine-readable descriptions of entity types (concepts) in a domain. We describe our approach to a domain ontology which is currently under development within the scope of the European project @neurIST, intended to serve as a module in a complex architecture aiming at the provision of a better understanding and management of intracranial aneurysms.

Keywords

Medical Informatics Applications; Ontology design; Intracranial aneurysm; Terminology

Introduction

The aim of the European project @neurIST [1] is the provision of an integrated information structure related to intracranial aneurysms and subarachnoid hemorrhage. The expected benefit for clinicians and scientists includes the support of diagnosis and treatment planning, particularly with regard to aneurysm rupture risk, and an easier access to knowledge in the field, provided by a set of elaborate software tools and platforms. In this paper, we describe our approach to the design of an ontology binding together the different levels of description of the disease intracranial aneurysm (e.g. from a clinicians or a geneticist's view) and different sources of information (e.g. literature, clinical databases, image databases).

Materials and Methods

Following the current state of the art of Semantic Web technology we use the ontology editor Protegé and OWL DL as a description language. The logical consistency of the ontology during the editing process is ensured by the RacerPro OWL reasoner . In the first place, we intend to reuse existing terminology sources (as the UMLS) and widely acknowledged ontologies like the Foundational Model of Anatomy.

Acquisition of types and relations

The first step to the identification of relevant entity types ("concepts") consists in collecting terms, terms describing disease and patient as well as terms related to technical devices and data structures used in the process of description, therapy and prognosis. Sources of relevant entity types in the domain were 1. clinical databases and information models (CRIM), 2. literature (high frequency domain specific terms extracted from literature), 3. domain experts, 4. the UMLS metathesaurus, and 5. open source databases (e.g. in the molecular biology field)

Ontology Design

Top level: Particular

We chose the *Descriptive Ontology forLinguistic and Cognitive Engineering (DOLCE*) [2] as the basic ontological framework of our ontology and included its DOLCE-Lite-Plus version via the OWL import mechanism. The root of DOLCE's top level ontology is named "particular". This reflects a consensus among top-level ontologies: The ontology is a system of semantic types which define classes of particulars (individuals or instances), and not of concepts in the sense of entities of mind. According to DOLCE, "particulars" are further subdivided in terms of:

- Endurant (including object- and substance-like entities, e.g. "Internal Carotid Artery", "Blood")
- Perdurant (event- and state-like entities, e.g. "Angioplasty", "Hypertensive Disease")
- Quality (individual attributes, e.g. "Blood Pressure", "Sex") and
- Abstract (mainly conceptual "regions" for structuring attributes – "values", e.g. "Male" as a possible value for the quality "Sex")

Results

Coverage

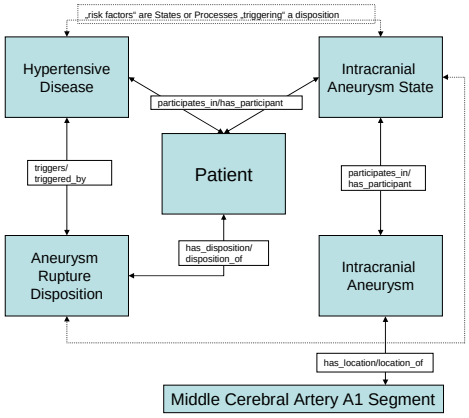
The actual representation of the domain covered by the @neurIST project includes over 2000 entity types, which

mostly belong to the realm of clinical medicine. They are classified throughout as perdurants, endurants, qualities and value ranges. Logical descriptions link nodes from different branches of the taxonomy, for example: The relation "participates_in/ has_participant" links e.g. patient ("human"), pathologic anatomical entity, and disease.

Model

Fig.1 shows a model of an exemplary clinical situation: A "patient", for example, participates in a disease ("Intracranial aneurysm state" which is the pathologic state of bearing an aneurysm), an "intracranial aneurysm (which is an anatomical abnormality) participates, too. The patient suffers from hypertensive disease; a fact which according to epidemiological knowledge leads to an increased probability for aneurysm rupture and subarachnoid hemorrhage.

Fig. 1: Model of a possible clinical situation in the project



Usability

A synonym database linking to the ontology classes provides a variety of names and acronyms used by partners in their own research areas. - We introduced a second hierarchy for the representation of entity types in certain application-related contexts of human knowledge (Particular in Context), including the possibility to extract ontology subtrees according to user's needs, for example for text mining purposes. - Finally, a web browser is under development which will provide easy access to the ontology content.

Discussion

Are top level categories necessary? In contrast to 'lightweight' ontologies, which focus on a minimal terminological structure (often just a taxonomy) fitting the needs of a specific community, the main purpose of foundational ontologies like DOLCE is to *negotiate* meaning, either for enabling effective cooperation among multiple artificial agents, or for *establishing consensus* in a mixed society where artificial agents cooperate with human beings. It is our experience that the use of the upper level categories facilitated a classification of the @neurIST entity types in the difficult field of clinical terminology with its often vaguely defined vocabulary. Our choice to use DOLCE depended on the estimation that an ontology with a "cognitive bias" was more appropriate for the representation of a conceptual space covering several scientific domains with their different views on the disease, than the more realistic, fundamental approach of the BFO (Basic Formal Ontology). While DOLCE aims at capturing the ontological categories underlying natural language and human commonsense, BFO claims that "each ontology (*SNAP* and *SPAN*) represents some partition of reality" [3]. In addition, DOLCE has been applied in the restructuring of the WordNet Lexicon with good results. [4]

Conclusion

In our opinion, a classification of the entity types from the @neurIST CRIM (describing mainly the clinical aspects of intracranial aneurysms) according to the Descriptive Ontology for Linguistic and Cognitive Engineering results in a sound classification of the domain, while a the separate presentation of human knowledge meets user's needs of a classification and concept representation in certain contexts.

Acknowledgements

This work was generated in the framework of the @neurIST Integrated Project, which is co-financed by the European Commission through the contract no. IST-027703. (http://www.aneurist.org).

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A Data Structure For Decision Support Systems, Medical Expert Systems and Clinical Decision Making

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Abstract

The International Classifications of disease (ICD10) is normalized the into a relational containing tables for the etiology, body regions, organs, pathogenesis, cells, subcellular organelles, direction of change, time course and degree. Functions and morphology of different organs are abstracted into the general organ. The hierarchal structures of the etiology and anatomy are implemented. The database enables the construction of diagnoses according to the equation d:=e+o+p, where d, e, o and p each is a variable holding names of a diagnoses, etiology, organ and pathogenesis, respectively. Together, the data structure and the equation d:=e+o+p allow structured clinical decision making and a combinatorial classification.

Keywords:

classification, database normalization, clinical decision making, computer decision support system, medical expert system, education

Introduction

Computerized medical decision support systems (CDSS) and medical expert systems (MES) need to be based on a clear and versatile data structure. Both CDSS and MES require a knowledge base containing the etiology, organs and their parts, and the pathogenesis. However, etiology and pathogenesis are used differently in different settings and their meaning overlaps. A clear concept of a general organ as an object, that abstracts functions and morphologically different components, are also lacking.

The present study aims to extract etiology and pathogenesis from dependencies in ICD10 and ICF and normalize ICD10 into a database. The dependences were identified semiautomatically using an application crafted for the goal. The database is used to create a combinatorial classification and construct diagnoses.

Materials and methods

Hardware and software

The programs and databases were run on ordinary PC's. MS Access 97® was used as database. The applications were implemented in MS Visual Basic 6® (VB6) using ADO to connect to the database [1]. All work on the classification was done interactively.

Normalization of ICD10

An English version of ICD10 was downloaded from WHO [2], and a Norwegian version from KITH [3]. ICD10 was converted it into Boyce Codd Normal Form (BCNF) [4,5] by identifying the entities and attributes of diseases in ICD10. An Entity-Relationship model (ER) was built from the entities, their attributes and relationships [4,5], storing the entities in separate tables.

The lists containing codes and diagnoses in ICD10 were automatically transferred from the sequential text files into a database table with fields for tagging. A VB6 application was developed to identify words with standard medical prefixes and suffixes associated with the etiology, pathogenesis, morphology and direction of change. The collection of tables is called a combinatorial classification

Results

Functional dependencies in ICD10

ICD10 shown to contain dependencies such as 'due to use of', 'due to' and 'of presumed'. Altogether 76 different dependencies were identified. The dependencies were used to automatically parse and display dependenciesand transfer them to the appropriate tables combinatorial tables. The process iterated until the whole ICD10 had been examined for dependencies.

The etiology is defined as all agents that cause disorder and are external to the individual in time (heredity) or space. Nymerous etiological agents were detected in ICD10. Anatomical regions were identified >184 diagnoses. The direction of change is given by the prefixes a, hypo, normo, hyper, dys, meta and neo. A total of 173 diagnoses with the direction of change were identified. Names organs and organ parts were common in ICD10 diagnoses. The general organ is an abstraction of features common to all organs: the parenchyma, tube systems, cavities or slits, and the functions and morphology of these three parts. Mechanical, electrical, chemical and optic functions were described in ICD10. Thus, the entities eti-

ologi, region, direction of change, organ (part), general organ functions, degree, time course are required for a combinatorial classification created from ICD10. In addition, morphological deviations require a separate entity. Surprisingly, ICD10 contained only six diagnoses related to organelles, but this is sufficient to require an organelle entity.

The pathogenesis is defined as a relation between organs and between cells. The pathogenetic mechanisms were identified by suffixes, disorders of mesenchyme, intercellular metabolism and regulators immunological reactions, disturbances of coagulation and psychic reactions. These elements were allocated to the pathogenesis entity.

Diseases and dagnoses as ternary relations

Causal connectives between the etiology, organs or cells and the pathogenesis were identified. In particular infection can be seen as a ternary complex consisting of microorganisms (etiology), functional and/or morphological disorder in the primary affected organ or cell, and immunological reactions (pathogenesis). Allergy also becomes a ternary concept where the etiology is some allergen, and the organ and pathogenesis are the same as in infection. All the above entities give rise to the entity-relationship diagram (Fig. 1).

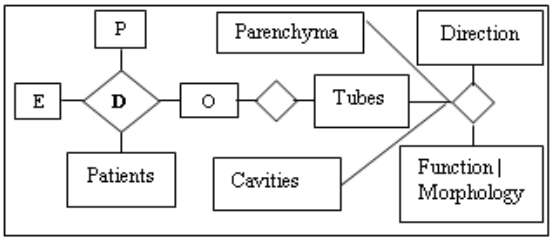

Figure 1 - Entity-relationship (ER) diagram modeling diagnoses or diseases (D), showing the relations of d to the etiology (E), organs (O) and pathogenesis (P). Organ is decomposed into the organ parts cells, tubes and cavities. These subcategories combine with the direction and function or morphology to make out a diagnosis. Diagnoses D are also related to patient

Since pre- and suffixes are recovered with the name of the elements in the entities they were used to construct diagnoses by the equation **d:=e+o+p** where d is the diagnosis, and e, o and p holds names from the etiology, organ and pathogenesis entities, respectively. A typical example is e:='bacterial ', o='endocard' and p='itis', which gives d='bacterial endocarditis'. An extended version of (1) generated diseases using all the entities described above allows the construction of about 10^{15} diagnoses (not shown).

Discussion

The present study shows that ICD10 can be normalized into a relational database. The entities (tables) can be used in a combinatorial classification and used to construct diagnoses according to the equation d:=e+o+p. This allows the construction of diagnoses simultaneously with the classification of a clinical case. The data structure is devoid of redundancy and seems well adapted to classification..

The clinical findings associated with different entities are largely disjunctive (not shown). Thereby, the prominent overlap in clinical findings between different diseases is eliminated. The combinatorial approach is therefore well suited to clinical decision making, decision support and medical expert systems.

In conclusion, ICD10 can be normalized into a relational database which allows a combinatorial classification that is easy to extend, fast and systematic, and allows the construction of diagnoses.

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.Acknowledgments

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A data structure for decision support systems, medical expert systems and clinical decision making

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ABSTRACT

- The International Classifications of disease (ICD10) is normalized.
- The emerging relational database containing disjunctive entities.
- The hierarchal structures of the etiology and anatomy are implemented.
- The database enables the construction of diagnoses according to the equation d:=e+o+p, where e, o and p are variables holding names of a etiology, organ and pathogenesis, respectively, and d is the emerging diagnosis.
- The data structure and d:=e+o+p implement a combinatorial classification and allow structured clinical decision making.

NORMALIZATION OF ICD10

- A text file containing the ICD10 classification was used.
- ICD10 was normalized semiautomatically.
- Normalization is based on the identified functional relationships between words in the diagnoses, prefixes and suffixes.
- Diagnoses are tagged.
- Word stems are extracted using pre- and suffixes.

CREATING ENTITIES

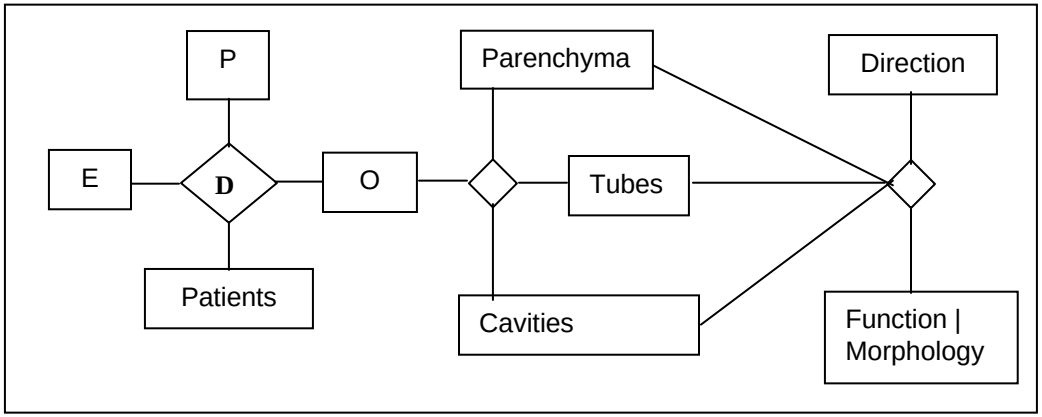
- The words are sorted onto entities related to the standard clinical curriculum: (pathological)anatomy, (patho)physiology, clinical chemistry, etc.

- This led to a database schema called a combinatorial classification which is implemented in a Microsoft Access database.

ENTITIES IN THE COMBINATORIAL CLASSIFICATION

- Etiology
- Regions
- Functions and morphology of the general organ divided on
  - parenchyma
  - tubes
  - slits and cavities
- Organs
- Pathogenesis
- Cells
- Subcellular organelles
- Direction of change
- Time course
- Degree

ENTITITY RELATIONSHIP DIAGRAM FOR THE COMBINATORIAL CLASSIFICATION



Entity-relationship (ER) diagram modeling diagnoses or diseases (D), showing the relations of d to the etiology (E), organs (O) and pathogenesis (P). Organ is decomposed into the organ parts cells, tubes and cavities. These subcategories combine with the direction and function or morphology to make out a diagnosis.

In the combinatorial classification diagnoses D are also related to patients.

THE EQUATION FOR CONSTRUCTING DIAGNOSES

- Let
  - e=“bacterial “
  - o=“myocard”
  - p=“itis”
- Then the equation d:=e+o+p gives rise to the diagnosis:

d=“Bacterial myocarditis”

USING THE COMBINATORIAL CLASSIFICATION TO CONSTRUCT DIAGNOSES

1. An application was developed to construct diagnoses.

2. The combinatorial classification gave access to the names and word stems of a wide variety of etiological agents, pathogenetic mechanisms, organs, etc.

3. Elements from the combinatorial classification were assigned to the variables in an extended version of d:=e+o+p.

4. Diagnoses were automatically constructed from elements in the entities and d:=e+o+p.

Accordingly, by steps 1-4 construction of diagnoses is algorithmic.

CLINICAL DECISION MAKING (CDM)

- Symptoms and signs from elements within each entity are (largely) disjunctive from each other (unpublished observation).

- Using d:=e+o+p to guide CDM largely eliminates the problem of overlapping sets of symptoms, signs and laboratory findings.

FUTURE OF THE COMBINATORIAL CLASSIFICATION

- Standard classifications (ICPCs, ICDs, SNOMEDs, DSMs) are steadily revised and clinical results using them are difficult to compare over years.
- The combinatorial classification is directly based on a socio-psycho-biological model of healthy and diseased individuals.
- The combinatorial classification needs no alphanumeric codes.
- A huge number of diagnoses that can be constructed by d:=e+o+p. The emerging diagnoses cover all the above mentioned classifications.
- The combinatorial classification needs to be continuously extended as medical knowledge increases, but will not require revision.
- Accordingly, the combinatorial classification is a promising tool for future clinical decision making and medical classification.

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Piecewise Synonym Construction Using WordNet for UMLS Source Integration

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Abstract

Source vocabulary integration forms the basis of the UMLS's content and its planned continued growth. When integrating a new term, it is essential to recognize situations where the concept expressed by that term already exists in the UMLS, even if it is represented by a different term (i.e., a synonym). A preliminary study has shown that even when using the UMLS's rich set of synonyms, a new term for an existing concept may not match any of them. A process for automatically constructing additional, potential synonyms from multi-word source terms is presented. This process consists of decomposing the source term into words, finding separate synonyms for each in WordNet, and then recombining those synonyms into multi-word terms. We call such synonyms piecewise synonyms, and we present a precise formulation for their construction. The methodology is tested in the context of a (partial) reintegration of the "Minimum Standard Terminology" into the UMLS. The results show that additional "source term/ UMLS term" matches are gained.

Keywords:

UMLS, vocabulary integration, terminology integration, WordNet, synonym

Introduction

The Unified Medical Language System (UMLS) comprises a large terminological database covering the biomedical and health-related fields. This database has been populated via the integration of a variety of source vocabularies, e.g., SNOMED CT , LOINC , and RxNorm . Currently, the number of sources is over 100. Plans call for integration of more terminologies in the future . At present, the Metathesaurus, the UMLS's concept repository, contains over 1,000,000 concepts and over 5,000,000 terms .

The overall process of integrating a new source terminology into the UMLS is defined by the National Library of Medicine to comprise four major phases: (1) analysis and inversion, (2) insertion, (3) human editing, and (4) quality assurance . In general, the process tends to be labor-intensive and error-prone. As such, facilitating source-vocabulary integration is a critical issue facing the UMLS curators. Many algorithmic aides have been developed in this context .

In this paper, we present a methodology for increasing the effectiveness and efficiency of the insertion phase of the integration process. One of that phase's major subtasks is the identification of terms and associated concepts from the source that already exist in the UMLS. Unfortunately, the same concept may be known by several different terms. Thus, it is a distinct possibility that a new source uses a term that differs from the UMLS term for an existing UMLS concept. This problem is exacerbated for terms that consist of several words.

In a preliminary study, we found a surprisingly small number of matches for the terms of a "new" terminology with terms in the UMLS. This is surprising when one considers the large number of terms already in the UMLS. One may conclude that the UMLS is missing valid synonyms for its concepts.

Our methodology automatically generates new synonyms for multi-word terms of a source vocabulary. It does so by first decomposing a term into its constituent words. It then gathers all synonyms for the individual words. These individual synonyms are found in the widely used WordNet , a lexical database for English. Finally, a set of novel, multi-word synonyms, called *piecewise synonyms*, is created for use in a term-matching algorithm. A precise formulation of this synonym-construction process is presented.

To test the effectiveness of our methodology, we utilize it in the process of reintegrating an existing source, called the "Minimum Standard Terminology" into the UMLS. The results show that our algorithmic lexical manipulation offers gains in "source term/UMLS term" matches.

Background

In order to create a baseline for evaluating our methodology, we chose to use a set of terms (a) that had already been included in the UMLS in previous research by other authors, and (b) for which a published record on the integration process exists . The chosen set of gastro-intestinal (GI) terms is known as the Minimum Standard Terminology (MST) . The version of the MST included in the UMLS is designated "MTHMST2001," though we will continue to refer to it simply as "MST."

The MST's designers set out to devise a "minimal" list of terms that could be included within any computer system used to record the results of GI endoscopic examinations. Overall, it comprises 1,944 such terms, which represent 1,636 unique concepts. Of the terms, 289 have explicit synonyms. The concepts also exhibit relationships, e.g., *part_of* (85 concepts), *has_location* (198), *manifestation_of* (235), and *treats (*2).

The concepts of the MST, as integrated into the UMLS, are assigned a total of 29 semantic types out of the UMLS Semantic Network's 135 semantic types. The MST was originally integrated into the 2002AA release of the UMLS, as described in . Since the MST is not a terminology but rather a standard (given in a group of tables) for reports involving GI endoscopy, the major effort in focused on creating a terminology reflecting the MST's content. That terminology then became the actual source of the integration.

Using the data rich format of the UMLS , we were able to remove the MST to derive what we call the UMLS⁻, which is the UMLS with the MST entirely excluded (Figure 1). Naturally, a number of terms from the MST were also introduced into the UMLS by other terminologies. We call this overlap of MST terms with pre-existing UMLS terms the UMST. In creating the UMLS⁻ and the MST, we used the 2006AC release of the UMLS, installed in our Oracle database server. The UMST has 390 terms with 328 concepts in this release. The goal of our larger research project is to reintegrate the MST (as algorithmically as possible) into the UMLS⁻ and compare the results with those of .

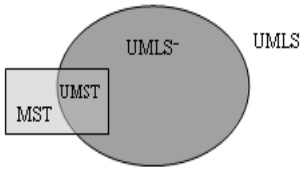

Figure 1 - The relationships between UMLS, UMLS⁻, MST, and UMST

A major step in the reintegration of the MST into the UMLS⁻ is the identification of the concepts of the UMST. Due to the addition of new sources and the update of old ones, there may be more such concepts now than in 2002, when the original integration took place. Thus, as a first step, we concentrated on the problem of finding all concepts residing in the UMST.

In a preliminary study, we found a surprisingly low number of matches between terms from the MTHMST2001 and terms in the UMLS⁻. Only 216 out of 1,944 terms matched (11.11%). Even syntactic transformations, such as removing dashes, did not improve matching results in any significant way.

The low rate of matches between the MST and the UMLS⁻ is surprising because the area of GI diseases is a core medical subject that should be well covered by the UMLS. We hypothesized that many MST terms may exist in the UMLS expressed by their synonyms. Thus, the problem to be solved was to discover new synonyms of terms that already exist in the UMLS. The complex relationships between concepts, terms, and strings in the Metathesaurus are elucidated by Table 1. Each bold number in this table is a unique identifier. As the table shows, one unique concept may correspond to several lexical terms, which are synonyms of each other.

Table 1 - Example of the relationships between Concepts, Terms, Atoms, and Strings in the UMLS

Concept (CUI)	Lexical Terms (LUI)	Strings (SUI)	Atoms (AUI)
C0009375 Colonic tumor Colonic Neoplasm Colonic Neoplasms	**L1834866** Colonic tumor	**S2142448** Colonic tumor	**A0027665** Colonic tumor (MTHMST) **A7591481** Colonic tumor (NCI)
	L0009375 Colonic Neoplasm Colonic Neoplasms	**S0363987** Colonic Neoplasm	**A0401918** Colonic Neoplasm (MSH) **A7576442** Colonic Neoplasm (NCI)
		S0026544 Colonic Neoplasms	**A0041001** Colonic Neoplasms (MSH)

For finding synonyms of individual words, we used WordNet 2.0 and JWNL (Java WordNet Library) 1.3 , a WordNet API. This API (Application Programming Interface) makes it possible to access WordNet from Java programs. Terms in WordNet are grouped into sets of cognitive synonyms, called *synsets*, used to express distinct concepts. Synsets are interlinked by conceptual-semantic and lexical relations such as hyponym, hypernym, etc. The newest version of WordNet is 2.1; however, the JWNL API was so far only implemented for WordNet 2.0. As shown in Table 2, WordNet 2.0 contains 152,059 strings. WordNet 2.1 contains 155,327. This increase is relatively small. Therefore, we found it acceptable to use the data from Version 2.0, allowing us to take full advantage of JWNL.

Table 2 - Statistics of WordNet 2.0

POS	Unique Strings	Synsets	Total Word-Sense Pairs
Nouns	114648	79689	141690
Verbs	11306	13508	24632
Adjectives	21436	18563	31015
Adverbs	4669	3664	5808
Totals	152059	115424	203145

Methods

Every MST term that is to be integrated into the UMLS⁻ is processed in several steps. Figure 2 contains a flow chart, comprising only the steps discussed in this paper. Step 1: Look for perfect matches and for matches of simple lexical variants, e.g., transformation of all letters into lowercase. Step 2: If the term consists of a single word, use synonyms from WordNet. Step 2 is not a new approach. Such a technique has already been used by Mougin *et al.*, while solving a slightly different problem . Step 3: Employ our novel matching methodology based on "piecewise synonyms."

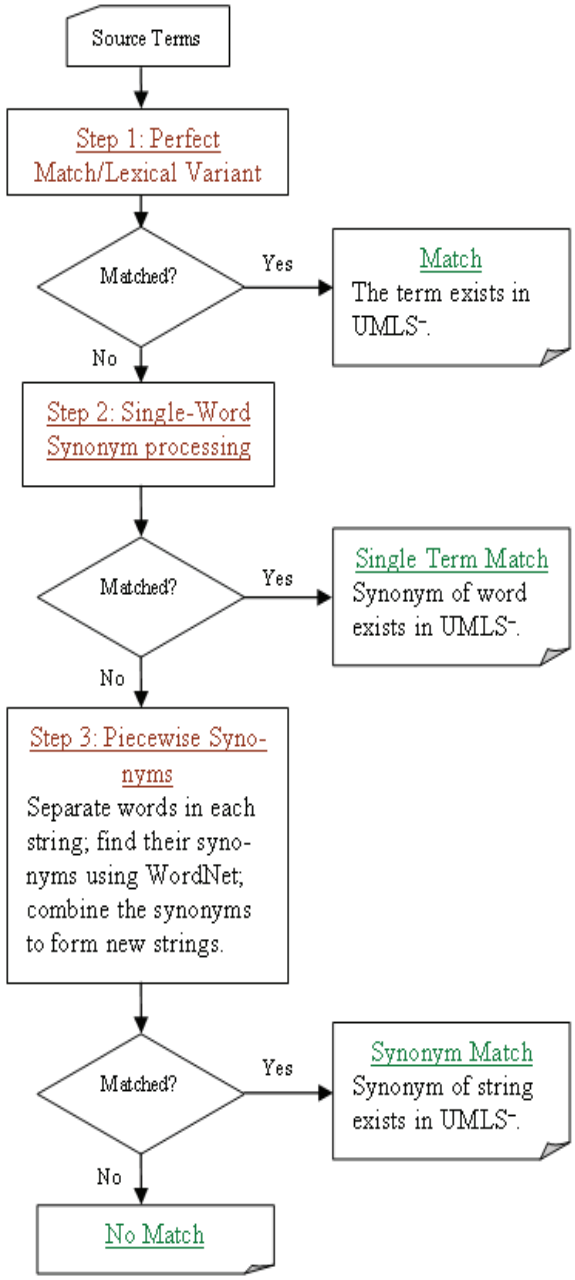

Figure 2 - Partial flowchart for string matching

Our method of constructing *piecewise synonyms* works as follows. If a medical term consists of two (or more) words, our algorithm looks in WordNet for synonyms of each individual word. Then the algorithm reconstructs two-word phrases from these individual synonyms. Then it looks for matches in the UMLS. To provide an intuitive, non-medical example, one might have a term "car insurance" and not find a match for it. Looking for synonyms

of "car" we find "automobile." Let us assume that we do not find any synonyms for "insurance." Now we reconstruct a two word term "automobile insurance" from the synonym of "car" and the original term "insurance" and attempt to find a match for it.

Our example was intentionally the simple case where only one of the two words in a two-word term has a synonym. The situation becomes more complicated if both of the terms have one or more synonyms. In this case, several piecewise synonyms are constructed. If T is a two-word term, we denote its set of piecewise synonyms as Piecewise_Synonyms(T).

We will formalize the Piecewise_Synonyms function using the Cartesian product. In simple terms, a Cartesian product creates every possible combination of members from one set with members of a second set, while maintaining the order between members. Thus, the Cartesian product ($\times$) of the set $\{a, b\}$ and the set $\{c, d\}$ would be:

$$\{a, b\} \times \{c, d\} = \{(a, c), (a, d), (b, c), (b, d)\} \quad (1)$$

In the following, we use the notation "word(T, n)" to be the n^{th} word of the term T. The WordNet synset of a word w will be denoted synset(w). The operator $\cup$ is set union.

$$\text{Piecewise\_Synonyms}(T) = \{\text{“}w_1\ w_2\text{”} \mid (w_1, w_2) \in (\text{synset}(\text{word}(T, 1)) \cup \{\text{word}(T, 1)\}) \times (\text{synset}(\text{word}(T, 2)) \cup \{\text{word}(T, 2)\})\} - \{T\} \quad (2)$$

In (2), "$w_1\ w_2$" stands for the string (i.e., potential synonym) consisting of w_1 as its first word and w_2 as its second word, such that (w_1, w_2) is an element of the Cartesian product of the synonyms of the two words in T. Note that the words of T are also utilized in the construction of the piecewise synonyms, as indicated by the two set union operations. For example, a potential synonym for T consists of its second word preceded by a synonym for its first word. This case was demonstrated above with "automobile insurance." Therefore, the complete term T must be excluded as a potential synonym of itself. This is done with the explicit use of the "set difference" operator (denoted "–") applied to the singleton set $\{T\}$ at the end of (2).

If any of the piecewise synonyms of T match an existing term in the UMLS$^-$, then we say that T is a newly discovered synonym of an existing UMLS$^-$ term. Our above approach may be easily extended to terms consisting of n (≥ 3) words. In that case, (2) would comprise an n-way Cartesian product. Its result would consist of n-tuples of words, instead of pairs of words.

One may be concerned that computing piecewise synonyms will result in nonsensical terms. For example, if "New York" is passed to the Piecewise_Synonyms() function, it might find that "Novel" is a synonym for "New" and return "Novel York." However, this is not a problem, for the following reason. We do not use a resulting piecewise synonym unless it is found as a matching term in the UMLS. Thus, we are using the UMLS itself as a filter to exclude nonsensical combinations. Any piecewise synonym that is found in the UMLS is by definition meaningful. Of course, it is recommended that a human expert review all results.

We now present a medical example. Table 3 shows the results of computing piecewise synonyms for "biliary tumor." This MST term was not found in the UMLS$^-$. However, one of the piecewise synonyms, "biliary neoplasm," was indeed found in the UMLS$^-$. Thus, we have now identified biliary tumor as a new, valid (after human review) synonym of biliary neoplasm.

Table 3 - Piecewise Synonyms of "Biliary tumor"

Original term	Biliary tumor	
Synonyms of separate words, including the words themselves	Biliary	tumor
	Bilious	neoplasm
		tumour
Piecewise synonyms, excluding the original term	Bilious tumor	
	Biliary neoplasm	
	Bilious neoplasm	
	Biliary tumour	
	Bilious tumour	

The UMLS contains many long terms. For example, "absence of bleeding of edematous duodenal mucosa" consists of seven words. Terms of more than eight words and terms with more than 100 characters occur. This would result in excessive computational runtimes. For example, the term "Ischemic colitis as reason for lower g.i. examination" would produce more than half a million potential piecewise synonyms ($2 \cdot 2 \cdot 20 \cdot 11 \cdot 1 \cdot 37 \cdot 2 \cdot 8$ = 520,960 combinations). To avoid this explosion of synonyms, our program only processes terms with fewer than six words. Even with this limitation, it takes hours to compute all potential piecewise synonyms and to check each of the generated piecewise synonyms against the whole UMLS list of terms, to verify a match.

Results

We have generated 785,155 synonyms from the MST with word length less than six. Table 4 shows the results of

matching piecewise synonyms against the UMLS. The "Matched Synonyms" column indicates how many synonyms were found. The "Matched Terms" column expresses the number of MST terms that generated these synonyms. As seen in the table, there are 132 synonyms, which came from 91 different MST terms, matched in the UMLS⁻. Of these 132 synonyms, 78 are piecewise synonyms from 65 different MST terms. The other 54 synonyms consist of one word.

Table 4 - MST matches based on synonyms

	Matched Synonyms	Matched Terms
Single-word Synonyms	54	26
Piecewise Synonyms	78	65
Total:	132	91

Table 5 shows the results of applying the matching process of Figure 1. The first and second rows (with two and three sub-rows, respectively) give the results of Step 1, i.e., perfect matches and lexical-variant matches, as defined by a transformation to lowercase letters only. For example, there were 142 perfect matches involving multi-word terms. (This number represents 3.81% of the total number of terms in the MST.) This number increased to 164 with lowercase letters only. Overall, the lexical-variant matching had an improvement of 10.19% over perfect matching. The third row in the table presents the results of Steps 2 and 3 in its first two respective sub-rows. For single-word terms, 26 matches (1.34%) were found. Finally, the main results show that the piecewise-synonyms match yielded 65 matches (3.34%). Of those 65, six are brand-new discoveries. That represents a 3.66% improvement over the results of the multi-word lowercase match.

Table 5 – Matching results

		# Matched Terms	% Matched
Perfect Match	**Single-Word**	74	3.81
	Multi-Word	142	7.30
Lower-case Match	**Single-Word**	74	3.81
	Multi-Word	164	8.43
	Improvement over Perfect	22 (10.19%)	
Synonym Match	**Single-Word**	26	1.34
	Piecewise	65	3.34
	Piecewise improvement over Lowercase	6 (3.66%)	

Table 6 shows the number of matched terms with respect to the number of words per term. Because the UMLS is concept-oriented as opposed to term-oriented, we also present the corresponding numbers for concepts. For example, two-word terms in the MST matched a total of 38 terms in the UMLS⁻. (They also matched 38 concepts.) In total, two-word terms matched 50 synonyms.

Table 6 - Matched terms with respect to number of words

	Matched Terms	Matched Concepts	Matched Synonyms
Single-Word	26	25	54
Two-Word	38	38	50
Three-Word	20	20	20
Four-Word	5	4	6
Five-Word	2	2	2
Total:	91	89	132

Table 7 shows all new matches for MST terms achieved by the piecewise synonyms methodology (Step 3). For example, the piecewise synonym "Biliary neoplasm" was used to find a match for the term "Biliary tumor" in the UMLS⁻.

Table 7 - New terms found by generating piecewise synonyms

MST Term	Piecewise Synonym
Biliary tumor	Biliary neoplasm
Colo-rectal cancer	Colorectal cancer
2nd part of the duodenum	Second portion of the duodenum
Bile ducts stone	Bile duct stone
Modification of bowel habits	Change of bowel habit
Extravasation of contrast medium	Extravasation of contrast media

Discussion

As in , we are using WordNet to improve matching of terms with the UMLS. The approach in used "Data Elements" as input and WordNet to either validate a match or select between several matches. In our approach, WordNet matching is used as one step in a larger terminology integration project, with the focus of this paper on the generation of piecewise synonyms. The key positive result of this research was the ability to generate 78 *new, valid, multi-word terms* (new from the point of view of the MST). "Validity" means that meaningful multi-word terms, which exist in the UMLS, were found, as opposed to terms such as "Novel York."

We generated these 78 new terms from 65 MST source terms; 59 of these source terms already existed in the UMLS; however, six terms did not exist. Thus, six genuinely new mappings were found. While this may appear to

be a small number, one needs to keep in mind three points: (i) The MST is fairly small, as medical terminologies go, and the 78 new terms have to be considered in relation to that fact; (ii) the UMLS is a huge repository of terms, and finding *any* new terms in a core area such as GI is important; (iii) only 216 out of 1,944 MST terms were found in the case of perfect matching, which was unexpectedly low. Thus, even a small absolute improvement by other methods of matching is meaningful.

Limiting ourselves to terms with at most five words appears acceptable, as our results show that the longer a term is, the less likely it is that its synonym has a match. We found only two matched synonyms for five-word terms, but 50 synonyms matched two-word terms. Among the 65 matched source terms, we found piecewise synonyms with matches in the UMLS^{-}, which were semantically wrong, because they belonged to concepts outside the GI domain. This reinforces the need for human review of all results.

Another unexpected result was that "subdivision of pancreas" and its piecewise synonym "branch of pancreas" belong to two different UMLS concepts, which should not be the case. This suggests a new method for auditing UMLS terms.

Conclusions

In this paper, a new methodology for enhancing automated term matching between a source vocabulary and the UMLS was presented. The methodology avails itself of the WordNet lexical database in the construction of new, potential synonyms for multi-word terms. These piecewise synonyms were shown to be another useful tool in the toolbox of medical terminology integrators and curators. Additionally, we found that our approach can have an impact on auditing the UMLS. The work described herein suggests a number of directions for future research: (1) increased use of syntactic categories (adjectives versus nouns); (2) use of one-word synonyms from the UMLS itself for constructing piecewise synonyms; (3) use of WordNet subclasses (hyponyms) and superclasses (hypernyms) of given terms; (4) use of piecewise mapping with synonyms of partial multi-word terms; and (5) use of piecewise-synonym generation as part of a complete algorithm for integrating a terminology into the UMLS.

Acknowledgments

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Managing Differently Structured Data Using the Clinical Element Model

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Abstract

One goal of many clinical information systems is to capture as much data as possible in structured form. This allows significant flexibility in using the data after it has been captured. While progress data standardization efforts are making this goal more achievable, the realities of clinical information present constant challenges. We present some of the challenges that we have encountered as we create clinical data representations using the Clinical Element Model. The majority of these challenges are due to either differences in information granularity or incompatible data types. We have devised strategies for dealing with these challenges. These strategies revolve around the use of two constructs within the Clinical Element Model. The Aggregate construct is used to address issues related to information granularity differences. The Alternative construct is designed to assist in situations where data types are not consistent.

Keywords:

clinical data models; information storage and retrieval

Introduction

Providing optimal care for patients in a modern healthcare setting requires the integration of many different types of information from many different sources. Assimilating large quantities of information and determining the role this information should play in caring for a patient is a demanding task for clinicians and those who support them [1]. Clinical information systems are designed to assist in this task by helping to capture and organize much of this information. When properly implemented, the organization of information in a clinical information system enables presentation and review of the stored information in a temporal and spatial arrangement that enhances a clinician's ability to provide appropriate care in a timely fashion. In addition to presenting back to the user useful arrangements of stored information, clinical information systems may also perform higher-level functions on the information such as making inferences about the state of a patient's health or recommending tasks for managing a disease.

Regurgitation of previously stored information in useful arrangements does not generally require much structurally from the information being handled. However, as a clinical information system strives to provide higher-level functionality, the structure of the underlying data becomes more important. Although natural language processing techniques can be applied to assist in the effort, it is generally more difficult to generate meaningful and accurate alerts on unstructured, textual documents than on well-structured information.

Clinical elements

We have previously described the Clinical Element Model [2], the data modeling formalism that we employ for structuring our clinical information. The Clinical Element Model defines a highly flexible and recursive data model. The foundational unit of the model is called a Clinical Element. A Clinical Element can primarily either (1) be assigned a data type and contain one piece of information conforming to that type, or (2) contain a group of other Clinical Elements. For example, in modeling vital signs, we would define a Clinical Element for respiratory rate with a data type of "physical quantity", likely named "RespiratoryRate". We would similarly define Clinical Elements for other components of a vital signs assessment such as heart rate, blood pressure, and temperature. We would then define a Clinical Element that would contain the components of the vital signs assessment and name it something like "VitalSignsPanel". Thus, the "VitalSignsPanel" Clinical Element would contain, amongst others, the "RespiratoryRate" Clinical Element. Clinical Elements can thus be represented as a simple tree structure with all internal nodes containing other Clinical Elements, and all leaf nodes containing data of an assigned type.

The data types that we use in the Clinical Element Model are derived from the data types that Health Level Seven (HL7) has defined for their Reference Information Model (RIM) [3]. They include types such as "time stamp", "coded concept", "physical quantity", "binary", and "string". While we have made a few changes to the HL7 versions of these types to support our needs, we strive to maintain a high level of compatibility to support semantic interoperability with other systems via HL7 messaging.

Within the Clinical Element Model, in addition to the primary type of data that a Clinical Element contains, every Clinical Element may also contain a set of qualifiers. Qualifiers are data items that provide additional informa-

tion relevant to the primary data. For example, the "RespiratoryRate" Clinical Element may contain a qualifier for the time at which the respiratory rate was measured. Structurally, the data captured in qualifiers is no different from other data in the model, and thus qualifiers are modeled as specializations of Clinical Elements. Therefore every qualifier may either be assigned a data type or may contain a group of other Clinical Elements. Likewise, qualifiers may contain other qualifiers. Although the decision as to whether a piece of data should be modeled as primary data or as a qualifier is not always straightforward, in practice these cases are the exception and do not pose significant problems for this modeling approach.

A fundamental aspect of our data management approach using the Clinical Element model is that we define a single standard representation for each type of clinical information that we use in our system. We then map all incoming information to these standardized structures. In developing the Clinical Element Model, we put significant effort into structuring the information such that it will support many higher-level functions that we deem to be of value. These functions included advanced clinical decision support and semantically interoperable exchange of information with other clinical information systems.

Differently structured data

Despite the effort that we put into modeling and mapping information appropriately, we recognize several situations where real-world concerns present us with information that does not fit neatly into our ideal models. When managing a system that receives clinical information from a large number of external sources, it is nigh impossible to have the power and influence necessary to ensure that all of the information that is received comes in a format that maps well into a standardized structure. Even when an enterprise strives to require high standards of data structure when negotiating with potential data sources, the realities of legacy data, unresponsive vendors, and lack of bargaining power often leave the enterprise with less than optimally structured inbound information.

Furthermore, even when external sources of information are cooperative, enterprises will encounter relevant and accurate clinical information that does not fit well in their internal data structures. The result of these situations is source data that is of different granularity than that of the target model, or that is of a form that is not compatible with the data type in the target. In the Clinical Element Model, we have developed several constructs that allow us to gracefully handle clinical information that does not fit nicely into the standard structures that we have defined.

Methods

Handling granularity issues with aggregate

The first construct we will consider is called Aggregate. As may be inferred from its name, Aggregate is used in situations when the granularity of the source information is not consistent with that of the target model. Specifically, we use aggregate when the inbound information is less granularly structured than the target Clinical Element. In these situations we use a system that we have created for decomposition of composite information into more granular pieces. Description of this decomposition system is beyond the scope of this paper, but the output of this system is information of appropriate granularity for use in the target Clinical Elements.

For example, in our inbound interface for an external microbiology system, we receive information about the body location, from which the relevant specimen was collected, in a single, unstructured, text field. The contents and format of the data in this field vary significantly between messages. In contrast, the model for body location defined in the Clinical Element Model is highly structured, with the ability to independently specify features such as body part, laterality, proximity, superiority, depth, and lesion type.

When the decomposition system is successful, it generates an appropriately populated set of Clinical Element instances containing the information from the source text. We have found it helpful, when capturing and storing these decompositions of clinical information, to store the original composite with each piece. It is useful to have this information available when we need to present back to the user what was originally received. One reason is that although a proper decomposition should contain all of the information content from the original source data, putting all of the pieces back in an order and format that is natural for a human to consume is not a simple task. In addition, we find it useful to have the original source data closely linked when we are verifying the results of our decomposition process.

The Aggregate structure in the Clinical Element Model is the place where we store the composite source information. Aggregate is a foundational part of the model, and therefore is available to all instances of Clinical Elements. Enhancing our description of Clinical Elements above, every Clinical Element will contain a primary data item (either a field of an assigned type, or a group of Clinical Elements), and may also contain qualifiers and an Aggregate. Since all information in the Clinical Element Model is stored as Clinical Elements, any piece of information can have an associated Aggregate. In addition to the textual source data in the microbiology interface use case described above, we have either real or expected use cases

for binary data and coded concepts as source data types. Thus, the Aggregate construct consists of an exclusive choice between a "coded concept" value and a "binary" value. These two data types support all of the used cases that we are aware of for composite data in our enterprise. Following the conventions of the HL7 data types, the "string" data type is a specialization of "binary", and is thus supported by Aggregate.

An example of when we would store binary data in Aggregate is when we receive information from an outside source as a document in a format such as Adobe Systems' Portable Document Format (PDF). If the PDF document contained relevant information that we would benefit from storing in a structured format, we would extract the information, creating and storing the appropriate Clinical Elements. Each of these Clinical Elements would be associated with the original PDF by placing the PDF in the binary value field of Aggregate.

We recognize that, in many cases, storing the original composition with each Clinical Element derived from it may result in large amounts of redundant data being stored and unnecessarily wasting space. To mitigate this condition, we have devised two strategies for referencing a single instance of the source data contained in Aggregate rather than copying it multiple times.

One of the properties of qualifiers in the Clinical Element Model is that they can be inherited by containment. This is similar to "context conduction" in the HL7 RIM. To illustrate how this works, consider two Clinical Elements, A and B, and a qualifier, C. In this example, Clinical Element A contains Clinical Element B (e.g. A may be a chemistry panel and B may be a serum sodium measurement). If the definitions of both A and B reference qualifier C, then we only need to specify C for A, and it automatically applies to B unless specifically overridden. For example, in a chemistry panel, we may define a qualifier for the specimen both at the panel level and within each individual chemistry in the panel. We can then specify the specimen at the level of the panel, and each of the individual chemistries will inherit this specimen unless they explicitly specify a different one. If the composite source data decomposes nicely into a series of Clinical Elements contained within a common parent, this same mechanism can be used with Aggregate to avoid repeating the composite source data multiple times.

Within the Clinical Element Model we have also defined a mechanism for specifying a link or reference from one data instance to another. Using this mechanism, we can store the composite source data as an independent, undivided, Clinical Element. We can then, from within the Aggregate, reference this composite Clinical Element by an indexed unique identifier rather than by inclusion of the source data directly.

Handling type discrepancies with alternative

Another construct within the Clinical Element Model which we use to manage data that doesn't fit well is called Alternative. In contrast to Aggregate, which was developed for managing granularity mismatches, Alternative was designed to handle data type mismatches.

As we develop our clinical models, we evaluate each piece of relevant data, define a Clinical Element for that data, and assign that Clinical Element a type. In most cases, assigning a data type is relatively clear-cut. Most laboratory data with numeric result values is handled nicely with the "physical quantity" data type. Points in time are represented with the "time stamp" type. And so forth. However, even when the assigning of data types appears simple, the realities of clinical data present interesting challenges.

The "physical quantity" data type consists of a numeric value and a coded concept representing the units of measure. Although most of the results for a given laboratory test may fit well in this structure, sometimes we will receive a result such as "below detectable limit". In a situation like this, the value we received does provide an answer to the question posed by the laboratory test, "how much of a given substance is present in the sample", but it does not fit nicely into our "physical quantity" data type.

To handle such cases, we use the Clinical Element Model's Alternative construct. Like Aggregate, Alternative is a foundational part of the model. It is available to any Clinical Element. Also like Aggregate, its structure consists of a choice of several data types. In the case of Alternative, the available data types are "coded concept", "binary" (which includes "string" as mentioned above), and "physical quantity".

Strictly speaking, to be appropriate for use in the Alternative construct, the source data must fulfill two requirements. First, the granularity of the source data must match that of the target Clinical Element. If there is a granularity mismatch, then Aggregate should be used instead of Alternative. Second, the source data, while structurally incompatible with the target data type, should be semantically consistent with the target Clinical Element. Expanding on the laboratory example above, "below detectable limit" answers the question of "how much" in a manner similar to a physical quantity of "2 mg/dL". However, if the value we received were "specimen hemolyzed", indicating that the test could not be performed because of an unfit specimen, this value does not answer the question of "how much" and therefore should be recorded elsewhere, leaving the value in the target Clinical Element null. In practice however, determining the semantics of data received in an alternative format is frequently a difficult task. Therefore information that this

stored in Alternative is not always as semantically congruent with the expected data as we would desire.

The reason for these requirements on the use of Alternative is that we want all of a given kind of information stored, and thus retrievable, in a common manner, even if the data type is not what is expected. When querying for a given laboratory test, we do not want our users to have to remember to query both for those stored in the expected "physical quantity" format as well as for those stored in other formats. Rather, we feel that is important that a query for a given kind of information retrieve all instances of that information regardless of data type. We recognize that this places an additional burden on the applications that receive the information to handle unexpected data types, but ultimately we are more comfortable forcing these issues to be dealt with up front rather than letting this useful information fall between the cracks.

The common scenarios for using the Alternative construct include data at the extremes of possible ranges, and data from unusual, infrequent, or uncontrolled sources. In addition to "below detectable limit", other examples of the use of Alternative include:

- We receive an optically scanned SOAP note from a referring physician when we have internally defined a well-structured model for a SOAP note.
- We receive a quantitative heart rate of "140 bpm" for the APGAR pulse component which is designed to contain one of the coded concepts for "no heart rate", "heart rate less than 100 bpm", or "heart rate at least 100 bpm".

We do not use the Alternative construct when the source data is of the expected data type, but needs to be translated, such as when we receive a concept from a different coding system than that which we use internally or when we receive a physical quantity with units that differ from our enterprise standard. For these cases, the "coded concept" and "physical quantity" data types, respectively, have built in mechanisms for handling translations.

Since the information captured in Alternative should be semantically compatible with the target Clinical Element, that information may sometimes be directly transformable to the target data type. For example, in the case of APGAR scores mentioned above, would could accurately generate a concept of "heart rate at least 100 bpm" from the physical quantity that we received. In situations where this is possible, and doing so would provide enough additional value, we would develop processes – either automated or manual – to populate the primary data field in addition to the Alternative construct, allowing the data to be handled more consistently with other instances of that kind of information.

Discussion

The Aggregate and Alternative constructs provide us with practical mechanisms for handling differently structured data. Some the principles behind this approach include:

- We want our data structured in ways that support robust clinical decision support and semantically interoperable data exchange.
- When transforming data into more useful, structured forms, we want to maintain the original form of the data.
- Even when data is not structured as expected, we do not want any data to be stored using obscure methods or constructs that make it easy to overlook.

The focus or our modeling efforts is largely on the common internal data models needed to support our traditional, "best-of-bread" approach. As described above, this approach, while addressing some concerns, creates its own set of challenges, particularly for applications that use the information stored as Clinical Elements. For applications over which we have influence, we are building in mechanism to support the capture, manipulation, and display of this differently structured data. For other applications, we have to address the difficulties on a case-by-case basis and choose the best solution for each.

Conclusion

The use of the Aggregate and Alternative constructs allows us to manage relevant data that doesn't fit our data model definitions in close proximity with its expected target. This enables us to maintain the integrity of the source data, support derivations into forms consistent with other data in the system, and keep the semantics of our data models well defined.

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Representing Clinical Knowledge as Archetypes

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Abstract

The Copenhagen Region has developed an extensive set of clinical content specifications to be used in EHR systems. A clinical content specification is a standard plan linking a clinical problem/diagnose with predefined, detailed plans/ activities and the expected outcomes. In order to achieve a more coherent structure of the clinical content specifications and to link terms to SNOMED CT, a part of the specification has been transformed into archetypes. In this trial, archetype tools and terminology tools were used and assessed. The trial indicated that by using the tools the quality of the clinical content specifications was improved and the specifications became more suitable for incorporation into EHR-systems.

Keywords:

archetype, clinical knowledge, SNOMED CT,
electronic health record

Introduction

The "Clinical Content Project" was established in the Copenhagen Region in 2004 as part of the EHR implementation plans. The purpose of the project is specifying the clinical content of a highly structured EHR, based on the National Basic Model for EHR. This model supports a problem-oriented, longitudinal and cross professional EHR for the purpose of continuity of care [1]. The Clinical Content Project aimed at contributing to improved quality of the clinical documentation, re-use of data in an interdisciplinary contexts, and enabling use of EHR data for quality improvement.

The clinical content specifications are similar to structured clinical guidelines or clinical care pathways [2], and supports clinical decision-making. It has been shown that clinical guidelines provided as real time decision support systems' in daily clinical workflow will improve patient care significantly [3] and are an effective instrument to decrease undesired practice variability [4].

The Clinical Content Project has produced an extensive, detailed set of specifications of what to document in various clinical situations. However, the project identified a need for reducing redundancy, improving the consistency of the structure, linking the clinical content specifications to SNOMED CT, and documenting the clinical content in a format more suitable for use in EHR systems. Therefore, a trial was set up to transform a part if the clinical content specifications into archetypes.

The archetypes discussed in this paper are based on the openEHR reference model [5]. This is equivalent to the CEN pre-standard 13606 (EHRcom), which is currently under revision [6]. OpenEHR describes archetypes as "… reusable, structured models of clinical information concepts that appear in EHRs". Archetypes are described in a formal language and concepts in the archetypes may be linked to a terminology.

The templates discussed are based on the openEHR concept where archetypes can be adjusted to local needs and connected to entry forms. OpenEHR describes archetypes as "a selection of archetypes, terminologies, language and other details relevant to the particular local use of archetypes"

Methods

The clinical content specifications have a diagnosis or clinical problem, as a starting point. For each diagnose/ problem the standard plan describes in detail, a number of activities normally carried out, what expected observations are connected to the activities, and what data to enter for each observation.

It is estimated that clinical content developed in the Copenhagen Region is covering more than 75 % off the clinical documentation need, containing more than 600 standard plans.

The material is currently documented in MS Word tables and Visio flow-charts. The clinicians are comfortable with using these programs, but the specifications produced cannot easily be imported into or integrated with EHR systems.

The trial was attempting to show that using archetype tools the clinical content specifications could be made more suitable for incorporation into EHR-systems and the quality of the clinical content specifications could be improved.

The tools used were the openEHR archetype editor and the template tool and the terminology server from Ocean

Informatics, i.e. software supporting the openEHR architecture [7].

The archetype editor is an open source authoring tool for expert clinicians to create and edit archetypes. The tool was used in the trial to transform the clinical content into an archetype format and to link elements to SNOMED CT.

The template tool is an authoring tool for templates supporting design of archetype-enabled data entry. The tool was used for combing archetypes, creating variants of one archetype, and generating examples of data entry forms.

The terminology service in combination with a terminology query editor was used to create subsets of SNOMED CT – linked to the archetype. In the entry forms the subsets provided the set of selectable terms for a given data field.

Results & discussion

The selected areas from the clinical content documentation had a relatively simple structure. Areas were selected in which archetypes already existed in the openEHR repository [8].

For the clinical content specifications transformed to the "observation" archetypes, there were in generally good coherence between the two representations.

The "observation" archetype distinguishes between the list of data about the observation, the patient state, the protocol (i.e. measuring methods), and the temporal aspects. By applying this structure to the clinical content specifications, the ambiguity could be reduced and it became clearer if parts of the specification were missing or omitted.

However, the following challenges were encountered when comparing archetypes with the clinical content specifications:

- In some cases the lists of data about the observation or the protocol list needed to be extended. Since the archetype is meant to be the "maximum data set", this calls for a change of the archetype.
- Allowable values of observations may be represented as a list. However, some professionals would need a larger classification in addition to the list. The archetype editor seems only to offer functionality to hold either a list or a link to a classification.

The "section" structure was tried out for a few specifications, and the functionality seemed to be sufficient. This structure mainly groups archetypes into a larger, compound archetype.

The archetype editor could be improved by integrating it with a data dictionary. In this way the author could get an overview over terms used as well as their definitions, and this would support the re-use of terms or parts of archetypes

The template editor was used to develop templates and entry forms for doctors and nurses respectively – based on the same archetype. This functionality seemed to be sufficient.

The terminology server was tried out with only a few examples. It was relatively easy to define a subset of SNOMED CT based on the clinical content specifications; the main challenge being to identify the correct terms in SNOMED CT based on the terms in the clinical content specifications. The terminology query editor has a good facility for creating a search tree where parts of the tree are for navigation only and other parts can be selected by the user.

The linking of the SNOMED CT subset to the archetype element did also function well. An URL pointer was introduced instead of a value list in the archetype. However, sometimes i.e. doctors and nurses in principle can share the same template but require different terminology subsets. This requires an option to make further restrictions of the SNOMED subset at the template level, which is currently not possible.

Conclusion

The archetype editor helped structuring the clinical content specifications. There was generally good coherence between the two representations. Using archetypes made the linking to SNOMED CT more manageable, and made the clinical content more suitable for incorporation into EHR-systems.

It is a challenge to manage a large number of the archetype components, templates and entry forms. A link to a data dictionary could be considered to ease the re-use of the elements.

It is a large advantage that the clinical content specifications can be stored and exchanged in a standardised format. However, it is still an outstanding issue if EHR vendors are able to handle the archetype concept and import the archetype format.

Many clinical areas are not covered by existing archetypes, and some archetypes needs to be extended. This calls for an improved strategy and tools for managing the development, maintenance and approval process at an international level.

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Ontology Model of CRF for Clinical Research in Traditional Korean Medicine

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Abstract

Multicenter trials progress in oriental and western medicine. The CRF for stroke clinical trial in oriental and western medicine is made up of syndrome differentiation, etiologic items and blood serum test, etc. To represent systematic and structural knowledge of CRF, we design stroke clinical ontology by Protégé 3.1. The result is just on stroke domain, afterward, it will be extended to the framework of the other specific disease. And it could be developed for decision supporting system.

Keywords:

ontology, traditional medicine, oriental medicine,
Case Report Form (CRF), clinical trial

Introduction

The Case Report Form (CRF), which is essential to clinical research, is a printed, optical, or electronic document designed to record all of the protocol-required information to be reported to the sponsor for each trial subject. However, it is a fact that writing the paper-based CRF claims takes many hours and causes errors. To solve such problems, the electronic Case Report Form (eCRF) has emerged as an alternative way to reduce risk of errors in filling out and send data from hospitals to research centers on a real-time basis. The trend toward multi-center clinical studies is also pushing the demand for web-based eCRF.

We suggest that the electronic CRF based on the ontology. That could be systematically collect and analyze clinical data.

Methods

This study established the conceptual model of CRF on oriental and western medicine, and developed ontologies. The CRF applied in this study is a draft through consensus of experts for stroke research at the Korea Institute of Oriental Medicine. The conceptual model is made up of syndrome differentiation, diagnosis, blood test, dietary life and history et al. This model was referenced ISO TC 215 22789 Patient Findings[1]. The OntoCRF(CRF based Ontology) is based on the conceptual model using Protégé 3.1. Ò°

Results

The OntoCRF builds on the standard CRF by domain experts. It organizes classes and properties and their relationships. Therefore preparation based ontology is more systematically than that based RDBMS at representing the knowledge. The ontology of CRF consisted of Label, ControlType and Value classes and hasControl, hasValue and hasSymptoms properties. The Label is the class of question items groups, so it could have CRF questionnaire instances. The ControlType is the class that expresses controls such as checkbox, text, etc in the HTML script. The Value class represents selections for each items.

Discussion and conclusion

This ontology model is developed in stroke domain. Furthermore it could use to construct the other disease diagnosis and clinical decision or reasoning by ontology.

Acknowledgement

This study was supported by the Clinical Database Construction of Oriental Medicine for Evidence Based Medicine Project (K07010) of Korea Institute of Oriental Medicine in 2007.

1 ISO/TC 215 WG3 N231 Draft ISO/DTS 22789 (ballot version.7) Health informatics - Conceptual framework for patient findings and problems in terminologies.

Ontology Model of CRF for Clinical Research in Traditional Korean Medicine

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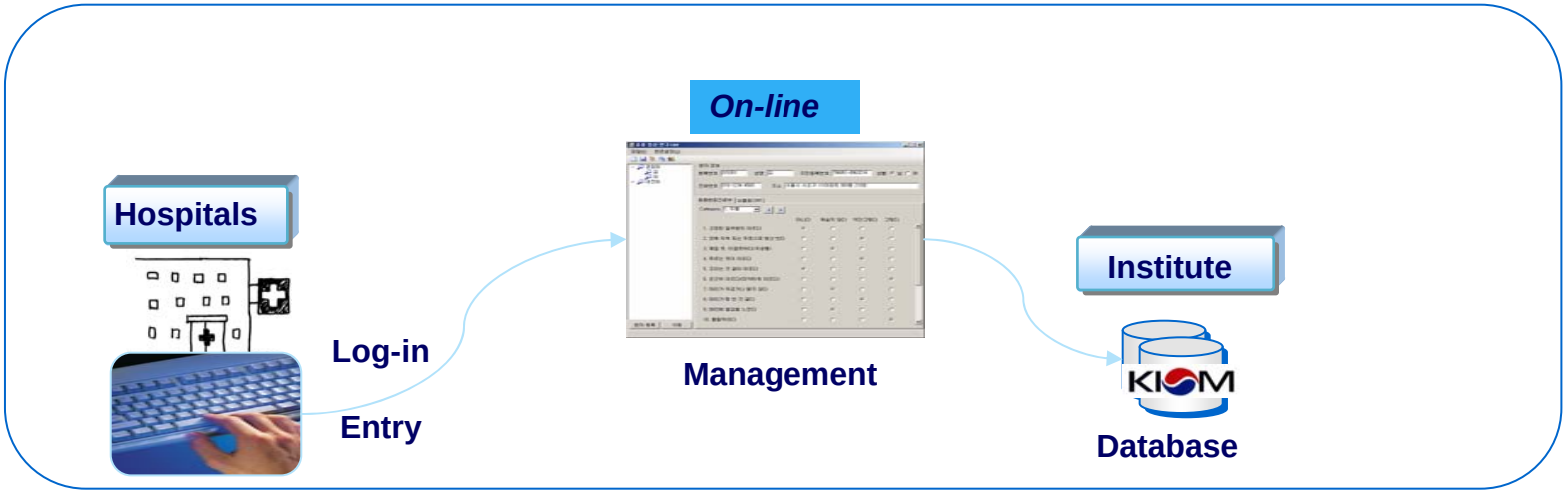
Background

- Multicenter trials progress in oriental and western medicine. A Case Report Form(CRF) is a questionnaire specifically used in clinical trial research. The CRF is the primary data collection tool from the investigator site. As a nowadays, as using electronic CRF, it decreases the errors that was generated for inputting data and be convenient to sending the clinical data.



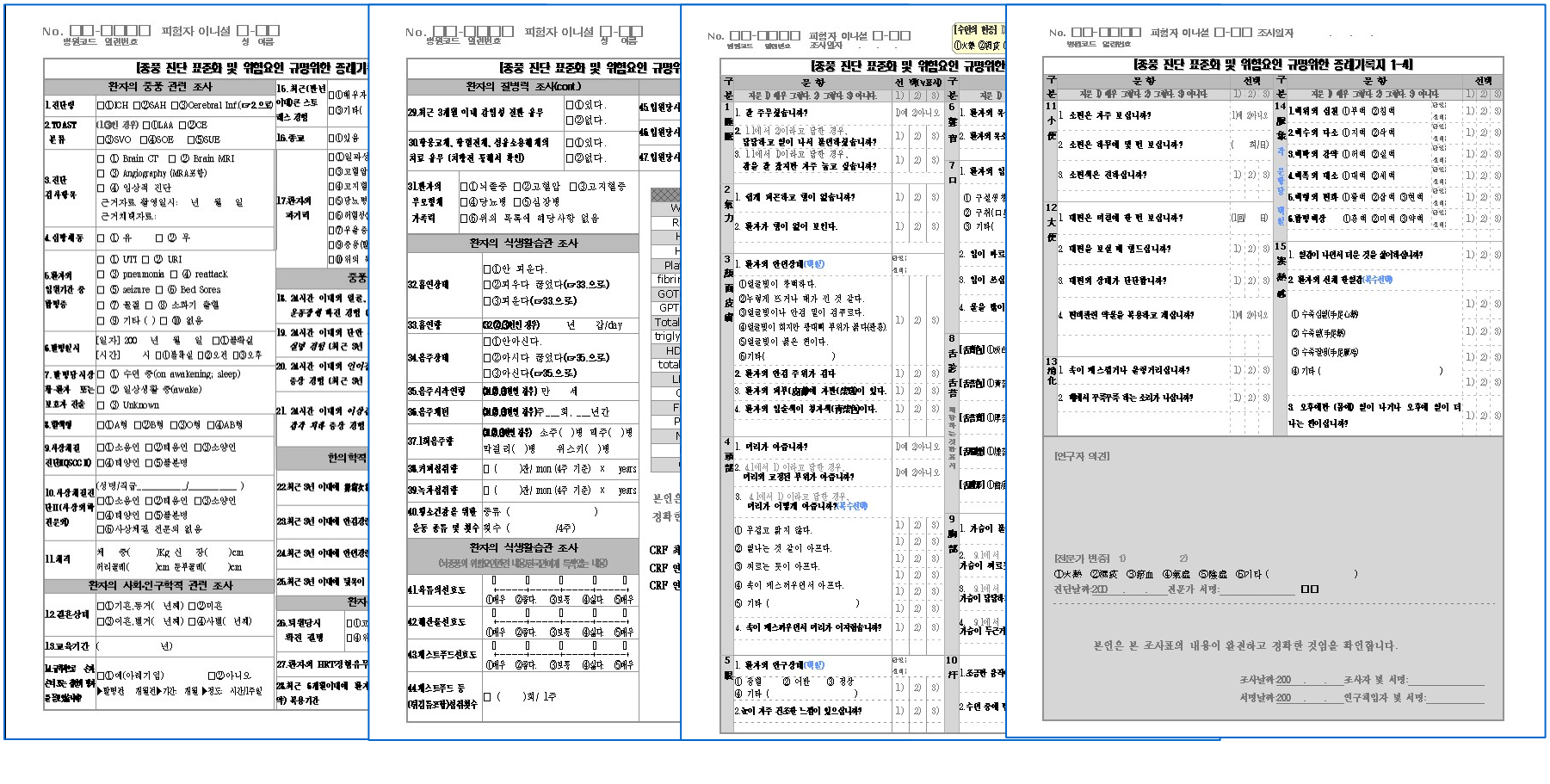
- We suggest that the electronic CRF based on the ontology. That could be systematically collect and analyze clinical data.

Methods

- The conceptual model is made up of syndrome differentiation(辨證), diagnosis, blood test, dietary life and history et al. This model was referenced ISO TC 215 22789 Patient Findings.

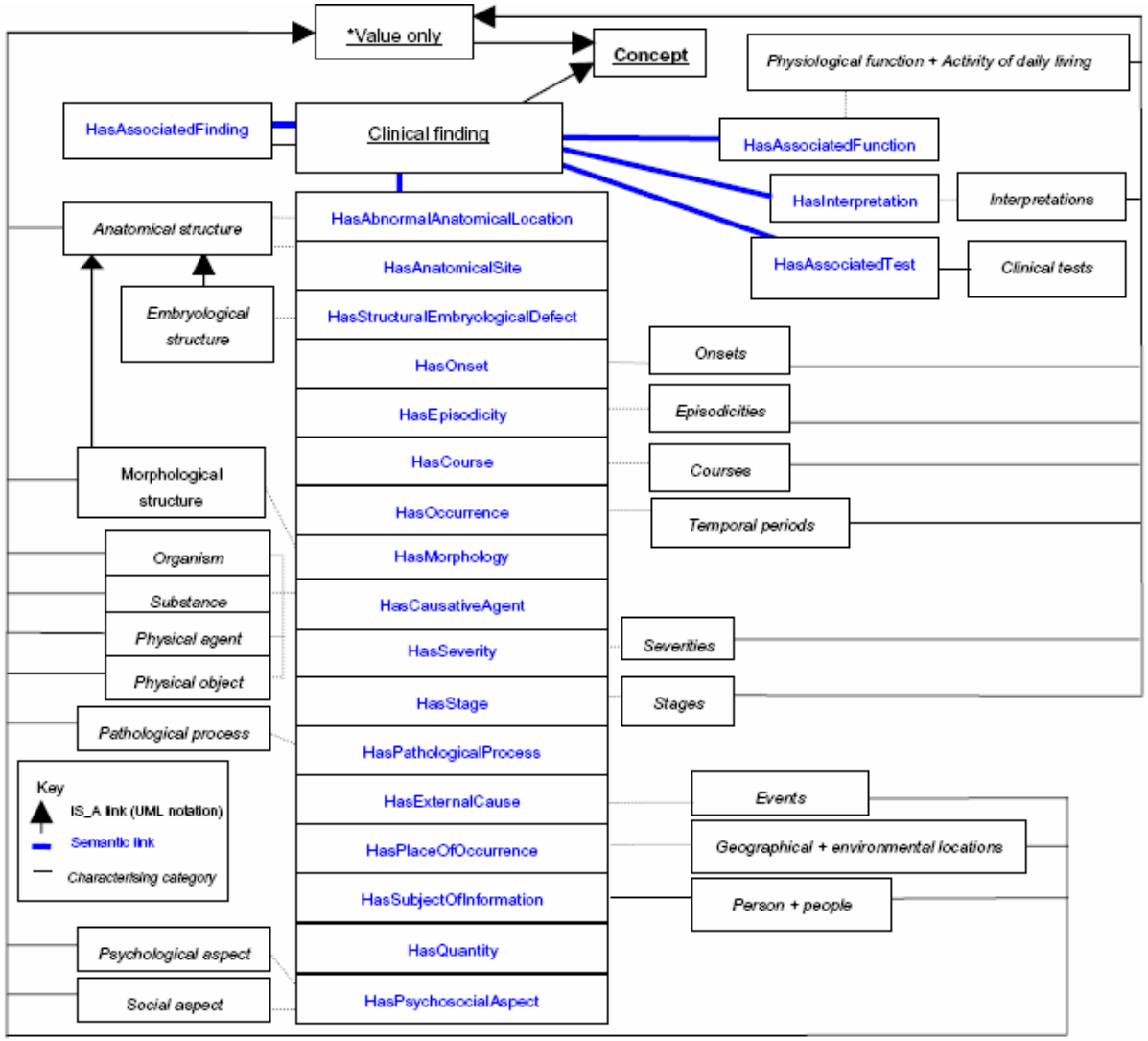
- The OntoCRF(CRF based Ontology) is based on the conceptual model using Protégé 3.1.

CRF for Stroke Clinical Trials made by KIOM

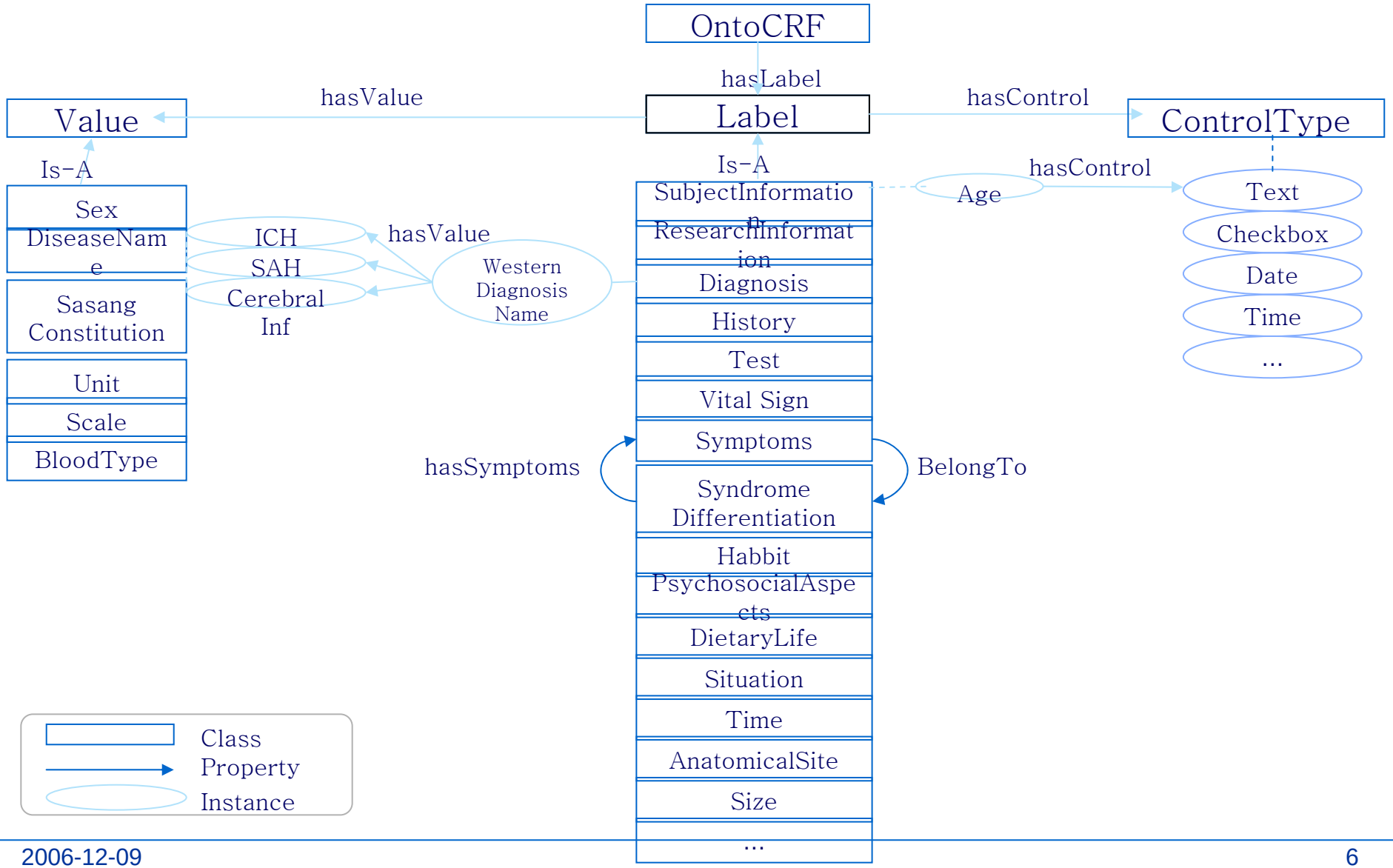


Reference Model

- ISO/TC 215 WG3 N231Draft ISO/DTS 22789 (ballot version.7) H ealth informatics
  - Conceptual framework for patient findings and problems in terminolog ies

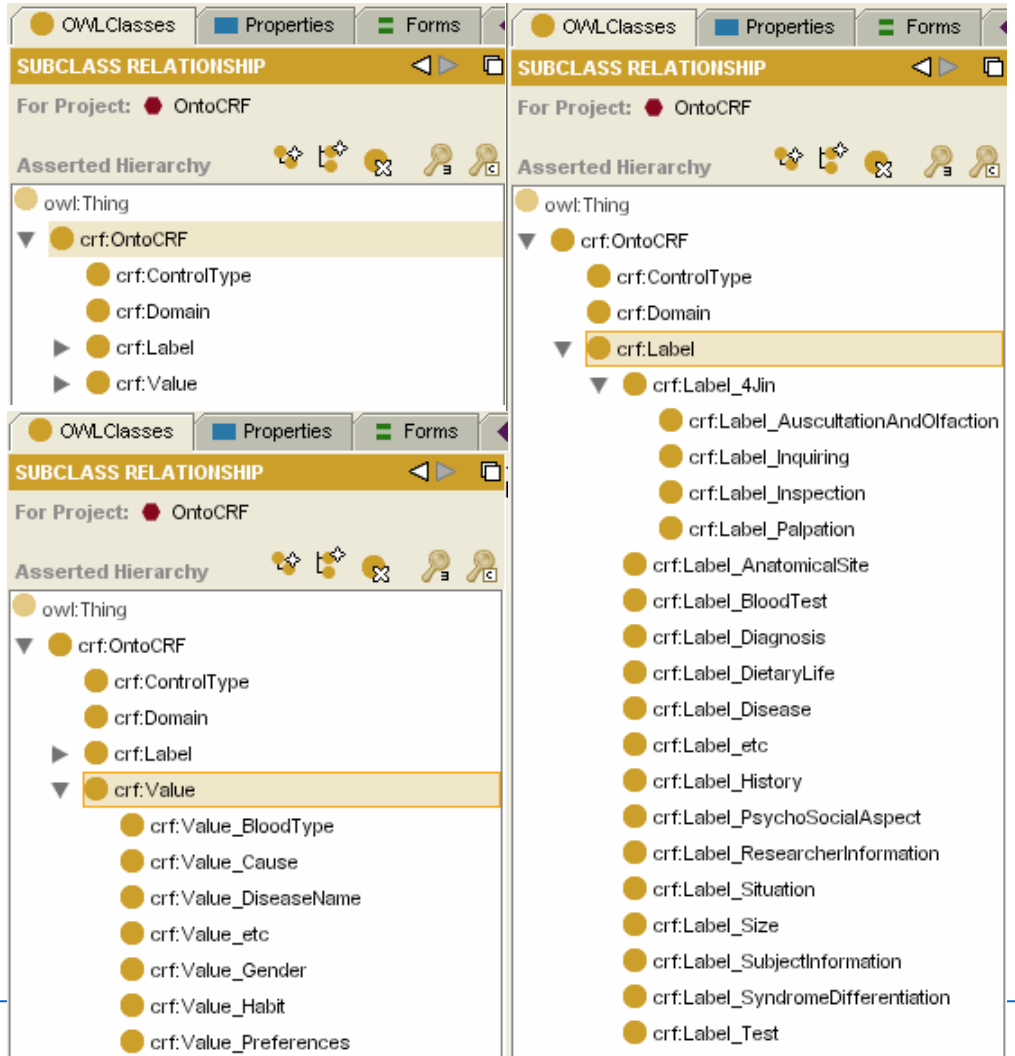


Conceptual Model of CRF



OntoCRF – Classes and Properties

❖ Classes



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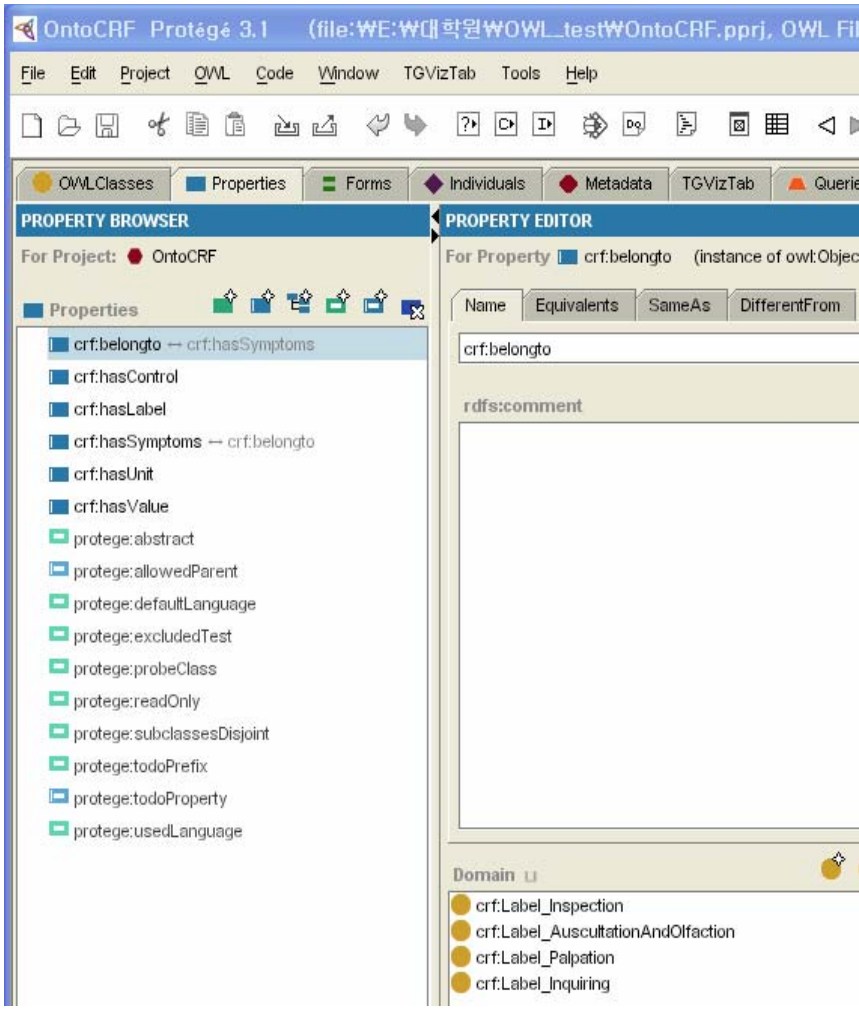
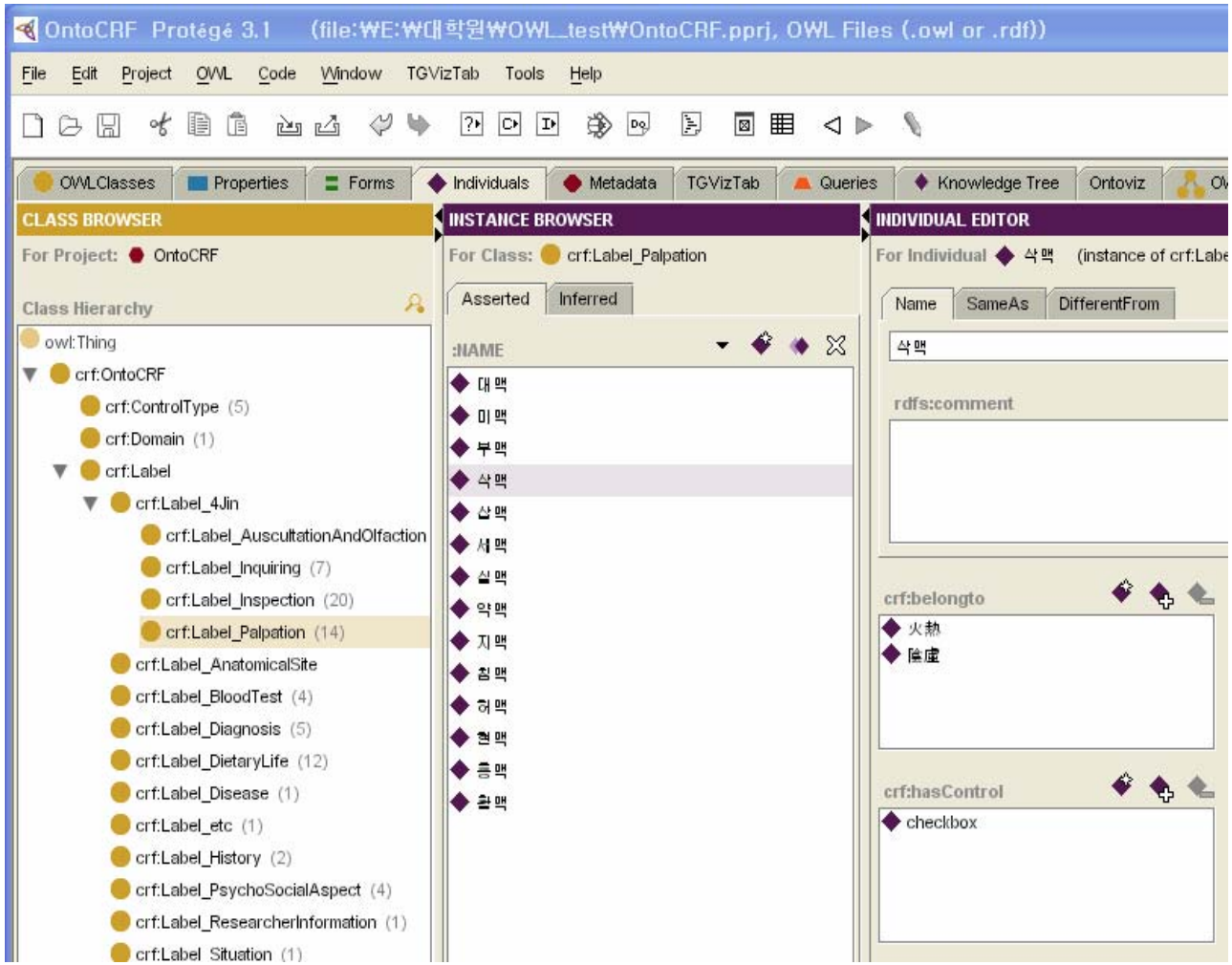


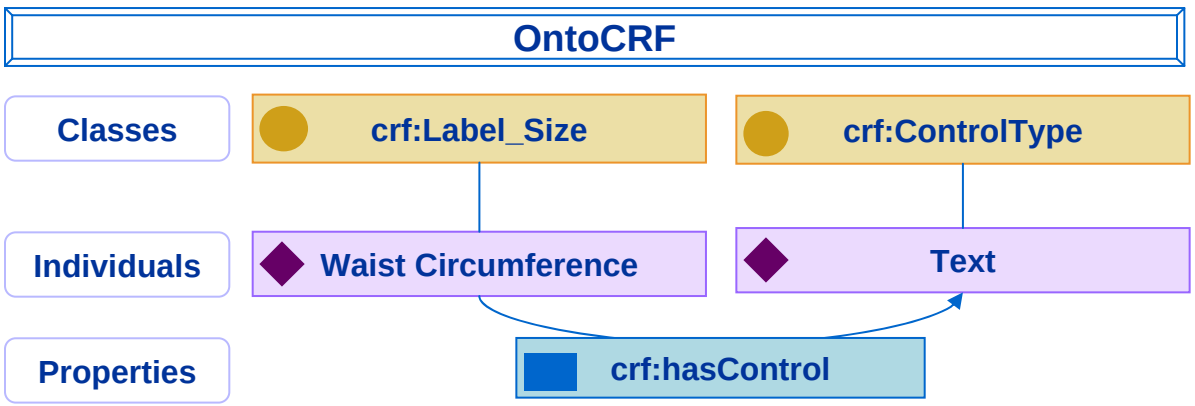
OntoCRF – Label

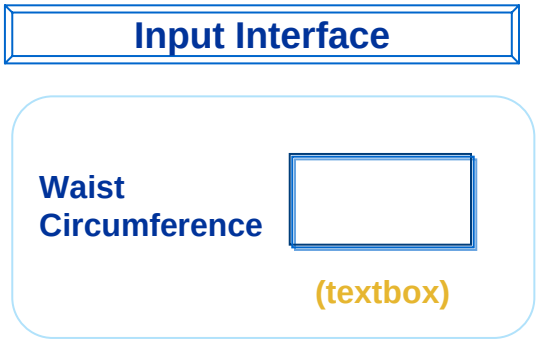
- Label Instance-hasControl, belongto



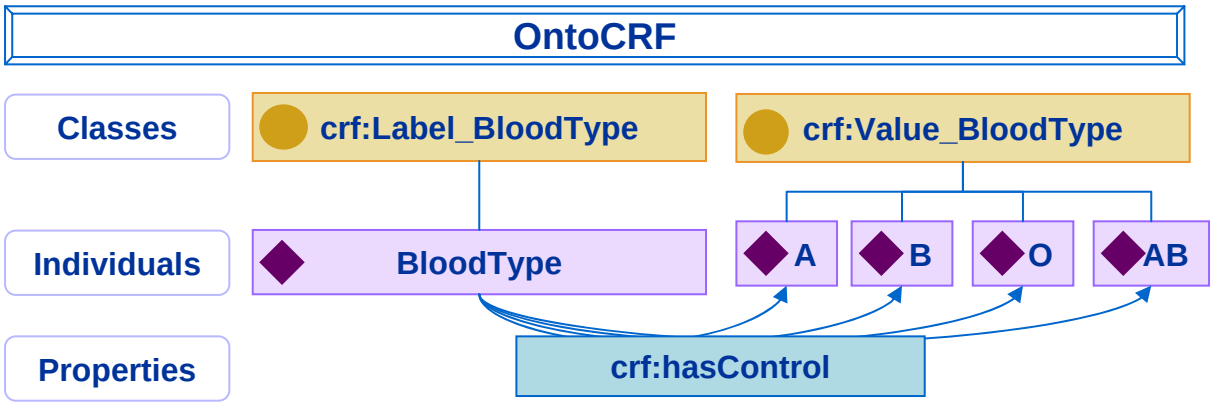
hasControl property generate interface

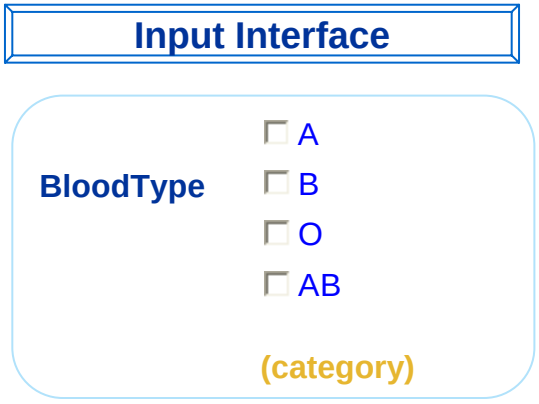
hasControl Text



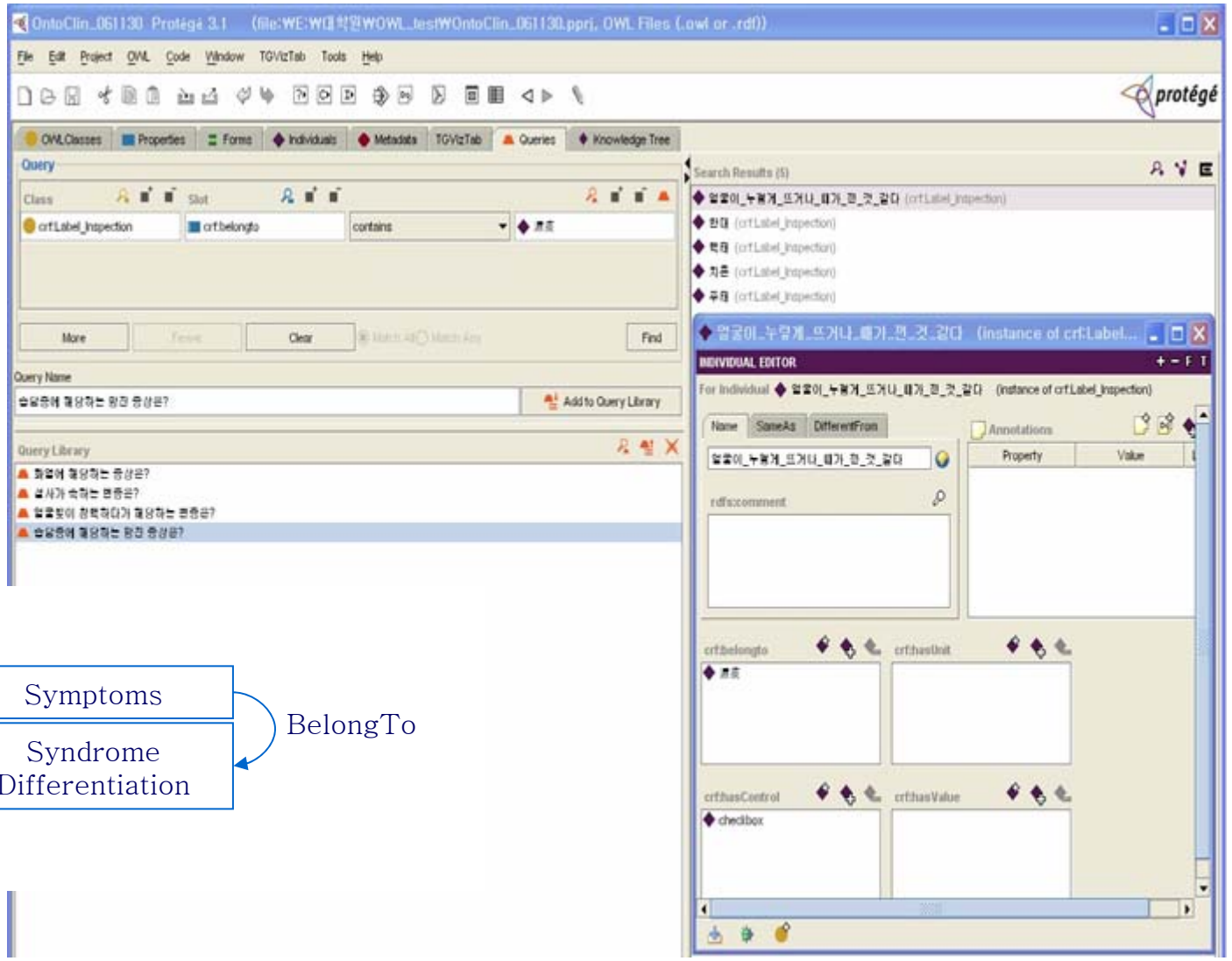


hasControl Value





Queries Tab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Query Name
Add to Query Library
Query Library
Search Results (5)
INDIVIDUAL EDITOR
Name SameAs DifferentFrom
Annotations
Property
Value
rdfs:comment
crf:belongto
crf:hasUnit
crf:hasControl
crf:hasValue
checkbox

hasSymptoms
Symptoms
Syndrome Differentiation
BelongTo

Discussion and Conclusion

- The OntoCRF builds on the standard CRF by domain experts, oriental medicine doctors. It organizes classes and properties and their relationships. Therefore preparation based ontology is more systematically than that based RDBMS at representing the knowledge.

- This ontology model is developed in stroke domain. Furthermore it could use to construct the other disease diagnosis and clinical decision support or reasoning by ontology.

- The traditional medicine ontology would link with existing western medicine ontology such as UMLS and SNOMED CT.

- Ontology of metadata in traditional medicine should consent among domain experts.

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A Framework to Extract, Interpret and Structure Clinical Information From Free-Texts

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Abstract

The major barrier in existing hospital information systems is that most information is stored in free-text medical narratives and is unavailable for decision support and research. Our aim is to develop a general medical text processing system to extract clinical information from different types of free-text clinical records. We propose a framework to encode and represent clinical information relying on UMLS Knowledge Resources.

Keywords:

natural language processing, medical records

Introduction

For more than three decades physicians, computer scientists and linguists have addressed Natural Language Processing (NLP) techniques in medicine. Applications include extracting selected types of information from free-text clinical notes and automatic coding of patient information in the terms of a controlled medical vocabulary [1, 2]. When referring to natural language commonly used in medicine, NLP systems are also called Medical Language Processing (MLP) systems [3]. When adequate processing of texts is achieved, MLP systems can make clinical information available for a variety of applications and still preserve the knowledge integrity while offering freedom of expression to physicians.

Conventional medical narratives are commonly stored in existing electronic medical records as free-text clinical notes. We propose a method and provide a framework to automatically process clinical free-text reports from different medical domains in order to extract and represent relevant clinical information. This information can then be easily accessed for other computer applications. In this paper we focus particularly on creating a structure to represent information from free-text clinical notes.

Materials and methods

We based the development of our system on the assumption that, when reading free-text clinical notes, physicians want to know what, when, where, and why health care activities were performed as well as their outcomes. These questions are related with general categories of information as follows: “Event”, “Time”, “Place”, “Reason” and “Outcome”. In our schema, designed to represent information from the free-text, we used the translation of above mentioned categories into semantic types from Unified Medical Language System (UMLS). In this way, “Event” was mapped to “Health Care Activity”, “Time”, to “Temporal Concept” and “Place” became “Health Care Related Organization”. The category “Reason” was mapped to both, “Disease or Syndrome” and “Sign or Symptom”. Since, in our schema, most classes and sub-classes are based on UMLS semantic types they can be related with each other by predicates existing in the UMLS Semantic Network. Thus, assertions such as, “Health Care Related Organization *carries_out* Health Care Activity” and “Diagnostic Procedure *is_a* Health Care Activity” are represented in our structure. However, the UMLS semantic types do not cover all classes of information necessary to represent and structure free-text clinical notes. Therefore, we added other classes to the schema, like “Outcome”. Similarly, we also added some relationships between classes that are well known as existing in free-text medical narratives, even though they do not exist in the UMLS Semantic Network. An example is the relation *occurs_in* between the classes “Health Care Activity” and “Temporal Concept”.

Results

We have created a schema to represent information from clinical notes. The idea here is to represent sentences from a clinical text using an expandable structure which consists of classes of information, relationships among them and a set of attributes for each class of information. At this stage we are evaluating the schema and applying automated techniques to discover rules for the processing task. To date, we have defined some hypotheses which have the potential to develop into these rules.

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A framework to extract, interpret and structure clinical information from free-texts

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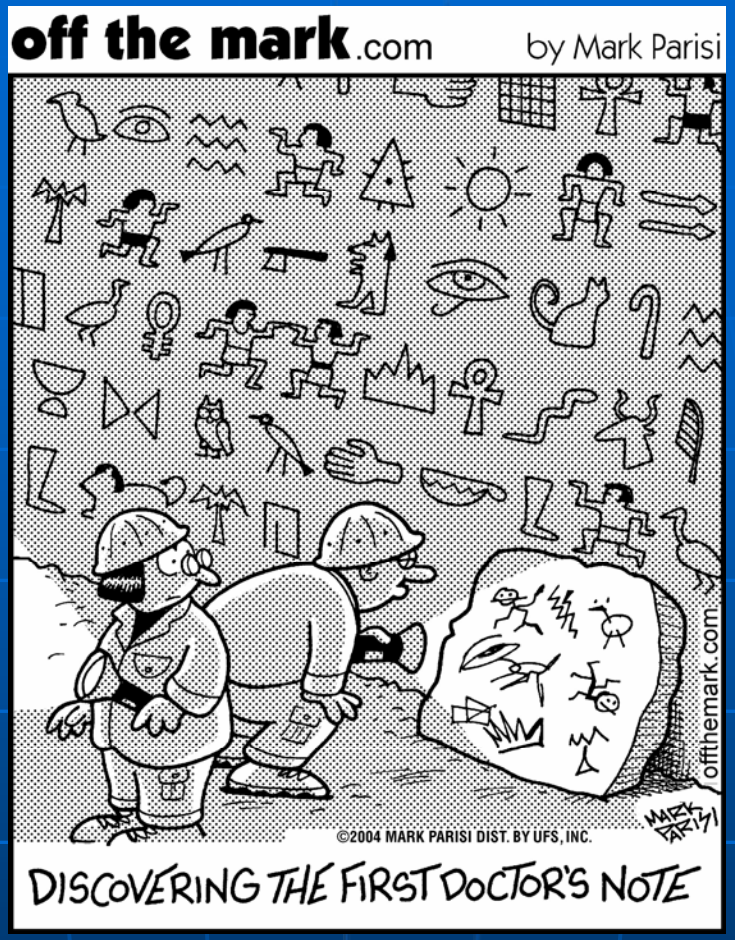


"For better or worse, most clinical data accessible to computer processing is still in the form of unstructured natural language."

(Peter Szolovits 2006 http://groups.csail.mit.edu/medg/projects/text/)

Reasons for having clinical data as free text

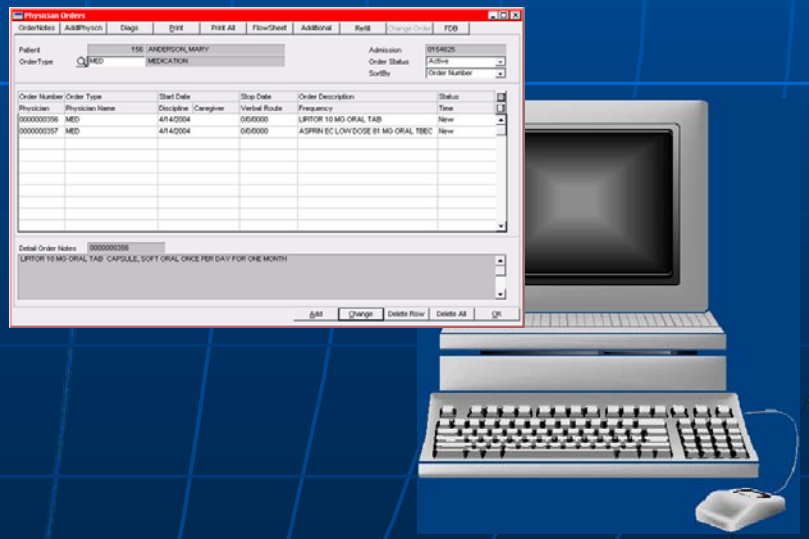
- Original paper-based medical records have been transferred to electronic systems;
- Lack of formalization and standardization;
- Textual Literature – main source of knowledge;
- Computerized Clinical Systems failed to provide structures for clinical information with same degree of expressiveness than free-text.

Some facts about the problem

Conventional medical narratives are commonly stored in existing electronic medical records as free-text clinical notes.

Searching for information in free-text is labour-intensive and demanding task

Computer applications require electronic data to be available in a structured format



To provide a framework and devise automatic methods for extracting relevant clinical information from clinical free-text reports.

Requirements

The system should be applicable to different medical domains

Extracted information should be represented in a form that can be easily accessed by

- medical professionals and
- other computer applications

Approach

We assume that physicians have 5 major questions in mind when reading free-text clinical notes:

What?

Where?

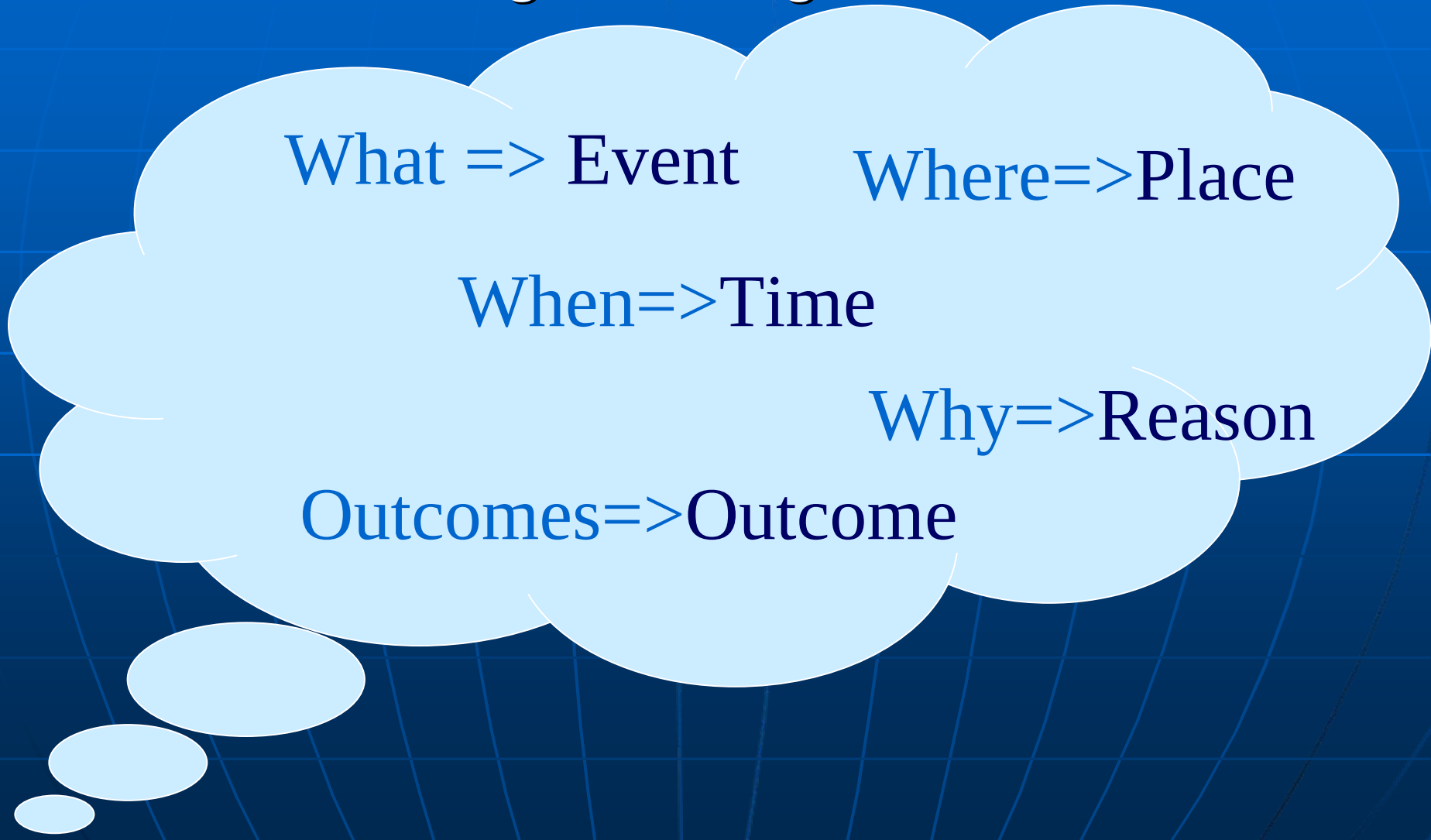
When?

Why?

Outcomes?

Approach

In our schema for representing clinical information, these questions are related to general categories of information.



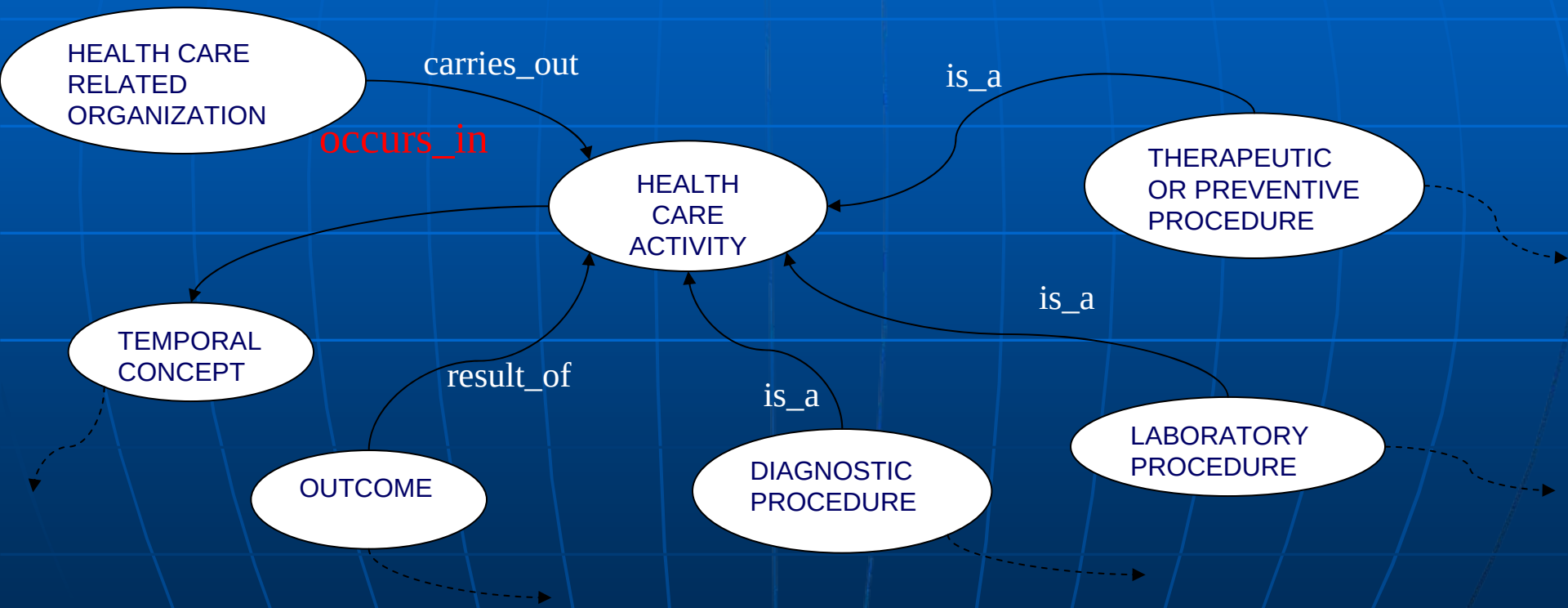
We translated the categories into semantic types from Unified Medical Language System (UMLS).

Event=>"Health Care Activity"
Place=>"Health Care Related Organization"
Time=> "Temporal Concept"
Reason=> " Disease or Syndrome " and "Sign or Symptom"
Outcome=> …..

Some classes like "Outcome" are not related to UMLS semantic types.

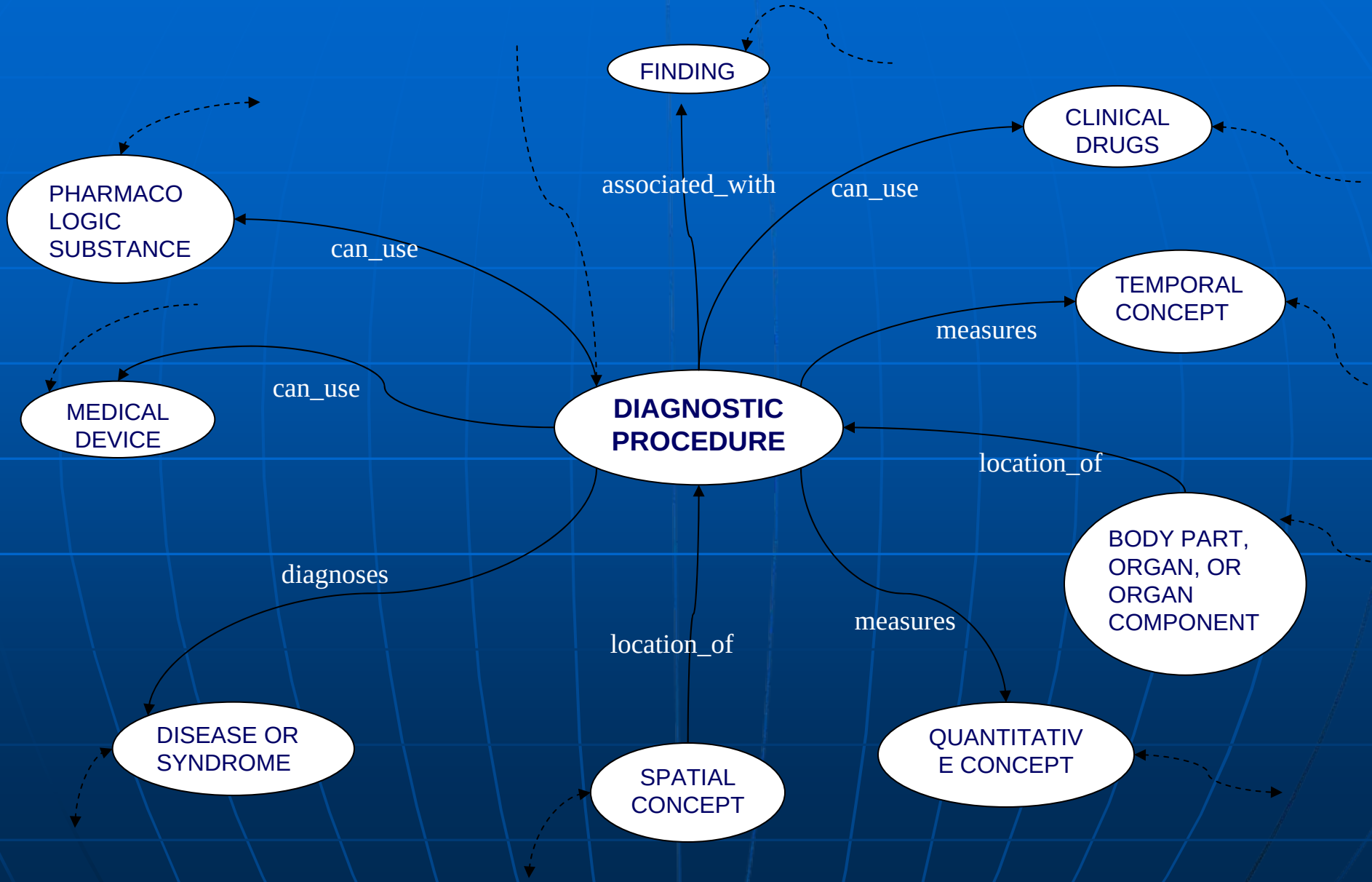
A structure for representing information from free-text clinical notes

The schema inherited predicates existing in the UMLS Semantic Network for classes related to UMLS semantic types.



We also added some relationships between classes that are well known as existing in free-text medical narratives, even though they do not exist in the UMLS Semantic Network.

Diagnostic Procedure - component



Results

Created a schema for representing information from clinical notes using an expandable structure which consists of

- classes of information,
- relationships among them and
- a set of attributes for each class of information.

[HEALTH CARE ACTIVITY]
(*occurs_in)* [TEMPORAL CONCEPT]
[HEALTH CARE RELATED ORGANIZATION] (*carries_out)*
[LABORATORY PROC] | [DIAGNOSTIC PROC] | [THERAPEUTIC OR PREVENTIVE PROC] (*is_a)*
[OUTCOME] *(result_of)*

[DIAGNOSTIC PROCEDURE]
[BODY PART, ORGAN, OR ORGAN COMPONENT] (*location_of)*
[SPATIAL CONCEPT] (*location_of)*
(diagnoses) [DISEASE OR SYNDROME]
(measures) [TEMPORAL CONCEPT]
(measures) [QUANTITATIVE CONCEPT]
(can_uses) [CLINICAL DRUGS]
(can_uses) [PHARMACOLOGIC SUBSTANCE]
(can_uses) [MEDICAL DEVICE]
[FINDING] *(associated_with)*

[BODY PART, ORGAN, ORGAN COMPONENT]
[SPATIAL CONCEPT] (*location_of)*
[QUALITATIVE CONCEPT] *(associated_with)*

[DISEASE OR SYNDROME]
[BODY PART, ORGAN, ORGAN COMPONENT]
(*location_of)*
[SPATIAL CONCEPT] (*location_of)*
[QUANTITATIVE CONCEPT] *(associated_with)*
[FINDING] [FIND] *(associated_with)*

Examples of the schema components

Current status

- Implementation - the schema represents 19 different entities and 34 relationships among them
- Representation - evaluating the schema
- Information extraction - applying automated techniques to discover rules for the processing task

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Constructing Evaluation Corpora for Automated Clinical Named Entity Recognition

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Abstract

We report on the construction of a gold-standard data set consisting of annotated clinical notes suitable for evaluating our biomedical named entity recognition system. The data set is the result of consensus between four human annotators and contains 1,556 annotations on 160 clinical notes using 658 unique concept codes from SNOMED-CT corresponding to human disorders. Inter-annotator agreement was calculated on annotations from 100 of the documents for span agreement (91% as positive specific agreement). For annotations found to be a match with respect to span, agreement was calculated for concept code (82% as positive specific agreement), context (85% as Kappa), and status (89% as Kappa). Complete agreement for span, concept code, context, and status was 75% as positive specific agreement. We consider this to be a conservative estimate for the upper bound for total system performance evaluated with the gold-standard. We found that creating a consensus set based on annotations from two independently created annotation sets can reduce inter-annotator disagreement by 32.3%. Surprisingly, we found little benefit to pre-annotating the corpus with a third-party named entity recognizer.

Keywords:

Natural language processing, named entity recognition, annotated corpora, inter-annotator agreement, SNOMED-CT

Introduction

The text analysis group at the Mayo Clinic College of Medicine has built and deployed a text analysis system that processes the entire repository of clinical notes in Mayo's electronic medical record. The system identifies, among other things, mentions of disorders and the context and status of those mentions. This output provides a concept-based index of the clinical notes repository used for retrieval purposes by researchers. We have anecdotal evidence based on browsing system output and end-user feedback that gives us a rough idea of the quality of our system. However, there has not yet been a formal evaluation of the final output of the system. By creating a gold-standard data set that represents complete and accurate system output, it becomes possible to measure the performance of actual system output in a way that is automated and comparable across multiple versions of the system. To this end, we have created a gold-standard corpus of annotated clinical notes for the disorder concepts that our system attempts to identify. In this paper we describe how we constructed this gold-standard corpus and evaluated its quality.

[1] provide a survey of gold-standard corpora that are available for the biomedical domain. They are few in number and vary widely in size and quality and none of them were designed with clinical data in mind. There have been no such publicly-available resources for the clinical domain until very recently[1]. This is due to the sensitive nature of patient data and the strict confidentiality laws designed to protect them[2]. Unfortunately, the development of gold-standard corpora is difficult and expensive because of the tedious and detailed nature of the work and the domain expertise required. Some of the well known challenges are outlined in [2]. Absent shared community resources for the medical domain, we are faced with the choice of creating our own or doing without. As we took up the challenge to build our own gold-standard data set, a key consideration was to determine the feasibility of creating a very high quality corpus with limited resources. Thus, the process of building our gold standard was designed so that we could measure the expense of additional review of the annotations against gains in quality of the data set. We also explored one way to potentially speed up annotation: pre-annotation with a third party system, MetaMap.

Materials and methods

Clinical notes corpus

The Mayo Clinic has a repository of approximately twenty million clinical notes that consist of documents dictated by physicians that are subsequently transcribed and filed as part of the patient's electronic medical record. The notes consist of sections such as *Chief Complaint, Current Medications,* and *Impression/Plan,* among others. The repository contains outpatient notes, discharge summaries, and inpatient service notes. From this repository we ran-

1 See https://www.i2b2.org/NLP/.

2 For this reason, our corpus will not be made publicly available in its current form. Contact chute@mayo.edu further information.

domly selected 160 notes for the corpus used for the gold-standard data set. The total number of words in the corpus is 47,975 with a median word count of 249 words per note.

Table 1 - UMLS Semantic types corresponding to disorders

TUI	type name
T019	Congenital abnormality
T020	Acquired abnormality
T037	Injury or Poisoning
T046	Pathologic Function
T047	Disease or Syndrome
T048	Mental or Behavioral Dysfunction
T049	Cell or Molecular Dysfunction
T050	Experimental Model of Disease
T190	Anatomical Abnormality
T191	Neoplastic Process

Annotation schema

The annotation task performed by the annotators consists of creating labeled spans of text that correspond to mentions of disorders found in the clinical note. Each annotation has one or more spans of text, a concept code, a context, a status, and a flag that indicates whether the mentioned disorder is related to the patient or not. An annotation's concept code is a string attribute that contains a concept identifier from a controlled vocabulary, in this case SNOMED-CT. The context of an annotation is an attribute with one of the following values: *current, history of, and family history of*. The status of an annotation is an attribute with one of the following values: *confirmed, possible,* and *negated*. Any combination of context and status values is permitted for an annotation. For example, the combination of the context *family history of* with the status *negated* means that the patient has no family history of the mentioned disorder. An annotation may also be flagged as unrelated to the patient if the mentioned disorder has little or nothing to do with the patient's health (e.g. an organization's name as in "Diabetes Clinic"). When an annotation is flagged as unrelated to the patient, the context and status are both automatically given the value *unrelated to patient.*

We created a subset of SNOMED-CT that contains only those concepts corresponding to disorders by leveraging the Unified Medical Language System[3] (UMLS) and its Semantic Network. The UMLS assigns to each concept in SNOMED-CT one or more semantic types defined in the Semantic Network. The subset of SNOMED-CT we used was created by selecting only those SNOMED-CT concepts assigned one of the semantic types shown in Table 1. This list was derived from [3][4]. The resulting subset of SNOMED-CT consists of 82,813 concepts and was provided to the annotators via an interface that provides keyword search and hierarchical navigation[5].

Annotators

Four clinical data retrieval experts performed the annotation task. All of them have been in their current work positions since 2002 and have prior experience in the medical coding of patient records. Each of the annotators has experience with various medical terminologies (e.g. ICD-9). However, none of them had prior experience with SNOMED-CT and no SNOMED-CT specific training was conducted.

Annotation software

Knowtato[6]r is a general purpose text annotation tool for creating gold-standard training and evaluation corpora for Natural Language Processing (NLP) systems described in [4]. The annotation schema described above was easily instantiated in Knowtator without any task-specific software development. Knowtator provides a mechanism to aggregate multiple sets of annotations into a single annotation project and various inter-annotator agreement (IAA) metrics for comparing multiple sets of annotations. Additionally, Knowtator provides a consensus set creation feature that provides a mechanism for resolving differences between two sets of annotations.

Table 2 - Annotation summary

set	description	count	hours
A1	MMTx pre-annotated	1105	53.5
A2	not pre-annotated	1142	53
A3	MMTx pre-annotated	1054	38
A4	not pre-annotated	1113	21
C1	consensus of A1 & A3	1125	8
C2	consensus of A2 & A4	1193	11
GS	consensus of C1 & C2	1164	13
MMTx	created by MMTx	664	<1

3 http://www.nlm.nih.gov/pubs/factsheets/umls.html. ver. 2005AC

4 We excluded *Finding* and *Signs and Symptoms* to limit scope.

5 See http://www.nlm.nih.gov/research/umls/meta6.html#s6_11

6 See http://bionlp.sourceforge.net/Knowtator

Pre-annotation of the corpus with MMTx:

We pre-annotated all 160 notes in the corpus using the MetaMap Transfer (MMTx)[7] tool. MMTx provides mappings from natural language text to UMLS concepts. The MMTx distribution provides a set of scripts that can build a customized target set of concepts to map to. Using these scripts we were able to provide MMTx with the set of SNOMED-CT concepts described in §2.1. Each annotation that MMTx presents has a span, a concept code, and a relevance score. We used only those mappings with a relevance score of 900 or greater (out of a possible 1000) in order to reduce the number of spurious matches. The resulting annotations were imported into Knowtator and were made available to two of the annotators as described below.

Annotation workflow

Each of the 160 notes was annotated individually by all four annotators, referred to as A1, A2, A3, and A4 (see Table 2). Two of the annotators, A1 and A3, were given MMTx annotations and were encouraged to use, discard or add to the provided annotations as they saw fit. The other two annotators, A2 and A4, were given the clinical notes without any MMTx annotations provided. Other than the presence or absence of MMTx annotations, all four annotators had exactly the same annotation task using the same annotation guidelines. After a note was annotated individually by A1 and A3, a set of pair-wise consensus annotations, C1, was created by A1 and A3 using the annotations they created individually and having them work together to resolve all differences. Similarly, a consensus set, C2, was created from A2 and A4's annotations. When both consensus sets were created for a document a master consensus set, GS, was created by all four annotators working together to resolve the differences between C1 and C2. The set GS is considered our final gold-standard set of annotations.

Sixty of the notes were annotated during a trial phase during which the annotation schema was finalized, the annotation guidelines were completed, and the annotators were trained. Frequent meetings were held during this phase to provide instruction, review examples, and receive feedback about the task. IAA results reported here exclude annotations from this set of 60 notes. However, we included these annotations into our final gold-standard data set because the annotation schema and guidelines were completed before a final round of four-way consensus annotation was performed as described above. During the annotation of the remaining 100 notes the annotation schema and guidelines were not changed, no meetings were held, and the annotators were given a strict prohibition from communicating with each other about the annotation task. IAA results reported below are only for these 100 notes.

Annotation guidelines

[5] show that careful consideration of annotation guidelines can have a marked impact on IAA. Therefore, we took care to create detailed and complete guidelines for the annotators. The annotation guidelines given to the annotators consist of about 3900 words and contain over 40 examples. The guidelines have the following four overarching principles:

1. *A mentioned disorder should be assigned the most specific concept code named by the span of text*. The text covered by the span of an annotation should be a reasonable synonym of the names associated with the concept. Descriptions of disorders should not be annotated, i.e. there should be little or no inference performed by the annotator.
2. *All mentions of disorders in each note are to be annotated.* Every disorder mentioned by name in the text of the clinical note should be annotated regardless of its relevance to the patient. If the disorder is not related to the patient's health, then the corresponding annotation should be flagged as *unrelated to patient*.
3. *A disorder is defined as any concept that appears in the subset of SNOMED-CT that has been provided.* This rule provides an unambiguous and clear definition of what a disorder is.
4. *There should be only one annotation per mentioned disorder.* In some cases a mentioned disorder could reasonably be assigned to more than one concept code. Always, choose the most specific concept that is named by the text.

The remainder of the guidelines consist of a detailed description of the annotation schema, Q&A styled instructions, and examples. Some example questions answered in the guidelines were: *How do I decide what the most specific concept is? Are nested annotations allowed? Are overlapping annotations allowed? Can the spanned text of an annotation be more specific than the assigned concept code?*

Calculating IAA

We report IAA as positive specific agreement described in [6] given by:

$$Ppos = \frac{2a}{2a + b + c} \quad (1)$$

7 See http://mmtx.nlm.nih.gov/

where *a* is the number of cases where the annotators agree and where *b* and *c* are non-matches from each annotator, respectively. Positive specific agreement is reported for match criteria requiring span selection agreement because negative instances are not easily counted and expected chance agreement is vanishingly small. We also report the Kappa statistic described by [7] and [8] given by:

$$\kappa = \frac{P(A) - P(E)}{1 - P(E)} \quad (2)$$

where P(A) is percentage agreement and P(E) is expected chance agreement. Kappa is reported for match criteria that compare only annotations that already agree with respect to span selection for the features concept code, context, and status. The procedure that we used for calculating Kappa is described in detail by [9].

IAA for annotation of texts in the biomedical domain have been reported as Kappa as in [10, 11] and as F-measure described in [12] by [5, 13, 14]. [6] show that positive specific agreement, balanced F-measure, and Kappa are equivalent as P(E) approaches zero. The calculation of IAA for a set of annotations can be varied in many ways by defining different match criteria. We report on the following match criteria: spans are identical, spans overlap, spans overlap and concepts match, spans overlap and contexts match, spans overlap and status's match, and spans overlap, concepts, contexts, and status's match.

This selection of match criteria reflects our attitude towards exact span matching versus approximate span matching. We consider the agreement of concept code, context, and status assignments to be far more important than having exact span agreement. By relaxing the span matching criteria to require only an overlapping span match we get a better idea of how well the annotators agree with respect to the other attributes.

Results

The final gold-standard data set consists of 1556 annotations from the master consensus sets from the trial and experimental sets of notes. A total of 658 unique concept codes were used in the concept code assignments of the annotations. Because sixty of the notes were annotated under uncontrolled circumstances (i.e. the annotators communicated with us and each other) we report only results on the annotations for the remaining 100 notes. Table 2 provides a summary of the annotation sets that were created for these 100 notes including the number of annotations in each annotation set and the number of hours it took the annotators to create them. Because it took a total of 185 hours to create A1, A2, A3, A4, C1, and C2 we conclude that the annotator time to create a single pairwise consensus set for 100 documents is about 92 hours or roughly one document per hour. Table 3 provides the IAA results as positive specific agreement and Table 4 shows the IAA results as Kappa for only those annotations that are considered matches with respect to overlapping span for the attribute's concept code, context, and status. A1, A2, A3, and A4 are compared as average 2-way IAA in both tables.

An estimate on the upper bound of system performance

One would not expect an NLP system to agree with a human generated gold-standard data set better than the humans agree with each other. As such, the IAA numbers reported here represent upper-bounds on system performance as measured against the gold-standard. The most important datum that best represents the overall consistency of the gold-standard on the entire annotation task is the agreement between C1 and C2, 74.6%, for the match criteria that requires the spans to overlap and the concept code, context, and status values to match shown in Table 3. Because the final gold-standard data set is the result of an additional consensus step based on C1 and C2 we would expect that the consistency of GS to be better than C1 and C2. Thus, we conclude that 74.6% is a conservative upper bound for complete system performance.

Table 4 - IAA as Kappa

	A1,A2,A3,A4			C1,C2		
	K	P(A)	P(E)	K	P(A)	P(E)
concept	82.6	82.7	0.5	89.9	89.9	0.5
context	75.4	90.0	59.2	84.5	93.4	57.1
status	82.8	92.2	54.3	88.8	94.7	52.3
concept + context + status	71.0	71.1	0.3	82.1	82.1	0.3

Another datum of importance is the positive specific agreement, 81.7%, between C1 and C2 for the match criteria that requires the spans to overlap and the concept codes to match. A related datum appears in Table 4 that reports Kappa on concept code agreement for those annotations that match with respect to overlapping spans for C1 and C2, 89.9%. However, this represents an inflated measure of concept code agreement because this computation of Kappa removes annotations that disagree with respect to span. This effectively removes annotations that disagree with respect to concept code because the tasks of span selection and concept code assignment are very closely related per the annotation guidelines. It follows that measuring concept code agreement on only those annotations that agree with respect to exact span matching is even

higher (= 95.0% between C1 and C2). Therefore, we believe 81.7% to be a more reasonable estimate of the upper bound for system performance on the task of normalized named entity recognition.

Because the tasks of assigning context and status to annotations is much less related to the task of span selection, we consider the Kappa results in Table 4 to be a better indication of how well the annotator's agree than the corresponding percentage agreement results in Table 3. Thus, we consider 84.5% and 88.8% as Kappa agreement between C1 and C2 for context and status, respectively, to be the fairest measure of annotator agreement for those attributes. However, the absolute percentage agreements of 93.4% and 94.7% probably represent a more appropriate upper bound on system performance.

Table 3 - IAA as positive specific agreement

compared annotation sets	compared attributes					
	spans exact	spans overlap	spans overlap +			
			concept	context	status	concept + context + status
A1, A2, A3, A4	75.7%	87.9%	72.7%	79.0%	80.9%	62.5%
C1, C2	81.4%	90.9%	81.7%	84.8%	86.0%	74.6%
C1, MMTx	42.3%	47.0%	42.3%	n/a	n/a	n/a
C2, MMTx	38.2%	44.1%	37.3%	n/a	n/a	n/a
GS, MMTx	39.8%	45.7%	39.5%	n/a	n/a	n/a

The effect of creating a pair-wise consensus set

We hypothesized that having two individuals annotating independently and creating a consensus set would result in a much more consistent set of annotations. For every match criteria that we examined, there is a marked improvement in IAA between pair-wise IAA of individuals and the corresponding pair-wise consensus-level IAA. Table 3 shows that the average pair-wise IAA for the match criteria that requires spans to overlap and the concept code, context, and status rises from 62.5% for individual annotation sets to 74.6% for consensus annotation sets, a 32.3% disagreement reduction.

The effect of pre-annotating with MMTx

We hypothesized that providing the annotators with annotations from a third party system, MMTx, would be a good way to improve the speed and consistency of the annotation task without introducing bias that favors our system. Unfortunately, Table 2 shows that the annotators given the MMTx annotations, A1 and A3, annotated slower than the other two annotators, A2 and A4. Both A1 and A3 complained that the existing annotations slowed them down because spurious annotations and multiple mappings for the same span made them consider more concept codes than they would have otherwise. There was also no clear trend that the MMTx annotation improved pair-wise IAA between individuals. Also, MMTx did not have any measurable impact on the final assignments made in the master consensus set. If MMTx was providing "better" concept codes, then one would expect this to be reflected in the agreement between GS and MMTx. Table 3 shows the percentage agreement with respect to overlapping spans and concept code matching for C1 and MMTx to be 42.3% and 37.3% for C2 and MMTx. The agreement between GS and MMTx is about halfway between these two points at 39.5%. This is the case for every other IAA number reported for MMTx in Tables 3 and 4. Thus, we conclude that while the MMTx annotations seemed to influence the annotations in C1, there was no clear benefit to introducing this bias.

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MedinfoParser: A Semantic tool for Information Extraction

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Abstract and objective

We have developed a semantic tool (MedinfoParser) for the information extraction of medical documents. The main role of the parser is to parse medical sentences and extract key information. It puts Part-of-Speech (POS) tags and conceptual tags for the extraction. The parser consists of a Korean parser, an English parser, a numeric detector, and a noun phrase detector. For the semantic extraction, it gets conceptual id from the UMLS knowledge server.

Keywords:

MedinfoParser, information extraction, medical document

Introduction

In the era of the electronic medical record (EMR), huge amount of medical documents are produced electronically. EMR provides many kinds of templates for the coded data entry, but most clinical notes are still written in free text. To catch the patient's clinical status in a short period of time, EMR should provide a neat tool for summarizing medical records. We have developed MedinfoParser which is a semantic tool for information extraction.

Methods

MedinfoParser consists of a Korean parser, an English parser, a numeric detector, and a noun phrase detector.

Korean parser: Korean parser breaks a document into sentence fragments and tokenizes sentences. It provides POS tags of words and those of morphemes. As a Korean parser we have used KLT parser[1]. We modified the numeric module of KLT parser in order to provide more sophisticated analysis. Numeric expressions are more distinctly denoted by separating the numeral tokens from the alphanumeric combined words. And numeral words are converted into Arabian numbers. A new tag of 'NB' and 'M' are introduced to annotate numeric expressions more precisely.

English parser: In general, Korean medical records are written in Korean and English mixed. However, most medical expressions are written in English. In order to parse those key medical expressions, English parser detects medical terms written in English. By sending queries to UMLS knowledge server, it gets UMLS cuis. Then it puts a 'MED' tag and a UMLS cui at the end of each medical term. Medical documents contain lots of abbreviations and locally defined terms which are used only in a specific institution. As these terms are not searched through UMLS, we designed user dictionaries.

Numeric detector: As the numeric expression contains very important meaning in medical records, we have improved the numeral identification function. Especially in order to extract key information in the chronological order, the identification of the temporal expression is the most significant. For the Numeric detector we designed a rule pattern based on data frames for the semantic extraction. Each data frame works as a unit concept. It has various methods to evoke functions. The numeric detection rule contains data frames which are necessary to extract numeric expressions from the medical records.

Noun phrase detector: Noun phrase (NP) detector identifies medical concepts that are consisted of more than two words. NP boundary can be identified in many ways according to the reviewer's view. Therefore we made principles to clearly identify noun phrases. About one hundred NP lists were extracted from the discharge summaries in Seoul National University Hospital. We analyzed the context of each NP occurrence and have been developing rule patterns for NP detection.

Discussion and conclusion

We have developed a semantic tool for the information extraction of medical documents. The implemented Korean parser and English parser generate the highly readable XML files that can be used for other medical applications. For the future work, we will display the output of MedinfoParser onto the timeline to make a chronological summary. We hope that MedinfoParser will be a promising tool for the information extraction in medical field.

1 From the NLP laboratory of Kookmin university in South Korea

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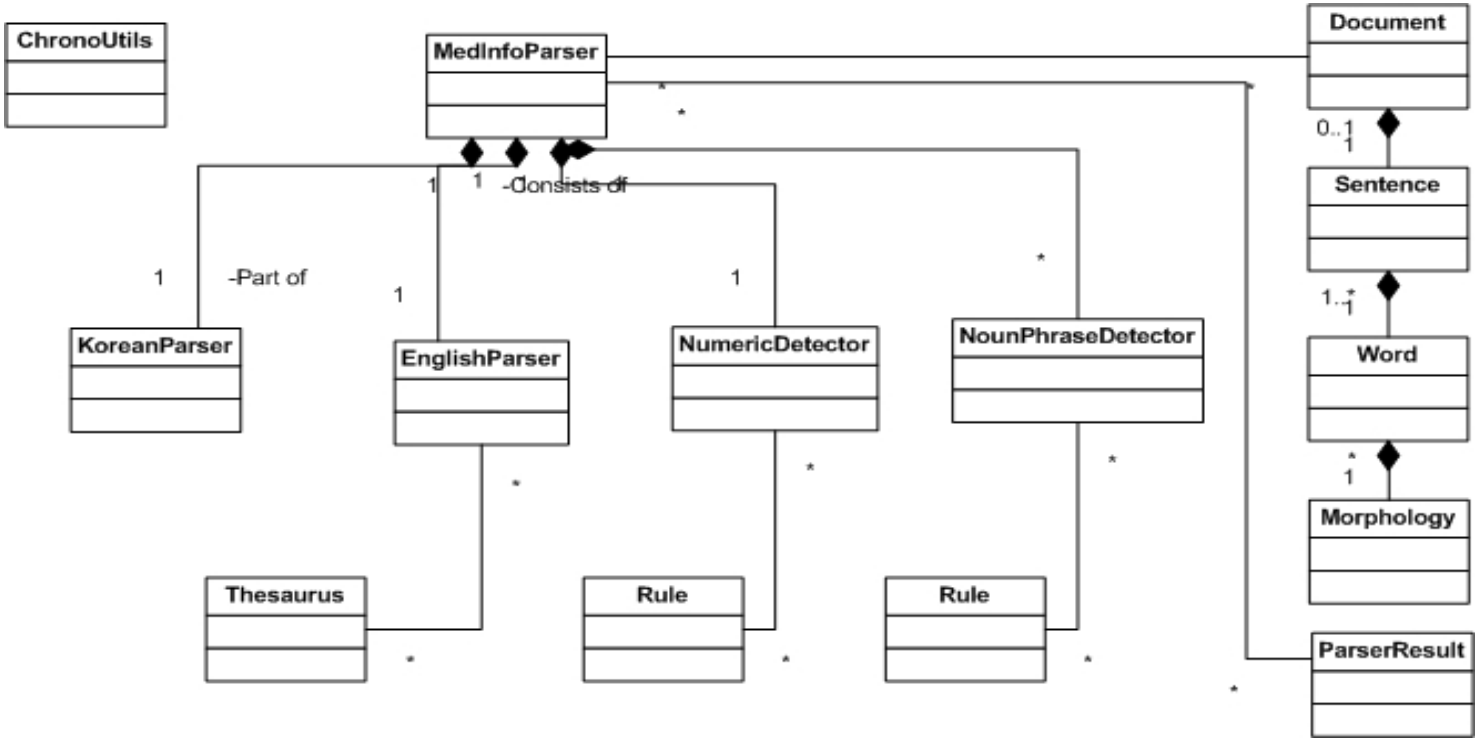
Introduction

- Background
  - Era of the electronic medical record (EMR)
  - Huge amount of medical documents are produced electronically
  - Most clinical notes are still written in free text
  - Difficulties in catching a patient's clinical status in a short period of time
  - Needs for a neat tool for summarizing medical records
- Purpose
  - Develop a semantic tool for summarizing medical records
- We have developed MedinfoParser

MedinfoParser

- A semantic tool for information extraction
- Role
  - Tokenization
  - POS tagging
  - Concept recognition
    - medical concept
    - numeric concept
    - noun phrase identification
- Components
  - Korean parser
  - English parser
  - Numeric detector
  - Noun phrase detector

A Classdiagram of the MedinfoParser



Korean Parser

- Tokenizes and parses Korean medical documents
  - Breaks a document into sentence fragments
  - Tokenizes sentences
  - Puts POS tags after the each parsed word and morpheme

<s>
<ins>Child C LC Chronic PSE Supportive care 위해 입원함</ins>
<anl>
Child|N|@|(Child|N)
C|N|@|(C|N)
LC|N|@|(LC|N)
Chronic|N|@|(Chronic|N)
PSE|N|@|(PSE|N)
Supportive|N|@|(Supportive|N)
care|N|@|(care|N)
위해|VM|?|(위하|V + 어|e)
입원함|NSM|?|(입원|N + 하|t + ㅁ|e)
</anl>
</s>
<s>
<ins>Ativan therapy 하며 밤에 재움 점차 Liver failure 진행되어 사망</ins>
<anl>
Ativan|N|@|(Ativan|N)
therapy|N|@|(therapy|N)
하며|VM|?|(하|V + 며|e)
밤에|NJ|N|(밤|N + 에|j)

An example of Korean parser output

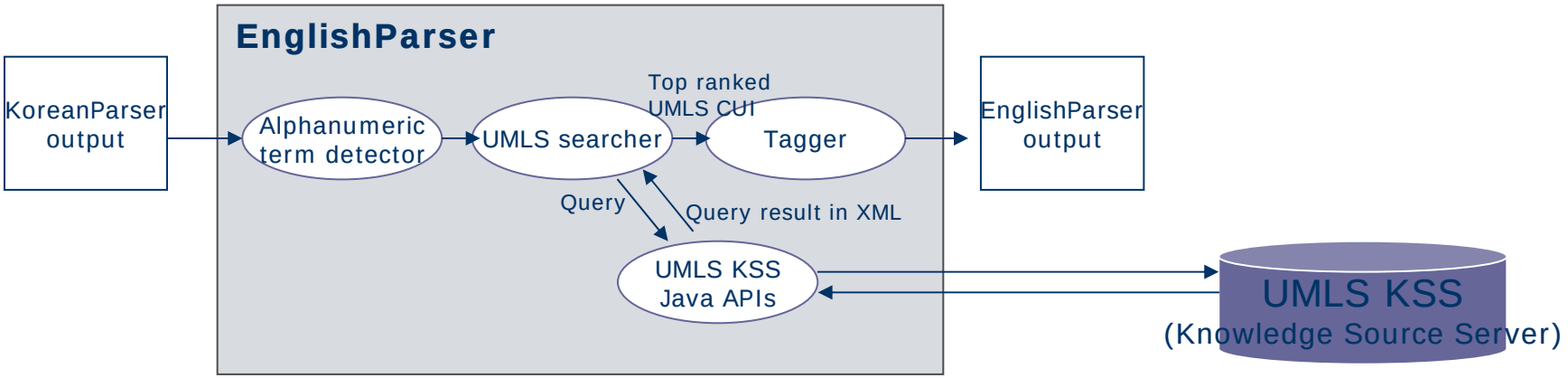
English Parser

- Characteristics of Korean medical records
  - Written in Korean and English mixed
  - Most medical expressions are written in English
  - Contain a lot of abbreviations and locally defined terms
- Parses key medical expressions
  - Detects alphabetic words
  - Sends queries to UMLS knowledge source server
  - If any UMLS CUIs are returned, puts ‘MED’ tag and a top ranked UMLS cui
- To detect medical terms that are not searched from UMLS, we designed user dictionaries

<s>
<ins>Child C LC Chronic PSE Supportive care 위해 입원함</ins>
<anl>
Child|N|**MED**|(Child|N|**C0008059**)
C|N|MED|(C|N|C0227087)
LC|N|MED|(LC|N|C0008565)
Chronic|N|MED|(Chronic|N|C0205191)

An example of ‘MED’ tagged result generated by English parser

MED tagging Process




```
<?xml version="1.0" encoding="UTF-8" ?>
- <ConceptIdCollection version="1.0">
  - <query>
    - <findCUI version="1.0">
        <release>2006AB</release>
        <term>AGE</term>
        <language>ENG</language>
        <approx />
      </findCUI>
    </query>
    <release>2006AB</release>
  - <conceptId>
      <cui>C0001779</cui>
      <cn>Age</cn>
    </conceptId>
  - <conceptId>
      <cui>C0001771</cui>
      <cn>Agar</cn>
    </conceptId>
  - <conceptId>
      <cui>C0242449</cui>
      <cn>Ageism</cn>
    </conceptId>
  - <conceptId>
      <cui>C0030543</cui>
      <cn>Age, Parental</cn>
    </conceptId>
  - <conceptId>
      <cui>C0024915</cui>
      <cn>Age, Maternal</cn>
    </conceptId>
```

<an example of query result in XML>

: the CUIs are ranked by the UMLS KSS

Numeric Detector

- Numeric expressions are key information for summarizing events in chronological order
- Extracts numeric terms and finds clinical events which are relevant to the terms based on numeric detection rules
- The numeric detection rules contain data frames which are necessary to extract numeric expressions from the medical records
- Defined seventeen numeric concepts that are critical in medical field, and other concept classes needed for the numeric concept extraction

```
@drugName
listed in thesaurus;
has umlsID;
;;

@drugUnit
listed in (drug unit) thesaurus;
following number;
;;

@medication
expressed in integer;
following drugName;
followed by drugUnit;
;;
```

A sample numeric detection rule for *'medication'*

Rule patterns

- Designed based on data frames (David W. Embley, 2004)
  - Representational frame that encapsulates the essential properties of everyday data items
- Each data frame contains functions, other concept classes, relations, expressions to extract single concept
- Each data frame works as a unit concept. It has various methods to evoke functions

Noun Phrase Detector

- Identifies boundaries of the medical noun phrases (NPs) which are consisted of more than two words
- Made principles to clearly identify boundaries of ambiguous cases
  - The main idea of the principles : the longest noun phrase which has an atomic medical concept should be identified as a NP
  - E.g., *'… Child C liver cirrhosis …'*
    - Possible NPs : *'liver cirrhosis', 'Child C liver cirrhosis'*
    - Noun phrase detector identifies *'Child C liver cirrhosis' as a NP*
- Have been developing rules for NP detection

<s>
<ins>**Child C LC** **Chronic PSE** **Supportive care** 위해 입원함</ins>
<anl>
<NP>
Child|N|MED|(Child|N|C0008059)
C|N|MED|(C|N|C0227087)
LC|N|MED|(LC|N|C0008565)
</NP>
<NP>
Chronic|N|MED|(Chronic|N|C0205191)
PSE|N|MED|(PSE|N|C1518860)
</NP>
<NP>
Supportive|N|@|(Supportive|N)
care|N|MED|(care|N|C0580931)
</NP>
위해|VM|?|(위하|V + 어|e)
입원함|NSM|?|(입원|N + 하|t + ㅁ|e)
</anl>
</s>
<s>
<ins>**Ativan therapy** 하며 밤에 재움 점차 **Liver failure** 진행되어 사망</ins>
<anl>
<NP>
Ativan|N|MED|(Ativan|N|C0699194)
…

An example of noun phrase tagged output

Discussion and Conclusion

- Have developed a semantic tool for the information extraction of medical documents
- Each module produces a highly readable XML file as an output
- Easily adoptable to other medical applications
- Future work
  - Display the output of MedinfoParser onto the timeline to make a chronological summary

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Collecting Presenting Problems From Patient Records by Text Mining

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Abstract

The presenting problem in emergency care largely determines the direction of activities and thus the workload of parts of the hospital. To determine the mixture of presenting problems in the emergency department of a teaching hospital we analysed text in patient records, using a set of regular excpressions to extract the patients' presenting problem/reason for encounter. Such a problem could be extracted in about 84% of cases, and suggests that such methods can be useful for creating statistics. Among anticoagulated patients, bleeding related problems were overrepresented, suggesting that this method could also be used to find adverse drug effects.

Keywords:

natural language processing, data mining, reason for encounter, adverse drug reactions, anticoagulant therapy

Introduction

A majority of the patients treated at our hospital present as non-planned emergency visits and are initially admitted through the emergency ward. When a patient is discharged the final diagnosis is reported for national statistics, but no information is collected routinely on the reasons for encounter. The distribution of patient problems in the emergency ward to a determines a large part of the workload and activities at the hospital. Manual coding of patients' reasons for encounter is time consuming, and no optimal coding system is available.

The aim of this study was to analyse the distribution of reasons for encounter in general as well as among patients treated with the anticoagulant drug warfarin. Data extracted this way could be aggregated to describe the case mix of actual patients, and help in planning the work and activities at the hospital. One hypothesis was that conditions related to bleeding would be more common with anticoagulation.

Materials and methods

Materials

All records from 1994-2005 of the database Melior[1], Departments of Surgery and Internal medicine, Östra Sjukhuset, Sahlgrenska University Hospital, Göteborg, Sweden, were analysed. We have no access to the database tables containing patient identity, which helps preserve patient integrity. The method of data collection has been approved by the local ethics committee and those responsible for security at the hospital.

Text in the patient record is sorted in the database under different record headings, and for this study only text under the heading "besöksorsak" (reason for encounter) from the physician emergency note was analysed. This text can consist of a single word, like "buksmärtor" (abdominal pains), or it can be made up of anything from a few words to several sentences, e.g. "patienten söker på grund av illamående och buksmärtor" (the patient seeks help because of nausea and abdominal pains). In addition to the reason for encounter text under this heading often describes other conditions of patients' admission, such as from where patient is referred (other hospital, GP, other clinic), or how patient comes to the emergency ward (by ambulance/brought in by relative…).

Methods

Text paragraphs were collected from the database by SQL queries, giving a relatively homogeneous set of text paragraphs, most of which contained a reason for encounter. The average length of each text line in medical and surgical notes were 38.7 and 38.3 characters, respectively. The longest text string was 1444 characters and the shortest 1 character. The result set was saved in a text file consisting of 49918 lines from surgery, 87037 from internal medicine, with text from one medical record on each line. Similar text files of 1035 lines from surgery, 8791 from internal medicine was produced with the additional criterion that the medical record somewhere contained the string "Waran", the trade name for Warfarin in Sweden.

The search method was developed using only the surgery material, and later applied to the internal medicine text. First analysis was made using a concordance (a list of all the words in the text presented with their closest context) was created from the larger text file using the software package Concordance 3.0[2], which count the number of instances of every unique word, and allows concordance lists to be sorted by the context that appears around the word - the word before or after, two words before or after, and so on.

1 Siemens Health Solutions

2 R.J.C Watts. http://www.concordancesoftware.co.uk/

S0rting the words by number of appearances made it possible to see which reasons for encounter were the most common. By looking at the concordance of a common reason for encounter with the context sorted in different ways it was easy to see in which surroundings the word often appears. Patterns in the text that were often associated with a reason for encounter were determined by manual analysis of concordances, and guided by these identified patterns, customized Perl[3] scripts could identify and count phrases matching reasons for encounter according to the patterns determined in the concordance analysis. The method of doing this was divided into two steps. In the first step, a Perl script reads through the text file one line at a time, trying to match each line with a pattern such as:

- a single word, like buksmärtor (abdominal pains) or skalltrauma (head trauma).
- two or a few words, or comma separated lists of such word groups, like commotio cerebri or svårighet att gå, buksmärtor (difficulties to walk, abdominal pains)
- a comma separated lists of single words, like buksmärta, illamående, diarreer (abdominal pains, nausea, diarrhea) or hematemes, melena samt buksmärtor (hematemes, melena and abdominal pains).

Table 1 - Reasons for encounter in surgery

Surgery - total		Occurrences	
Reason for encounter		*n*	%
Buksmärtor	abdominal pains	9036	18,0
Buksmärta	abdominal pain	4224	8,43
Kräkningar	vomiting	1455	2,90
Misshandel	abuse	953	1,90
Sårskada	wound	834	1,66
Illamående	nausea	813	1,62
Feber	fever	712	1,42
Falltrauma	fall	609	1,22
Trafikolycka	traffic accident	585	1,17
Diarreer	diarrhea	512	1,02
Skalltrauma	head injury	412	0,82
Melena	melena	409	0,82
Hematemes	hematemesis	402	0,80
trauma skalle	head trauma	383	0,76
Diarre	diarrhea	344	0,69
Förstoppning	obstipation	268	0,54
Obstipation	obstipation	264	0,53
epigastralgier	epigastralgia	257	0,51
Urinstämma	urinary obstruction	209	0,42
trauma thorax	thorax trauma	181	0,36

- longer text strings where keywords or keyphrases indicate the reason for encounter, like ...frågeställning om appendicit (suspected appendicitis) or ...söker pga högersidig buksmärta, illamående och kräkningar (seeking care due to abdominal pain, nausea and vomiting). In these cases only the rest of the sentence after the keyphrase (here frågeställning om and söker pga) is regarded as the reason for encounter, even if there is more text after that sentence.

In the second step another Perl script reads through the hashtable to further split and analyze the phrases identified in step 1, often containing long strings of text or comma separated lists of words, by pattern matching.

Some examples of patterns handled in step 2 are:

- Words in lists and enumerations separated by commas, full stops and conjunctions are regarded as separate reasons for encounter, like buksmärta, illamående, diarreer (abdominal pain, nausea, diarrhea) which result in three reasons for encounter.
- Lists or enumerations of word groups consisting of a few words separated by commas, full stops and conjuctions are regarded as separate reasons for encounter, like svårighet att gå, högersidiga buksmärtor (difficulties to walk, abdominal pains on the right side). Here svårighet att gå is one reason for encounter, högersidiga buksmärtor is another.

Results

The Perl scripts were able in the surgery material to identify a reason for encounter according to the patterns in 42961 of the 49918 lines in the text file (86.1 %). In all, 50093 occurrences of any of 10459 different reasons for encounter were found. 406 reasons for encounter were identified 10 times or more, accounting for 35934 occurrences (72% of all). 8283 reasons for encounter only appear once (16% of occurrences, 79% of types) some of which may be e.g. spelling errors or in need of further processing. The most common reasons for encounter consist of one or two words, like illamående (nausea) or trauma skalle (head trauma). 3387 (32% of types) of the reasons for encounter consist of one or two words, and most of these seem to be correct and relevant.

Table 2 - Reasons for encounter in surgery among warfarin patients

Surgery - Waran		Occurrences	
Reason for encounter		*n*	%
buksmärtor	abdominal pains	158	14,74
buksmärta	abdominal pain	58	5,41
melena	melena	27	2,52
falltrauma	fall	25	2,33
illamående	nausea	23	2,15
kräkningar	vomiting	23	2,15
hematemes	hematemesis	19	1,77
feber	fever	18	1,68
hematuri	hematuria	14	1,31
gastrointestinal blödning	GI bleeding	13	1,21
rektalblödning	rectal bleeding	12	1,12
svart avföring	black stools	10	0,93
sårskada	wound	10	0,93
diarre	diarrhea	10	0,93
urinstämma	urinary obstruction	9	0,84
ikterus	icterus	8	0,75
trauma skalle	head trauma	8	0,75
anemi	anemia	8	0,75
blödning per rektum	rectal bleeding	7	0,65

3 ActivePerl 5.8 http://www.activestate.com

In the Waran text file a preliminary reason for encounter was identified in 883 of the 1035 lines (85.3 %). 1072 occurrences of 502 different reasons for encounter were found. 411 of the reasons for encounter were only found once (38% of occurrences, 82% of types) and 264 consist of one or two words.

The most common reasons for encounter in surgery, in both the total material and the Waran text file is buksmärtor (abdominal pains). The most common reasons for encounter in each file is shown in tables 1-2. Among patients of internal medicine, however, stated reasons for encounter are quite different. The most common all over is chest pain, and bleeding related disorders are rare, reflecting the different patient panorama in internal medicine – thus it can be expected that bleeding complications are presented at the dept of surgery even

Table 3 - Reasons for encounter in internal medicine

Medicine - total			
Reason for encounter		n	%
bröstsmärta	chest pain	6748	11,90
yrsel	dizziness	3311	5,84
huvudvärk	headache	2061	3,63
andnöd	dyspnea	2008	3,54
bröstsmärtor	chest pains	1951	3,44
dyspne	dyspnea	1851	3,26
brsm	chest pain	1398	2,47
feber	fever	1394	2,46
hjärtklappning	palpitations	1271	2,24
andfåddhet	dyspnea	1096	1,93
hosta	cough	1037	1,83
illamående	nausea	1022	1,80
intox	intoxication	905	1,60
trötthet	tiredness	779	1,37
förmaksflimmer	atrial fibrillation	730	1,29
andningsbesvär	breathing problems	696	1,23
syncope	syncope	640	1,13
kräkningar	vomiting	622	1,10
dvt	DVT	529	0,93
nedsatt at	poor general status	462	0,81

though the warfarin medication is given for diseases of neurology / cardiology at the dept of internal medicine.

Table 4 - Reasons for encounter in internal medicine,among Warfarin patients

Medicine - Waran		**occurrence**	
reason for encounter		n	%
bröstsmärta	chest pain	775	10,43
förmaksflimmer	atrial fibrillation	452	6,08
dyspne	dyspnea	435	5,85
andnöd	dyspnea	364	4,90
andfåddhet	dyspnea	327	4,40
yrsel	dizziness	326	4,39
hjärtklappning	palpitations	241	3,24
bröstsmärtor	chest pain	225	3,03
trötthet	tiredness	183	2,46
brsm	chest pain	167	2,25
dvt	DVT	146	1,96
feber	fever	138	1,86
illamående	nausea	106	1,43
hosta	cough	98	1,32
andningsbesvär	breathing difficulties	92	1,24
huvudvärk	headache	90	1,21
snabbt förmaks-flimmer	rapid atrial fibrillation	87	1,17
stroke	stroke	83	1,12
hjärtsvikt	heart failure	78	1,05
syncope	syncope	77	1,04

Table 5 - Ratio of frequencies of warfarin related surgical reasons for encounter (warfarin cases compared to total material).of individual reasons for encounter

Surgery - ratio		Frequency (‰)		Ratio W/
Sv	En	Total	Waran	Total
hematuri	hematuria	2,73	13,06	4,78
gastrointestinal blödning	GI bleeding	2,66	12,13	4,57
svart avföring	melena	2,20	9,33	4,25
rektalblödning	rectal bleeding	3,35	11,19	3,34
blödning per rektum	rectal bleeding	2,10	6,53	3,12
melena	melena	8,16	25,19	3,08
subileus	subileus	1,02	2,80	2,75
rektal blödning	rectal bleeding	2,38	6,53	2,75
makroskopisk hematuri	macroscopic hematuria	1,04	2,80	2,70
nedsatt at	general malaise	1,80	4,66	2,60
ikterus	icterus	2,91	7,46	2,56
Trötthet	tiredness	2,69	6,53	2,42
Anemi	anemia	3,25	7,46	2,29
hematemes	hematemesis	8,03	17,72	2,21
nedsatt allmäntillstånd	general malaise	1,28	2,80	2,19

urinstämma	urinary obstruction	4,17	8,40	2,01
Blodiga kräkningar	hematemesis	1,46	2,80	1,92
falltrauma	fall	12,16	23,32	1,92
urinretention	urinary retention	2,04	3,73	1,83
smärtor under höger arcus	pain upper right abdomen	1,04	1,87	1,80

Table 6 - Frequency ratios (warfarin/total) among internal medicine patients

Medicine - ratio		number tot al	war an	Ratio W/ Total
nyupptäckt förmaksflimmer	new AF	15	15	7,5
sviktsymtom	heart failure	5	5	7,5
fladder	atrial flutter	4	4	7,5
högt inr	high INR	3	3	7,5
högt pk-värde	high PK	3	3	7,5
nydebuterad förmaksflimmer	new AF	3	3	7,5
recidiverande förmaksflimmer	recurring AF	3	3	7,5
smärta i vä skulderblad	shoulder pain	3	3	7,5
smärtor vänster underben	Pain left calf	3	3	7,5
susp cerebral insult	Suspected stroke	3	3	7,5
waranblödning	warfarin blee-ding	3	3	

To assess which reasons for encounter were more frequent among warfarin patients, we calculated the ratio of frequencies between the two patient groupsgroups, and the highest ratios are presented in table 2, in falling ratio – larger ratio means this problem is more common among warfarin treated patients. It is quite clear in the surgical material that bleeding related reasons for encounter are much more common among the warfarin patients than in the whole patient. In internal medicine, however, this is not so clear – there are many overfrequent problems but here the more frequent problems are rather related to indications for anticoagulation, such as atrial fibrillation and stroke, and no obvious relation to adverse effects can be seen.

Discussion

We have developed methods to identify and extract reasons for encounter from plain text in patient records of a department of general surgery at a teaching hospital. We find a reason for encounter in about 85 % of the records, suggesting that the method could be useful for example in statistical calculations and studies of patient groups. As a separate group we considered patients where "Waran" is mentioned. This is the trade name of warfarin in Sweden, the only oral anticoagulant currently on the market. Mention in the text does not necessarily imply that the patient is treated with warfarin before hospital admission, and this is a weakness in the design, but at least it suggests that patient has some condition where warfarin is discussed. Methods to ascertain whether current treatment includes warfarin would be very interesting, but this adds a lot of complexity to the information retrieval strategy. Experience from other authors suggest that general negation-detecting methods {{c:\fo\refs\ir.ref #120; Chapman et al., 2005}} can be used to distinguish "Waran" from "not Waran" which seems hopeful.

The possibilities of text data mining is getting a lot of recent attention within biomedicine, but most of the work is done in the domain of identifying genes and biochemical entities in published literature, much less work is focused on patient data[4]. Also coding of "chief complaint" has been attempted[5],[6],[7] . In Sweden, we also need to adapt all methods to our language, and we are not aware of any similar work done in Swedish.

Many of the reasons for encounter identified with this method are only found once and consist of long text strings. These reasons for encounter often result from a string matching where the rest of the sentence after words like inkommer för (comes because of?) is saved. Some of these lines and the lines where no reason for encounter was found need to be further analyzed and perhaps handled in a different way to make it possible to decide which the actual reasons for encounter are.

The result of the study could probably be improved by adding more patterns to the string matching scripts and by improving the already existing patterns. Analyzing the lines where a reason for encounter have not been found might help in doing this. A thorough analysis of the identified reasons for encounter is also needed to see what kinds of mistakes are made during identification, and what can be done to improve the precision and remove incorrect reasons. A larger text material would probably make the

4 Pakhomov, S.V., A. Ruggieri &C.G. Chute; Maximum entropy modeling for mining patient medication status from free text. *Proceedings / AMIA Symposium. Annual Symposium*, 587-591, 2002.

5 Mikosz, C.A., J. Silva, S. Black, G. Gibbs &I. Cardenas; Comparison of two major emergency department-based free-text chief-complaint coding systems. *MMWR. Morbidity and Mortality Weekly Report*, 53 Suppl, 101-105, 2004.

6 Shapiro, A.R; Taming variability in free text: application to health surveillance. *MMWR. Morbidity and Mortality Weekly Report*, 53 Suppl, 95-100, 2004.

7 Chapman, W.W., L.M. Christensen, M.M. Wagner, P.J. Haug, O. Ivanov, J.N. Dowling &R.T. Olszewski; Classifying free-text triage chief complaints into syndromic categories with natural language processing. *Artificial Intelligence in Medicine*, 33, 31-40, 2005.

numbers and calculations more accurate and would also be a way of further improving the results.

Many of the reasons for encounter are different morphological forms of the same word and should be considered synonyms, like buksmärtor and buksmärta (abdominal pain/pains). Natural language processing techniques, like part-of-speech tagging and stemming, can be applied to the material to help joining morphological forms. Work to accomplish this improvement has begun.

Grouping and categorizing the reasons for encounter could be achieved by looking for certain indicators of for example location, laterality or time. These indicators can then be used to search for reasons for encounter that are synonymous but not variants of the same word, like "hematemes" and "blodiga kräkningar" which refer to the same health condition. To accomplish this we hope to use medical morphemes from the Morphosaurus project[8], where we have been participating in entering Swedish morphemes.

It would be interesting to apply this method to different kinds of medical text and some work on this has already been started. The initial tests show that some modifications of the method are needed, and the pattern matching algorithm might have to be changed according to the text at hand.

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Supplementing the UMLS with Acronym/Abbreviation Knowledge for Natural Language Processing Applications

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Abstract

Background: *With the widespread use of acronyms/abbreviations (denoted as short forms, abbreviated as SFs) in biomedical domain, a terminology knowledge source that associates SFs with their descriptive expressions (denoted as long forms, abbreviated as LFs) needs to be supplemented further for the improvement of natural language processing (NLP) systems in the biomedical domain.* ***Objectives:*** *We investigate a framework to supplement the UMLS, a terminology knowledge source, with information of SFs and LFs extracted from text.* ***Method:*** *Given a pair of (SF, LF) automatically collected from text using certain patterns such as parenthetical expressions, there will be three (exclusive) scenarios: (1) LF and SF are listed in the UMLS as synonyms, (2) only LF is listed in the UMLS, and (3) LF is not included in the UMLS. For the second scenario, we can safely supplement the UMLS with SF and mark SF with the annotations associated with LF. For the third scenario, even though we are unable to associate SFs with existing concepts in the UMLS, we can annotate LFs and SFs with UMLS semantic groups under the assumption that the UMLS semantic classification system is comprehensive. Utilizing a collection of (SF, LF) pairs obtained previously using five months' worth of Medline abstracts and also a semantic group assignment system constructed based on headwords and suffixes, we evaluate the framework.* ***Results:*** *We found that approximately 18k of SFs could be newly marked with existing concepts in the UMLS, and furthermore 40k of (SF, LF) pairs could be assigned with UMLS semantic categories with an average precision as 79%. Supplementing the UMLS with such acquired acronym/abbreviation knowledge would be critical for NLP applications that depend on the UMLS for their terminology needs.*

Keywords:

medical informatics; natural language processing; vocabulary, controlled

Introduction

From healthcare news to journal articles in medicine, acronyms/abbreviations have been widely used to provide concise presentations for domain-specific concepts. However, they pose a great challenge to automated text processing systems as well as to human readers. Unlike their corresponding full forms, acronyms/abbreviations are usually not descriptive representations of their referred concepts. For example, when skimming through paper titles at PubMed, one may have difficulty in understanding the meaning of acronyms such as VHA[1] and HIT[2] in the title *"An HIV collaborative in the VHA: do advanced HIT and one-day sessions change the collaborative experience?"* (PMID: 16776387). Since most acronyms/abbreviations represent important domain-specific concepts, and they are highly ambiguous, associating them with the correct concept is a critical task for building natural language processsing (NLP)-based systems for clinical decision support (CDS) or Evidence-Based Medicine (EBM) (see, e.g., [1]). A comprehensive terminology knowledge source that lists all possible full forms associated with an acronym/abbreviation is needed for the task. In the following, for simplicity, we call acronyms/abbreviations as short forms (SFs) and the corresponding full forms as long forms (LFs).

In the UMLS, SFs and their corresponding LFs are considered as synonyms, but the coverage of the UMLS regarding to acronym/abbreviation is not comprehensive. In this paper, we propose a framework for supplementing the UMLS with the acronym/abbreviation knowledge [2]. The framework consists of two steps: (i) automatic extraction of SFs and their corresponding LFs from text, and (ii) assignment of semantic categories with SFs. Both tasks in these steps have been tackled in this domain (e.g., [3, 4]), and the automatic supplementation of terms to the UMLS has also been considered (e.g., [5]). In this work, we aim to integrate theses two tasks and propose a framework specialized in supplementing the UMLS with SF knowledge and evaluate the framework utilizing results from two previous studies: one is to compare different SF definition detection systems, and another is to build a UMLS semantic category assignment system based on headwords and suffixes [6].

1 "VHA" = "Veterans Health Administration"
2 "HIV" = "health information technology"

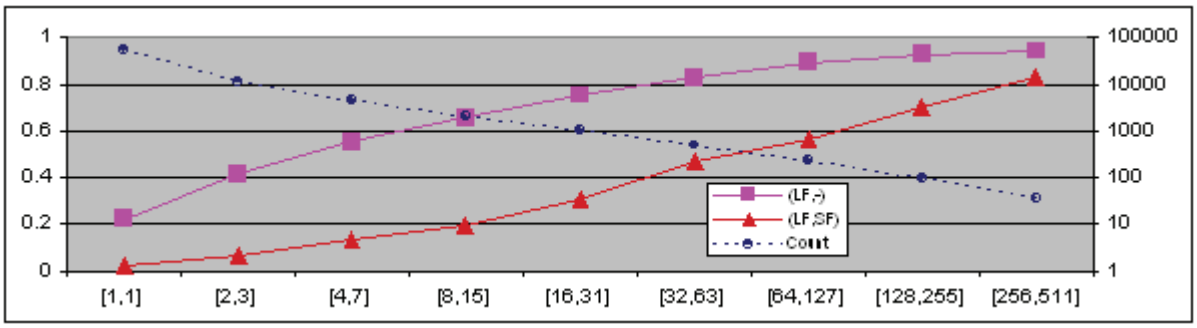

Figure 1 - X-axis represents bins of SF.LF pairs with different frequency ranges. A dotted line shows the number of pairs in each bin (read the right axis). Two solid lines show (i) the coverage of LF, i.e., (LF,-), and (ii) the coverage of LF.SF pairs, i.e., (LF,SF), in UMLS (read the left axis)

Resources and previous work

The UMLS

The UMLS, developed and maintained by National Library of Medicine (NLM), is an extensive terminology knowledge source in the medical domain. We used two components of the UMLS for this study, Metathesaurus (META) and SPECIALIST lexicon. In META, terms referring to the same biomedical concept (i.e., synonyms) are assigned with the same concept ID, e.g., "human immunodeficiency virus" and "HIV" are assigned with a concept ID C0019682. Moreover, in META, each concept (represented by a concept ID) is associated with UMLS semantic types, e.g., C0019682 is associated with a type Virus. As for SPECIALIST lexicon, we used one of its tables LRABR that records SF and LF phrase pairs. We also used another table LRAGR for normalizing noun tokens.

The SF definition detection comparison study

In this study [7], we used three independent systems ([8-10]) to extract pairs of SF and LF from *parenthetical expressions*, e.g., given a sentence "An electronic medical record (EMR) is a …", the systems will extract phrases "electronic medical record" and "EMR" as LF and SF. The three systems were applied to Medline abstracts published between January and May 2006 (210k records), and we collected 224k pairs (denoted as SF.LF) that are recognized by all of the three systems. After merging identical pairs[3], we obtained 74,428 unique SF.LF pairs. We manually inspected over 500 pairs randomly sampled from the obtained SF.LF, and found that all the pairs were valid SF and LF pairs.

Given this set of SF.LF pairs, we repeat the procedure described in [7] and summarized below to show the coverage of the UMLS over SF.LF pairs. We first grouped SF.LFs according to the frequency of their occurrences in their corpus to several bins. We then reported (i) the coverage of LF in the UMLS, and (ii) the coverage of both SF and LF in UMLS. The result is shown in Figure 1 where X-axis indicates bins according to frequency and Y-axis indicates the percentage. From Figure 1, we can see that (i) the coverage of SF.LF pairs lags behind that of LF (i.e., the gaps between the two solid lines), and (ii)even for frequent pairs, LFs may not be included in the UMLS

Semantic group assignment based on headwords and suffix

Headwords and suffixes of headwords are the two most effective features for automatic semantic group assignment (see, e.g., [4-6]). For example, a headword "virus" as in "Human Immunodeficiency Virus" strongly implies the semantic category of the concept referred. Similarly, a suffix "cyte" as in "Acanthocyte" implies that the referred entity is a cell. Hence, as in our previous work [6], we built a simple assignment system that assigns semantic groups to name phrases using headword/suffix information. In short, the system first extracts headwords/suffixes from a category-annotated list of name phrases (e.g., META), and then associate each headword/suffix with the most prevalent semantic category assigned to the phrases bearing the same headword/suffix.

Methods

Framework for supplementing the UMLS

- Our framework to supplement the UMLS consists of the two major subtasks (shown in Figure 2):
- Automatic extraction of SF.LF pairs from biomedical text
- Development of a semantic category assignment system

3 Identity of pairs is tested after the normalization of LF, which includes normalization of upper/lower cases, singular/plural forms, hyphen/blanks, etc.

After extracting SF.LF pairs in the first subtask, there would be three scenarios in terms of our objective:

1. Both SF and LF are recorded as synonyms in the UMLS
2. Only LF is in the UMLS but SF is not in the UMLS as a synonym of LF
3. LF is not in UMLS.

In the first scenario (1), we do not need to do anything because both SF and LF are already in the UMLS as synonyms. In the second scenario (2), we can safely mark SF with the concept ID of the paired LF. In the third scenario (3), we cannot associate LF with an existing concept ID, but we can assign the UMLS semantic category to SF and LF based on headwords and suffixes of LF.

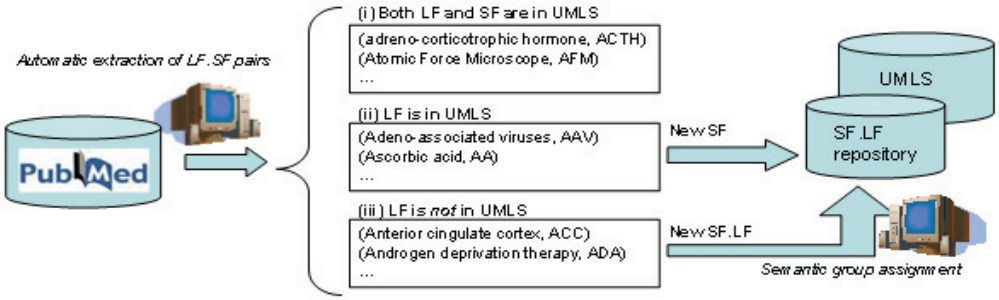

Figure 2 - Overview of the framework to suppplement UMLS

Evaluation method

For step 1, we used the collection of SF.LF pairs obtained in the comparison study to evaluate the framework (see the section Resources and Previous Work)[6]. For the semantic assignment step, instead of using the entire META for obtaining headwords and suffixes, we used only LFs from the collection that can be looked up in META through a procedure that normalizes textual variants (i.e., ignoring punctuations and normalizing using the Specialist lexicon). Similarly to [6], we used 15 semantic groups to provide reasonable granularity for the assignment system. After extracting headwords/suffixes from those LFs, we recorded them together with semantic groups assigned to the source name phrases, e.g., ”leukemia” appears as a headword in 39 phrases in META, of which 39 are annotated as Disorders, but one is annotated as Genes (note that a phrase can be annotated with more than one semantic type in the UMLS). When these headwords/suffixes are used for semantic group assignment, only the majority group is considered for assignment. For example, given a phrase “chronic mylogenous leukemia”, it is annotated with Disorders because the majority group of its headword “leukemia” is associated with Disorders. The system is then applied to pairs where LFs are not in the UMLS. Similarly to the comparison study in the previous section, we report the results with respect to different frequency bins. In order to investigate the precision of the semantic group assignment system, from each bin of LF.SF pairs (where bins from [32,63] to [256,511] were merged as [32,511]), we randomly picked as many as 100 LF.SF pairs where the assignment rules are applicable to LFs.

Results

Assignment of semantic groups to novel SFs

Of 74,428 unique SF.LF pairs automatically extracted from five month’ worth of Medline, approximately 5% of them were recognized as synonyms using the UMLS. However, in 30% of the cases, LF could be found in the UMLS. Therefore, by incorporating the SF.LF relations automatically recognized, SFs in 25% (30-25) of the pairs (i.e., 18k SFs) could be associated with existing concept IDs in the UMLS.

For the remaining 52,348 pairs where LFs cannot be found in the META, the semantic group assignment system was applicable to 81% of them. Among pairs where the system was applicable, the distribution of assigned semantic groups varied much: some with higher percentage (e.g., Chemicals & Drugs 18%, Procedures 16%, Disorders 13%), and some with lower percentage (e.g. Occupations 0.2%, Geographic Areas 0.1%). Given this highly skewed distribution, we looked into the performance of the five significant semantic groups, Procedure, Chemicals & Drugs, Disorders, Anatomy, and Organizations. The results about these five semantic groups are shown in Table 1. The first row of the table indicates that there are 42,579 pairs occurring once in the text. Around 80% of them can be automatically associated with UMLS semantic groups with a precision of 86%. There is a slight

increasing trend of percentage of pairs where the assignment system was applicable based on the third column of table 1, but not significant.

Discussion

As for 19% of the pairs where the assignment system was not applicable, we observed several reasons, e.g., typos (e.g., 12-lipoxygeanse), or adjectival phrases (e.g., single-stranded).

Though we found that the system achieved the precision of 80% or more for the most of the semantic groups, we concern the poor performance for the important and distinct semantic group Disorders. After looking at the error cases for the group Disorders, we found some of the shortest suffixes are used in the error cases, e.g., "sion" which is extracted from "hypertension", "occlusion", "convulsion", etc. In our previous study, short suffixes were not the major problem: those short suffixes are not used often because there are longer suffixes and headwords that have precedence over them. For example, given a phrase "rapid maxillary expansion" (RME), the phrase can be properly associated with a group Procedure owing to phrase entries with the headword "expansion" or even "maxillary expansion" in the UMLS. We can easily resolve the problem by increasing the amount of source name phrases when building the assignment system. For example, we can use the whole collection of Medline abstracts to have a large collection of LF.SF pairs or use all META phrases that appear in text at least once.

Freq. Range	Num. pairs	Type assigned	hand-checked	Procedures	Chemicals & Drugs	Disorders	Anatomy	Organizations	All
[1,1]	42,579	80%	100	95% (20)	88% (25)	68% (19)	90% (10)	100% (3)	86% (100)
[2,3]	6,712	81%	100	95% (13)	100% (14)	52% (21)	86% (14)	100% (2)	74% (100)
[4,7]	1,990	82%	100	72% (29)	85% (20)	47% (15)	75% (8)	100% (2)	70% (100)
[8,15]	698	82%	100	96% (23)	93% (14)	53% (17)	100% (4)	0% (1)	85% (100)
[16,31]	252	84%	100	79% (33)	88% (16)	75% (12)	100% (7)	100% (2)	83% (100)
[32,511]	117	83%	97	81% (16)	85% (26)	59% (13)	86% (7)	100% (3)	75% (97)

Table 1 - precision of semantic group assignment for five semantic groups

Conclusion

In this study, we proposed a framework to supplement a biomedical thesaurus with SFs as well as LFs. In general, SFs can be highly ambiguous semantically and it is difficult to determine their semantic categories. In our framework, SFs are annotated with semantic categories through the corresponding LFs. Another idea employed was that, in building a semantic category assignment system, we did not use the entire META, but we used only those phrases that are actually used in text so as to identify viable name phrases in biomedical text.

In sum, from the five month's worth of Medline records, approximately 18k SFs are newly associated with existing concept IDs in UMLS, and furthermore, 40k SFs and LFs are supplemented to the UMLS, where these phrases were assigned with semantic categories with the over all precision of 79%.

While we investigated the framework over the five month's worth of Medline records, the framework can be extended to a larger set of records. With a larger corpus, we could not only supplement the UMLS further, but we might incorporate more source name phrases in building a semantic category assignment system, which may improve the performance of semantic category assignment system further.

Acknowledgments

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Implementing Literature-Based Discovery System using Semantic Relations

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Abstract

Literature-based discovery (LBD) is a method for automatically generating hypotheses from the research literature. Current LBD systems depend on co-occurrence for finding relations between concepts. In previous research we proposed an enhanced method using semantic relations supplied by two natural language processing systems, BioMedLEE and SemRep. The use of these relations reduces the number of hypotheses proposed and simplifies their evaluation. Here, we describe an implementation (based on BITOLA LBD system) of our methodology using semantic relations.

Keywords:

literature-based discovery, natural language processing, text mining, Medline, UMLS, knowledge discovery

Introduction

Current literature-based discovery systems (for example [1]) use concept co-occurrence as their primary mechanism. No semantic information about the nature of the relation between concepts is provided. The use of co-occurrence alone has several drawbacks, since not all co occurrences underlie "interesting" relations: (a) Users must read large numbers of Medline citations when reviewing candidate relations; (b) systems tend to produce large numbers of spurious relations; and, finally, (c) there is no explicit explanation of the discovered relation.

In our previous research [2] we proposed a theoretical methodology to address the deficiencies of using co-occurrence only, which involved augmenting co-occurrences with explicit predications obtained through use of two natural language processing systems: SemRep and BioMedLee. Here we report on the implementation of LBD system based on the methodology described in [2].

Methods and results

We implemented the *Maybe_Treats1* discovery pattern which can be used to find new treatments for a disease or to find new therapeutic applications for an existing drug. *Maybe_Treats1* is satisfied when there is a change in a substance, body function, or body measurement (concept Y) associated with the starting disease X, and there is also an opposite change in concept Y associated with the drug or substance Z; additionally, drug or substance Z should not be already used to treat disease X. The *change* relations were extracted by BioMedLee and the *Treats* relations by SemRep.

The new web interface (Figure 1) that we developed integrates the co-occurrence-based interface of the BITOLA LBD with the semantic relation extracted by BioMedLee and SemRep. We take a top-down approach. We consider co-occurrence of two concepts as an indication of a relation, however then we present in an aggregated fashion the semantic relations extracted from the Medline citations. At the next level the user is shown as evidence the sentences from which the semantic relations were extracted (Figure 2). In other words, we go from concept co-occurrence to semantic relations to sentences supporting these relations.

The user first selects a starting disease X (Parkinson disease in Figure 1). All co-occurring Y concepts are provided in the blue area; information about those that have a semantic relation is also given, so that the user can select concepts that are changed in relation to the starting disease (for example, gamma-Aminobutyric Acid in Figure 1). Further use of the interface displays drugs Z that cause an opposite change to the intermediate concepts Y. The sentences from which the semantic relations were extracted are also accessible (Figure 2). The new interface, enriched with semantic relations, makes it easier for the user to evaluate a smaller number of proposed hypotheses.

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BITOLA - Biomedical Discovery Support System (Authors: D. Hristovski, B. Peterlin, C. Friedman, T.C. Rindflesch)

Find Starting Concept

Concept: Parkinson Disease **Chr.Loc.:**

Semantic Types: Disease or Syndrome/ **CUI:** C0030567

Find Related Ys

Limit Ys

Contains:

Semantic Group: Any Semantic Type: any

Frequency >= 0 Confidence >= 0 Page size: 50 Change

Order by (Ys)

Frequency / Confidence / Semantic type / Concept name — Descending / Ascending

Related Concepts Y: (first 35 of 35)

Selected	Concept Name	Semantic Type	X-Relation-Y	Changes Y	Freq	Conf(%)
☐	Levodopa	Neuroreactive Substance or Biogenic Amine	SE(inv): TREATS(31), TREATS(INFER)(14),	BL(inv): increase(1),	4640	17.241
☐	Dopamine	Neuroreactive Substance or Biogenic Amine	BL: decrease(2), SE(inv): TREATS(10), TREATS(INFER)(6),		2602	9.669
☐	Alzheimer's Disease	Disease or Syndrome		BL(inv): increase(2),	1664	6.183
☐	Dementia	Mental or Behavioral Dysfunction		BL: decrease(1), BL(inv): increase(1),	1406	5.224
☐	Dyskinesia, Drug-Induced	Disease or Syndrome	BL(inv): increase(2), decrease(2),	BL: decrease(2),	675	2.508
☐	Movement	Organism Function	BL(inv): increase(2), decrease(2),		670	2.490
☐	Huntington Disease	Disease or Syndrome		BL: decrease(1),	663	2.464
☐	Aging	Organism Function		BL: increase(1),	568	2.111
☐	Depressive disorder	Mental or Behavioral Dysfunction		BL: increase(2), decrease(2), BL(inv): increase(1),	385	1.431
☐	Homovanillic Acid	Organic Chemical	BL: increase(1), decrease(1),		299	1.111
☐	Syndrome	Disease or Syndrome		BL(inv): decrease(1),	208	0.773
☐	gamma-Aminobutyric Acid	Amino Acid, Peptide, or Protein	BL: decrease(1),	BL(inv): increase(1),	168	0.624

Figure 1 - Web interface for BITOLA LBD enriched with semantic relations. Parkinson disease is the starting concept. Shown are related (intermediate concepts) Y that are changed (e.g. gamma-Aminobutyric Acid) in association to Parkinson or in TREATS relation (current treatments)

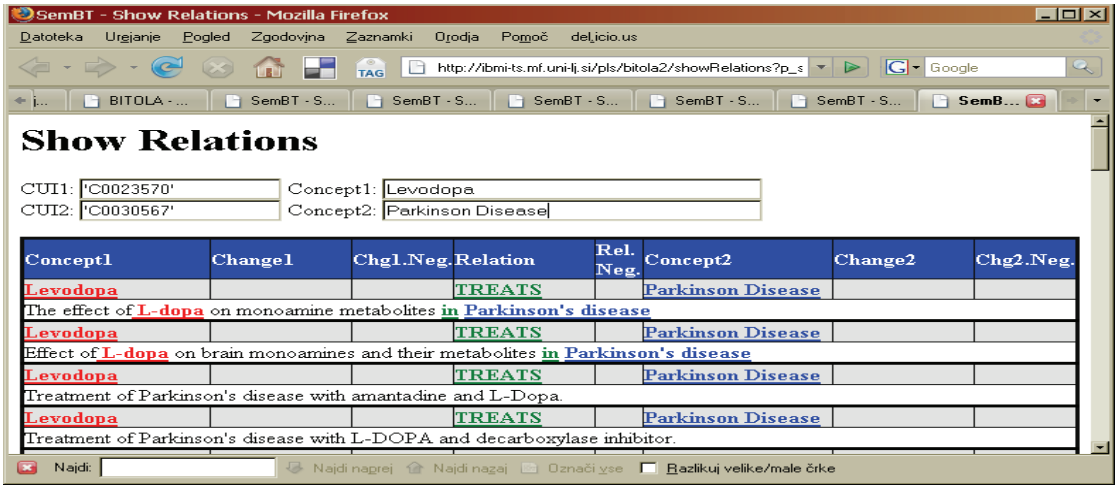

Figure 2 - Some of the sentences from which the TREATS relations between Levodopa and Parkinson disease are extracted

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The Development of a Natural Language Generation System For Personalized e-Health Information

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Abstract

Personalization—adaptivity to the individual—is becoming an essential component of any computer-based system. In e-health systems, personalization of health information is emerging as a key factor in the trend to patient-centric care. Patient-centric healthcare aims to engage patients in their treatment to promote greater compliance and satisfaction with their therapeutic regimens, resulting in both better patient outcomes and reduced healthcare costs. We have developed a prototype Web-based Natural Language Generation system for the authoring and subsequent personalization of patient education materials. Our initial domain of application is reconstructive breast surgery, but our Natural Language software tools and authoring methodologies are generally applicable to all medical interventions.

Keywords:

patient education; personalized e-Health; natural language generation; artificial intelligence

Introduction

E-health services are playing an increasingly important role in health-care management by providing relevant and timely information to patients about their medical care. An important factor in the rapid growth of online health services is the trend in health management to *patient-centric* health care: patient-centric care aims to involve the patient directly in the medical decision-making process by providing better access to the relevant information that patients need to understand their medical condition and to enable them to make more-informed decisions about their prescribed treatment.

An important new approach in patient-centric care is through 'Information Therapy': prescribing the right information to the right person at the right time. Ideally, Information Therapy promises to deliver specific medical information to individual patients at just the right time to assist with decision-making or behaviour changes [5]. So far, however, the kinds of information delivered through specific patient portals or other individualized 'information prescriptions' is still quite generic (Claudette DeLenardo, Program Director, My CARE Source Patient Portal, Grand River Hospital, personal communication).

An effective means of providing patient-centric healthcare would be through the personalization of health information: with individually tailored information, the patient would be both better-educated about their specific condition and better able to make informed decisions. As a key element in e-health services, personalized health education has great potential to provide relevant, patient-specific information that would integrate the clinical process with 'anywhere, anytime' healthcare delivery to produce both better-informed patients and enhanced patient outcomes. Some improvements in patient outcomes we may hope to see: greater compliance and satisfaction with therapeutic regimens, fewer complications, shorter hospital stays, and fewer return visits.

Natural Language Generation System for personalized health information

The fundamental problem in personalization of patient education is that the process involves much more than just producing each brochure or leaflet in half a dozen different versions for different audiences. Rather, the number of different combinations of factors can easily be in the tens or hundreds of thousands. It is impossible to produce and distribute, in advance of need, the large number of different editions of each publication that is entailed by individual tailoring of health information. Recently, researchers in Natural Language Generation have begun to apply methods from Artificial Intelligence and Computational Linguistics to develop automated systems for tailoring health information to individual patients (e.g., [1][4][6]).

The key components in our health information tailoring system are:

- Creation of corpora of content variants written in language that will engage the patient and address individual concerns.
- A *Physician's Authoring Tool* that assists the physician in mapping from the various options at each stage of a medical intervention to corresponding content variations.
- *A Natural Language Generation Tailoring Engine* that will automatically select, assemble, and revise content from a library of reusable text to produce a customized version for an individual patient [2].

Project team roles and competencies

The HealthDoc Project (1994-present) [3] involves team members from the University of Waterloo, the Waterloo Institute for Health Informatics Research, the University Health Network of the University of Toronto, and the University of Southern California. Our project team includes a wide variety of academic, clinical, and health IT professionals fulfilling the following roles:

Health IT Leader: A professional who provides strategic leadership regarding all aspects of IT/IM for health organizations.

Healthcare Providers: Clinicians who provide specifications for design of our technology based on their day-to-day practices and who evaluate our systems and software tools.

Patient Education Providers: Experts in patient education are available to our project as advisors and evaluators through the University Health Network (University of Toronto) and Grand River Hospital (Kitchener-Waterloo).

Health Portal Developers: Experts in development of health portal systems and software tools.

Computational Linguists: Researchers in theory and design of Natural Language Generation systems.

Linguists: Researchers in rhetoric of medical language, physician/patient communication, and communication design.

Software Manager: Professional software developer who oversees all aspects of system design and development.

A pilot tailoring system

The initial stage of our project focused on the creation of a corpus of patient-specific educational content by our surgeon team members covering a selected subprocedure of reconstructive breast surgery. We developed an initial Web-based authoring environment that allows the medical domain expert to interact directly with the system from any provider location.

To demonstrate the results of our research so far, we implemented a pilot Web-based delivery system for generating tailored health information materials. The pilot system integrates the main components of our project—the corpus of content variants, the Authoring Tool, and the Natural Language Generation Tailoring Engine—with a Web-based framework for delivery of tailored health education, i.e., a 'personal patient portal'. Several sample domains for tailored health information (e.g., smoking cessation, reconstructive surgery) have been tested with the pilot system.

Acknowledgements

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The Development of a Natural Language Generation System for Personalized e-Health Information

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Natural Sciences and Engineering Research Council
of Canada

Preoperative Education

The Problem:

Patients only retain approximately 15% of information discussed prior to surgery

Preoperative Education

Possible solutions:

- "Take-away" information
- Brochures, booklets, etc
- Online information

How to take care of your wound from the operation

- Keep the bandage clean and dry at all times.
- Leave the bandage on until you return for your follow-up appointment.
- If your surgeon has told you to remove the bandage, do so as instructed.
- If you have Steri-strips® under the bandage (small white tapes), leave them in place. When they start to peel off, remove them and throw them away. Keep your arm or foot covered until the wound heals or the stitches have been removed (usually 7 to 10 days after the surgery).
- If you have stitches, they will be removed at your next follow-up appointment.

Preoperative Education

Potential benefits of improved information:

- Reduced anxiety
- Higher patient satisfaction
- Improved outcomes, therapy compliance

Our solution: Tailored information:

- Previous studies on tailoring:
  - Nutrition
  - Smoking cessation
  - Diagnostic testing (mammography)
- However, surgical literature sparse

The HealthDoc Approach:
'Generation-by-selection-and-repair'

– Contains all text snippets needed for any patient

– Specific choices for individual patient

– Automatic restoration of good style

Authoring of the Master Document

Three levels of authoring:

- Knowledge level
  - Knowledge engineer
- Content level
  - Domain expert = Physician
- Deep-linguistic level (for repairs)
  - Computational linguist

Authoring: Knowledge level

- Knowledge engineer defines high-level structure of the master document.
- Goal: Map patient and physician concerns, components of surgical procedure, to organization of master document.
- Ideal: Authoring tool should maintain cognitive model to guide mapping of complementary, sometimes conflicting, concerns.

Authoring: Content level

A new model of composition

- Surgeon fills in raw ‘medicalese’ blocks of content in spreadsheet-like format.
- Rhetorician shapes content using models of argumentation:
  - Physician wants to *engage* patient, ensure *compliance*.
  - Patient wants *adaptivity* to preferred style of learning.
- Creation of stylistic variations:
  - By the physician.
  - By the rhetorician.
  - Automated?
- On-going: Modification by individual surgeon.

An Authoring Tool for Creating Tailorable Content

The Basic Tool: Specifications

- Domain expert directly enters textual variations, accompanied by Boolean selection conditions.
- Gradual editing at any re-entry point, by multiple authors.
- Automated checking of conditions for consistency and completeness.
- Displaying sets of text variations for validation.
- Many regular text-processing features:
  - cut-and-paste, spell-checking, thesaurus.

An Authoring Environment for Physicians: What would it look like?

- Both *push* and *pull* content authoring:
  - Physician directly enters procedure-specific text components (*push*).
  - Wizard-like query engine prompts author for details (*pull*).
- Reuse of discourse structure, text passages from similar surgical procedures.
- Natural Language Generation text-repair engines
  - Relieve physician of worrying how selected text will go together.
  - Need for both stylistic and semantic repair.

A Web-based Delivery System

- Automated transformation creates customization form from Master Document: Fill in form, press a button, display customized document.
- Can progressively update Master Document as add/refine surgical procedure, re-invoke transformation, view results.
- Using “Web Informatics Development Environment” (WIDE): wizard-like development of Web-based system that supports databases, shared virtual spaces, rich multimedia content.

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Application of Multiple Neural Networks to Time Sequence Data - Prediction of Nosocomial Infection in Intensive Care Unit Patients

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Abstract

We have invented the method of modeling time sequence data for prediction using multiple neural networks (NNs). In this study, we examined whether multiple NNs outperforms logistic regression and single NN in the prediction of nosocomial infection in intensive care unit patients (n=16,584). The three predictive models were developed using the 80% training subset and their predictive performances were assessed using the 20% testing subset in terms of classification accuracy and the area under a receiver operating characteristics curve. Overall the highest predictive performance was found in multiple NNs, followed by logistic regression and single NN. The predictive performance of multiple NNs was kept at a constant level, whereas that of logistic regression and single NN decreased with increasing a follow-up period.

Keywords:

Comparative study, predictive model, time sequence data, neural networks, nosocomial infection, intensive care units

Introduction

Multivariate regression models, particularly logistic regression, have commonly been used to estimate probabilities of outcome events. The predictors are usually selected from baseline data. Accordingly, the developed predictive models take no account of subsequent events, which may affect the patient's outcome.

We have invented the method of modeling time sequence data for prediction using multiple neural networks (NNs). The model was designed to use baseline data and subsequent events for estimating the probability of the outcome event - nosocomial infection in intensive care unit patients. We compared the predictive performance of multiple NNs with that of logistic regression and single NN using the cross-validation method.

Methods

A large cohort database was accumulated from the Japanese Nosocomial Infection Surveillance System. In the cohort of 16,584 eligible patients aged 16 years, hospitalized in 28 intensive care units for 2 days, there were 915 patients (5.5%) who had at least one episode of nosocomial infection during the first 10 days. After stratification by the outcome event, the original data set was randomly divided into 80% training and 20% testing subsets. The three predictive models - logistic regression, single NN, and multiple NNs were developed using the training subset and their predictive performances were assessed using the testing subset in terms of total classification accuracy (TCA) and the area under a receiver operating characteristics curve (AUC).

Logistic regression and single NN incorporated the following baseline data: sex, age (16-39, 40-69, 70+), severity of illness (0-10, 11-20, 21+; APACHE II), operation (none, elective, urgent), ventilator (yes, no), urinary catheter (yes, no), central venous catheter (yes, no). Multiple NNs incorporated subsequent events (ventilator, urinary catheter, and central venous catheter used at a specific period after admission) in addition to the baseline data.

As shown in Figure 1, multiple NNs consisted of 4 three-layer networks, which were responsible for predictions at four periods (Day 3-4, 5-6, 7-8, and 9-10 after admission), respectively. Two neighboring networks were connected in series to represent dependencies of subsequent periods. As shown in Figure 2, estimates for period t_a, $P(t_a)$ were passed forward to a subsequent network as inputs and used to enhance estimates for the following period t_b, $P(t_b)$. The first network with 13 input, 10 hidden, and 1 output neurons was used to input baseline data (sex, age, severity of illness, operation, ventilator, urinary catheter, and central venous catheter) to estimate the probability of the outcome event at Day 3-4 after admission. The second network with 4 input, 10 hidden, and 1 output neurons was used to input the output of the first network and subsequent events (ventilator, urinary catheter, and central venous catheter used at Day 3-4 after admission) to estimate the probability of the outcome event at Day 5-6 after admission. The third and

fourth networks followed the second network in a similar fashion (Figure 1). Each network employed back propagation learning with the momentum of 0.8. The learning rate was 0.01.

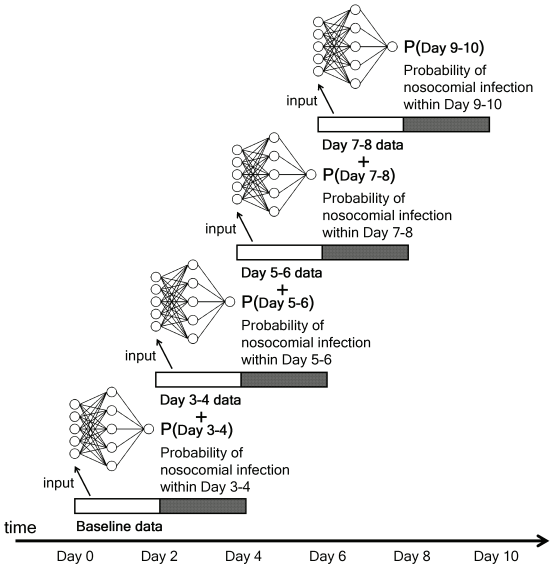

Figure 1 - Multiple NNs

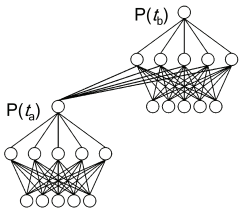

Figure 2 - Connection of two neighboring networks

Results and discussion

Table 1 shows the classification accuracy of the three predictive models. Multiple NNs showed the highest classification accuracy for total (TCA), positive (sensitivity), and negative (specificity) cases among the three predictive models.

Table 1 - Classification accuracy

	Total (TCA)	Positive (sensitivity)	Negative (specificity)
Logistic regression	0.63	0.71	0.62
Single NN	0.37	0.85	0.35
Multiple NNs	0.73	0.92	0.72

The receiver operating characteristics curve nearest to upper left corner was found in multiple NNs, followed by logistic regression and single NN. The AUCs of multiple NNs, logistic regression, and single NN were 0.83, 0.73, and 0.60, respectively. These results suggest that multiple NNs may be superior to logistic regression and single NN in terms of the discriminatory ability at a threshold level (indicated by TCA) and also the overall discriminatory ability independent of the setting of threshold level (indicated by AUC).

Table 2 shows the predictive performances of the three predictive models by period. Multiple NNs showed no significant change in TCA or AUC, whereas logistic regression and single NN showed noticeable declines in TCA and AUC. This result suggests that multiple NNs may be useful for improving predictive performance especially at later periods.

Table 2 - Predictive performance by period

		Day 3-4	Day 5-6	Day 7-8	Day 9-10
Number of patients (positive cases)		1625 (68)	610 (51)	292 (34)	612 (21)
Logistic regression	TCA	0.75	0.61	0.52	0.38
	AUC	0.79	0.73	0.67	0.62
Single NN	TCA	0.43	0.37	0.33	0.25
	AUC	0.63	0.58	0.55	0.55
Multiple NNs	TCA	0.73	0.66	0.79	0.77
	AUC	0.86	0.77	0.84	0.82

Conclusion

Multiple NNs outperformed logistic regression and single NN in the prediction of nosocomial infection in intensive care unit patients. The predictive performance of multiple NNs was kept at a constant level, whereas that of logistic regression and single NN decreased with increasing a follow-up period.

Acknowledgements

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Application of Multiple Neural Networks to Time Sequence Data - Prediction of Nosocomial Infection in Intensive Care Unit Patients -

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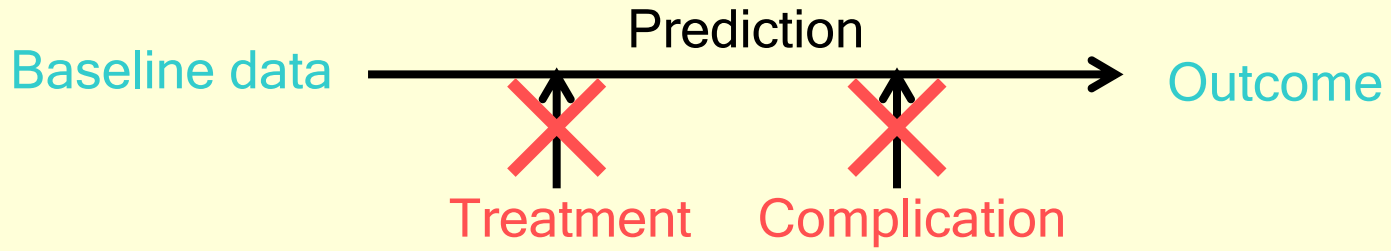
Background

- Multivariate regression models, particularly logistic regression, have commonly been used to estimate probabilities of outcome events.
- The predictors are usually selected from baseline data.
- Accordingly, the developed predictive models take no account of subsequent events, which may affect the patient's outcome.

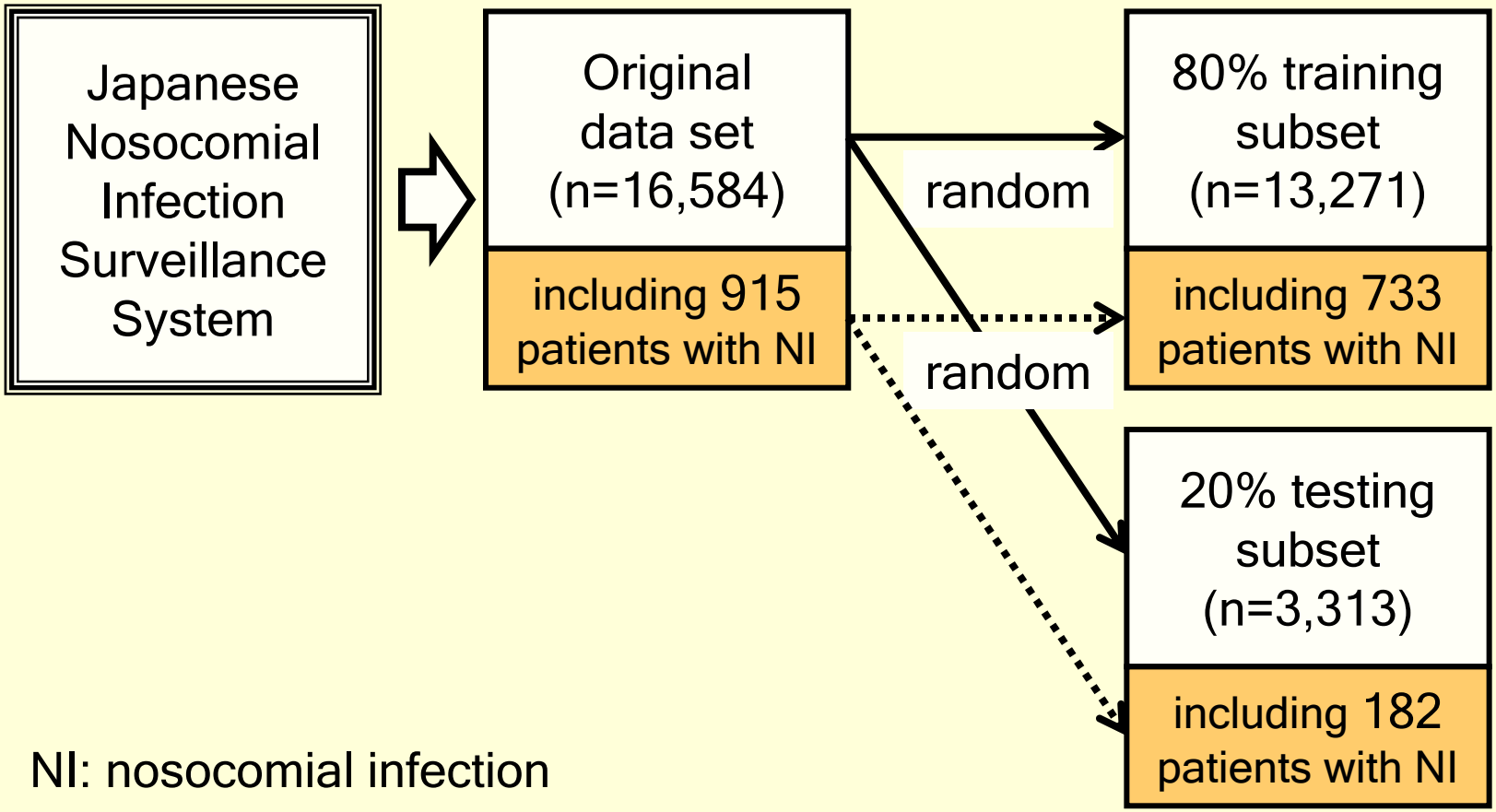


Objective

- We have invented the method of modeling time sequence data for prediction using multiple neural networks (NNs).
- The model was designed to use baseline data and subsequent events for estimating the probability of the outcome event - nosocomial infection in intensive care unit patients.
- We compared the predictive performance of multiple NNs with that of logistic regression and single NN using the cross-validation method.

Methods (1)

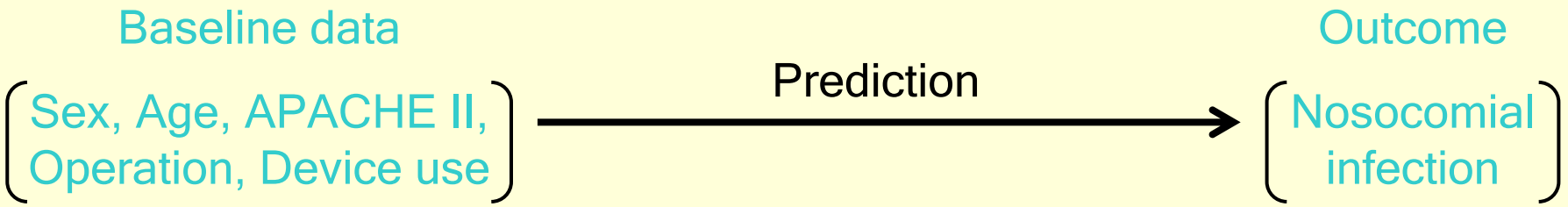
- Preparation of data sets (cross-validation)



NI: nosocomial infection

Methods (2)

- Development of three predictive models
  - Logistic regression
  - Single NN



  - Multiple NNs

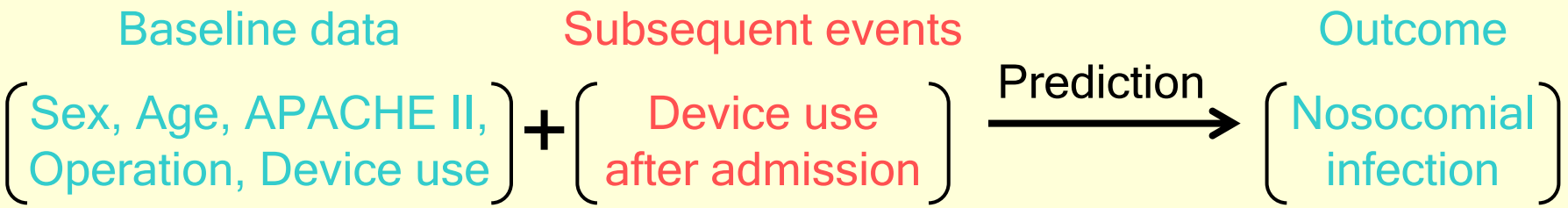
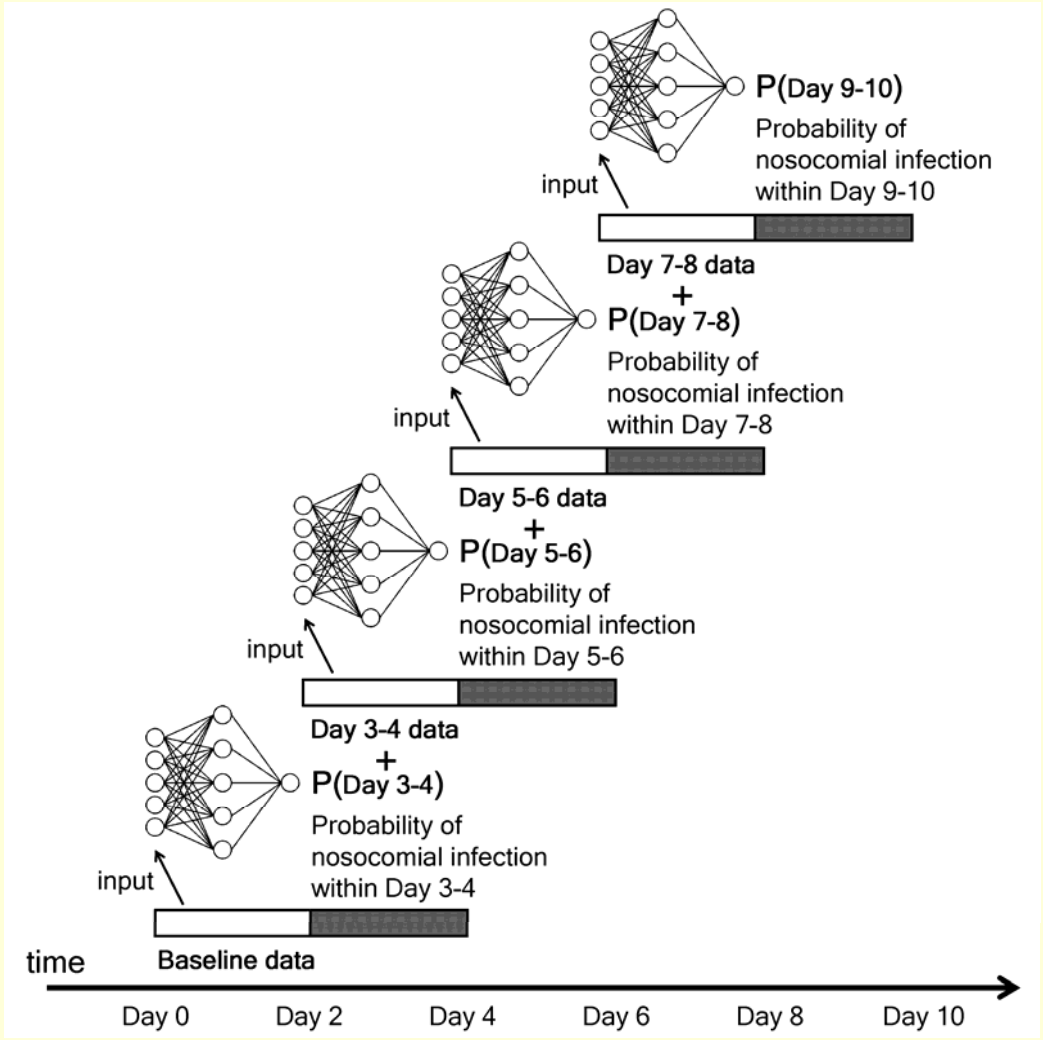
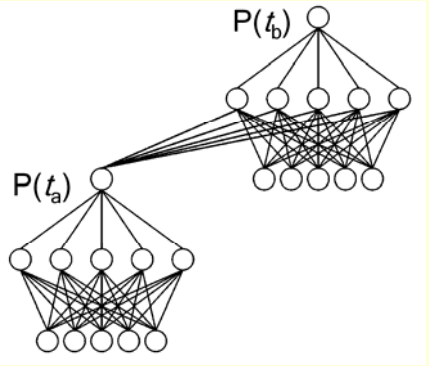


Figure 1 - Multiple NNs





Estimates for period t_a, P(t_a) were passed forward to a subsequent network as inputs and used to enhance estimates for the following period t_b, P(t_b).

Methods (3)

- Assessment of predictive performance
  - Total classification accuracy (TCA)

    A proportion of correctly classified cases.
  - The area under a ROC curve (AUC)

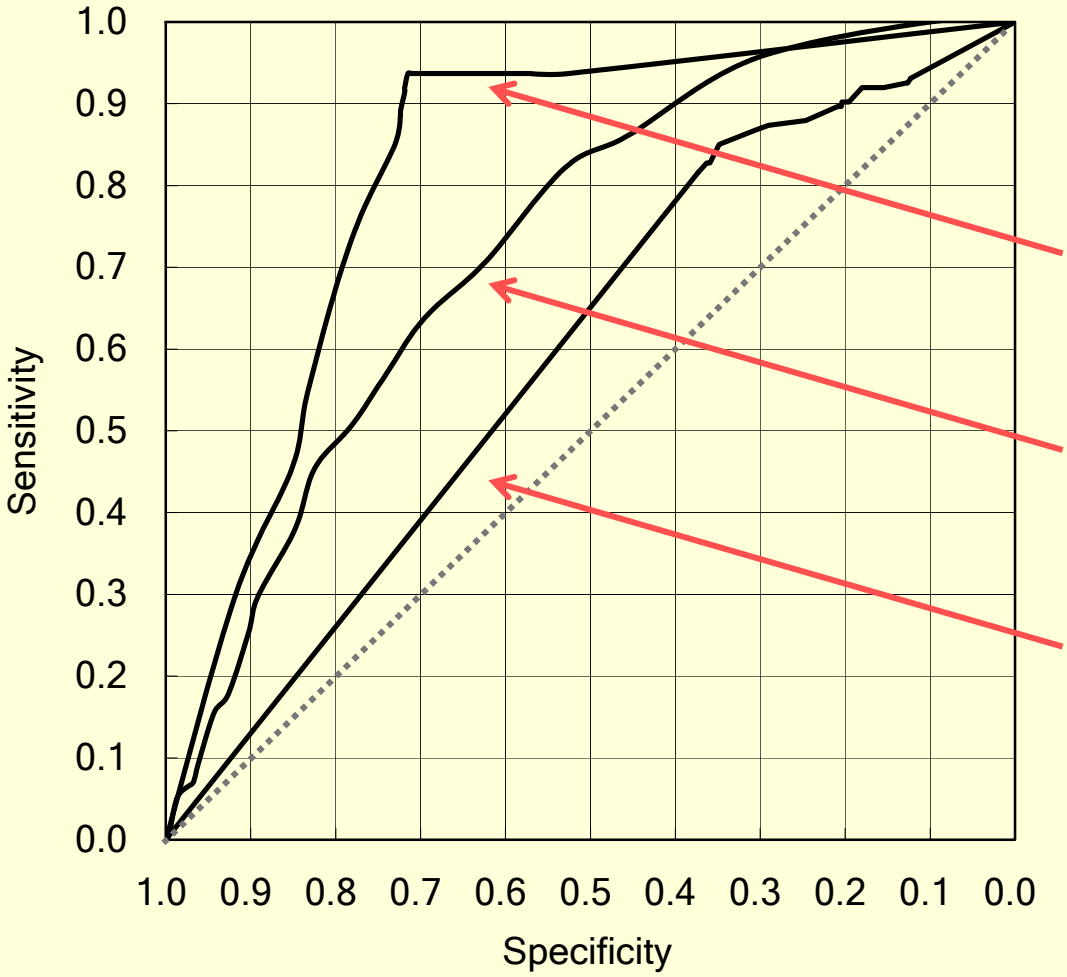
    A trade-off between sensitivity and specificity.

Table 1 - Classification accuracy

	Total (TCA)	Positive (sensitivity)	Negative (specificity)
Logistic regression	0.63	0.71	0.62
Single NN	0.37	0.85	0.35
Multiple NNs	0.73	0.92	0.72

Multiple NNs showed the highest classification accuracy for total (TCA), positive (sensitivity), and negative (specificity) cases.

Figure 2 - ROC curves



Multiple NNs
(AUC=0.83)

Logistic regression
(AUC=0.73)

Single NN
(AUC=0.60)

Table 2 – Predictive performance by period

		Day 3-4	Day 5-6	Day 7-8	Day 9-10
Number of patients (positive cases)		1625 (68)	610 (51)	292 (34)	612 (21)
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Multiple NNs showed no significant change, whereas logistic regression and single NN showed noticeable declines in TCA and AUC.

Conclusion

- Multiple NNs outperformed logistic regression and single NN in the prediction of nosocomial infection in intensive care unit patients.
- The predictive performance of multiple NNs was kept at a constant level, whereas that of logistic regression and single NN decreased with increasing a follow-up period.

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Multi-label Text Classification of German Language Medical Documents

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Abstract

At nearly every patient visit, medical documents are produced and stored in a medical record, often in an unstructured form as free text. The growing amount of stored documents increases the need for effective and timely retrieval of information. We developed a multi-label text classification system to categorize free text medical documents (e.g. discharge letters, clinical findings, reports) written in German into predefined classes. A random sample of 1,500 free text medical documents was retrieved from a general hospital information system and was manually assigned to 1 to 8 categories by a domain expert. This sample was used to train and evaluate the performance of 4 classification schemes: Naïve Bayes, k-NN, SVM, and J48. Additional tests of the effect of text preprocessing were done. In our study, preprocessing improved the performance, and best results were obtained by J48 classification.

Keywords:

machine learning, classification, medical records, multi-label

Introduction

At nearly every patient contact with healthcare-providers, medical documentation is generated and stored in medical or nursing records, often as free text. With the increasing amount of stored, unstructured free text information, the need for effective and timely retrieval of relevant information is growing. In this work, we describe the development and the evaluation of an information system for multi-label classification of medical documents into predefined classes.

Methods

A random sample of 1,500 unstructured, free text documents written in German was extracted from an electronic medical record (EMR) of a general hospital in Austria. A domain expert (physician) manually classified the retrieved documents into one or more of the following classes: surgery, vascular surgery, casualty surgery, internal medicine, neurology, anesthesia and intensive care, radiology and physiotherapy. In average, 1.47 labels were assigned to a document. We built an automated multi-label text classification system in Java based on Weka [1], an open-source machine-learning framework. Four different kinds of classification schemes were compared: Naïve Bayes, k-NN, SVM and J48. 10-fold cross validation was used for evaluation. Moreover, the influence of text preprocessing (e.g. stop-word-removal, stemming, lowercasing) was studied.

Results

Evaluation results for the F-measure [2] with and without text preprocessing are illustrated in Figure 1.

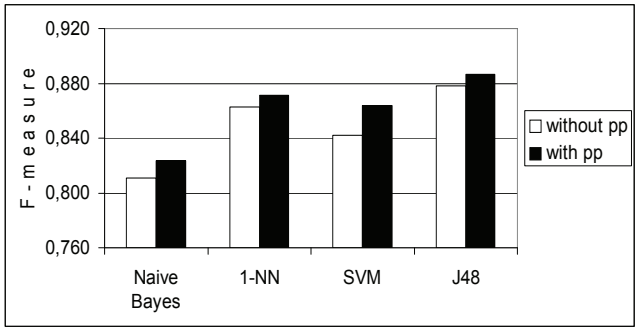

Figure 1 - F-measure with and without text preprocessing (pp)

Evaluation results *without* text preprocessing:

J48 classification model achieved best results with an F-measure of 0.877. The F-measure of the 1-NN model is 0.864 and SVM obtained a value of 0.850. Naïve Bayes achieved the worst result with a value of 0.811.

Evaluation results *with* text preprocessing:

Best result achieved again the J48 classification model with an F-measure of 0.886. 1-NN and SVM are middle-ranking models with values of 0.871 and 0.864. Naïve Bayes achieved an F-measure of 0.824, which was again the worst result of the models. Table 1 and shows the

improvement of the F-measure in percentage caused by text preprocessing

Table 1 - Improvement of the F-measure in percentage caused by text preprocessing (pp).

F-measure	Naïve Bayes	1-NN	SVM	J48
without text pp	0.811	0.864	0.850	0.877
with text pp	0.824	0.871	0.864	0.886
improvement	**+ 1.53** %	**+ 0.83** %	**+ 1.61** %	**+ 1.05** %

In order to compare classification models regarding their achieved F-measures more clearly, differences are given in Table 2. For this comparison F-measures are calculated for classifications with text preprocessing. For example, the 1-NN model achieved an F-measure better by 5.76 % than Naïve Bayes and the F-measure of Naïve Bayes is 4.66 % worse than the F-measure achieved by the SVM model.

Table 2 - Differences in percentages of F-measures achieved by evaluated classification models for classifications with text preprocessing

	Naïve Bayes	1-NN	SVM	J48
Naïve Bayes	0.00 %	**- 5.45** %	**- 4.66** %	**- 7.07** %
1-NN	**+ 5.76** %	0.00 %	**+ 0.84** %	**- 1.72** %
SVM	**+ 4.88** %	**- 0.83** %	0.00 %	**- 2.53** %
J48	**+ 7.61** %	**+ 1.75** %	**+ 2.60** %	0.00 %

Discussion

Evaluation results indicate that J48, SVM and 1-NN are preferable to Naïve Bayes. This finding corresponds to the results of [3]. Text preprocessing increased F-measures for all models. A reason for the rather small effect of text preprocessing on the evaluation results might be medical language. Medical language is quite specific with its own grammar and terms. Hence, for example standard stop word removal or stemming might not be that effective. [4] states that the result of text preprocessing strongly depends on the underlying terms. Thus, text preprocessing might be improved by using domain specific stop word lists and adapted stemming algorithms.

Conclusion

Results show that it is possible to classify medical documents written in German originating from a general hospital with automated machine-learning classification schemes with promising results, comparable with [5].

The classification system is used in a prototype of an information retrieval system for score-calculation, thus influencing the display order of search results. Further studies are needed to evaluate the accuracy of the developed system in other hospitals as well as the user-perceived benefits of this prototype.

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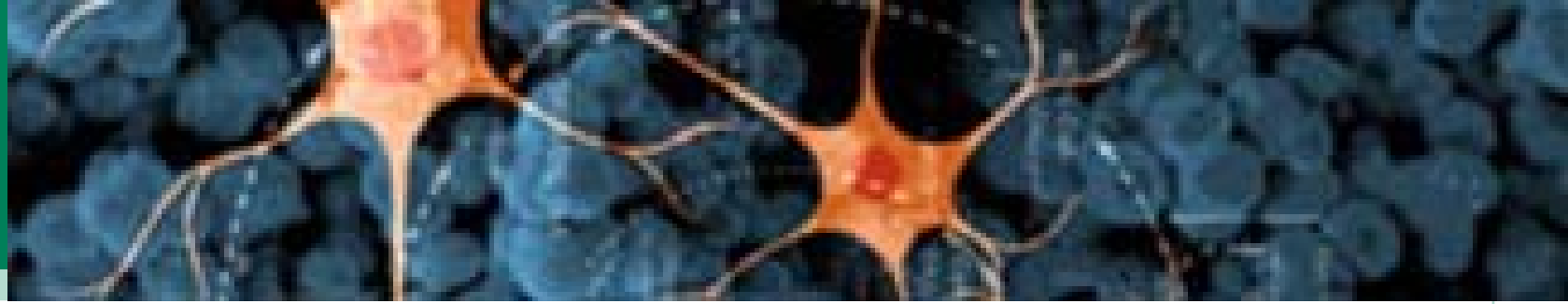

Multi-label text classification of German language medical documents

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Objective and Abstract

Generating metadata to improve quality of information retrieval in **medical free text documents**

⇒ **multi-label classification system** to classify medical free text documents written in German into predefined classes

- ***random sample of 1,500*** *medical free text* ***documents****, assigned manually to* ***1 to 8 categories*** *by a* ***domain expert*** *(physician)*

- *the sample was used to train and evaluate the* ***performance of 4 classification schemes: Naïve Bayes, k-NN, SVM*** *and* ***J48****,*

  additional tests of the effect of ***text preprocessing*** *were done*

- ***preprocessing improved performance****,* ***best results*** *were obtained by* ***J48 classification***

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Introduction

- Increasing amount of **medical free text documents**
- Need for effective and timely retrieval
- **Additional metadata** to improve quality of information retrieval in medical free text documents

  ⇒ Development of a **multi-label text classification system** for medical free text documents originating from a **general hospital** in Austria

Methods

- random **sample of 1,500** free text **documents** written in German from an electronic medical record of a **general hospital** in Austria

- **domain expert** (physician) **manually classified** the retrieved documents into **one or more** of the following classes:

  - surgery,
  - vascular surgery,
  - casualty surgery,
  - internal medicine,
  - neurology,
  - anesthesia and intensive care,
  - radiology and
  - physiotherapy

Methods

- in average **1.47 labels** were assigned to a document
- automated **multi-label** text classification system was built in Java based on **Weka** [1], an **open source machine learning framework**
- **four** different kinds of **classification schemes** were compared:
  - **Naïve Bayes,**
  - **k-NN,**
  - **SVM and**
  - **J48**

Methods

- **10-fold cross validation** was used for evaluation
- the influence of **text preprocessing** (e.g. stop-word-removal, stemming, lowercasing) was studied

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Results

- Evaluation measure: **F-measure** [2]
- **J48 performed best**, followed by k-NN, SVM and Naïve Bayes
- J48 with text preprocessing achieved an **F-measure of 0.886**
- **text preprocessing improved the results**

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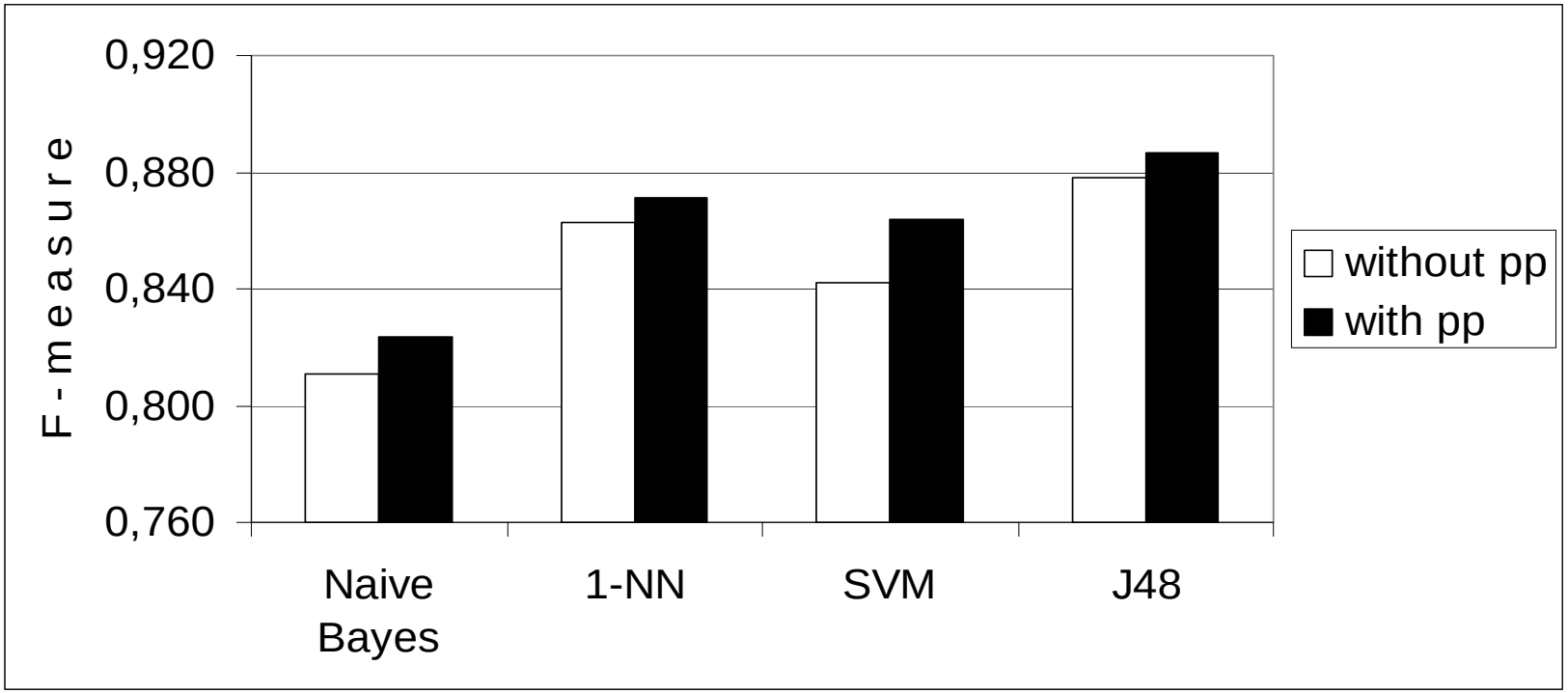
Results

Comparison of the F-measure **with and without text preprocessing** (pp) of four different classification models:



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Results

Evaluation results of document classification **with and without text preprocessing** and the improvement in percentage:

F-measure	Naïve Bayes	1-NN	SVM	J48
without text preprocessing	0.811	0.864	0.850	0.877
with text preprocessing	0.824	0.871	0.864	0.886
improvement	**+ 1.53** %	**+ 0.83** %	**+ 1.61** %	**+ 1.05** %

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Results

Comparison of the F-measure achieved with document pre-processing **by twos** evaluated **classification models** in percentage:

	Naïve Bayes	1-NN	SVM	J48
Naïve Bayes	0.00 %	**- 5.45** %	**- 4.66** %	**- 7.07** %
1-NN	**+ 5.76** %	0.00 %	**+ 0.84** %	**- 1.72** %
SVM	**+ 4.88** %	**- 0.83** %	0.00 %	**- 2.53** %
J48	**+ 7.61** %	**+ 1.75** %	**+ 2.60** %	0.00 %

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Conclusion

- **Classification of free text medical documents** written in German with machine learning classification schemes achieves **promising results,** comparable to [3]
- text preprocessing improves classification results
- **generated metadata** from classification is used in a prototype of an **information retrieval system** for score-calculation, thus influencing the display order of search results

References, Acknowledgement, contact details

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Trial Evaluation of Automatic Lung Cancer Staging from Pathology Reports

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Abstract

This paper presents a system that classifies lung cancer stage using automatic text categorisation of free-text pathology reports. The system has been evaluated in a trial where its output was compared to that of two clinical experts for 179 lung cancer cases. The system achieved 77% accuracy for T staging and 87% for N staging. Inter-expert agreement was also studied.

Keywords:

cancer staging, lung cancer, machine learning,
Clinical Decision Support Systems

Introduction

Evidence-based treatment guidelines for lung cancer treatment are informed by analysis of patient outcomes, where data is first stratified into comparable cases according to the AJCC TNM (tumour, nodes, metastases) staging standard [1]. The preferred method for staging lung cancer is through multi-disciplinary team (MDT) conferences. In Queensland, the Integrated Lung Cancer Outcomes Project (QILCOP) collects formal stage data from MDTs. However, due to the resource- and time-intensive nature of MDTs, the state-wide coverage of QILCOP stage data is approximately 50-60% of all lung cancer cases.

The purpose of this study was to develop a prototype system to automatically determine a T stage (TX, T1-T4) and N stage (NX, N0-N2) for lung cancer patients from free-text pathology reports stored in clinical information systems. As metastatic lung cancer is defined as involvement of other organs, it is not usually assessable from pathological studies of the lung, and therefore the current system does not attempt to determine the M stage. The system uses automatic text categorisation techniques to detect individual observations within reports that are relevant to staging, and to automatically assign a stage. Such a system could be used to obtain stage data for patients not formally staged by an MDT, allowing more comprehensive population-level analysis of lung cancer outcomes.

This paper reports findings from a trial comparing automatic staging to that of two clinical experts on a set of 179 lung cancer cases.

Method

The system architecture is illustrated in Figure1. The input to the system is the set of lung cancer related pathology reports for a patient. All report text is first standardised (spelling, acronyms, numbers, removal of punctuation, etc.) and sentence boundaries are identified using a set of search and replace regular expressions. Sequences of words are then transformed into codes from the UMLS Specialist Lexicon using a dynamic programming search for optimal allocation. Phrases implying negation are identified and associated with surrounding terms using the NegEx algorithm [2]. Each transformed report is then classified for relevance to T and N staging by support vector machines. Reports deemed irrelevant are omitted from further processing. If all reports for a patient are classified as irrelevant to T or N staging then the patient is assigned a stage of TX or NX respectively (i.e. stage cannot be assessed). Support vector machines were implemented using the SVM^{light} package [3].

Each sentence of each relevant report is then input to a series of sentence level classifiers corresponding to specific factors from the staging guidelines (e.g. extension of primary tumour into the visceral pleura, involvement of mediastinal lymph nodes, etc). A broad keyphrase filtering step first disregards completely unrelated sentences. Remaining sentences are then passed to the classification step. For factors that were sufficiently well represented in the training set, the classification step is implemented as a two level support vector machine (SVM). The first level binary SVM classifies a bag-of-words representation of each sentence as relevant (or not) to the factor in question. Relevant sentences are then classified as supporting either a positive or negative finding by the second level SVM. For staging factors that were not well represented in the development data set, manually coded rule-based classifiers make a decision based on the proximity of specific sets of words or phrases. The final stage assignment is the highest stage associated with any of the factors classified as positive across all sentences for that patient.

The system was developed on a set of pathology reports for 710 lung cancer patients. Gold standard T and N stages were obtained from a database of pathological TNM stages previously assigned by expert pathologists or multidisciplinary team meetings. Unbiased accuracy results of

77.6% and 81.8% for T and N staging respectively were obtained across the complete development set.

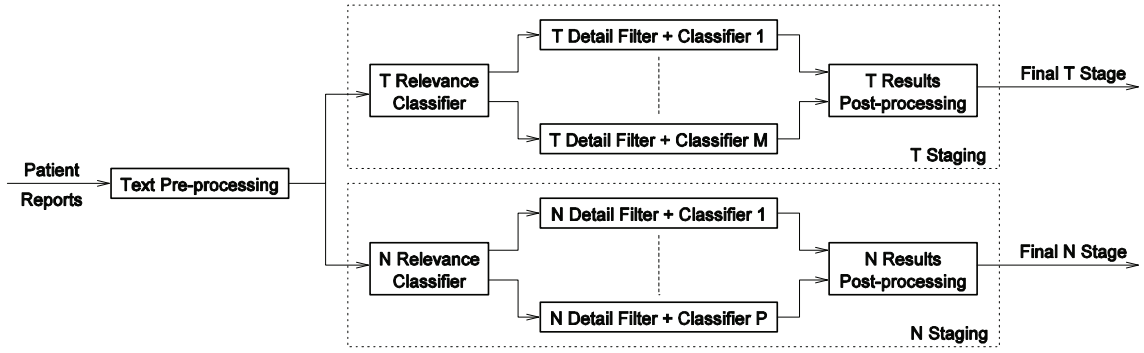

Figure 1 - Automatic staging system architecture

The system was then validated in an independent trial, where automatically assigned T and N stages were compared with stages assigned by two pathologists with expert knowledge of the TNM staging guidelines for lung cancer. The trial set consisted of pathology reports for 179 lung cancer patients previously unseen by the development team. The two main objectives of the trial were:

1. To study the level of agreement in expert staging decisions, and use this to establish a consistent gold standard for evaluating the automatic system.
2. To evaluate the reliability of the automatic staging system.

A post-trial meeting was convened with the clinical experts in order to discuss cases where different stages had been assigned. A consensus stage decision was assigned for as many cases as possible. Where a consensus could not be reached, both stages were retained as the gold standard for evaluating the automatic system performance.

Results

The main trial findings were:

1. On the 179 case trial set, the inter-expert agreement was 89.9% (18 disagreements) and 97.8% (4 disagreements) for T and N staging respectively. Most disagreement was due to ambiguity in the reporting, which resulted in experts applying different assumptions and interpretations to reach a final decision. In the post-trial meeting with the clinical experts, a consensus decision was reached on all but 8 T staging decisions.
2. The automatic system was evaluated against the expert-assigned T and N stages. T staging performance was 75.4% and N staging performance was 87.4%, corresponding to the confusion matrices in Table 1. The observed results are similar to those obtained during system development, and the difference in T and N staging performance mirrors the difference in expert agreement levels.

Table 1 - Trial set confusion matrices for automatic staging

Experts \ System	T1	T2	T3	T4
T1	**39**	10	0	1
T2	5	**81**	2	13
T3	1	7	**2**	0
T4	1	4	0	**13**

Experts \ System	NX	N0	N1	N2
NX	**10**	6	1	0
N0	2	**105**	0	1
N1	0	8	**27**	1
N2	0	3	2	**13**

Conclusion

The prototype system for automatically staging lung cancer was validated against expert decisions in a trial setting with promising results. Future work will focus on improving the current system and adapting the automatic techniques for staging other cancer types and staging protocols.

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Cost-Sensitive Decision Trees Applied To Medical Data

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Abstract

Classification plays an important role in medicine, especially for medical diagnosis. Health applications often require classifiers that minimize the total cost, including misclassifications costs and test costs. In fact, there are many reasons for considering costs in medicine, as diagnostic tests are not free and health budgets are limited. Our aim with this work was to define, implement and test a strategy for cost-sensitive learning. We modified an algorithm for decision tree induction to consider costs, including test costs, delayed costs and costs associated with risk. Then we applied our strategy to train several cost-sensitive decision trees in medical data. Built trees were tested following some strategies, including group costs, common costs, and individual costs. Using the factor of "risk" it is possible to penalize invasive or delayed tests and obtain decision trees patient-friendly.

Keywords:

classification, costs and cost analysis, artificial intelligence, cost-sensitive learning

Introduction

In medical care, as in other areas, knowledge is crucial for decision making support, biomedical research and health management [1]. Data mining and machine learning can help in the process of knowledge discovery. Data mining is the non-trivial process of identifying valid, novel, potentially useful and ultimately understandable patterns in data [2]. Machine learning is concerned with the development of techniques which allow computers to "learn" [3].

Classification methods can be used to build models that describe classes or predict future data trends. It generic aim is to build models that allows predicting the value of one categorical variable from the known values of other variables. Classification is a common, pragmatic tool in clinical medicine. It is the basis for finding a diagnosis and, therefore, for the definition of distinct strategies of therapy. In addition, it plays an important role in Evidence-Based Medicine. Machine learning systems can be used to enhance the knowledge bases used by expert systems as it can produce a systematic description of clinical features that uniquely characterize clinical conditions. This knowledge can be expressed in the form of simple rules, or decision trees [4].

The majority of existing classification methods was designed to minimize the number of errors. Nevertheless, real-world applications often require classifiers that minimize the total cost, including misclassifications costs (each error has an associated cost) and test (attribute) costs. In medicine a false negative prediction, for instance failing to detect a disease, can have fatal consequences; while a false positive prediction may be less serious (e.g. giving a drug to a patient that does not have a certain disease). Each diagnostic test has also a cost and, for deciding if it is worthwhile pay the costs of tests, it is necessary to know both misclassification and tests costs. There are many reasons for considering costs in medicine. Diagnostic tests, as other health interventions, are not free and budgets are limited.

Misclassification and test costs are on the most important costs, but there are also other types of costs [5]. Cost-sensitive learning (also known as cost-sensitive classification) is the area of machine learning that deals with costs in inductive learning.

Our aim with this work was to study and implement a strategy for learning and testing cost-sensitive decision trees, considering several costs, and with application to medical data.

The rest of this paper is organized as follows. In the next section we expose the main types of costs. Then we review the related work. After that, we explain our cost-sensitive decision tree strategy. Next we present and compare some experimental results. And finally, we conclude and point out some future work.

Types of costs

Turney [5] presents a taxonomy for many possible types of costs that may occur in classification problems. From his enumeration, misclassification and test are on the most important costs. Costs can be measured in many distinct units as, for instance, money (euros, dollars), time (seconds, minutes) or other types of measures (e.g., quality of life).

Misclassification costs

A problem with n classes is normally associated with a matrix $n*n$, where the element in line i and column j represent the cost of classifying a case in class i being from class j. Usually the cost is zero when $i = j$. Typically, misclassification costs are constant, that is, the cost is the same for any instance classified in class i but belonging to class j. The traditional error rate measure occurs when the cost is 0 for $i = j$ and 1 for all other cells.

In some cases, the cost of misclassification errors could be conditional, that is, it could be dependent of specific features or dependent of the moment in time. The cost of prescribing a specific drug to an allergic patient may be different than prescribing that drug to a non allergic patient.

The cost of misclassification can be associated with the moment it occurs. A medical device can issue an alarm when a problem occurs and, in this situation, the cost is dependent simultaneously on the correctness of the classification and on the time the alarm is issued, that is, the alarm will only be useful if there is time for an adequate action [6]. Misclassification costs can also be dependent on the classification of other cases. In the previous example, if one alarm is correctly and consecutively issued for the same problem, then the benefit of the first alarm should be greater than the benefit of the others.

Cost of tests

In medicine, the majority of diagnostic tests have an associated cost (e.g., an echography or a blood test). These costs can be highly distinct between different tests (attributes).

The costs of tests may be constant for all patients or change according to specific patient features. A bronchodilatation test, for instance, have a higher cost for children under 6 years, which means that the feature age have influence in the test cost.

Medical tests can also be very distinct when considering their influence in the "quality of life". A range of tests are completely harmless for patients (e.g., obstetric echography), others can be dangerous and put patient life at risk (e.g., cardiac catheterism), and some can be (only) uncomfortable (e.g., digestive endoscopy).

Some tests can be cheaper (and faster) when ordered together (in group) than when ordered individually and sequentially (e.g., renal, digestive and gynecological echography). Some tests can also have common costs that can be priced only once. Blood tests, for instance, share a common cost of collecting the blood sample. There is not only an economic reduction but also a non-economical reduction in the cost of "worry" the patient.

A number of tests might depend of the results of other tests. The test "age", for instance, may influence the cost of the bronchodilatation test. Some tests can have an increased price as result of secondary effects. Other tests can have patient specific, time dependent or emergency dependent costs.

In general, tests should only be ordered if their costs are not superior to the costs of classification errors.

Related work

In inductive learning (learning by examples), the majority of the work is concerned with the error rate (or success rate).

Nevertheless, some work has been done considering non-uniform misclassification costs, that is, different costs for different types of errors [7, 8]. Other literature is concerned with the cost of tests, without taking into account misclassification costs [9, 10].

And there is also some work concerned simultaneously with more than one type of costs, including the work of Turney [11], Zubek and Dietterich [12], Greiner et al. [13], Arnt and Zilberstein [14], and Ling et al. [15-20]. At this level, the work of Turney [11] was the first to consider both test and misclassification costs. Next, we give a brief overview of this work considering both costs.

Turney [11] implemented a system, the ICET system, that uses a genetic algorithm for building a decision tree that minimizes test and misclassification costs. The ICET system was robust but very time consuming.

Several authors associated the cost problem to a Markov decision process that has the disadvantage of being computationally expensive. Zubek and Dietterich [12] used an optimal search strategy, while. Arnt and Zilberstein [14] included a utility cost for the time necessary to obtain the result of a test.

Greiner et al. [13] analyzed the problem of learning cost-sensitive optimal active classifiers, using a variant of the probably-approximately-correct (PAC) model.

Chai et al. [15] proposed a cost-sensitive naïve Bayes algorithm for reducing the total cost. Ling et al. [16] proposed a decision tree algorithm that uses a cost reduction splitting criteria during training, instead of minimum entropy. After that, Sheng et al. [17], presented another approach where a decision tree is built for each new test case. In another paper, Sheng et al. [18] proposed a hybrid model that result from the integration of a decision tree sensitive to costs with a naïve Bayes classifier. Zhang et al. [19] compared strategies for checking if missing values should be or not obtained and stated that, for tests with high costs or high risk, it should be more cost-effective to not obtain their values. Recently, Ling et al. [20], updated their strat-

egy for building cost-sensitive decision trees, with the inclusion of sequential test strategies.

Our cost-sensitive strategy

Next, we briefly describe our strategy for implementing a cost-sensitive decision tree. Our aim was to implement a tool for building decision models sensitive to costs, namely test costs, misclassification costs and other types of costs.

We opt to use decision trees because they have several interesting characteristics for health professionals. They are easy to understand and use, and present an intuitive and appealing structure. Their structure is congruent with decision making methods that physicians normally use in daily routine, when they try to understand which is the best diagnostic test or the best treatment for one patient [21].

We modified the C4.5 algorithm [22] to contemplate costs and, consequently, to generate cost-sensitive decision trees. Specifically we used de j48 class, implemented in the open source package for data mining Weka [3].

Cost function

We adapted the decision tree splitting criteria to contemplate costs, through the following cost function (1):

$$\frac{\Delta I_i}{\left(C_i \phi_i\right)^{\omega}} \tag{1}$$

Where ΔI_i is the information gain (or gain ratio) for attribute i, C_i is the cost of attribute (test) i, ϕ_i is the factor of "risk" associated with attribute (test) i, and ω is the factor of power.

When building a tree, for each node, the algorithm will select the attribute that maximizes the defined heuristic for the cost function. The cost function does not consider misclassification costs, as these costs do not have influence in the decision tree splitting criteria [22].

Attributes without cost, as age and gender, are assigned the value 1. Attributes with higher costs lead to lower results in the cost function and have, consequently, fewer chances to be selected.

The factor of "risk" is an influent piece in the cost function. This factor was introduced to penalize attributes that might be invasive, may cause discomfort and disturb, or could somehow contribute to low patient quality of life (e.g., the invasive test "coronary angiography"). The value 1 means absence of influence and is equivalent to a completely innocuous test, while values higher than 1 means that exists influence. Higher factors leads to lower results in the cost function and, therefore, to lower possibilities for and attribute to be selected.

If both test cost and factor of "risk" are equal to one, then their participation is neutral and, thus, the cost function is basically the traditional information gain function. The cost of the attribute can be adjusted in two ways. It can increase or decrease considering the inoffensiveness of the test (factor of "risk"), or it can be modified by the factor of power. The factor of power is a general parameter that is equally applied to all tests, reducing or increasing the influence of costs in attribute selection.

The factor of "risk" can also be used to penalize delayed tests. A longer test can have consequences in the patient quality of life and may increase other costs, as those related to staff, facilities and increased length of stay. Between two similar tests, but with one longer than the other, it makes sense that the faster test should be preferred. Hence, considering the average length of tests, an adjustment can be made through the factor of "risk".

The factor of power regulates the influence of costs, as it can make trees more (or less) sensitive to costs. This factor may also be used to adequate the cost function to the used scale. An inexpensive test, such as the "age" test, has the same cost for any scale. But, tests with real costs have clearly different values in different scales. If a test "A" cost 10 in the Euro scale then it costs 1000 in the centime scale, that is, the ratio between the tests "age" and "A" are 1 to 10 in the Euro scale and 1 to 1000 in the other. To avoid that a change in the scale could benefit some attributes, it is important to adjust it with the factor of power.

For a factor of power of 0 the costs are not considered as the denominator of the cost function became 1. This situation is equivalent to consider the original information gain. With an increase in the factor of power, the costs of tests will have more influence and less expensive tests will preferred. The factor of power typically will assume a value between 0 and 1.

For making our model sensitive to misclassification costs, we used a meta-learner implemented in Weka, CostSensitiveClassifier [3].

Decision tree test and usage strategies

After building cost-sensitive models, we want to test and use them. For that, we have a test strategy where we consider the cost of a test individually or in a group. Within groups of tests it is possible to distinguish between (i) tests ordered simultaneously or (ii) tests that have a common cost.

Sometimes (i), there is a big difference between the cost of a group of tests and the sum of individual tests costs. Many medical tests do not have an immediate result and there-

fore it also important to consider the length of time for the group against the total delay of the individual tests. When a medical doctor is at a node of the decision tree, and have the first of a group of tests, he must decide if he will ask for a group of tests or only for the node test. If he orders a group of tests, then the cost considered will be the group cost, even if some tests in the group are not used.

In the other situation (ii), it is possible to separate a common cost for a group of tests. In a group of blood tests, for instance, the cost of collecting blood is a common cost for all tests in the group. Only the first test of the group will be priced for that common cost.

Delayed tests are considered in the training phase of the decisions tree. Slower tests will, therefore, have tendency to be tested only after faster ones.

Individual costs

Our strategy also allows (a) to consider specific patient characteristics, (b) to modify test costs in situations where their values are already known (tested previously), and (c) to consider availability and slowness of certain tests.

The cost of each test can be conditional on the characteristics of the patient, that is, it is possible to have a variable cost associated with specific features of the patient. As seen before, the age can change the cost of the test "bronchodilatation" (higher for children less than 6 years). The comorbidity index of a patient is another example, as it can influence the cost of some tests and, therefore, could be used to adjust the cost of the test. For a specific test, different patients may require additional tests, consequently with an increase in costs.

In other circumstances (b), some tests might have been obtained previously and, logically, their original costs should not be considered again. Consequently, we adopt another approach for building trees where, for each new instance (patient), tests with known values are considered without cost and without "risk". For each new vector of distinct costs a new decision tree is built.

Resources are not infinite neither are always available. A specific test may be conditional on the availability of a medical device in a specific time period. In these cases, it is possible to exclude that test and build a new tree. Optionally, it is possible to increase de factor of "risk" of that test, decreasing it probabilities of being selected. As the availability is not constant over time, this problem should be analyzed for each case (patient); this is a circumstantial cost and not a cost intrinsic to the patient.

Experiments

We tested our cost-sensitive decision tree with several datasets, including the Pima Indians Diabetes. This dataset contains 768 instances and a class that assumes 2 values, "healthy" (500) or "diabetes" (268)[1]. In Table 1 we can see test costs (all attributes are numeric).

Table 1 - Attribute costs for Pima Indians diabetes

Test	Cost ($)	Group cost ($)
a. Number of times pregnant	1	
b. Glucose tolerance test	17.61	b+e=38.29
c. Diastolic blood pressure	1	
d. Triceps skin fold thickness	1	
e. Serum insulin test	22.78	b+e=38.29
f. Body mass index	1	
g. Diabetes pedigree function	1	
h. Age (years)	1	

Tests "glucose tolerance" and "serum insulin" are not immediate and have a distinct cost (other attributes have a symbolic cost of $1). Moreover they share a common cost, $2.1, from collecting blood. As these attributes are not immediate, when using the tree it is necessary to decide if both tests will be ordered together (in group) or not.

We ranged the factor of power from 0.0 to 1.0 and induced decision trees using 10-fold cross-validation. After that, we considered cost zero for cases classified correctly and varied misclassification costs, from $10 to $1000, with equal costs for false negative and false positives. In Table 2 we can see the results of the evaluation of five decision trees for that range of misclassification cots. Notice that for factor of power equal to zero, the model is equal to the obtained by the traditional C4.5.

1 UCI Repository Of Machine Learning Databases, ftp://ftp.ics.uci.edu/pub/machine-learning-databases/

Table 2 - Average costs in the evaluation of 5 decision trees, for a range of misclassification costs and factors of power

fp:	**0.0**	**0.1**	**0.2**	**0.5**	**1.0**	**95% IC var.**
Accuracy (%):	73.8	73.7	72.3	68.5	68.2	
$10	23.4	21.9	19.5	6.4	5.7	±0.5
$20	26.0	24.5	22.2	9.5	8.8	±0.8
$50	33.8	32.4	30.6	19.0	18.4	±1.7
$100	46.9	45.5	44.4	34.7	34.2	±3.3
$200	73.1	71.8	72.2	66.2	66.0	±6.5
$500	152	151	155	161	161	±16
$1,000	283	282	294	318	320	±32

In this example, for low misclassification costs, the best results are obtained for a factor of power between 0.5 and 1.0. In these situations, average costs are much lower when compared with C4.5. For high misclassification costs, compared to test costs, best results occur with factor of power equal to 0.0 (C4.5) and 0.1, but without substantial differences for the other models.

As misclassification costs rise, test costs tend to be negligible. That is, for sufficiently higher misclassification costs and considering equal cost for false negatives and false positives, a higher accuracy rate corresponds to a lower average cost.

In this evaluation we distinguished between individual and group costs, and realized that results considering group costs always had higher average costs. This happened because the serum insulin test, which shares group costs with the glucose tolerance test, only intermittently appeared in the decision trees and, therefore, there was an extra imputed cost nothing or little used.

We also tested the factor of "risk" with other datasets and obtained interesting results. Sometimes, with minimum increase in the total cost it is possible to obtain models that are more patient-friendly.

Conclusions

In this paper we present approaches to build cost-sensitive decision trees, considering different aspects of test costs, where are included economic and non-economical costs. Our framework integrates also a cost-sensitive meta-learner to consider the situations where misclassifications costs are different. Results show that it outperforms the traditional, non cost-sensitive, C4.5.

As technologies became more expensive, it is even more rational to consider all the cost involved. A big challenge is to have better healthcare using less money. The factor of "risk" is an important item of the proposed framework as it can induce models patient-friendly. Decision trees represent a natural representation for classification problems (for diagnosis or prognosis) that includes costs.

In our future work we will continue to evaluate our strategies, with new experiments in other datasets, with real data and real costs. We will try to incorporate other costs associated with delayed tests, emergency situations, staff, facilities, and increased length of stay. The cost function will also be refined and tested for different scenarios. We will also study other methods for building and testing decision trees with the application of a cost-sensitive pruning strategy.

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Linking and Analysing Health Data with Appropriate Privacy and Security

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Abstract

In this paper we discuss current approaches for linking and analysing sensitive health data for research, and discuss associated security and privacy risks. We also provide an overview of two CSIRO tools, HDI™ and PPA®, developed for enabling secure access to personal health data for research while providing the required privacy protection, in some situations.

Keywords:

medical record linkage; privacy; statistics; health research

Introduction

The increasing number and size of health data repositories can provide the health and medical research communities with information which is important to clinical treatment and medical research. There is a need not just to access the data, but to locate records relating to the same patient in multiple databases and bring the records together for analysis and research.

Various approaches and protocols have been developed for attempting to simplify the linkage and provision of separate data sources to end users for analysis and research whilst preserving the privacy of individuals, including two and three party protocols and blind record linkage algorithms [1]. The technological approaches differ in their architecture and software/hardware platforms, and there are differences between the applicable legislative and policy frameworks.

Model architectures range from single large databases[2], separate databases linked only as required[3], chains of links type data systems[4], and federated databases[5]. In most cases access to the data is controlled by ethical review boards and the released data is usually in de-identified format, with names, addresses and dates of birth removed.

The role of data custodians in the provision of health data to users varies: with some custodians releasing the data completely and others entrusting third parties to manage the privacy and security issues. As the number of data sources increases, the complexity of privacy and security agreements will obviously increase, placing a substantial amount of responsibility upon the parties involved [6].

Once a linked data set is available, usually in de-identified format, the analysis of the data is generally carried out using statistical or reporting software. In some cases results of subsequent statistical analyses are assessed for disclosure risk prior to publication [2], whilst in others the burden resides upon the trusted third party undertaking the analysis. Whilst ethics agreements may contain clauses governing how results of statistical analyses may be disseminated, there remains a real risk of disclosure [7].

In this paper we propose one solution for linking and analysing health data that may reduce the risk of identifying individual records in some situations.

Health data integration™ (HDI™)

The core functionality of HDI™ enables linking of patient records from different data repositories whilst maintaining the privacy of the patients. It is a virtual repository, and external release of the data is controlled by the data custodian, and can be stopped at any time. HDI™ provides support in software for data custodians to develop a strong governance framework providing rules for: release of data for use in projects; management of the HDI™ installation; support for the separation of identifying and clinical information, and the building of a virtual linked data set by Project Administrators for Users to access linked data. HDI™ offers this data on-line, allowing real time query and retrieval without using a data warehouse.

The HDI™ model allows data custodians to release demographic information to HDI™. As HDI™ is installed locally there is also the provision for third party software to link directly to HDI™ and the data. Within the governance framework provisions can be made that only certain types of analyses may be performed on sensitive data.

Privacy-preserving analytics® (PPA®)

Privacy-Preserving Analytics® (PPA®) is a menu-driven web-based software package for conducting statistical analysis on raw microdata in a secure computing environment. Outputs of an analysis are filtered before

presentation, with the aim that no individual unit record is disclosed or can be inferred.

Reducing the risk of disclosure is achieved in several ways:

- Variable names that are a privacy risk are de-identified
- Some models are fitted on subsamples of the dataset to limit attempts at re-engineering
- Some data transformations are restricted
- Some parameter estimates are rounded, standard errors and exact significance values are not produced, and
- Some higher order interactions are limited.

PPA™ can be used as a knowledge discovery tool for testing hypotheses before developing a full research proposal.

The use of PPA™ may reduce (though will not entirely remove) the administrative burden of consent provisions, custodian security compliance, ethics committee processes and address the requirements of HIPAA (Health insurance Portability and Accountability Act 1996 (US)).

Analysis of health data in an HDI™ and PPA® framework

As an example of HDI™ and PPA® working together, consider that in the HDI™ environment, data custodians may allow HDI™ access to sensitive information such as individual demographic details, surgeon, and hospital. In that case, a flag may be attached to a sensitive field to inform HDI™ that this field may be used as an explanatory variable in an analysis using PPA® but no estimate may be published. PPA® can then use that information for constructing and running a full statistical model to gain reliable information about other explanatory variables, where the estimates can be published. In a knowledge discovery context a researcher can test hypotheses regarding the effect of factors such as age, gender and comorbidities on clinical outcomes, for example, while having the effect of the surgeon modeled but not released.

Conclusion

A data custodian has responsibility to ensure that no identifiable information is released to an unauthorised third party. Project agreements normally require that data is used only for the specific aims of the project for which it was released, and that the data is destroyed at the end of the project. The release of results from the project must also satisfy privacy agreements. This is the limit of control a data custodian has over their data once it has been released. The HDI™/PPA™ model may support the fulfillment of a significant amount of the responsibility of the data custodian by significantly reducing the risk that identifiable information is publicly released from a project. Similarly, researchers may benefit by being able to use more sensitive and valuable information for testing hypotheses, though without actually seeing the data. The HDI™ and PPA™ tools may also allow less authorised third-parties such as graduate students, and other researchers to conduct analysis on raw data without having to modify existing data agreements with data custodians.

Acknowledgments

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Comparison of Perceptions of Patients' Information Privacy in Dealing with Nurses in Japan

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Abstract and objective

It has become very important to maintain the proper balance between protecting the privacy of patients' information while adequately sharing their information in the era of ICT. This study aimed to compare perceptions regarding patients' information privacy between patients and nurses to discuss appropriate ways of future interdisciplinary communication. A self- administered survey was conducted to obtain perceptions on patients' information privacy among 595 patients and 1770 nurses from 37 hospitals in 3 prefectures in Japan. A factor analysis was performed to clarify the concept of patients' information privacy, and t-test was performed to compare the level of perceptions. As a result, the concept of patients' information privacy was almost the same between patients and nurses, while nurses were more aware of patients' information privacy than the patients themselves. This indicates the importance of asking patients their intentions with regard to information sharing among healthcare professionals in order to protect the patient's right to information privacy.

Keywords[1]:

interdisciplinary communication, privacy, information sharing

Introduction

In Japan, an electronic medical health records system has been rapidly implemented to facilitate interdisciplinary communi- cation through information sharing. At the same time, a debate has ensued over whether information privacy is properly protected among healthcare professionals. Maintaining the proper balance between protecting the privacy of patients' information and adequately sharing patients' information has become a critical issue. The aim of the study was to compare perceptions on patients' information privacy between patients and nurses to discuss appropriate ways of future inter- disciplinary communication.

Methods

A self-administered survey was conducted to obtain current perceptions of patients' information privacy among a total of 595 patients and 1770 nurses from 37 hospitals in 3 prefec- tures in Japan. The questionnaire contained 26 items that related to information privacy, such as "diagnosis," "name," "toilet habit," "history of family disease," and so on, that were scored using a 6-point Likert scale (1:high sensitivity to 6: low sensitivity). Patient surveyed were asked to complete an anonymous self-administered questionnaire. Also, nurse par- ticipants were asked to recall one specific patient, and reply to the questionnaire by assuming how the patient would respond to each question. The survey was conducted in accordance with a certain ethical procedure.

Results

The valid response rate was 40.2% (n=239) from patients and 51.4% (n=909) from nurses. As a result of a factor analysis for patient responses, four common factors were extracted, "Treatment-Related Information," "Identification-Related Information," "Daily Life Behavior-Related Information," and "Personal Life-Related Information," as shown in Table 1. The result of factor analysis for nurse responses showed ex- traction of four common factors, whose components were almost the same as the result of patients as shown in Table 2. By analysis of the score differences between patients and nurses, nurses responses were significantly lower to most questions than patients ($p<0.05$). No differences were found among three questions; "name," "birthday," and "allergy," as shown in Table 3.

Discussion

As a result of factor analysis for patient responses (Table 1), patients' perceptions of information privacy were confirmed to be composed of four factors. The items included in each extracted factor are considered very important information in the range of care provided by all healthcare professionals. In particular, nurses not only use medical information, but also various other types of information related to life at home in order to provide nursing care. Therefore, the proven four factors relating to information privacy are considered to be very meaningful for the col-

1 A part of this research was funded by a Grant-in-Aid for Scientific Research (B)(18390571) from the Ministry of Education, Cultures, sports, Sciences and Technology

lection, use, and sharing of patients' information for treatment as well as protecting the hospitalized patients' information privacy.

Also, the result of factor analysis for nurse responses showed extraction of four common factors, whose components were almost the same as the result of patients. This result indicates that both patients and nurses shared virtually the same views about patients' information privacy.

However, the score differences between patients and nurses, nurses responses were significantly lower to most questions than patients, which means nurses are more sensitive to patients' information privacy than patients-selves. According to Ota's study[1)] conducted in 2002, nurses considered their own privacy more important than patients' privacy. Compared to Ota's result, Japanese nurses' concern for patients' infor- mation protection is growing. This may be influenced by the Personal Information Protection Law enacted in Japan in April 2005.

Conclusion

The study was conducted to compare perceptions on patients' information privacy between patients and nurses to discuss appropriate ways of future interdisciplinary communication.

This study revealed that both patients and nurses shared vir- tually the same views about patients' information privacy, but their level of awareness was the different. Therefore, it is important to ask patient themselves how they want healthcare professionals to share their privacy related information to protect their right to information privacy.

Table 1 - A factor analysis for patient responses

(n=239; KMO: α=0.950)

Q No.	Item	Factor Loadings F1	F2	F3	F4	Communality
Factor 1: Treatment-Related Information (Cronbach's α=0.962)						
14	Laboratory Results	0.872				0.779
15	Medication	0.836				0.854
16	Medical History	0.768				0.829
17	Physical Disabilities	0.751				0.763
12	Progress of Treatment	0.675				0.825
11	Diagnosis	0.664				0.822
21	Toilet Habits	0.577				0.762
13	Infection Data	0.521				0.600
10	Worries during Hospitalization	0.511				0.664
Factor 2: Identification-Related Information (Cronbach's α=0.953)						
2	Name		0.988			0.834
3	Date of Birth		0.944			0.872
4	Occupation		0.753			0.788
1	Address/Telephone No.		0.710			0.711
6	Family Structure		0.686			0.826
5	Educational Background		0.604			0.740
Factor 3: Daily Life Behavior-Related Information (Cronbach's α=0.947)						
20	Sleeping Habits			0.786		0.898
19	Diet			0.760		0.831
18	Allergy			0.640		0.818
23	Alcohol or Smoking Habits			0.618		0.696
Factor 4: Personal Life-Related Information (Cronbach's α=0.894)						
26	Sexual Life				0.742	0.555
24	Personal Value				0.684	0.699
25	Leisure Activity				0.633	0.760
9	Financial Problem				0.590	0.723
8	History of Family Disease				0.463	0.649
	*Contribution Ratio	65.5	5.8	4.7	4.2	
	*Accumulated Contribution Ratio	65.5	71.2	75.9	80.2	

*Accumulated Contribution Ratio based on Initial Eigenvalues

Table 2 - A factor analysis for nurse responses

(n=909; KMO: α=0.961)

Q No.	Item	Factor Loadings F1	F2	F3	F4	Communality
Factor 1: Treatment-Related Patients' Information Perceived by Nurses (Cronbach's α=0.947)						
14	Laboratory Results	0.875				0.772
16	Medical History	0.819				0.810
12	Progress of Treatment	0.809				0.774
15	Medication	0.804				0.809
11	Diagnosis	0.772				0.722
17	Physical Disabilities	0.711				0.714
13	Infection Data	0.690				0.574
10	Worries during Hospitalization	0.450				0.555
Factor 2: Identification-Related Patients' Information Perceived by Nurses (Cronbach's α=0.923)						
3	Date of Birth		0.924			0.811
2	Name		0.795			0.644
1	Address/Telephone No.		0.701			0.612
6	Family Structure		0.629			0.725
4	Occupation		0.624			0.574
Factor 3: Daily Life Behavior-Related Patients' Information Perceived by Nurses (Cronbach's α=0.900)						
25	Leisure Activity			0.806		0.716
23	Alcohol or Smoking Habits			0.784		0.730
20	Sleeping Habits			0.757		0.820
24	Personal Value			0.715		0.655
19	Diet			0.713		0.720
Factor 4: Personal Life-Related Patients' Information Perceived by Nurses (Cronbach's α=0.857)						
9	Financial Problem				0.762	0.696
7	Relationship with YourFamily				0.672	0.693
8	History of Family Disease				0.668	0.698
26	Sexual Life				0.614	0.416
22	Confidential Talk withYour Doctor and Nurse				0.484	0.439
	*Contribution Ratio	54.3	7.6	6.5	5.3	
	*Accumulated Contribution Ratio	54.3	61.9	68.4	73.7	

*Accumulated Contribution Ratio based on Initial Eigenvalues
(Extraction Method: Unweighted least squares-Promax Rotation)

Table 3 - The score differences between patients & nurses

	Item		N	Score Ave.	SD	p-value
1	Address/Telephone No.	NS	907	3.83	1.44	0.019 *
		PT	238	4.10	1.58	
2	Name	NS	909	4.71	1.35	0.166
		PT	239	4.56	1.52	
3	Date of Birth	NS	906	4.41	1.44	0.724
		PT	238	4.45	1.54	
4	Occupation	NS	906	3.93	1.46	0.000 **
		PT	238	4.45	1.55	
5	Educational Background	NS	904	3.36	1.46	0.000 **
		PT	239	4.19	1.63	
6	Family Structure	NS	909	3.78	1.38	0.000 **
		PT	239	4.14	1.58	
7	Relationship with Your Family	NS	909	3.28	1.37	0.000 **
		PT	239	3.92	1.63	
8	History of Family Disease	NS	907	3.09	1.33	0.000 **
		PT	239	3.77	1.65	
9	Financial Problem	NS	907	2.88	1.33	0.000 **
		PT	238	3.61	1.67	
10	Worries during Hospitalization	NS	908	3.40	1.28	0.000 **
		PT	238	3.96	1.52	
11	Diagnosis	NS	908	3.60	1.41	0.000 **
		PT	239	4.26	1.56	
12	Progress of Treatment	NS	909	3.67	1.37	0.000 **
		PT	238	4.27	1.51	
13	Infection Data	NS	903	2.87	1.41	0.000 **
		PT	231	3.71	1.66	
14	Laboratory Results	NS	909	3.31	1.36	0.000 **
		PT	239	3.96	1.57	
15	Medication	NS	908	3.84	1.37	0.000 **
		PT	237	4.30	1.51	
16	Medical History	NS	907	3.60	1.35	0.000 **
		PT	237	4.18	1.56	
17	Physical Disabilities	NS	907	3.83	1.44	0.000 **
		PT	237	4.22	1.54	
18	Allergy	NS	906	4.49	1.35	0.057
		PT	237	4.68	1.39	
19	Diet	NS	908	4.08	1.35	0.000 **
		PT	238	4.51	1.42	
20	Sleeping Habits	NS	909	4.17	1.33	0.000 **
		PT	239	4.63	1.37	
21	Toilet Habits	NS	908	3.34	1.37	0.000 **
		PT	238	4.11	1.52	
22	Confidential Talk withYour Doctor and Nurse	NS	909	2.61	1.21	0.000 **
		PT	238	3.68	1.63	
23	Alcohol or Smoking Habits	NS	906	4.13	1.37	0.000 **
		PT	237	4.68	1.42	
24	Personal Value	NS	907	3.58	1.33	0.000 **
		PT	238	4.01	1.59	
25	Leisure Activity	NS	908	3.81	1.35	0.000 **
		PT	239	4.23	1.51	
26	Sexual Life	NS	898	2.12	1.25	0.000 **
		PT	235	3.20	1.75	
	Total Score	NS	909	3.61	1.00	0.000 **
		PT	239	4.15	1.25	

*p<0.05; **p<0.01

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Development of a Hospital Financial Analysis System Using Rule-Based Engine

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Abstract

The financial analysis is needed to evaluate efficiency in hospitals. A prototype using rule-based engine was developed and the results of the user evaluation suggested the effectiveness of the system.

Keywords:

financial management, computer reasoning, rule-based engine

Introduction

The financial analysis is a method to analyze the financial status of companies. It is used both for external analysis and for internal analysis to evaluate the status of one's own company. Hospitals, which are non-profit organizations, are required to manage efficiently these days, and the financial analysis in hospitals is needed. Financial analysis by computer systems is expected to save cost and time for hospitals. The objective of this research was to develop a financial status analysis system for hospitals.

Methods

Requirements

The mandatory functions to analyze financial status in hospital are to be segmented as follows: 1) Define Indices 2) Calculate Index Values 3) Evaluate Index Values 4) Find Root Cause. Rule-based engine and forward chaining was thought to be suitable for the financial analysis, because of the characteristics of the financial data which can be obtained as a group of data, and the characteristics of the financial analysis of which the knowledge system is relatively simple.

Prototype system

A prototype using a rule-based engine and forward chaining was developed. Figure 1 shows the architecture of the prototype.

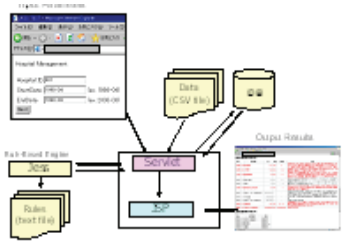

Figure 1 - Architecture of the Prototype

Jess[1], a rule-based engine described in Java was adapted. 16 financial indices were selected and defined in rules. Rules to calculate and evaluate the index values were also set in rules. Decision tree analysis was developed to infer the reasons why the operating profit was less than the threshold value by using the relationships between the indices.

Evaluation

5 end-users joined the evaluation of the prototype. All 5 subjects agreed to the evaluation item "Evaluation of the index values are reasonable". 2 subjects chose "I agree" and 3 chose "I agree a little" for the item "the system can analyze the financial status comprehensively." It showed that the results analyzed by the prototype suit the results analyzed by users.

Results

A possibility of the hospital financial analysis system using rule-based engine was shown. Rule-based engine is expected to solve the root problems in hospitals.

References

[1] Ernest Friedman-Hill: JESS IN ACTION Rule-Based Systems in Java, MANNING, 2003.

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Development of a Hospital Financial Analysis System Using Rule-Based Engine

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Abstract

The financial analysis is needed to evaluate efficiency in hospitals. A prototype using rule-based engine was developed and the results of the user evaluation suggested the effectiveness of the system.

Keywords

- Financial Management
- Computer Reasoning
- Rule-Based Engine

Backgrounds

- Financial analysis
  - a method to analyze the financial status of companies
  - used both for external analysis / for internal analysis

- Demand for efficient management to hospitals

  → Demand for financial analysis in hospitals

- Financial analysis system for hospital managers is possible to save cost and time.

Objective

To verify the effectiveness of financial analysis system for hospital managers by developing a prototype system and evaluating it.

Methods(1) - Requirements

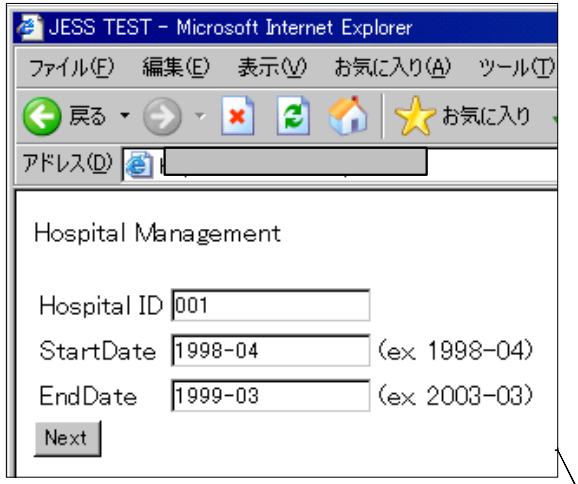
- Mandatory functions
  1) Define indices
  2) Calculate index values
  3) Evaluate index values
  4) Find root cause.

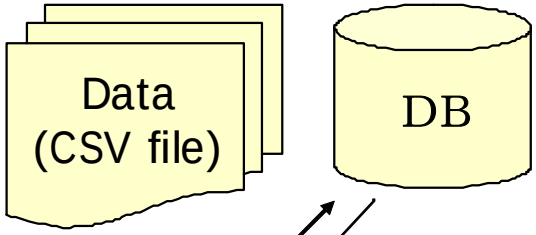
- Development methods
  - Rule-based engine
  - Production system and knowledge representation using frames
  - Forward chaining

  (from the characteristics of the financial data and financial analysis)

Methods(2) - Prototype System

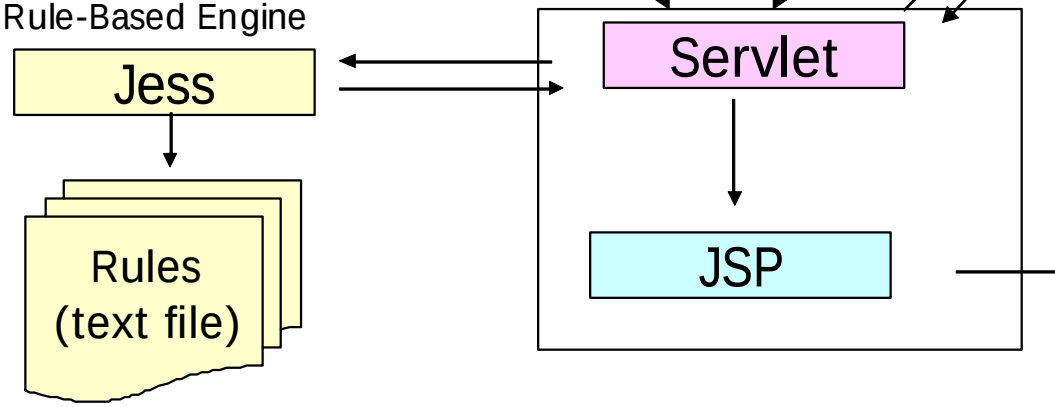
Input Parameters





Output Results

Rule-Based Engine



System Output (Examples)

- Financial Indices Evaluation

Viewpoint	Index	Value	Evaluation	Standard	Explanation
Stability	Labor Productivity per person	8,301,128.21	--	-	This index shows ....
Stability	Labor's Share	94.57	NG	60 - 70	This index shows .... When it is too low, it will.... and when it is too high, it will...

- Profit Tree Analysis

Operation profit does not meet the standard because...
=> Operation cost does not meet the standard
Operation Cost does not meet the standard because...
=> Personnel expense does not meet the standard
Personnel expense does not meet the standard because...
=> Personnel expense per labor does not meet the standard

Methods(3) - Evaluation

- Levels of agreements to the analyzed results
  - By 5 end-users (medical doctors)
  - By 5 professional consultants
- Required functions for financial analysis
  - By 5 professional consultants

Evaluation Results
(Levels of Agreement)

	End-users					Consultants				
	1	2	3	4	5	1	2	3	4	5
a. Index items are enough for practical use	0	**2**	**3**	0	0	0	0	**1**	**4**	0
b. election of the index items are reasonable.	0	**2**	**3**	0	0	0	**2**	**2**	**1**	0
c. Evaluation of the index values are reasonable	0	**5**	0	0	0	0	**1**	**4**	0	0
d. Explanation of the evaluation is enough	0	**2**	**2**	**1**	0	0	**1**	**3**	**1**	0
e. From the synthetic viewpoint, the financial status is analyzed.	0	**2**	**3**	0	0	0	0	**2**	**3**	0

[Levels of Agreement] 1: I agree a lot. 2: I agree. 3: I agree a little. 4: I don't agree. 5: I have no idea.

- All Evaluation result by end-users is in the affirmative.
- Evaluation result by consultants is not positive, but not completely negative.

Possibility of hospital financial analysis system using rule-based engine was shown.

Evaluation Results
(Required Functions for Financial Analysis)

#		Number of subjects to check each item
	(Input Data)	
1	Input of non-financial data (ex. years after foundation)	1
2	Input of financial data for longer period	2
	(Output)	
3	More detailed explanations	**3**
4	More variety of representation (ex. graphical interface)	**4**
5	Comprehensive evaluation (not only evaluation of each index)	2
	(Analysis Methods)	
6	Adjustment of standard value by characteristic of hospitals	**4**
7	Evaluation by multiple steps (ex. Good / Fair/ Bad)	2
8	Comparison with best-practice facilities	**4**
9	Analysis over consideration of external environment change	2
	(Others)	
10	Others	2

Discussion

#3 More detailed explanations
#4 More variety of representation (ex. graphical interface)

→ Additional functions are required for better comprehension.

#6 For adjustment of standard value by characteristics of hospitals
#8 Comparison with best-practice facilities

→ Additional input data are required.

Ex.
- Years after foundation
- Type of the organization (private / public)
- Size of the organization (number of beds etc.)

Conclusion

- A prototype system for hospital financial analysis using rule-based engine was developed.
- Possibility of hospital financial analysis system using rule-based engine was shown.
- It is suggested to add :
  - More functions for better comprehension
  - More input data for adjustment of standard value by characteristic of hospitals and for comparison with best-practice facilities

By equipping those functions and data...

It is expected to increase end-users' satisfaction and to reach the level enough for practical use.

- References

[1] Ernest Friedman-Hill: JESS IN ACTION Rule-Based Systems in Java, MANNING, 2003.

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Risk Analysis – A Tool for IT Development and Patient Safety
A Comparative Study of Weaknesses Before and After Implementation of a Health Care System in the County Council of Ostergotland, Sweden

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Abstract

There is a lack of tools to secure patient safety considering information security and health care systems. Risk analysis can be used as a systematic method for identifying risks before a medical error occurs. In healthcare is this type of analysis uncommon use. An indicator for this need of systematic proactive work is the amount of adverse advents that are reported in the deviation system .In this comparative study of a health care system during 2004 and 2006, one of the results is an reduction in the numbers of risks due to technique & equipment and in the area of training & competence. This study gives an indication of that risk analysis helps the health care organisation to develop and manage routines for reducing possible risks.

Keywords:

information system, safety management, risk management/methods, medical errors, systems analysis, quality of health care

Introduction

In the county council in Ostergotland, Sweden has a supporting system for requests and laboratory reports, called LR, and been implemented during the last year and a half. A risk analysis has been performed before and after implementation and is planned to continue regulary for the coming years. The aim of this study was to perform a comparative risk analysis for a recently implemented health care system.

Methods

Risk analysis has been performed before and after the implementation of the system. Risk analysis is a systematic tool, including: process mapping, risk identification, determination of the severity and probability of each risks and action plans. The analysis has a patient safety perspective and has been performed with a trained risk analysis team including members from different roles/specialities. The risks were categorised in areas of six potential sources; technique & equipment, rules/policies/procedures, environment, training & competence, barriers and communications & information.

Results

The risk analysis shows that the total risk points are lower during 2006 for the areas technical solutions and procedures compared to the points of the same areas during 2004.

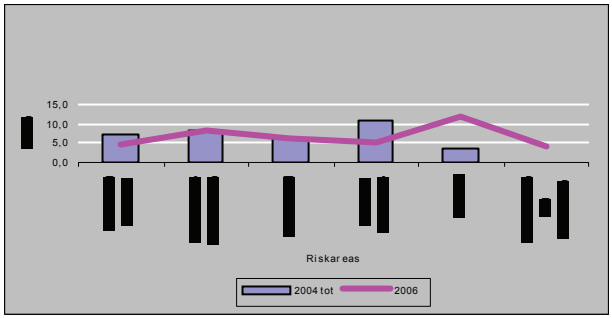

Figure 1 – Risk profile, comparison 2004-2006 LR

Discussions

The risk analysis performed demonstrated differences between the results obtained prior and after the implementation. This was especially true within the sources; technique & equipment, training & competence as well as for barriers. The risk profile within technique & equipment demonstrated that most of the risks prior to the implementation have been dealt with. Training of the personal drastically decreased the risk profile within training & competence. However, increased risks were found for the source barriers as a consequence of the introduction of new barriers, which reduced the accessibility of laboratory results. This was a consequence of the Swedish legislation for patient related information in medical records, which prevents full access of a patient's laboratory test data without the patient consent.

The risk profile for the source; rules/policies/procedures is unchanged. The numbers of risks have decreased but the

risks with a high score, which were identified prior to the implementation, were never dealt with.

Conclusion

Risk analysis is a useful method for identifying and managing possible patient safety risks and also a method for proactive work in health care organisations. Systematic and regular risk analysis is preventive of managing new routines. This may be a constructive tool for the patient safety work.

References

[1] Stalhandske E, DeRosier J, Patail B, Gosbee J. How to make the most of failure mode and effect analysis, Biomed Instrum Technol. 2003 Mar-Apr;37(2):96-102

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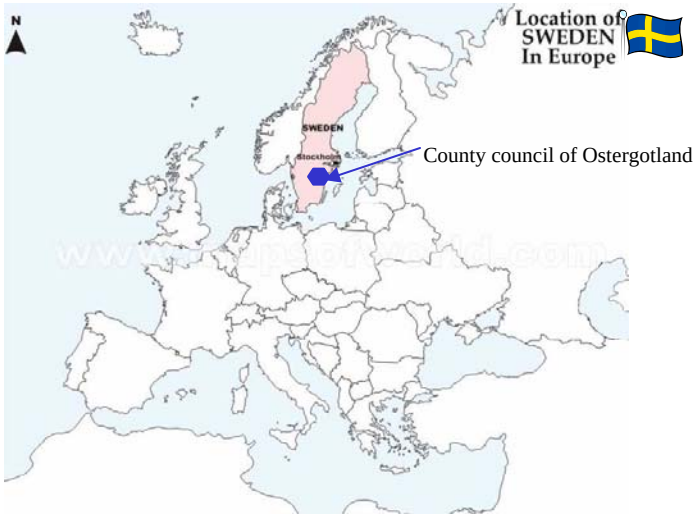
Risk Analysis
– a tool for IT development and patient safety



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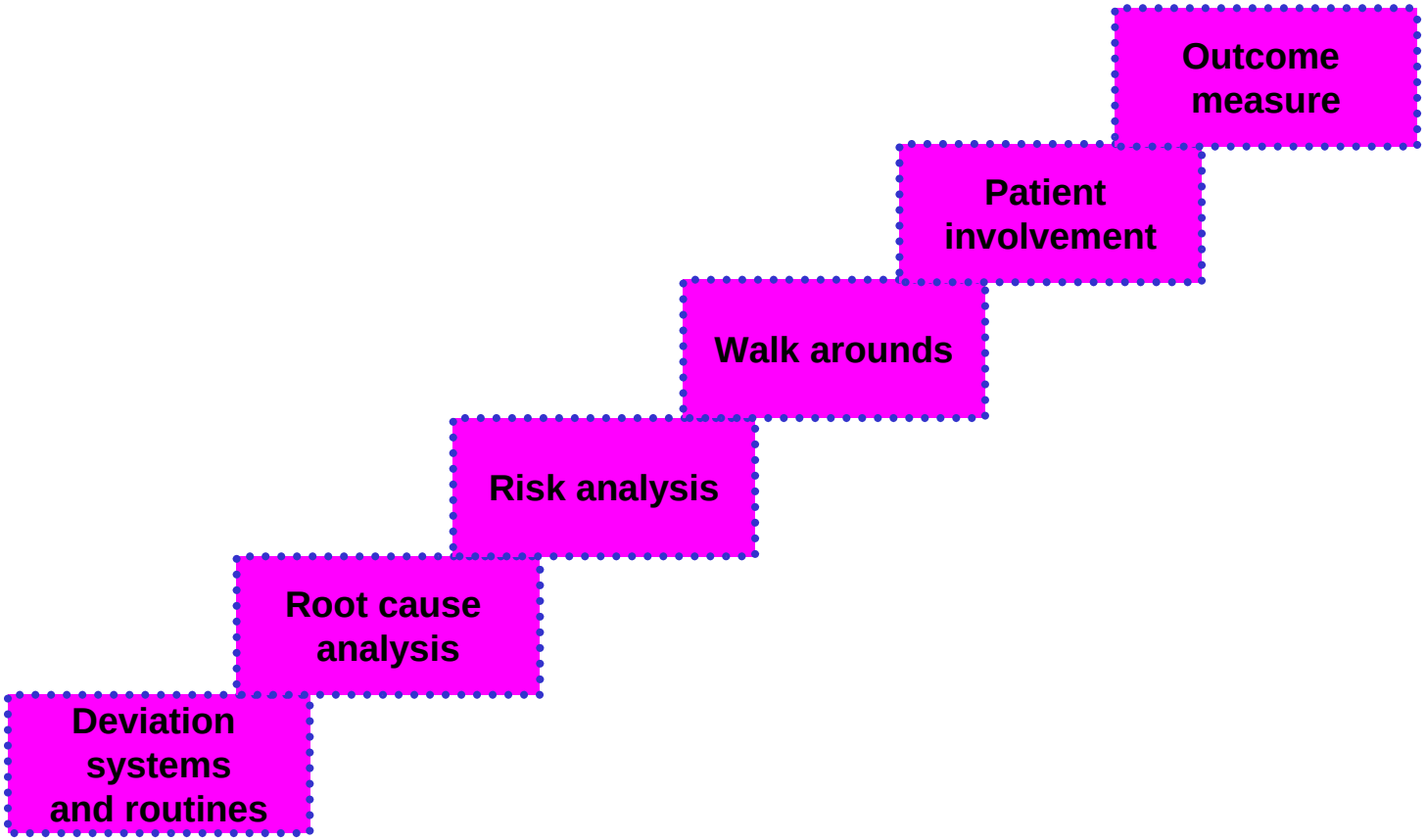
Aim

A comparing study of weaknesses before and after implementation of a health care system

Introduction

- The county council in Ostergotland, Sweden
  - work systematic and structure with patient safety since year 2000
  - has implemented a supporting system for requests and laboratory reports during the last year and a half.

Introductions



The model for patient safety in county council of Ostergotland, Sweden

Methods

- Risk analysis has been performed before and after the implementation of the system

- Risk analysis is a systematic tool, including:
  - process mapping
  - risk identification
  - determination of the severity and probability of each risks
  - action plans

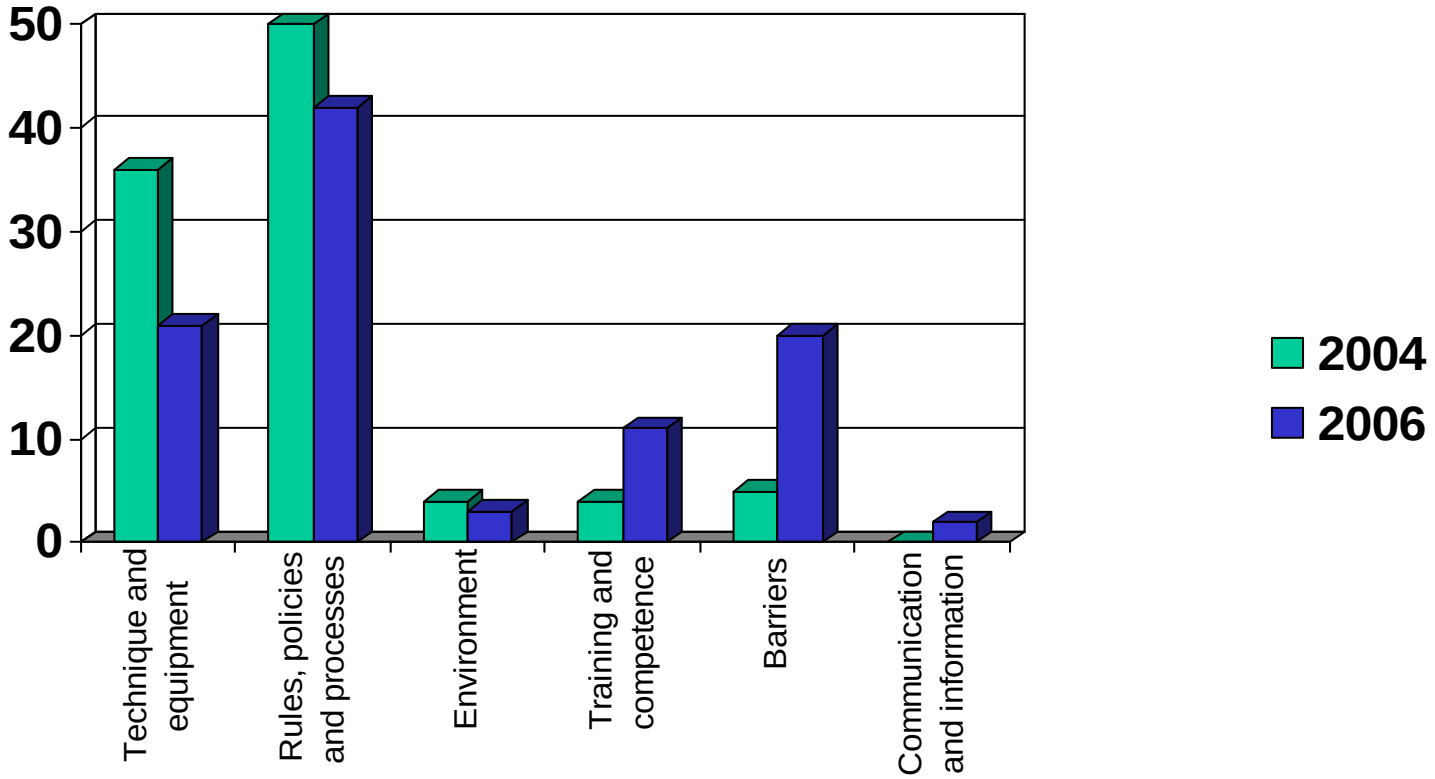
Methods

- The analysis has a patient safety perspective
- Team with trained risk analysis team including members from different roles/specialities.

Methods

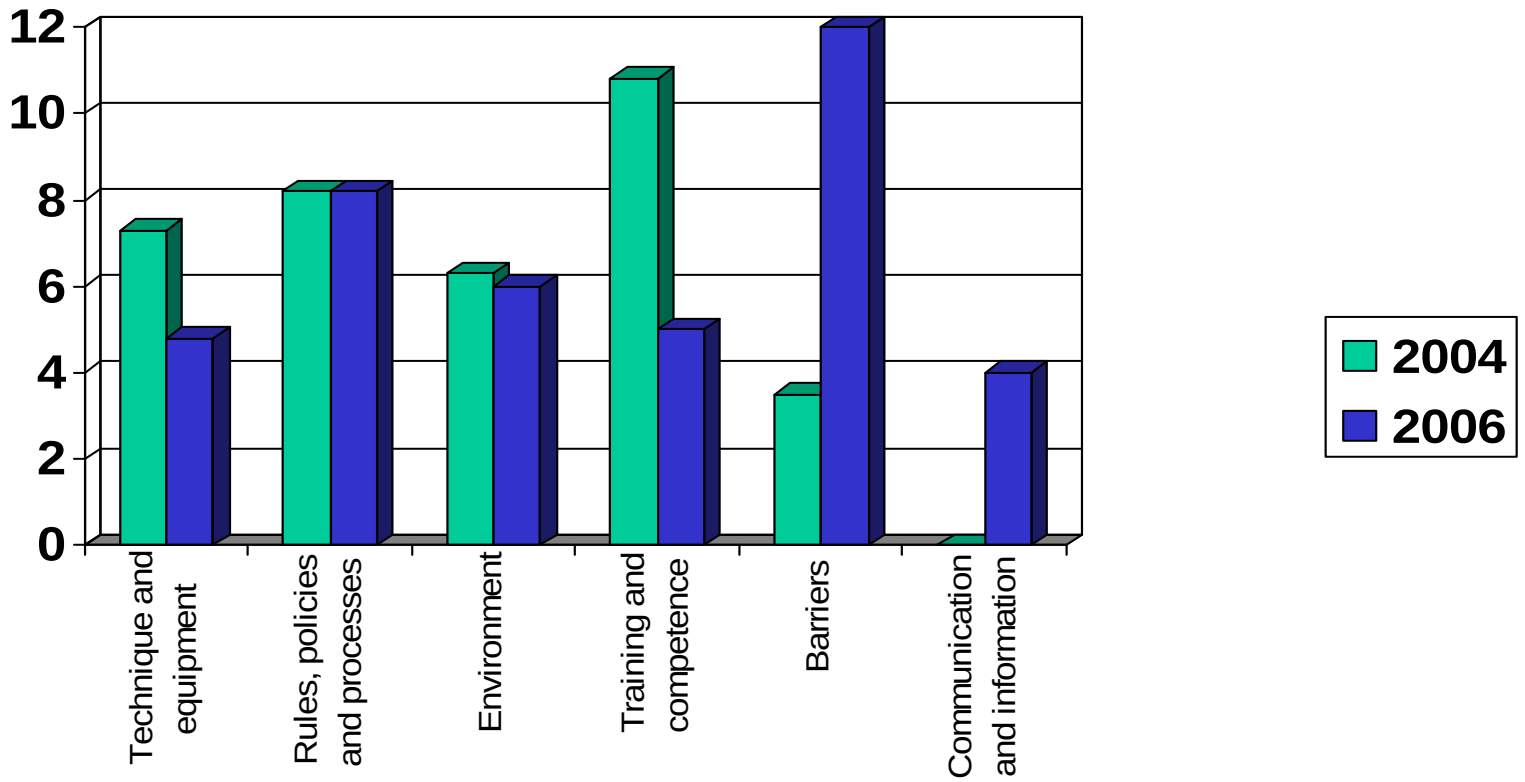
- The risks were categorised in areas of six potential sources;
  - technique & equipment
  - rules/policies/procedures
  - environment
  - training & competence
  - barriers
  - communications & information

Results



The risk share/risk areas. A decrease in the number of risks in technique & equipments and rules, policies/procedures shows but the risks in training & competence and barriers has increase between the year 2004 and 2006.

Results



The risk profile/risk areas.
A decrease in the risks severity in technique & equipments and training & competence shows but the severity in barriers has increase between the year 2004 and 2006.

Results

- The risk profile within technique & equipment demonstrated that most of the risks prior to the implementation have been dealt with.

- Training of the personal drastically decreased the risk profile within training & competence.

Conclusion

- Risk analysis is a useful method for identifying and managing possible patient safety risks and also a method for proactive work in health care organisations.
- Systematic and regular risk analysis is preventive of managing new routines.
- This may be a constructive tool for the patient safety work.

References

Stalhandske, E. DeRosier, J. Patail, B. Gosbee, J.
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Discrete Event Simulation Analysis for Optimization of Outpatient Flow

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Abstract

The Okayama Central Clinic is a community hospital located in a city with a population of 680,000. A routine customer-satisfaction survey showed that the most important and critical issue of the clinic is "long waiting-time." The purpose of this study was to utilize discrete simulation analysis to optimize outpatient flow and resource allocation.

Discrete simulation analysis (DES) using Simul8 software (Simul8, Inc., Boston, MA) was used to model a work flow of the clinic, and to identify the bottlenecks of the model. Time data was derived from the time survey at the clinic.

Baseline data showed that the average waiting time before examination by a physician was 35.3 minutes, and only 1.6% of the patients waited for less than 10 minutes. The physician's examination was identified as the bottleneck of this model. The DES demonstrates that setting up warm-up time is an efficient way to decrease average patient time spent at the clinic without increasing the physician's workload.

Keywords:

discrete event simulation, process optimization, outpatient

Introduction

The Okayama Central Clinic is a community hospital located in a city with a population of 680,000. A routine customer-satisfaction survey has demonstrated that the most important and critical issue of the clinic is the "long waiting-time." The "long waiting-time" is also a critical issue at hospital emergency rooms in the U.S.A. [1]. The patients' satisfaction is one of the factors constituting to the quality of care, and it is clear that the long waiting-time will lead to the degradation of quality of care.

Systematic problem solving of ambulatory care is needed for a long time. Identification of bottlenecks and planning countermeasures may have been considered in hospitals, however, it seems that practical applications of improvement plans are difficult.

Simulation is one of the most widely used operation research and management science techniques for evaluating systems. Discrete Event Simulation is one of the simulation techniques, that has been used to analyze ambulatory care [2, 3]. Improvement plans for ambulatory care can be inspected by the simulation, and it can prevent risks attending application of the improvement plans directly to the real world.

The purpose of this study is to simulate outpatient flow in a primary care clinic, identify the bottleneck of the flow, and develop a quality improvement plan.

Materials and methods

Figure 1 shows a work flow of the Okayama Central Clinic.

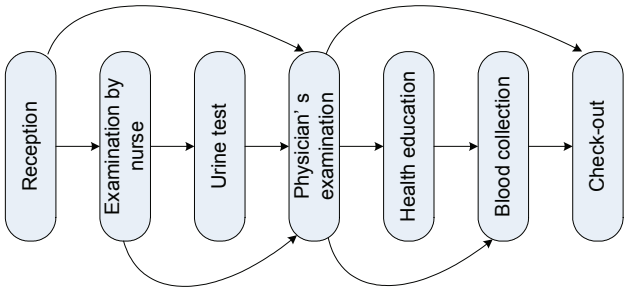

Figure 1 – Simplified Work flow at the Clinic

All patients were required to check-in at the reception desk. There were two types of patients: those with and without an appointment with the physician. Depending on the patient conditions, patients would receive (1) an initial interview by the nurse, (2) a urine test, or (3) both. Subsequently, all patients see a physician for examination. Some patients would have blood collected, and others may need health education for diet and exercise. Finally, all patients were required to check out.

We used Simul8 software (Simul8, Inc., Boston, MA) for the discrete simulation. Time data was derived from the time study at the Okayama Central Clinic.

Prerequisites

1. Table 1 shows the time data from the time study at the Okayama Central Clinic

Table 1 – Simulated Patients' time Spent at the Clinic

Name of Work Station	Patient's Time spentminutes
Reception 1	8
Reception 2	5
Nurse's Inquiry with urine test	10
Nurse's Inquiry without urine test	15
Urine examination	20
Physician's examination	10
Blood collection	5
Blood examination at Laboratory	30
Check out	10

2. Patients

   According to the average distribution at the clinic, 70% of patients received the nurse's inquiry with urine examination, 20% received nurse's inquiry without urine examination, and 10% passed through the steps of nurse's inquiry.

3. Resources

   One doctor, three nurses, four receptionists, and four laboratory technicians were used in this model.

4. Operation time of clinic

   The opening time of the clinic is 9:00 AM. Patients were accepted until 12:00 PM. Patients arrived at the clinic every 10 minutes.

Results

Baseline data show that the average waiting time before the physician's examination was 35.3 minutes, and patients waiting less than 10 minutes were 1.6%. The physician's examination is identified as a bottleneck of this model.

The time pattern used by the physician shows that the doctor did not work for 40–45 minutes after the opening time of the clinic because the patients had not been ready to have physician's examination at that time.

Table 2 reveals the result of the simulation. Average time spent at the clinic can be decreased without increasing physician's time (which is more important) if we set-up a one-hour warm-up time (i.e., the first patient is asked to visit the clinic at 8:00 AM, although the scheduled time is 9:00 AM). However, little difference was observed in number of patients who visited the clinic.

Table 2 – Simulated Patients' time Spent at the Clinic

Patients' time spent at the clinic	Average Time Spent(minutes)	Number of Patients
Open at 9:00 AM	99.9	23
Open at 9:00 AM with 1 hour warm-up	85.5	24
Physician start work at 8:45 AM	81.5	24

Conclusion

This analysis demonstrates that we could increase the efficiency without increasing the bottle-neck or the physician's workload. Further analysis is needed to identify the optimal resource utilization to improve the availability of the doctor and throughput of the system.

References

[1] Fottler MD, Ford RC. Managing patient waits in hospital emergency departments. *Health Care Manag (Frederick).* Sep 2002; 21(1):46-61.

[2] Hall I, Parkes C, Samuels S, Hassiotis A. Working across boundaries: clinical outcomes for an integrated mental health service for people with intellectual disabilities. *J Intellect Disabil Res.* Aug 2006; 50(Pt 8):598-607.

[3] Zilm F, Culp K, Dorney B. Virtual ambulatory care. Computer simulation applications. *J Ambul Care Manage.* Jan-Mar 2003; 26(1):7-21.

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Discrete Event Simulation Analysis for Optimization of Outpatient Flow

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g *Oishi Clinic, Kyoto, Japan*

Introduction

- "Long waiting-time" was the most important and critical issue for ambulatory care. (*Annual consumer satisfaction survey at Okayama Central Clinic*)
- To identify the bottleneck of the outpatient flow and plan the countermeasures against them is the possible way to solve the systematic problem.
- Discrete Event Simulation is one of the simulation techniques, that has been used to analyze ambulatory care. Improvement plan for ambulatory care can be inspected by the simulation.

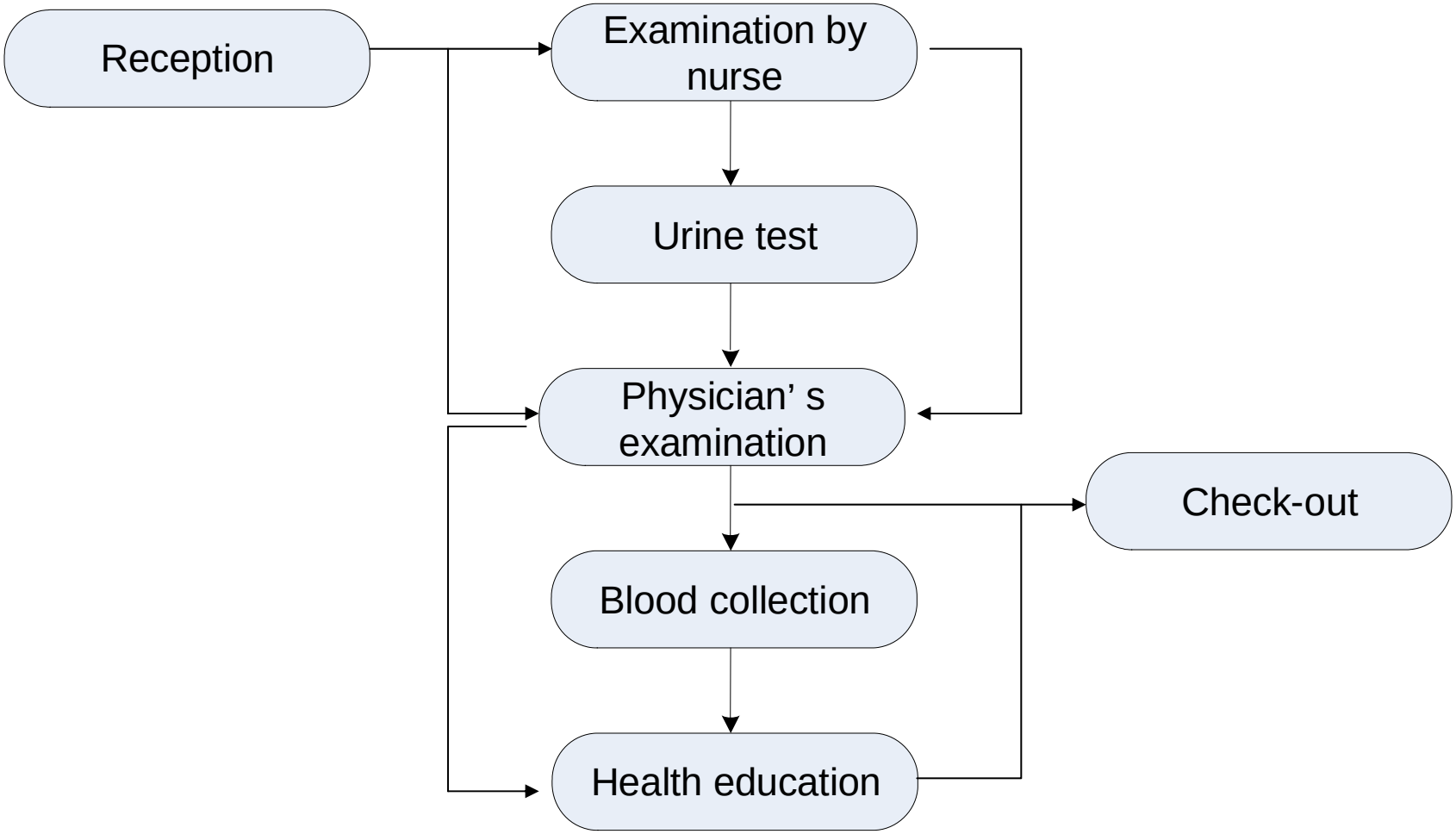
Purpose

Simulate the outpatients flow in a primary care clinic to develop a quality improvement plan

Methods

- Identify the process main activities from start to end – Used SIMUL8 software to model the process
- Apply time data derived from the time study undertaken at the Okayama Central Clinic
- Analyze and identify potential problems and suggest improvements
- Implement the changes and analyze the impact on the overall process

Simplified Work Flow at the Clinic



Prerequisites

- Data of time spent in each work station

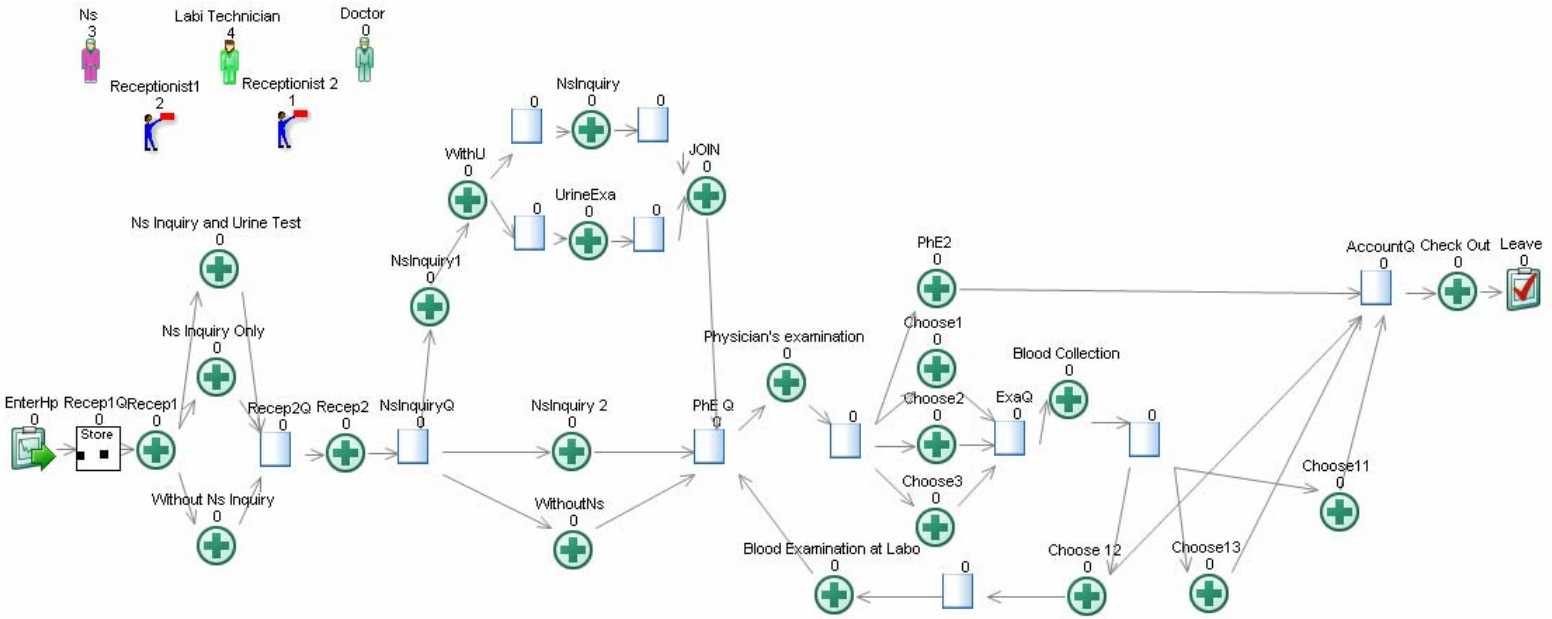
Name of Work Station	Patient's Time spent (Minutes)
Reception 1	8
Reception 2	5
Nurse's Inquiry (Patients with urine test)	10
Nurse's Inquiry (Patients without urine test)	15
Urine examination	20
Physician's examination	10
Blood collection	5
Blood examination at Laboratory	30
Check out	10

Prerequisites

- Item (patient)
  - Label 1 (70%); Who has nurse's inquiry with urine test
  - Label 2 (20%); Who has nurse's inquiry without urine test
  - Label 3 (10%); Who passes nurse's inquiry and urine test
- Resources

  Doctor; 1 Nurse; 3 Receptionist; 4 Lab Technician; 4
- Operation Time
  - The opening time of the clinic is 9:00A.M.
  - Acceptance of the patient; until 12:00

The model on Simul8



Base line data

The number of Patients completed 23

Average time spent in the model 99.9 min

Work Station	Average Time Waiting (minutes)	patients waiting less than 10 minutes (%)
Reception 1	0.2	100.0
Reception 2	0.1	98.1
Nurse Inquiry	0.8	98.1
Physician's examination	35.3	1.6
Check Out	9.0	60.3

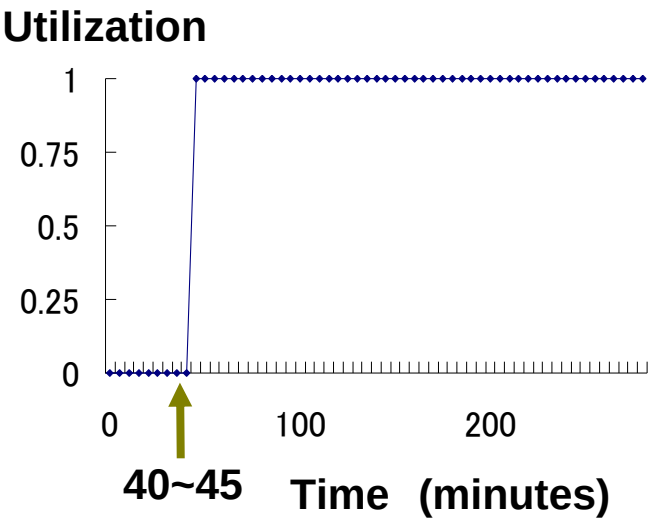


Fig. Time trend of utilization of the physician

Implementation of improvements

- Suggested Improvement area

  The bottleneck in the model; physician′s examination

- Results of the simulation

Simulation Requirements	Average Patients' Time Spent (minuts)	Number of Patients	Availability of doctors (%)
Open at 9AM (similar to real clinic)	99.9	23	98.8
Open at 9AM with 1 hour warm-up	85.5	24	95.8
Physician start work at 8:45AM	81.5	24	95.8

Conclusion

- This analysis demonstrates that we could identify the bottleneck of the system using Discrete Event Simulation.
- The simulation proved that the improvement plan increase efficiency without increase bottle-neck capacity, physician workload.
- Further analysis is needed to identify the optimal resource utilization to improve availability of the physician and throughput of the system.

References

[1] Fottler MD, Ford RC. Managing patient waits in hospital emergency departments. *Health Care Manag (Frederick).* Sep 2002;21(1):46-61.

[2] Hall I, Parkes C, Samuels S, Hassiotis A. Working across boundaries: clinical outcomes for an integrated mental health service for people with intellectual disabilities. *J Intellect Disabil Res.* Aug 2006;50(Pt 8):598-607.

[3] Zilm F, Culp K, Dorney B. Virtual ambulatory care. Computer simulation applications. *J Ambul Care Manage.* Jan-Mar 2003;26(1):7-21.

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WorkWeb: Enhancing Collaboration and Communication in Community Based Clinical Research through Innovative Uses of Wikis

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Abstract

*The NIH Roadmap Initiative aims to re-engineer the clinical research enterprise in the United States. The **InterTrial** project at Columbia University is re-engineering clinical research in community practice settings by improving collaboration and communication. Our intervention, informed by numerous studies of needs and workflow, is an online, collaborative space, named the WorkWeb that brings together many different stakeholders (such as clinical research coordinators [CRCs] and investigators) and resources to facilitate clinical trials. The WorkWeb includes tools to support several research tasks and allows stakeholders to create peer-to-peer support groups. The WorkWeb has been built entirely using the wiki philosophy and thus represents a paradigm shift in providing its end-users almost full control over the content and features.*

Keywords:

clinical research, workflow, software, Wiki

Introduction

The National Institutes of Health (NIH) Roadmap Initiative is a landmark development in the area of clinical and translational research informatics [1]. This initiative aims to significantly increase the clinical research capacity in the US. Such an increase in capacity is contingent on the development and successful adoption of information technology (IT) to improve efficiency, communication and collaboration among the diverse and distributed research networks and patient communities.

Methods

The InterTrial project has focused its re-engineering efforts on clinical research in community practices and particularly on the CRCs, who are the main hub of work and information. The requirements for our intervention have emerged from extensive empirical studies that were conducted in community practices through surveys, interviews, focus groups and onsite observations to elucidate the needs and workflow [2].

Results

Two over-riding themes from our studies motivated the development of our collaborative space, which we call the WorkWeb. One was the need to enhance *collaboration*, especially between research sites and the other to provide users more *control* over the systems they use. The WorkWeb provides a platform for coordinators and investigators in a research network to share information and experiences and it provides various tools to support daily tasks in clinical research. Our innovation has been to build the entire system using wikis. A wiki is a web page or online resource that allows users to add or edit the resource collectively [3]. Wikis in conjunction with other social collaborative content generation methods like forums and blogs are emerging as viable alternate means of online content creation and management. Also, wiki-based systems give their users a greater degree of control than conventional software, an important element towards promoting end-user adoption.

The WorkWeb is presented to the user as a number of different internal webs. Each web is a collaborative workspace that can contain topics (pages) created by the users, files (MS Word, Excel, etc.) that can be attached to topics to provide a shared document repository, links to other topics or to any Internet URL, or external components that embed functions from other components (applications to support routine clinical research work like a to-do list, calendar or a services and patient tracking system). The webs presented to a user are organized in an onion-like manner, with the innermost webs being the private web of the user and the outermost to the entire InterTrial Community. The WorkWeb includes forums, blogs (used to build a support community) and features to broadcast news or announcements to its community wide users. The initial feedbacks to the prototype have been very positive and we expect to begin a phased roll out in the beginning of 2007.

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Conflict Resolution Tactics in Participatory Design of Health Information Systems

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Abstract

During the development of health information systems, different types of conflicts arise, and are addressed with suitable conflict resolution tactics. This study examines the tactics used to cope with the antagonisms that occurred during the design of an information system for 175 000 users in an occupational health context. Discourse analysis methods were used for data collection and interpretation. The results display differences in selected resolution tactics based on the nature of the conflict and a preference for low risk tactics associated with an ambition to keep decisions clearly within the given mandate of the design group Further studies comparing conflict resolution tactics and their implications in health service settings are warranted.

Keywords:

information systems development, participatory design, discourse analyses, organizational studies.

Introduction

Health information systems (HISs) are extending their scope towards regional networks and health IT infrastructures. Accordingly, integration, interoperability and interaction design are today's core problems. To produce viable IT solutions, each critical attribute needs to be specifically addressed and prioritized. Recent studies indicate that traditional methods used to derive these requirements and attributes are often inadequate and the risks that are faced in ensuring a safe and secure system are highly application dependent and dynamic [1]. In response to this situation, contextual design methodology in conjunction with participatory design have been introduced for HIS development and showed to be promising tools in several settings [2]. However, there is little knowledge available about the practical use of these methods.

The aim of this study is examine decision-making tactics during participatory design of HISs. The research was performed in an occupational health setting.

Methods

The theoretical approach to the data collection and analysis used in this study was discourse analysis (DA). DA focuses on the interactional accomplishment of specific social activities. Accordingly, the methodology combines a contextual sensitivity of language use with analyses of talk as a means for social action [3]. DA can be performed at different levels, where the lowest levels include lexical choice and turn design. The present analysis was performed at the level of social epistemology and social relations. In the case study setting, conflicts occurring during the system design process and the tactics used to resolve them were identified in the interaction during the design group meeting and thereafter integrated into a strategic framework.

Data collection

All 20 design-meetings in the case study project were videotaped, and the audio track, 65 hours in all, was transcribed. The transcript was detailed with a close-to-verbatim match between audio track and transcripts. The four meetings where the design specification was discussed (no. 7-10) were selected for specific analysis in this study.

Data analysis

Data were first examined to identify conflict instances during the design group meetings. A conflict instance during a meeting was defined as one or a series of utterances that addressed a particular conflict involving the future system.

The technological conflicts identified during the prototype evaluation meeting (n=86) were used for the final analysis of conflict resolution tactics. Specific tactics were first identified as interaction patterns using DA, and these patterns were thereafter associated and aggregated. A second order of analysis was then performed to validate the issue descriptions and associate them to the development of an overall strategy for conflict resolution during health information system design meetings. The last phase of the analysis focused on integrating the micro- and macro-level analyses. Correspondingly, specific attention was paid to the points of passage between the micro- and macro-level findings. The results from these were compared, discussed, and integrated in order to identify specific implications for design method development.

Results

The analysis reconstructed a strategy for conflict resolution used by the design group during the design specification processes. The strategy displays that problem-solving in HIS design is shaped by control, power, and the relationships between interest groups. In order to be permitted access to the important design decisions, a participatory design group has to successfully accommodate the interests of the critical stakeholders. Two basic tactics to resolve conflicts and resume a balance in the design process were identified; change of the design specification and acceptance (and acknowledgement) of the conflict.

Primary tactic: Change design

In accordance with that the nature of system design being construction of artefacts, the natural tactic to resolve conflicts was to change the actual specification at hand. This tactic was further specialized by the case study group into deciding to adjust the design of the actual system, and to stipulate adjustments of conditions external to the system. The latter adjustments were characterized by that they could not be implemented or directly controlled by the design group.

Subtactic 1: system adjustments

The most common way to deal with conflicts was to decide adjustments to the system. These adjustments were in the analysis divided into deletions and modifications,

Subtactic 1.1: Deletion of system component

Design implications: A design group is in total control of the deletion tactic, which also brings immediate closure to a conflict. One negative aspect is that the decision is hard to reverse if it is proven to be wrong.

Subtactic 1.2: Modification of system component

Design implications: A design group is in control of the modification tactic, but the effect may be difficult to evaluate. The decision is less difficult to reverse if shown to be wrong.

Subtactic 2: Adjust organizational environment

Design implications: A proposal to adjust the organizational environment is out of control for a design group, and therefore associated with high risk. If the adjustment fails, serious problems may occur downstream in the design process.

Subtactic 3: Adjust technical environment

Design implications: Also this tactic is associated with risks. Even though the tactic solves the conflict for the design group responsible for the design and implementation of the system, it may endanger the effectiveness of the system if not all potential users can conform to the requirements.

Alternative tactic: Accept conflict

The second, and less common, tactic to resolve conflicts in the system design was to accept and acknowledge the identified antagonisms as a limitation of the design.

Subtactic 1: Allow conflict in system

Design implications: The design group is in control of a decision to allow conflicts in the system design. Verification of the conflict is essential in order to avoid secondary problems for users and during later design stages.

Subtactic 2: Allow conflict between system and organization

Design implications: This tactic is associated with an extremely high risk, due to that the design group cannot control the actions of the organization in conflict with the system. Verification of the conflict is essential

Discussion

The aim of this study is examine decision-making tactics during participatory design of HISs. Previous research has suggested that participatory design of HISs may be less feasible in centralistic environments [4]. Our results display that, given the existing power relations, the continuous engagement with interest groups is a central aspect of decision-making during participatory design in HIS settings. The users that contribute to a design have to be associated to groupings both within and outside the actual design group. We suggest that existing optimistic expectations of user participation in HIS development inhibit acknowledgement of the troubling work of balancing power relations. Rather than denying such power relations, participatory design projects should be expected to plan for them.

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User Participation in Design of a Process Oriented Medical Record – When and How?

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Abstract

User participation is crucial to the success of a project but the challenge is to determine how and when to involve the users. Our experience from a project designing a Process Oriented Medical Record (POMR) is that choice of user participation methods must be based on the degree of expected organizational change and the type of design questions to be answered.

Keywords:

electronic health record, user participation

Introduction

When implementing EHR systems, changes are introduced in the organization. It is therefore crucial to the success of a project to have the users participating in all the phases of the project [1]. The purpose of involving the users differs in the phases of the project, for instance system specification, system assessment, designing user interfaces or facilitating end user ownership to the system. One of the challenges of involving users in the design of clinical systems is to determine which methods to use and when to use them.

Materials and methods

The EHR project intended to purchase an interdisciplinary POMR for about 25.000 clinical users in the Capital Region of Denmark. Before project initiation it was decided that the EHR should:

- be interdisciplinary
- be problem oriented
- contain the concept of period of care
- contain highly structured data
- make it possible to reuse data for different purposes, for example quality assurance, management information, research and billing

The vast majority of the region's hospitals use monodisciplinary, chronological paper based records and the designed interdisciplinary POMR would therefore introduce a new concept for clinical documentation and thereby the introduction of Second-order changes in the organization [2].

The clinical users participated right from the beginning of the project and during the design phase more than 100 clinical users were involved in the project. Being able to support the users in making decisions about an interdisciplinary POMR required different methods based on the type of questions to be answered.

In the early phases of the project the methods were primarily based on textual descriptions of the IT-system's functionality that were reviewed by the users and later discussed on follow-up workshops. Later in the project more visually based methods were used and in total we used four fundamentally different methods of user participation in the design of the system:

1. Focus groups - Review and discussions of the system specification documents
2. Scenario based approach – designing data presentation facilitating clinical overview of the POMR
3. Use case[3] – describing process oriented data capture
4. Prototyping and usability testing – deciding principles for data capture

Results

The focus groups were used to review and discuss system specifications. The specifications consisted of textual descriptions of the POMR functionality complemented with user interface sketches. The review process resulted in hundreds of comments from the clinicians including

- comments to the documents wording
- rejections of functionality
- proposing new functionality
- concerns about the described functionality

Focus groups reviewing and discussing system specifications often left users in great uncertainty of whether the POMR could support the clinical workflows.

In the next phase of the project *the scenario method* was introduced to design the user interface for obtaining overview of the POMR. Relevant articles about the subject 'reading the medical record' were initially examined, discussed and combined with clinical practice resulting in nine generic clinical scenarios.

The method had the advantage of relating the known daily workflow to the needs of data presentation and thereby linking the two concepts of clinical documentation (chronological based record and process oriented record).

The Use case method was introduced to focus on the system's necessary workflow support in capturing data. The result was long textual structured descriptions of data capturing processes. The clinicians found the production of new long textual descriptions difficult and time-consuming and the use case method wasn't suitable for a large involvement of clinicians. Nevertheless applying the use case method in small interdisciplinary groups answered several questions about how the system should support clinical workflows.

Prototypes and their usability testing were considered the most inspiring method by the clinicians, visualizing the new concept of clinical documentation and facilitating concrete decisions about the user interface. The prototypes were tested for usability by clinicians and the principles for documentation in the POMR could be decided on this background.

The prototype method established the best conditions for the clinicians making decisions about the new system's functionality. The vendor agreed in this observation, but considered this method the most demanding as regards the use of resources.

Discussion

It was evident that many of the 100 clinicians who were involved in the project found it difficult to relate the textual descriptions of the POMR system to the future clinical practise. The POMR would introduce a second order change in the organization and the need for a more sophisticated method to visualize the system's impact to the future clinical practice was identified.

The scenario method made it possible for many of the clinicians to see how the EHR could change and actually support clinical work. Thereby the clinicians could more precisely express their need for different surveys of the data in a patient's EHR. The scenario method doesn't contain elements to structure and detail the steps in work practise and therefore this method was found most suitable for answering generic questions about data presentation.

The use case method was difficult to use for the clinicians, but made it possible for the IT consultants from the customer and the vendor to gain a common understanding of the need for process support by the system. Searching for and piecing together the information to make a clinical survey of the relevant data in the patient record is not a logical step by step procedure and the use case method was therefore primarily used to describe data capturing processes.

Finally and on the background of the above mentioned methods it was possible for the vendor to make prototypes that were understood and accepted by the coming users. The prototypes could visualize the system functionality and the support of the future clinical documentation process but still the visualisation of the consequences for the future clinical work practise were missing. In case of second order changes to the organization it could be necessary to test the prototypes in medical settings or in medical simulation environments.

In summary the total design phase using four methods for user participation was a protracted and time consuming process that could have been conducted better if the understanding of the purpose of user participation and the complexity of the questions to be answered had been better described in advance.

The possibilities and limitations of the four user participation methods are well described in the literature[3][4][5] but in addition our project identified a need for a reflective approach to choose between the different methods based on the degree of organizational change and type of design questions. Examples of questions to be answered before choosing the method to user participation could be:

- Which degree of organizational change will the system implementation cause?
- How many end users are to be involved in decisions about the system design?
- Are the questions about data capturing or data presentation?
- Are the questions about principles or detailed functionality
- Is the purpose to facilitate end user ownership or to capture detailed information about clinical practise?

Conclusion

Our experience regarding the development of an interdisciplinary POMR shows that one universal method of user participation in system design does not exist. Decision about methods of user participation must be based on the degree of organizational change and the concrete system design questions to be answered (data presentation or data capturing) in the design process.

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REGION

User participation in design of a Process Oriented Medical Record

- when and how?

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Introduction

- The described EHR project was aimed at developing a Process Oriented Medical Record (POMR) for about 25.000 clinical users in the Capital Region of Denmark
- We knew that an it-project's success depends on user participation
- And we learned that you must clarify from the beginning:
  - What is the purpose of user participation in this phase of the project
  - Which methods of user participation are the best to use in this phase of the project

Materials

The EHR project was based on the following principles. The POMR should:

- Be interdisciplinary
- Be problem oriented
- Be based on the concept of period of care
- Contain highly structured data
- Make it possible to reuse data for different purposes like:
  - Quality assurance and quality development
  - Management information
  - Research
  - Billing

Meaning that the POMR would introduce a second order change in the organization

Methods

Four fundamentally different methods of user participation were used in different phases of the design process:

- Focus groups – in review of system specification
- Scenario based approach – in design of data presentation
- Use case – in design of process oriented data capture
- Prototyping and usability testing – in design of principles for data capture

Results – Focus groups

- Were used to review and discuss system specifications consisting of textual descriptions
- Resulted in a lot of comments including:
  - Comments to the wording of a specification
  - Rejections of functionality
  - Proposals of new functionality
  - Concerns

➢ Users were often uncertain whether the functionality described could support the clinical workflows

Results – Scenario based approach

- Was used to design the user interface for obtaining overview of the POMR
- Nine generic clinical scenarios were designed based on a combination of literature and knowledge of clinical practice

➢ The method helped relating the known daily workflow to the needs of data presentation i an EHR – linking together the known chronological based record to the new and unknown process oriented record

Results – Use Case

- Was used to focus on the application's workflow support in capturing data
- Resulted in long and very detailed textual descriptions

- The users in general found the method difficult and time-consuming
- But several questions of how to support clinical workflow were answered
- The vendor developed prototypes based on the use cases

Results – Prototyping

- Was used to design the user interface
- Facilitated the users' decision-making
- The prototypes were usability tested

- The users preferred the use of prototypes for designing system functionality and user dialogues
- The vendor recognized the benefit of prototyping, but found it time-consuming and expensive regarding the need of resources

Discussion

- Focus groups
  - Many users have difficulties in visualising a future system when descriptions are solely paper-based and textual
- Scenario based approach
  - Less useful for designing detailed workflows, but suitable for answering generic questions of data representation
- Use case
  - Difficult to use for ”ordinary” users, but very useful in designing data capture processes
- Prototyping
  - Facilitate users ability to make decisions about the system design, but even more useful if tested in medical simulation environments

Discussion - Which user participation method?

- Which degree of organizational change will the system implementation cause?
- How many end users are to be involved in decisions about the system design?
- Are the questions about data capturing or data presentation?
- Are the questions about principles or detailed functionality?
- Is the purpose to facilitate end user ownership or to capture detailed information about clinical practise?

Conclusion

- The development of an interdisciplinary POMR means second order change in Danish clinical work
- There is no universal method for user participation
- Methods must be chosen based on the degree of organizational change
- The more organizational change a project implies the more the need of using visualizing methods for system design
- You must distinguish strictly between designing functionality for data presentation or data capture and let your choice of method of user participation depend hereon

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Spatial Analysis of Referrals from Secondary Care and to Aftercare in a Tertiary Care University Hospital in Japan

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Abstract

All Japanese citizens are covered by the national insurance system, which provides universal free access to healthcare services. We studied the pattern of referral of inpatients from secondary care hospitals to a tertiary care university hospital and the pattern of reverse referral in Japan using a geographic information system (GIS). The results showed that 55.7% of the patients were directly admitted to the hospital without referral from other hospitals or clinics and that 89.1% of the inpatients were referred to the outpatient department of the hospital to which they had been admitted. GIS analysis for the inpatients service area showed that the tertiary care university hospital functions also as a primary and secondary care hospital for patients living near the hospital. There were several foci of inpatients with prolonged length of hospital stay. These results suggest that the function of university hospitals in Japan is unspecialized and that the referral route from a university hospital to aftercare is also ill equipped.

Keywords:

geographic information systems, university hospitals

Introduction

In Japan, all citizens are covered by the national insurance system, which provides universal free access to healthcare services. There are no general physicians or "gatekeepers" in the Japanese healthcare system. Patients in Japan can freely choose between going to a physician's office or a hospital [1]. Hospitals are popular because of their prestige and high quality of care. On the other hand, there is no clear differentiation between large and small or public and private hospitals or between hospitals and private practices in the healthcare system in Japan [1]. Functional differences between hospitals and nursing homes for the elderly are also not clear despite the introduction of long-term care insurance [2]. Hospitals often function as nursing homes for the elderly, which is one of the main reasons for the extraordinarily long hospital length of stay (LOS) in Japan. LOS is very long in Japan compared with that in other Organization for Economic Co-operation and Development (OECD) countries [3], particularly for the elderly. The government has tried to address the issue of undifferentiated functions of health care facilities. A system of fees for referral was introduced in 1988, and outpatient consultation fees for university hospitals were increased if more than 30 percent of their new ambulatory care patients came with referrals [4]. Since 1996, patients who visit a large hospital without referral from a primary care physician have had to pay an extra charge [5]. In 2003, an inclusive payment system for acute inpatient care was introduced in university hospitals [6]. These systems are based on a policy of facilitating functional differentiation of health care facilities. However, little is known about the actual patterns of referral from secondary care hospital to tertiary care university hospitals and the reverse referral in Japan. We therefore studied the pattern of referral form secondary care hospitals to a tertiary care university hospital and the pattern of reverse referral in Japan.

Materials and methods

Data

Niigata University Hospital had 810 inpatient beds, 23 clinical departments and medical staff of 818 in 2004. The service area of the hospital as a tertiary care hospital covers all districts in Niigata Prefecture, which has a population of 2,400,000. The size of the hospital is typical for a Japanese university hospital. Data were analyzed for all patients who had received inpatient care at Niigata University Hospital during the period from April 2004 to March 2005. Data on patient age, sex, residential address, route of referral to Niigata University Hospital, discharge diagnosis classified by Japanese case mix classification for inpatients (diagnosis procedure combination, DPC) [5,6], length of hospital stay (LOS), outcome of admission and route of referral from Niigata University Hospital were obtained from the hospital information system. In the DPC system, patient discharge is classified into 16 major diagnostic categories (MDC) and 1,727 case-mix groups. Data on average and standard deviation (SD) of LOS of the patients in Japan, who were assigned to each DPC, were obtained from the Ministry of Health, Labor and Welfare. Spatial analyses were performed using GIS software ArcView GIS 3.1a and ArcGIS 9 (Environment Systems Research Institute Inc., CA, USA). Road network data (Pasco, Tokyo, Japan) also contain codes for different classes of roads, average car speed and rules of the roads in order to calculate how long it would take to drive along a particular road segment [7].

Referral from clinics and other hospitals

To study the geographic distribution of patients admitted to Niigata University Hospital, the geographic distributions of all inpatients were geo-coded by residential addresses to a GIS map. Empirical Bayesian estimates for the rate of inpatients per population at risk were plotted on a GIS map with 2 km meshes [8]. To study the relationship between spatial accessibility to Niigata University Hospital and the distribution of patients, the number of inpatients who lived within an area that is a certain time by car from Niigata University Hospital was calculated by using Network Analyst (ESRI Japan). The same procedure was performed for other hospitals in Niigata Prefecture in order to compare the inpatient service areas of Niigata University Hospital and general hospitals. The distribution of patients referred from other medical facilities was plotted on GIS maps using the kernel density method [9,10].

Referral to aftercare

Aftercare was defined as referral to an aftercare program, such as outpatient care and transfer to inpatient wards of other hospitals, not including foster care, a group home or a nursing home [11]. Distributions of patients referred to the Outpatient Department of Niigata University Hospital, patients referred to outpatient care of other medical facilities and patients transferred to paediatric wards of other hospitals were plotted on GIS maps. Since delay in referral of a patient to aftercare prolongs LOS of the patient, spatial differences in LOS of inpatients might reflect the spatial differences in accessibility to aftercare. To estimate the spatial differences in accessibility to aftercare, LOS of each patient was scored and plotted on a GIS map. The SD scores for LOS (LOSSDS) of a patient who was assigned to a DPC were calculated as follows:

$$\frac{\left[\left(actual\ LOS\ of\ the\ patient\right)-\left(average\ LOS\ of\ the\ DPC\right)\right]}{SD\ of\ the\ LOS\ of\ the\ DPC}$$

Contour maps of LOSSDS of the patients were produced by interpolation using the ordinary Kringing method [12].

Results

Referral from clinics and other hospitals

During the study period, a total 8,545 patients were admitted to Niigata University Hospital (Table 1). Among them, data for 8,177 patients living in Niigata Prefecture were used for analysis in this study. The empirical Bayesian estimates for the rate of inpatients per population at risk were plotted on a map with 2 km meshes. Although these patients were predominantly distributed around Niigata City, the capital of Niigata Prefecture, there were some meshes with large numbers of inpatients far from Niigata City. This indicated that patients visited Niigata University Hospital from a broad area of the prefecture. In addition, there were marked spatial differences in the distribution of residences of inpatients living in or near Niigata City, suggesting competition with other primary and secondary care hospitals to get inpatients.

Table 1 – LOSSDS of all inpatients

Major Diagnostic Category	Number of patients	LOSSDS Average (SD)
Nervous system	646	-0.19 (3.70)
Eye	743	0.36 (2.11)
Ear, nose, mouth and throat	413	0.90 (5.65)
Respiratory system	444	0.48 (6.26)
Circulatory system	547	0.83 (4.44)
Digestive and hepatobiliary system	1,273	0.04 (2.28)
Musculoskeletal system	715	-0.05 (1.91)
Skin and subcutaneous tissue	250	-0.35 (1.65)
Breast	48	-0.53 (1.36)
Endocrine, nutrition and metabolic system	362	-0.06 (2.21)
Kidney and urinary tract	634	-0.04 (3.76)
Female reproductive system and pregnancy	1,202	-0.41 (2.20)
Blood and immunological disorders	135	2.31 (6.00)
Newborn and other neonates	640	-0.71 (1.69)
Children	76	-0.17 (5.27)
Injury, poison and burns	417	0.36 (7.68)
Total	8,545	0.06 (3.67)

The number of patients admitted to Niigata University Hospital without referral from other hospitals and clinics was 4,524 (55.3%), which differed remarkably by MDC or clinical department from 38.8% to 63.0% (median 55.7%). Detailed information on referral was obtained by analyzing data for inpatients admitted to the Pediatric Department. The rate of the inpatients referred from other medical facilities was found to be 38.8%. Only 19.0% of patients admitted to Niigata Hospital lived in an area 30 min from the hospital by car, suggesting that even patients living far from the hospital are often admitted to the hospital without referral from other medical facilities. Results obtained by using the kernel density method indicated that pediatric inpatients living near Niigata City tended to be admitted directly to Niigata University Hospital, whereas inpatients living far from Niigata University Hospital tended to be referred from other medical facilities (Fig. 1). This tendency was the same for other clinical departments. These results suggest that a tertiary care university hospital in Japan has characteristics of both a primary care hospital and a secondary care hospital for inpatients living near the hospital.

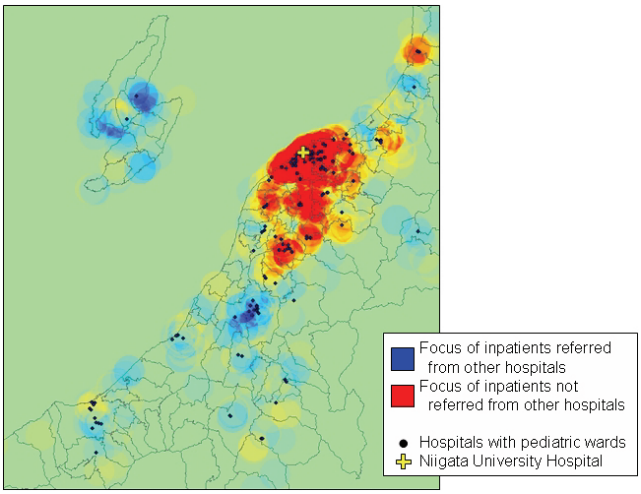

Figure 1 - Focus of inpatients referred from other medical facilities

Referral from clinics and other hospitals

Almost all of the inpatients (7,745 out of 8,177, 94.7%) received referral to aftercare, and 6,907 (89.1%) of them received care in the Outpatient Department of Niigata University Hospital after discharge. Only 838 patients (10.2%) were referred to clinics or outpatient departments of other hospitals, and 199 patients (2.4%) were transferred to other hospital wards after discharge from Niigata University Hospital. The patients referred to clinics or outpatient departments of other hospitals and the patients transferred to wards of other hospitals tended to be distributed far from Niigata City and in Sado Island, which is located 40 km away from Niigata City. The situation was the same for pediatric inpatients. Almost all of the pediatric inpatients (96.4%) received referral to aftercare, and 82.8% of them received aftercare in Niigata University Hospital. Only 11.6% of them were referred to clinics or outpatient departments of other hospitals, and 2.0% of the pediatric patients were transferred to other hospital wards after discharge from the hospital.

Next, we investigated spatial difference in trends of referral using LOSSDS in order to ascertain whether there were barriers to referral to aftercare in each district. The LOSSDS of each MDC of Niigata University Hospital is shown in Table 1. There were also remarkable differences in LOSSDS among clinical departments. Figure 2 shows the data for pediatric inpatients. There were some foci with high LOSSDS near Niigata City (A and B), where there might be some barriers to referral to aftercare. We paid special attention to one of the foci (A) and investigated why the patients who lived in that focus showed high LOSSDS. There were no problems in spatial or physical accessibility in the focus, because the focus was located over arterial roads. The focus was located within an area 30 min by car from two hospitals. Although these hospitals had beds for children, each hospital had only one pediatrician. Therefore, shortage of pediatric manpower is one of the reasons for the clustering of patients.

Discussion

The results of our study indicate that about half of inpatients visited a tertiary care hospital in Japan without referral from other medical facilities and that more than 80% of inpatients were referred to the outpatient department of the hospital. Most of the inpatients received outpatient care, inpatient care and aftercare in the same hospital. Patients living near the hospital tended to use the hospital as a secondary care hospital or were admitted without referral from other medical facilities. As a secondary care hospital, the hospital was in competition with other secondary care hospitals to get inpatients. On the other hand, patients who lived far from the hospital tended to use the hospital as a tertiary care hospital and were referred to the hospital from other medical facilities.

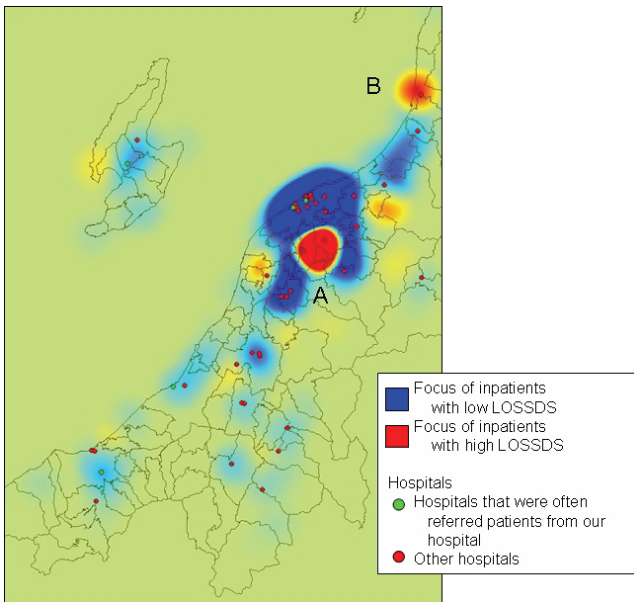

Figure 2 - Focus of inpatients with high and low LOSSDS.Our results showed that even a tertiary care university hospital functions as a secondary care hospital, especially for patients living near the hospital. Moreover, acute care hospitals in Japan usually provide care that is usually provided by nursing homes and home caregivers in other countries such as the USA and UK. The undifferentiated functions of acute care hospitals in Japan make LOS of inpatients extraordinarily long compared with that in other advanced countries [3]

Although the care provided by so-called acute care hospitals in Japan is a mixture of various kinds of care, there are trends toward differentiation and specialization in these

hospitals. One such example is the introduction in 2003 of a new inclusive payment system for acute inpatient care in the eighty main hospitals at universities and national centers to replace the traditional fee-for-service payment system [6]. Under this payment system, hospitals can obtain medical fees more efficiently as the LOS decreases. Actually, the LOS of inpatients in these hospitals has become significantly shorter after the introduction of the new payment system [13]. Reduction in LOS leads to a new incentive to acquire new patients to fill the unoccupied inpatient beds. This can be accomplished by an increase in referrals from other medical facilities, and the reduction in LOS needs a close partnership between medical facilities participating in aftercare. The results of our study clearly showed spatial differences in partnership between other medical facilities in terms of both referral to the hospital and referral from the hospital. By using GIS, we could easily find districts where the hospital had not established a strong partnership with medical facilities. The results of analysis of LOSSDS provided a hint as to why inpatients living in a region stay in the hospital for a long time. The methodology described in this article can be used to study regions in which a partnership between medical facilities has not been established and why a partnership has not been established in the regions [14-16]

Conclusion

The results of our study suggested that the function of university hospitals in Japan is unspecialized and that the referral route from a university hospital to aftercare is also ill equipped.

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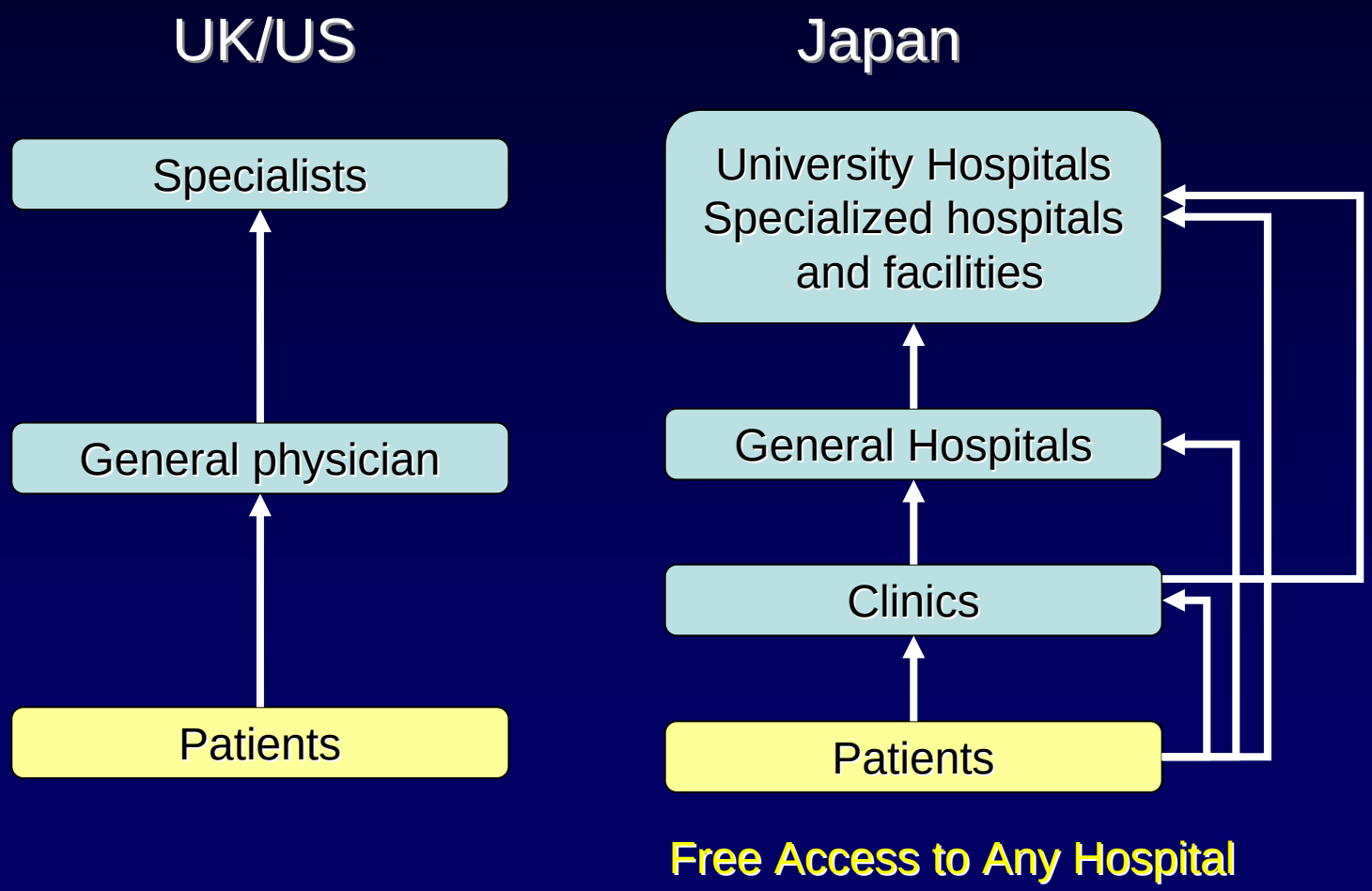
Spatial Analysis of Referrals from Secondary Care and to Aftercare in a Tertiary Care University Hospital in Japan

Shin-ichi Toyabe, Kouhei Akazawa

Department of Medical Informatics, Niigata University Medical and Dental Hospital, Japan

Background #1: Free access to hospitals in Japan leads to undifferentiated functions of university hospitals



Background #2: Policies to facilitate functional differentiation of university hospital in Japan

- Outpatient Consultation Fees (1988)
- Extra charges for patients without referrals from primary care physicians (1996)
- Inclusive payment system for acute inpatient care in university hospitals: higher payment to hospitals with more advanced functions (2003)

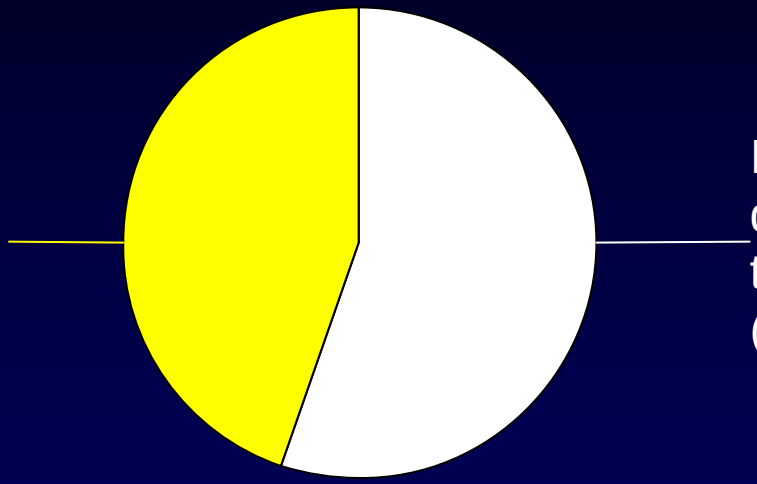
Objectives

- To study actual condition of referrals from secondary care hospitals to university hospital in Japan
- To study actual condition of referrals to aftercare from university hospital in Japan
- To study spatial difference in trends of the referrals using geographic information system (GIS)

Methods

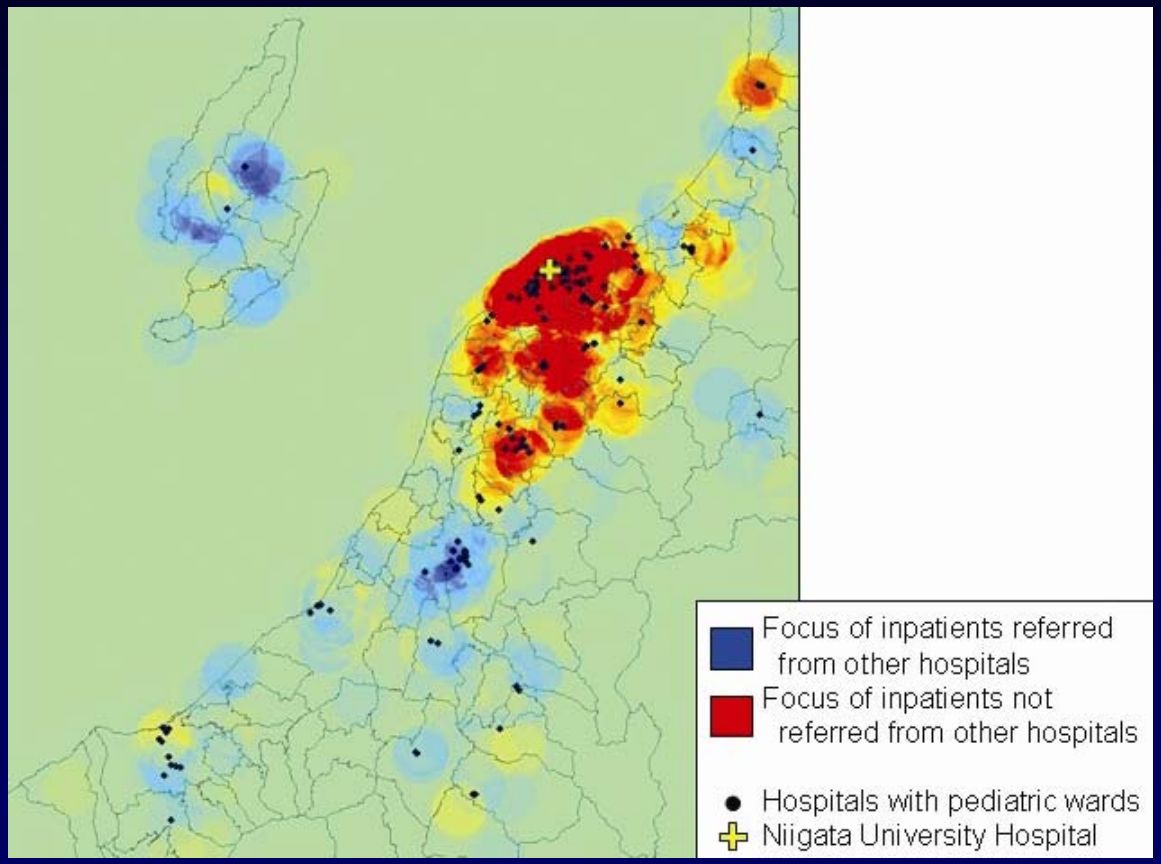
- All patients who received inpatient care in Niigata University Hospital from April 2004 to March 2005
- Data on age, gender, residential address, route of referrals, diagnosis (Japanese case mix classification)
- Spatial analysis
  - Geocoding of all patients
  - Empirical Bayesian Estimates for rate of inpatients
  - Medical service area for secondary and tertiary care
  - Spatial difference in trend of referrals: kernel density method, ordinary Kriging

Referrals from other hospitals



- The rate of inpatients who directly admitted to the hospital differed by disease (major diagnostic category) from 38.8% to 63.0% (median 55.7%)

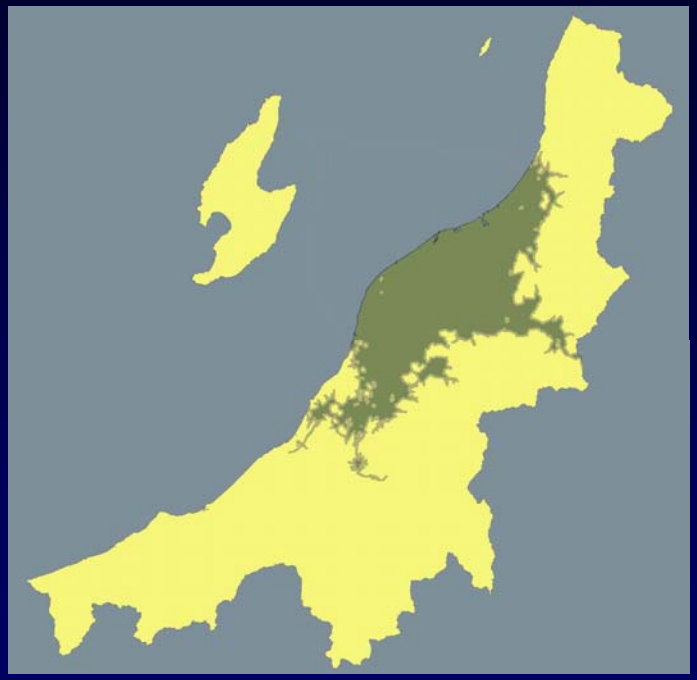
Spatial distribution of inpatients who referred from other hospitals



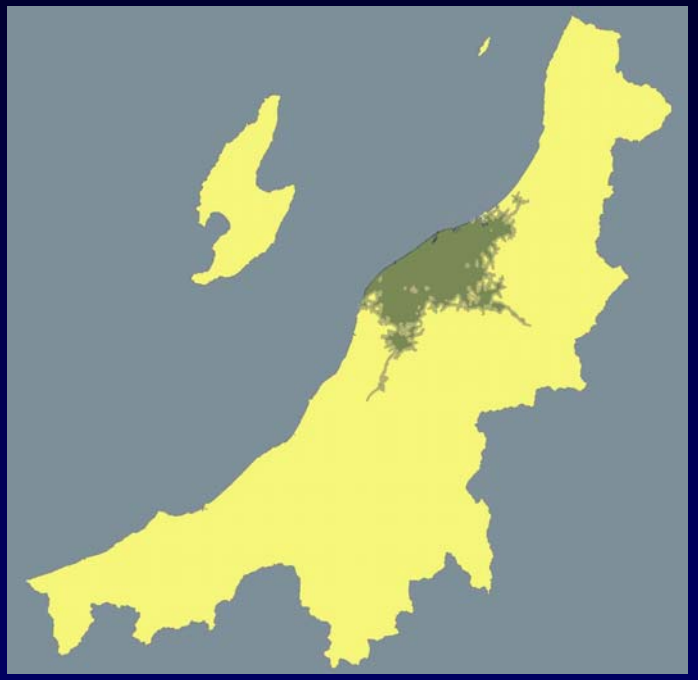
Patients who lived near the hospital have tendency to directly admit to the university hospital

University Hospital has two different kinds of medical service area

For tertiary care

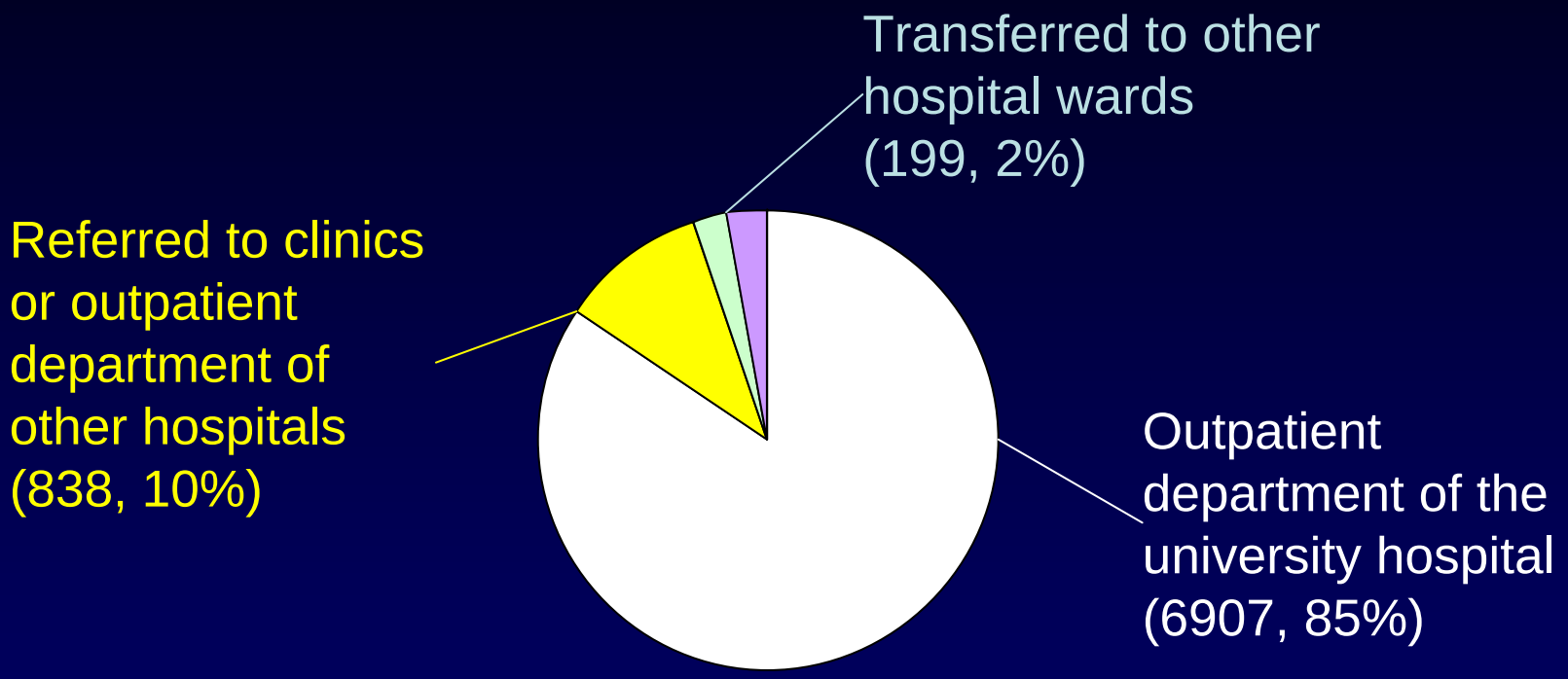


For secondary care



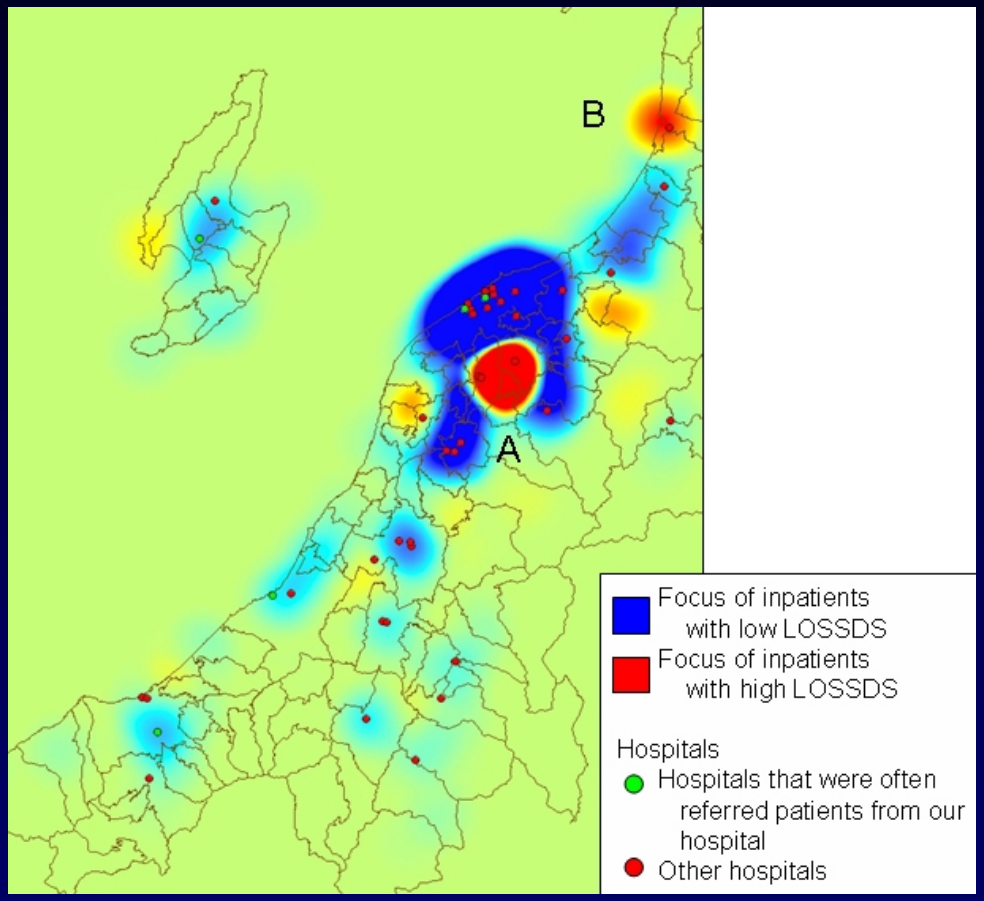
- Medical service areas covering 80% of inpatients belonging to the case-mixes with or without complicated clinical courses (coma, surgical operation, invasive treatment and complications)

Referrals to aftercare



- 89.1% of the patients who referred to aftercare received care in the outpatient department of the university hospital

Spatial focus of inpatients with long and short length of stay



There are barriers to referrals to aftercare in focus A and B. In these foci, there are hardly any hospitals which have good cooperation with the university hospital.

Summary

- 55% of inpatients admitted to the university hospital without referrals from other hospitals
- The university hospital is in competition with neighborhood general hospitals to acquire inpatients
- The university hospital has two types of medical service areas for secondary and tertiary care
- 89% of inpatients who referred to aftercare received care in the outpatient department of the university hospital
- There were several foci of inpatients with prolonged length of stay, which originated from lack of hospital-to-hospital cooperation

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A Qualitative Study to the Telemedicine System in Taiwan: The Views of Medical Profession

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Abstract

Taiwan launched a telemedicine service for rural area since 1995. In this study, a qualitative evaluations of Taiwan's telemedicine was performed to assess various measures of effectiveness (e.g., diagnostic accuracy), efficiency (e.g., cost), and participant's altitudes to determine its success. Qualitative data were collected from semistructured interviews with thematic analysis. Basically the system was successful to perform tele-consultation. However, network quality improvement, special instruments for different disease, and more specified training were also need for further telemedicine services.

Keywords:

telemedicine, qualitative study

Introduction

The use of telemedicine is beginning to change the health care industry[1-2]. The challenge now is to integrate these new technologies into the delivery of high quality health care. Patient and provider satisfaction is critical to the success of any health care delivery system. Costs and conveniences of telemedicine are critical issue for the Taiwan's telemedicine service.

Taiwan launched a telemedicine service for rural area since 1995. Four medical centers connected with remote medical organizations and, provided essential telemedicine services to the rural area [3]. However, lack of quality survey about the Taiwan's telemedicine project. Using qualitative research methods, we tried explored the experiences of users of Taiwan's telemedicine system.

Materials and methods

Telemedicine system in Taiwan

A low cost telemedicine system which constructed with inexpensive, commercially available parts and used SDSL network was developed for teleconsultation. This system contains two important devices: a videophone (TIA-8000, Tatung Inc, Taiwan) was used to provide video and audio communication; and a integrated platform which written by LabVIEW (National Instruments, TX) was used to provide heart and breathing sound, blood glucose, O2 saturation, and vital sign via SDSL network (512kbps). Figure 1 shows the function block diagram of this integrated platform.

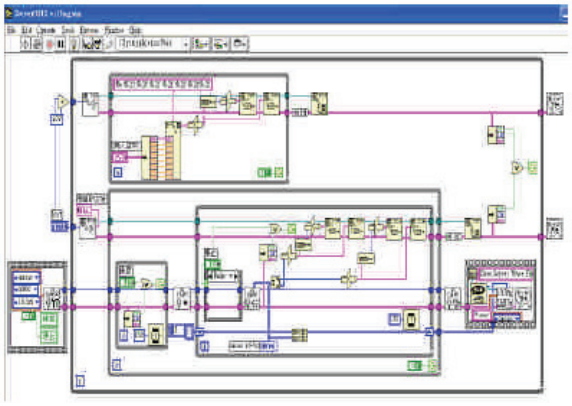

Fig 1 Block diagram (in Labview®) of the integrated platform

We cooperated with two national medical centers, two regional hospitals, and five remote native tribes which are all located inside Taiwan Central Mountain Area. This telemedicine communicated with internet to National Taiwan University Hospital (NTUH). The same data could also transmit to Puli Christian Hospital at mid-Taiwan. Meanwhile, National Cheng-Kung University Hospital which was a national medical center located at south Taiwan, is fully participating and connected with other four rural villages.

Study design

Qualitative data were collected from semistructured interviews with thematic analysis. First we used a questionnaire based to identify further respondents for the study, than we conducted in-depth interviews to collect additional free text data from the participants[4]. Our goal was to evaluate how the participants felt about the system in general..

Results

Nine healthcare professionals, including three family physicians, one physician of physical medicine and

rehabilitation, one general surgeon, one dermatologist, one obstetrician-gynecologist, one dietitian, and one physiotherapist, received our interviews. All the participants had at least two year experience about teleconsulting before this study. We reviewed efficiency, convenience of Taiwan telemedicine system, and attitudes towards telemedicine.

Efficiency of Taiwan's telemedicine system

To evaluate the efficiency of the system, the key point was to find out the medical profession felt that they could make medical decision by the telemedicine system. This was dependent on the quality of the video images and the high fidelity of the physiologic signals.

All of the participants mentioned that the telemedicine facilities were relatively simple and easy to be operated. However, special instruments should be included for special patients. Lung sounds were not clear to determine the tiny features of different diseases. They also hoped to have ultrasound image for liver and abdominal diseases screenings.

Beside the qualities of instruments, quality of network communication was also criticized by all participants. When it is in use, unstable bandwidth in the distance resulted in blurred vedio. Increasing the bandwidth and its stability can solve this problem.

Convenience of Taiwan's telemedicine system

Another question was lack of proper training to use the telemedicine facilities although all the participants were familiar with using a personal computer, webcam, internet, and other IT products. They also felt they need more training to perform teleconsulting.

Attitudes towards telemedicine

We also interviewed our participants about the attitudes towards telemedicine. All of our participants felt the telemedicine emerges mainly because people in rural area were inaccessible to quality services, so it should not be compared with traditional face-to-face medical services.

One major limitation of telemedicine was also mentioned by the surgeon and the obstetrician-gynecologist: No emergency procedure could be taken by internet.

However, one family physician suggested the telemedicine should be the screening system for the emergency case.

Discussion

It is clear that participants are more than willing to discuss their feelings about telemedicine, and that in general, they perceive telemedicine in a positive manner. Initial qualitative findings from this study will provide a valuable assessment of satisfaction with the system as it is being implemented.

All of the participants mentioned that the telemedicine facilities were relatively simple and easy to be operated. However, special instruments should be included for special patients.

As for special cases, telemedicine system should have the functions of real time diagnosis, long-term observation, and acute complication prevention, thus improve the quality of medical services, narrow the gap between doctors and patients, and build up the patients' confidence in the system.

Our participants' attitudes towards telemedicine were positive. Lack of patients' view points was a major limitation of this study. We only presented perceptions of health providers who were participate the telemedicine project. However, patient satisfaction was an important issue.

Conclusion

The Taiwan's telemedicine system was evaluated by an quantitative methods in the study. Basically the system was successful to perform teleconsultation. The medical profession that joined this telemedicine project suggested that this telemedicine system can provide suitable services for primary healthcare. This system might be able to improve the health care quality for the rural residents by a comprehensive medical service.

Restricted by environment differences, geographical distances, cost and time, the future development of the telemedicine system should be to satisfy the special need of different medical specialists, gain the patients' confidence, and provide more training about how to use the telemedicine instruments.

Acknowledgments

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Measuring Race and Ethnicity in SNOMED Patient Records

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Abstract

One of the challenges facing informatics today is the collection of useful data on racial and ethnic background. The collection of these data is complex and problematic. The current system for coding racial and ethnic data in patient records is often inconsistent and confusing, as an examination of the example of SNOMED illustrates. Principles drawn from the social science research on the topic can be used to improve our methods of collecting racial and ethnic data.

Keywords:

race, ethnicity, Systematized Nomenclature of Medicine (SNOMED), computerized patient record

Introduction: The complexity of "race"

Although "race" and "ethnicity" are social, not biological, constructs, it is nonetheless important that these social groups be measured appropriately in medical informatics. Developing coding systems that use racial and ethnic concepts in a logically consistent way is challenging. Our ideas about measuring race and ethnicity developed in an often haphazard response to nation-specific historical ideas about racial and ethnic difference. We have no internationally comparable or systematic nomenclature for capturing race and ethnicity in health contexts [1-2]. In an effort to contribute to the development of a valid method of coding racial and ethnic groups, I discuss ways that the social scientific evidence on measuring race and ethnicity could be incorporated into informatics systems.

Accurately categorizing "race" and "ethnicity" is not simple. Variation in how these data are collected can significantly change our understanding of the relationship between ethnicity and health. First, some datasets identify patients by appearance, while others allow patients to self-identify. In vital statistics data in the United States, for example, death certificates are often completed based on the appearance of the deceased or other observable factors, which leads to an undercount of Latinos and other minority groups [3].

Second, small differences in the way questions about race and ethnicity are worded or formatted lead to large differences in how individuals identify. For example, many U.S. surveys separate Latino "ethnicity" from the question on "race" [4]. This results in higher rates of identification as "Latino" than questions that include all of the groups in a single question [5]. Survey respondents are also strongly influenced by the examples they are given and the placement of the question [6].

Third, some ethnic groups are simply left out of many data collection efforts. Individuals of Middle Eastern or Arab descent, for example, typically cannot identify that heritage on U.S. health surveys, despite significant health disparities [7].

Results: Racial/ethnic categories in SNOMED

I use SNOMED as an example of a comprehensive clinical terminology to illustrate how race and ethnicity are currently being captured in medical informatics. The January 2006 release of SNOMED [9] codes "ethnic group" and "racial group" data as part of a patient's social context.

The list of "ethnic groups" included in SNOMED is extensive and detailed, ranging from nationalities (e.g. Germans, Dutch), ethnic groups within national boundaries (e.g. Basques, American Indian tribes), religio-ethnic groups (e.g. "Oriental Jews"), panethnic groups that refer to skin color (e.g. "Black") and region of the globe (e.g. "Asian"). Major "racial groups" in SNOMED are based in part on Census terminology [1]. These lists are not based on a single, consistent set of criteria. They include categories based on geography, skin tone, national boundaries, and cultural distinctions.

The separation of "racial groups" from "ethnic groups" is also a potential source of confusion. In the absence of claims based on biological racism, it becomes more difficult to articulate why the categories should be separated in health data [10-11]; for patient records, we simply need to be able to accurately identify the social groups to which the patient belongs.

Discussion: Principles for racial and ethnic data

The social science research on racial and ethnic identification suggests several principles for race and ethnicity vocabulary.

First, *self-identification should be preferred over observer identification*; staff and clinicians should be reminded to *ask* individuals about their ethnicity directly. Self-identifi-

cation is preferable to create consistency across datasets, give clinicians information about the social group that influences the patient's actions, and eliminate the strong influence of observer bias [12-13]. Ethnic self-identification is related to the selection of peer groups, communities, media and cultural outlets. If observer identification is used, it should be identified as such.

Second, *the dichotomy of "race" and "ethnicity" found in the SNOMED classification of ethnicity should be discarded*. Instead, "ethnic origins" should be collected together. As noted above, the inconsistent use of the terms makes their separation nonsensical in most contexts. Racial and ethnic questions that are formatted differently from how patients and staff think have higher rates of inaccuracy and nonresponse [4].

Third, *patients should be allowed to choose more than one ethnic origin*. Multiracial identification is increasing rapidly, increasing the importance of understanding the multiple ethnic origins that influence patients.

Fourth, *patients should also be asked to choose a single ethnic category that they find **most** representative of their ethnicity.* At times it is necessary to cluster patients into larger groups; it is more meaningful to do this by asking patients about their identification than by arbitrary allocation rules [8, 14-15].

Finally, *patients must be allowed to select from a list of ethnic categories that includes **all** of the groups that face ethnic discrimination or inequality.* If we hope to target populations that are facing increased health risks due to persecution or differences in socioeconomic opportunities, we cannot exclude meaningful categories. In this respect, the 2006 SNOMED categories are admirable in their level of detail; they include, for example, not simply panethnic categories (e.g. "American Indian") but a detailed list of ethnic categories (e.g. tribes). Conversely, terms that are not socially meaningful for any groups today should be dropped from the list.

It is wise to periodically reassess the ethnic data collected for patients, both because popular understandings of ethnicity change, and because identities are fluid over time [16]. The examples we give patients influence their identification, so it is also important to administer in the questions in a consistent way. National and regional differences will also influence how ethnic labels are understood and interpreted [2].

Conclusion: Recommended question format

I recommend asking patients:

"What are your ethnic origins or ancestry? Please select all the groups that apply." The entries currently found on the detailed list of ethnic and racial groups in SNOMED could be used as the potential answers to the question, once those categories have been pared down to include only categories that are socially meaningful to patients. (For example, the term "Mongoloid" is generally not used as an ethnic group identifier today.) In order to make this rather lengthy list comprehensible to users, it could be organized geographically, by region of ethnic origins.

Individuals who identify more than one ethnic group should also be asked a follow-up question: "Which one of these groups would you say BEST represents your ethnic origins or ancestry?" The same list of potential answers can be used.

The advantages of this format are many. First, questions that combine "ethnic" and "racial" categories into one question have lower rates of nonresponse, improving data quality [4]. The current SNOMED "racial groups" allow Hispanics to belong to a white or black subgroup, but do not do the same for any other "racial group," leading to potential confusion. Second, the level of detail found in the SNOMED ethnic categories is crucial, since panethnic categories such as "Hispanics" and "Asians" mask a tremendous amount of heterogeneity that is important to health outcomes. Third, the follow-up question asking each respondent to choose a single category is essential. Allocating multiracial respondents arbitrarily leads to grouping highly disparate individuals together and incorrectly identifies the category they would have chosen on a single-race survey [8, 14-15]. Using this follow-up question for allocation leads to much better information, since multiracial individuals tend to most resemble the single-race group they choose for themselves.

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Measuring Race and Ethnicity in SNOMED Patient Records

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Measuring Race and Ethnicity

- *How might the social science evidence on the measurement of race and ethnicity be useful for the design of informatics systems?*
  - This study uses SNOMED as an example of a comprehensive clinical terminology to illustrate how race and ethnicity are currently captured in medical informatics, and discusses how recent research on the measurement of race and ethnicity can be distilled into five useful principles that can guide measurement of race and ethnicity, leading to better data quality.

The complexity of classifying "race" and "ethnicity"

- Measurement of race and ethnicity is very sensitive to question format
  - We have no internationally comparable or systematic nomenclature for capturing race and ethnicity in health contexts [1-2].
  - Self-reported race & ethnicity is different from the race & ethnicity that observers assign to patients [3-5].
  - Minor differences in the wording of questions leads to major differences in self-identification [6-8].

Racial and Ethnic Categorization in SNOMED

- The January 2006 release of SNOMED codes "ethnic group" and "racial group" data as part of a patient's social context.
  - The list of "ethnic groups" is extensive, ranging from nationalities (e.g. Germans, Dutch), ethnic groups within national boundaries (e.g. Basques, American Indian tribes), religio-ethnic groups (e.g. "Oriental Jews"), panethnic groups that refer to skin color (e.g. "Black") and region of the globe (e.g. "Asian").
  - Major "racial groups" in SNOMED are based in part on Census terminology [6, 8]. They are: African, American Indian/Alaska Native, Asian or Pacific Islander, Australian Aborigine, Caucasian, Hispanic, Indian, and Mixed Racial Group (with subgroups included under several of these groups).

Racial and Ethnic Categorization in SNOMED, continued

- Measurement of race and ethnicity has important implications for health data [9-10].

- These lists of groups are not created based on a single, consistent set of criteria. They include categories based on geography, skin tone, national boundaries, and cultural distinctions [11-12].

- These contradictions are potentially confusing. For example, the “racial groups” allow Hispanics to belong to a white or black subgroup, but do not do the same for any other “racial group” [6].

Principles for racial and ethnic data

1. *Self-identification should be preferred over observer identification*; staff and clinicians should *ask* individuals about their ethnicity. This is preferable for several reasons:
   a. Creates consistency across data sources,
   b. Gives clinicians information about the social group that actually influences the person's identity and actions, and
   c. Eliminates the strong influence of observer bias [3-5]. (An observer's own racial identification strongly influences estimates of another person's ethnic group.)

Principles for racial and ethnic data, continued

2. *The dichotomy of "race" and "ethnicity" found in the SNOMED classification of ethnicity should be discarded*.

"Ethnic origins" should be collected together. The separation of "racial groups" from "ethnic groups" is often a source of confusion. In the absence of claims based on biological racism, it becomes difficult to articulate why the categories should be separated in health data [11-12]; for patient records, we simply need to be able to accurately identify the social groups to which the patient belongs. Racial and ethnic questions that are formatted differently from how patients and staff think of themselves have higher rates of inaccuracy and nonresponse [6].

Principles for racial and ethnic data, continued

3. *Patients should be allowed to choose more than one ethnic origin*.

   Multiracial identification is increasing rapidly, increasing the importance of understanding the multiple ethnic origins that influence patients.

4. *Patients should also be asked to choose a **single** ethnic category that they find **most** representative of their ethnicity*.

   At times it is necessary to cluster patients into larger groups; it is more meaningful to do this by asking patients about their identification than by arbitrary allocation rules [10, 13–15].

Principles for racial and ethnic data, continued

5. *Patients must be allowed to select from a list of ethnic categories that includes **all** of the groups that face ethnic discrimination or inequality*.

   If we hope to target populations that are facing increased health risks due to persecution or differences in socioeconomic opportunities, we cannot exclude meaningful categories [9]. In this respect, the 2006 SNOMED categories are admirable in their level of detail.

Recommended question format

- “What are your ethnic origins or ancestry? Please select all the groups that apply.”

- Individuals who identify more than one ethnic group should also be asked a follow-up question: “Which one of these groups would you say BEST represents your ethnic origins or ancestry?”

Advantages of this format

1. Questions that combine “ethnic” and “racial” categories into one question have lower rates of nonresponse, improving data quality [6].
2. The level of detail found in the SNOMED ethnic categories is crucial, since panethnic categories such as “Hispanics” and “Asians” mask a tremendous amount of heterogeneity that is important to health outcomes.
3. The follow-up question asking each respondent to choose a single category is essential, because multiracial individuals tend to most resemble the single-race group they choose for themselves. Allocating multiracial respondents arbitrarily leads to grouping highly disparate individuals together and incorrectly identifies the category they would have chosen on a single-race survey [10, 13-15].

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The New Digital Divide: Bridging the Gap Between Patients and Practice

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Abstract

Introduction*: This paper examines a new digital divide between patients and health care professionals in the context of emerging Information and Communication Technologies (ICTs).* ***Methods:*** *Through a survey of Staff Oncologists, Fellows and Residents, this study examines how the Internet is currently being used in clinical practice, research and continuing education. This study also probes the physician's view of the benefits and barriers of the Internet as a resource for their patients.* ***Results:*** *Analysis revealed that a large majority consider the Internet as essential to their practice and see its use increasing in the future, but have reservations about adopting new paradigms for clinical care.* ***Conclusions:*** *Though nearly all physicians recognize the benefits the Internet offers to patients, few are integrating new technologies such as email communication with their patients into their clinical practice.*

Keywords:

internet, consumerisms, radiation oncology practice, information and communication technologies

Introduction

A new digital divide is emerging. This new divide is between what patients are demanding from new technologies, and what professionals and organizations are prepared to provide. Many patients are becoming sophisticated consumers of health care services and just as they utilize new technologies in almost every other facet of the life, there is an expectation that health services also adopt a paradigm appropriate for the knowledge age. At the same time, health professionals are adopting these technologies in their own lives, but are reluctant to provide care utilizing these technologies. This reluctance is creating a chasm between the health system and health consumers. It is a chasm they are not certain how to bridge and reluctant to cross.

There is little doubt that that the prevalence of Information Communication Technologies (ICTs) and a wealth of information on the Internet is having a profound effect on clinical practice. The amount of information available to clinicians and their patients can be overwhelming, confusing and difficult to process. Developing strategies for dealing with this information explosion is essential if this information is going to have a positive, rather than negative effect on the clinical encounter[1] .

Many doctors use the Internet in their own practice for a variety of uses including obtaining medical information from online journals and e-mailing colleagues.[2] Continuing education/continuing medical education (CE/CME) programs that adopt self-directed, computer-based instruction formats via the Internet or CD-ROM can ease the demands placed on clinicians who are required by licensing boards to accumulate CE/CME credits as part of their career-long learning [3]. Having CE/CME courses on the Internet creates a flexible learning environment; the information in the courses is updated easily, time away from the workplace is reduced, and the learning can happen at the individual's own pace.[3-5]

The advent of ICTs has also had a profound effect on the delivery of care; patients are accessing information and educational tools and resources that have the potential to empower them as active participants in their care. As Shaw has noted, health care professionals appear to have a great deal of trepidation about what impact the "expert patient" could potentially have on clinical practice: "The suspicion is that for many doctors, the expert patient of the imagination is the one clutching the sheaf of paper from the internet, demanding a particular treatment that is unapproved, manifestly unsuitable, astronomically expensive or all three [6]."

The discipline of radiation medicine is inherently driven by computer-based technologies that profoundly shape the ways in which care is delivered. Yet it is not clear that the experience with computer-based technologies, depended upon for the provision radiation based treatments, extends to other aspects of the clinical interaction. This study will examine the perceptions, attitudes and barriers for radiation oncologists incorporating ICTs into their practice to improve the access to and the delivery of quality patient care.

Rationale/Purpose

To conduct a study of Radiation Oncologists at a large, academic, comprehensive cancer centre to determine current attitudes towards the Internet as a component of health care delivery, and to explore attitudes related to increased integration of Web-based applications and resources into the practice and delivery of radiation medicine.

Methods and materials

This study focused on the impact of the Internet on the practice of radiation therapy from the radiation oncologists' viewpoint. Radiation oncologists were surveyed to explore to what extent they use online resources for their own professional education and their attitudes towards further integration of Web-based strategies for patient education and care delivery into their clinical practice.

Study design

The survey instrument contained 18 items as well as demographic questions pertaining to age, sex and professional status. The questionnaire was divided into three sections. 1) The impact of the Internet on the education and practice of radiation oncologists. 2) The current reliance on the Internet to provide clinical services to their patient. 3) The oncologists' perceptions of the potential impact on clinical practice of patients using the Internet for education and clinical purposes. The questionnaire was pre-tested for face validity with three oncologists. Modifications to clarify and improve questions were made based on the feedback.

All radiation oncologists as well radiation oncology fellows and residents at a comprehensive cancer centre were eligible to participate in the study; at the time the survey was administered, there were 64 potential participants. The survey was initially administered in paper-format, but was also made available through an online version.

University Health Network Research Ethics Board approval was obtained for this study.

Results

Demographics

A total of 51 respondents completed the questionnaire for a response rate of 80%. Half of the respondents 49% were staff oncologists, 31% fellows and 20% residents. Just over half 60% were male; 54% are between the ages of 21 and 40 and 44% between 41 and 60. The respondents specialized in a wide range of cancer sites; the most common sites of specialization were breast cancer (24.5%), gastrointestinal (24.5%), genital-urinary (30.6%) and head and neck (20.4%).

The Internet and clinical practice and education

Three-quarters (75%) of the respondents perceived the Internet as essential and 24% as important to their clinical practice. All respondents have network access at work and 90% have home Internet access. The majority of respondents 81% consult online practice guidelines. Only 57% of respondents reported using the Internet to research new medications; trainees, however, appear to be more likely to use the Internet for this research with 90% of the residents, 75% of the fellows and 32% of the staff oncologists reporting researching medications online (See Table 1).

The Internet was also used by respondents for collaborative activities including clinical consultation, research and the review and publication of research manuscripts. The majority (92%) stated that they email colleagues for clinical advice or referrals. Many of the respondents (69%) use online avenues for improving international collaboration, but only 22% are currently conducting online meetings or conferences. Over three-quarters (78%) use the Internet to collaborate on research projects; this includes 30% of the residents, 81% of the fellows and 76% of the staff oncologists. Online publishing of their research and reviewing manuscripts, was done by 76% of respondents.

Table 1 - How do you use the Internet?

	Oncologist	Fellow	Resident
Accessing medical journals	24 (96%)	16 (100%)	10 (100%)
E-mailing colleagues	25 (100%)	13 (81%)	9 (90%)
E-mailing patients	11(44%)	4 (25%)	1 (10%)
Checking info on Web sites	9 (36%)	10 (63%)	7 (70%)
Researching new medications	8 (32%)	12 (75%)	9 (90%)
Looking for practice guidelines	19 (76%)	13 (81%	10 (100%)

The majority of respondents believed that the Internet usage will continue to increase as part of the clinical practice (80%), research (87%) and education (80%). Over half of the respondents (60%) see themselves using the Internet for telemedicine and 58% think they will use the Internet for online training or teaching of students. Thinking to the future, 77% of respondents see themselves using the Internet for online conferences, and 67% think they will use the Internet for formal online learning and distance education. All most all the respondents (90%) believe that the Internet will continue to be important for promoting their academic activities and research.

Patient-physician communication online

The majority of oncologists do not encourage patients to communicate with them using email. Approximately one-third (31%) of respondents use the Internet to email patients and only 33% would like patients to have the ability to email them concerning their treatment: 50% of the residents want to have this ability, 25% of fellows and 32% of the staff oncologists. Email exchange was rarely or never encourage by 73% of respondents. However, half of the respondents include their email address on their business cards and 59% are interested in having a separate email account dedicated to exchanging email with patients that are related to the clinical encounter.

Patients on the Internet: Physician perspective

Respondents believe that patients benefit from accessing information online, with 81% stating the online information is somewhat helpful to patients. According to the respondents, 96% of patients sometimes (47%) or often (49%) bring information that they have found on the Internet with them to their appointments. More than half (61%) report referring patients to information on the Internet. Although a few respondents referred patients to common search engines such as Google™, the majority referred them to specific, well-known sites including the National Cancer Institute's (NCI) education database (PDQ™), the American and Canadian Cancer Societies and Cancer Care Ontario. Only 51% of respondents reported checking and/or assessing information on popular Web sites for patients.

More than half (61%) of respondents agree or somewhat agree that patients should research their condition on the Internet before they accept treatment recommendations and 78% agree or somewhat agree that patients who do Internet research before their clinical consultations are better informed about their options than those who do not. The majority (80%) also agrees that patients who come with information that they found on the Internet generally take more time during consultation and 78% agree that these patients often request treatments not offered in Canada. However, almost half of the respondents (47%) do not believe that patients who do research on the Internet have a better consultation with their physicians than those who do no research prior to the appointment. There is also general agreement that the Internet is not being used to its full advantage as a patient tool for clinical care at the cancer centre.

Limitations

Despite the fact that the Princess Margaret Hospital houses the largest Radiation Oncology program in Canada, and despite the fact that this study enjoyed an 80% response rate, the numbers dealt with in the survey (n = 51) are still quite small. Such a sample size does not allow for the accurate extrapolation of information based on professional status and demographics. This study took place at only one, academic cancer centre involving only radiation oncologists, fellows and residents. The opinions and perspectives gathered, therefore, cannot be considered representative of radiation oncology practice in general or for larger physician populations.

Discussion

Communication with patients via e-mail

An overwhelming majority of respondents in this study stated that the Internet is essential to their clinical practice and education. However, the use of the Internet for patient communication and education lags behind other aspects of online activities for radiation oncologists. Very few physicians (33%) would like their patients to be able to e-mail them directly. This reluctance to correspond through e-mail could be due to a number of factors. The most obvious of these factors is time. Other important factors may include the already large number of e-mails received daily, the inability to effectively bill for time spent e-mailing patients, the dangers of e-mail reliance in urgent cases, the lack of a system to document patient e-mails in their medical record and issues of confidentiality,.

Despite the hesitations felt in regards to patient e-mail, several factors will make the adoption of such systems inevitable: (1) these technologies are becoming common place in every other industry; (2) a growing number of patients are expecting to be able to use these technologies to manage their health care; (3) these technologies can potentially promote self-managed care in areas such as chronic diseases and (4) these technologies have the potential to improve the delivery and accessibility of health care [7, 8] .

The Internet as a patient education resource

A concern amongst physicians for patients seeking health information on the Internet is the accuracy, reliability and appropriateness of the information they receive [9]. Patients would more likely trust resources recommended by their doctor [10], but a surprisingly large number of oncologists (40%) rarely or never do so. Many staff do point their patients in the direction of reputable sites such as the Canadian Cancer Society (www.cancer.ca), the American Cancer Society (www.cancer.org) and the National Cancer Institute (www.cancer.gov), but our respondents also acknowledged that, the Internet is not being used to its full potential as an educational resource at the Princess Margaret Hospital.

Concerns about the digital divide

There is a growing concern among physicians about the possible ramifications of responding to patients' demands for online interactions. This paradigm shift could potentially create barriers to care for certain patient populations. Shaw's study *How the Internet affects patients' experience of cancer: A qualitative study* shows that significantly fewer elderly patients access the Internet for medical information (Shaw, BMJ 2004). Even those who are able to access the Internet may not wish to do so for obtaining medical information. Henwood argues that with increased information and empowerment comes increased responsibility (Henwood, Sociology of Health and Illness, 25:6, 2003) [11]. He asserts that many patients are more than happy to trust their doctors and leave decisions to them. This resistance, on the part of providers towards adopting a more wide spread use of ICTs, could in part explain the reluctance of our respondents.

While some may argue that providing communication and information options on the Internet neglects non-users such as the elderly, few would agree that withholding such options from those who could take advantage of them would be a suitable practice. The goal of any health care organization should be to provide their patients with as many options as possible to increase their understanding of their disease and treatment. The Internet should not be seen as a replacement to traditional forms of information gathering and communication but rather as a complement to them.

The Internet's role in professional development

Though not every radiation oncologist surveyed in this study supported the Internet as a means of patient communication or education, nearly all agreed on its value to their professional development. The Internet has become an integral part of professional development, research and peer communication. In fact, 75% of respondents said that the Internet was essential to their practice and education and all but one said it was at least important.

The next generation of oncologists

Although the low number of participants prevents tests of statistical significance, the trends suggest there is no difference in the way that residents and fellows are using the Internet for clinical services. However, there do appear to be a few notable exceptions. Residents and fellows appear to be searching for new medications online more than staff oncologists. They also seem to spend more time on the Internet checking or assessing information on popular websites for patients. As for their own professional development, staff and fellows are much more likely to use the Internet to review or publish manuscripts than residents and are also more likely to go online to improve international collaboration. This result is, of course, in line with regular career development for radiation oncologists. In the future, fellows and residents see themselves participating in formal online learning much more than the staff and are also more likely to involve themselves in telemedicine and online consulting. Despite these few differences, staff, fellows and residents have similar opinions on the current and future roles of the Internet in their careers and professional development.

Conclusions

While physicians have realized the potential for the Internet in their research and professional development, the potential in their clinical practice is not being realized. Although evidence shows that having better informed patients should have a positive impact on their experience, the emergence of the expert patient also means a change in the way clinicians approach a patient's clinical care. In order to better accommodate the expert patient, physicians need to take an active role in examining the information available to patients on the Internet and steer their patients towards reliable, accurate and relevant sites. New systems and approaches need to be developed to assist oncologists in bridging this new emerging gap between patient expectation and current practice.

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Variation in Use of Informatics Tools Among Providers in a Diabetes Clinic

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Abstract

Direct observation and semi-structured interviews were used to examine variability in health information technology (HIT) use among four nurse practitioners (NP) and four physicians (MD) in an ambulatory diabetes clinic. One of the goals of the study was to understand the rationale behind variability in HIT use and to assess the impact of this variability on patient care. The study provides direction for future design to improve usability and efficiency.

Keywords:

qualitative research, observation, interviews

Introduction

We investigated workflow and information flow in an ambulatory specialty clinic, the Vanderbilt Eskind Diabetes Clinic. Variability of use of HIT among providers was examined as part of the study, and analyzed for impact on patient care. The variability reveals some of the strengths and weaknesses of existing HIT and provides suggestions for modifications.

Methods

The clinic provides diabetes care to approximately 6000 patients, who typically visit the clinic at 3-month intervals. Clinic providers have been using an electronic medical record (EMR) for approximately 3 years. All 8 providers had equal access to HIT features and training except for dictation software, which was available only to the physicians. Verbal assent was obtained from staff and providers prior to direct observation in offices, work areas, hallways, and exam rooms. Patients gave verbal assent prior to observation of patient-provider interactions. We conducted 52 hours of observation in the clinic. Observational data were supplemented through the use of semi-structured interviews.

Results

Use of HIT in the clinic can be grouped into three categories. Information access included examining existing data in the EMR. Information input involved altering existing data or entering new data. Communication involved using the EMR to communicate with others. Use of HIT varied both within and between the groups of providers and variability extended across all three categories of use (Table 1).

Table 1 – Variability in HIT use

Functionality	NP				MD			
	1	2	3	4	1	2	3	4
Category: Information Access								
Look up information (in exam room)	◢	◢	◢	◢	◢	◢	◢	◢
Look up information (outside exam room)	◢	◢	◢	◢	◢	◢	◢	◢
Graphical views of patient data	◢	◢	◢	◢	◢	◢	◢	◢
Category: Information Input								
Input note (in exam room)	◢	◢	◢	◢	◢	◢	◢	◢
Correct data in record (in exam room)	◢	◢	◢	◢	◢	◢	◢	◢
Input note (outside exam room)	◢	◢	◢	◢	◢	◢	◢	◢
Dictation software	◢	◢	◢	◢	◢	◢	◢	◢
Category: Communication								
Message basket communication	◢	◢	◢	◢	◢	◢	◢	◢
Write prescriptions	◢	◢	◢	◢	◢	◢	◢	◢
Patient portal	◢	◢	◢	◢	◢	◢	◢	◢
Non-secure email with patients	◢	◢	◢	◢	◢	◢	◢	◢

◢ Uses routinely
◢ Uses sometimes (not routinely)
◢ Uses rarely or never

Discussion

Variability of providers' HIT use has implications for both patient care and informatics design. Understanding the rationale for variability provides direction in the redesign of current applications and suggestions for features of new HIT. Direct observation and interviews can provide critical data about whether informatics tools are meeting user needs and supporting their workflow and can help guide design.

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Variation in Use of Informatics Tools Among Providers in a Diabetes Clinic

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Introduction

- Study conducted in the Vanderbilt Eskind Diabetes Clinic
- Examined variability of electronic medical record (EMR) use and assessed impact of variability
- Clinic: outpatient clinic providing speciality care to over 6000 patients with diabetes
  - EMR used by clinic providers for ~3 years

Methods

- Observed 4 physicians (MD) and nurse practitioners (NP) during their daily work including patient interactions
  - 52 hours of observation (18 hours for MDs, 18 hours for NPs)
- Took detailed notes during observation with focus on interaction between people, processes, and technology
- Supplemented observations with semi-structured interviews

Similarities in EMR usage

- Providers gathered information from the EMR prior to visiting patient
- Consulted EMR to clarify information or understand medical history
- None of the providers completed all of their documentation while with the patient
- All providers utilized secure messaging features

Variability in EMR usage

- EMR as information repository vs integrated tool for disease management
- A few of the providers started notes in the EMR while in the exam room, most did not
- Use of graphical displays of data
- Time to complete patient documentation varied, dependent on EMR use in exam room
- Only MDs had access to dictation software

Information Access: Examining data already in EMR

Functionality	NP				MD			
	1	2	3	4	1	2	3	4
Look up information (in exam room)	●	●	●	●	●	●	●	●
Look up information (outside exam room)	●	●	●	●	●	●	●	●
Graphical views of patient data	○	●	○	○	○	●	○	○

● Uses routinely
◐ Uses sometimes (not routinely)
○ Uses rarely or never

Information Input:
Altering existing data, entering new data

Functionality	NP				MD			
	1	2	3	4	1	2	3	4
Input note (in exam room)	●	○	●	◐	○	○	○	○
Correct data in record (in exam room)	●	●	●	●	●	◐	◐	◐
Input note (outside exam room)	●	●	●	●	●	●	●	●
Dictation software	○	○	○	○	●	●	●	●

● Uses routinely
◐ Uses sometimes (not routinely)
○ Uses rarely or never

Communication:
Using the EMR to communicate with others

Functionality	NP				MD			
	1	2	3	4	1	2	3	4
Message basket communication	●	●	●	●	●	●	●	●
Write prescriptions	●	◐	○	○	○	○	○	●
Patient portal	●	●	●	●	●	●	◐	●
Non-secure email with patients	●	●	●	●	○	○	○	○

● Uses routinely
◐ Uses sometimes (not routinely)
○ Uses rarely or never

Discussion

- All 8 providers had access to the same EMR in the same clinical environment and were treating the same disease in the same patient population
- Expectation: similar patterns of EMR adoption and use
- Observation: substantial variability in use
- Implication: providers not taking advantage of all EMR features - why not?

Contributors to variability

- Familiarity with the EMR features
- Typing ability
- Workload
- Patient needs
- Personal preferences

Implications for EMR design

- Redesign system to better fit user needs, abilities, and workflow
  - Pursue alternative approaches to data entry
  - Better match technology to workflow
- Workarounds point to need for new functionality or alternative implementation of existing functionality
- EMR modifications to promote standardization

Acknowledgements

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- The authors also would like to thank Nancy Lorenzi and Kevin Johnson for their contributions to this project.

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Web 2.0 in Building Nursing Information Portal

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Abstract

The purpose of the study is to use the web 2.0 concept in developing the nursing Information portal (NIP) in a large medical center with 1800 nurses. The website contents have been created and maintained by end users instead of traditional website manager. The website manager chose Microsoft SharePoint Service 2003 as the portal website developing tool to meet head nurses' information management needs, such as news, documentations exchange and survey taking. According to the study results for users' acceptance, nurses are very satisfied with the NIP.

Key words:

Web 2.0, nursing information, portal

Introduction

Nursing management is a complex work because nurses represent the largest group in hospital. Generally, nursing domain includes clinical and administrator work. As time going, there are many nursing specialist needed in the hospital. They are asked to do special nursing function such as case managers, nursing quality managers, disease control managers etc. The common need for all of them is a useful Information tool to help them deal with their work more efficiently. For example, they usually need to collect data from every unit via paper forms, E-mails and hone calls. Then they do their statistics manually. This manual data collection process is very time consuming. Furthermore, if they would like to deliver newest information to all units or to share documentations to all nurses, they often use the emails. It is important for these nursing managers to overcome these problems and help them work more efficiently.

According to the study, experts think the attitudes toward the computer are the most important computer competency for the nursing profession in Taiwan[1]. However nurses are seldom trained with the skills in computer usage and what IT tools could help them to do their work more efficiently. They often depend on IT people to design the information systems to help their work. Unfortunately, the IT people in hospital have difficulty to satisfy all users' Information needs[2]. In recent years , to solve the nurses' Information problems, some nurses try to develop Information system by themselves in nursing scheduling, discharging plan system etc.[3-5]. But these nurses are few and they still need to resolve the challenges in programming learning and organizational poor support [6]. The nurses' attitude toward developing information systems by themselves is positive[7].

In order to let the general nurses who never take any professional IT programming training, the information tools must be very easy to learn and easy to use. At the same time, collaboration is also important for them. So the web-based platform seems an important tool for these nursing managers.

In the last decade, there are numerous websites created in the world. People use internet for searching information. The creators or managers of websites know how to create and manage the websites. Website users rarely participated in the website content generation and maintenance process. In this old model, the website managers are responsible for almost all website management. The Web 2.0, a phrase used by O'Reilly Media in 2004, refers to a new generation of Internet-based services such as social networking sites, communication tools that emphasize online collaboration and sharing among users[8]. In the new model, the websites are co-managed by all interested users. Many Web 2.0 websites have successfully attracted many users to participate, like Wikipedia for free encyclopedia, YouTube for videos, Blogs for personal web diary etc.

One of the key important factors that Web 2.0 concept becomes so popular is users' participation. Users could easily edit their own information and put their documentations or multimedia materials on the websites. They could share everything to each other if they want. In this kind of sharing mechanism, websites could attract more people and all users could become the authors of the websites. If the users think the website is important for them, they will become aggressive to maintain and keep the information updated. The maintenance of the websites becomes easy and efficient. Therefore, the burden nursing website management might be improved if those who need the websites can participate to help managing the websites.

In this study, we chose Microsoft SharePoint Service 2003 (SPS) as our Nursing Portal platform. SPS is under Microsoft Windows SharePoint Services[9]. It comes with many common components that users can use right away. The web components are based on the technology of 'Web Part'. A Web Part is a modular unit of information that has a single purpose and that forms the basic building block of a Web Page. In order to incorporate the specific requirements of nurses in a user-friendly manner, this platform provides a web components based interface for integrating tailoring functionality. Based on this environment, nurses are allowed modify any application by reassembling components without programming. SharePoint Services can deliver a set of core functions that allow nurses to develop their own specific web application through the web-browser. It offers flexibility, ease of use and can enhance the productivity of applications[10].

In a 2357-bed medical center in Taipei, Taiwan, there are 88 clinical units and 1800 nurses. According to their major work, there are clinical nurses, head nurses, nurse supervisors. Among them, there are nine kinds of special functional nurses serving in this medical center. Some of them are in charge of the disease management like DM, TB, nurse managers, wound care, heart failure etc. Some of them are in charge of the administration like quality assurance, discharge plan. In the old days, they depended on the website manager, who was an information nurse, to help them to design and update the nursing website. However this was not an efficient way to maintain the website. There has been always too for a single website manager to take care of. Therefore, SPS seems a right platform for improvement. The objective of this study was to know if the nurses could accept the Web 2.0 tool like SPS to help their work and how they thought about the SPS as an easy tool for them or not?

Materials and methods

In May 2006, we started to use the SPS to build our new nursing information portal (NIP). The structure is showed in Figure1.The informatics nurse plays a role the initial role to manage and design the website. When the prototype website was created, more nursing managers were assigned to participate in the training courses. There was a 2-hour training course in the first week and 1-hour in the following two weeks. Training materials cover the introduction of the NIP and demonstration of the functions, like how to upload and download files, to created documentations base, to create photo base, and to create a survey etc. After a total of 4-hour training, they were asked to design and to manage their assigned website and if there were any problem they could ask the informatics nurse's for help. Three months later, the NIP was formally for open to all nurse members. The NIP is showed in Figure 2. We introduced the website to all head nurses and clinical nurses in one hour speech to teach them how to use the NIP. After another three months, one questionnaire (5-Point Likert scale) was designed to nursing managers to ask for their acceptance.

Results

We totally created 28 sub-sites in NIP. There are 24 nursing managers assigned to manage the website, including 13 nurse supervisors, 8 special functional nurses, 3 administrators. After the training course, 7 special functional nurses design their assigned website on their own. Nurse supervisors were too busy to design by themselves and to supply the materials and to ask the informatics nurse to help them in beginning. However, they sometimes needed to collect data form units so they would ask informatics nurse to teach them how to create a survey in NIP. With this regard, the NIP became their useful tool to data collection.

There were 29 questionnaires returned with a return rate of 36.7%. The result of questionnaire survey is shown in Table 1. Overall, they were very satisfied with the NIP and its performance.

Discussion

The NIP appears to be a useful tool for nurses to meet their information needs. They could collect the data more efficiently then before. They furthermore became to ask other nurses who were not familiar with the NIP to learn how to use that. Some head nurses even asked informatics nurse to integrate more functions into NIP, like the documentation records. Some nurses did appreciate this website.

Conclusion

Within few months, the NIP has helped nurse supervisors and special functional nurses in improving different work flow and made their work more productive. The Web 2.0 concept in nursing information portal appears successful from our study. There are still many nurses afraid to use this new website. So in the future study, we would like to encourage them and continuous to integrate more easy but useful functions in NIP like document searching. Besides, we would also like to teach our head nurses to manage their unit websites to improve their wok performance then before and to increase their acceptance of NIP.

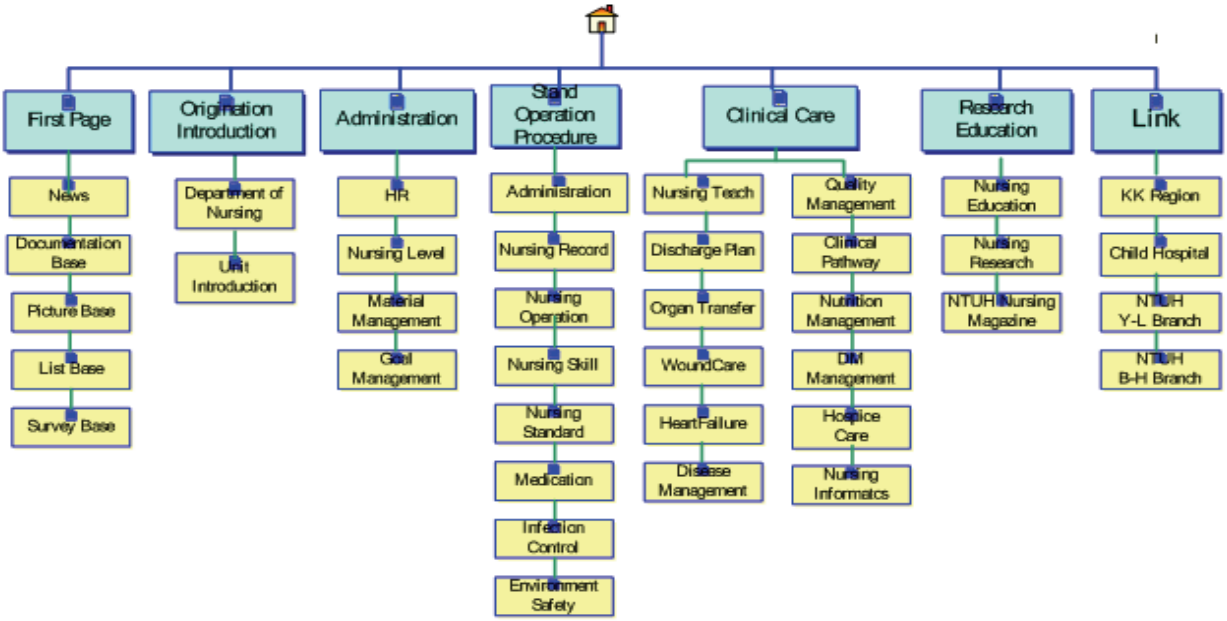

Figure 1-The Structure of Nursing Information Portal

Figure2-The Nursing Information Portal

Questions	Strongly Agree	Agree	Undecide	Disagree
The history data of website can be kept for a long time.	4(13.79%)	10(34.48%)	15(51.72%)	
The website can save of my total working time	8(65.52%)	19(65.52%)	2(6.90%)	
I feel that the website is easy to use.	6(20.69%)	16(65.52%)	3(10.34%)	1(3.45%)
I feel that the website is reliable	3(10.34%)	21(72.41%)	5(17.24)	
I feel that the functions of website are complete.	1(3.45%)	21(72.41%)	4(13.79%)	3(10.34%)
I feel that the data in the website are correct.	3(10.34%)	23(79.31%)	3(10.34%)	
I feel that the website could precisely record the execution time.	10(34.48%)	15(51.72%)	4(13.79%)	
I feel that the data of the website is easy to get.	3(10.34%)	22(75.86%)	3(10.34%)	1(3.45%)
I feel that the functions of the website are easy to understand.	4(13.79%)	16(55.17%)	8(27.59%)	1(3.45%)
I am satisfied with this website	4(13.79%)	20(68.97%)	5(17.24%)	
I feel that the website is useful for my work.	6(20.69%)	21(72.41%)	2(6.90%)	
I feel that the website is friendly to use.	3(10.34%)	25(86.21%)	1(3.45%)	
I feel that the website has improved the working flow.	6(20.69%)	19(65.52%)	4(13.79%)	
I often use the website information.	2(6.90%)	22(75.86%)	3(10.34%)	2(6.90%)
Overall, the website could improve the communication and	5(17.24%)	18(62.07%)	5(17.52%)	1(3. 45%)

Table 1- The results of nurses' acceptance of the NIP

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Web 2.0 in Building Nursing Information Portal

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Abstract

- *The purpose of the study is to use the web 2.0 concept in developing the nursing Information portal (NIP) in a large medical center with 1800 nurses. The website contents have been created and maintained by end users instead of traditional website manager. The website manager chose Microsoft SharePoint Service 2003 as the portal website developing tool to meet head nurses' information management needs, such as news, documentations exchange and survey taking. According to the study results for users' acceptance, nurses are very satisfied with the NIP.*

- ***Key words:*** ：Web 2.0, Nursing Information, Portal

Introduction

- Nursing management is a complex work because nurses represent the largest group in hospital.
- The common need for all of them is a useful Information tool to help them deal with their work more efficiently .
- In order to let the general nurses who never take any professional IT programming training, the information tools must be very easy to learn and easy to use.

- The Web 2.0, a phrase used by O'Reilly Media in 2004, refers to a new generation of Internet-based services such as social networking sites, communication tools that emphasize online collaboration and sharing among users.
- Users could easily edit their own information and put their documentations or multimedia materials on the websites.
- In this study, we chose Microsoft SharePoint Service 2003 (SPS) as our Nursing Portal platform.

Materials and Methods

- In May 2006, we started to use the SPS to build our new nursing information portal (NIP).The structure is showed in Figure1..
- The informatics nurse plays a role the initial role to manage and design the website.
- When the prototype website was created, more nursing managers were assigned to participate in the training courses.
- There was a 2-hour training course in the first week and 1-hour in the following two weeks.
- Three months later, the NIP was formally for open to all nurse members. The NIP is showed in Figure 2 .

Figure 1-The Structure of Nursing Information Portal

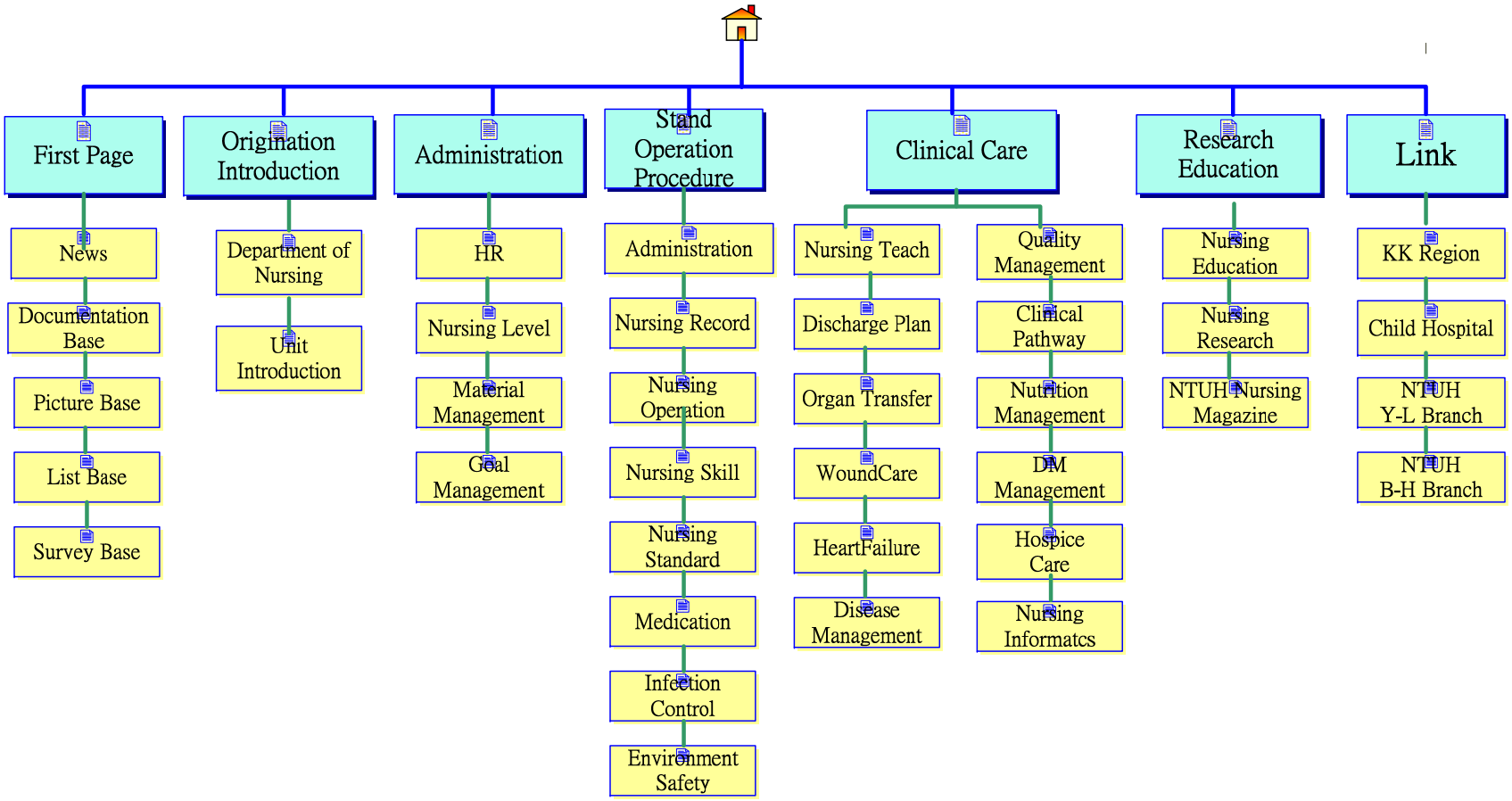
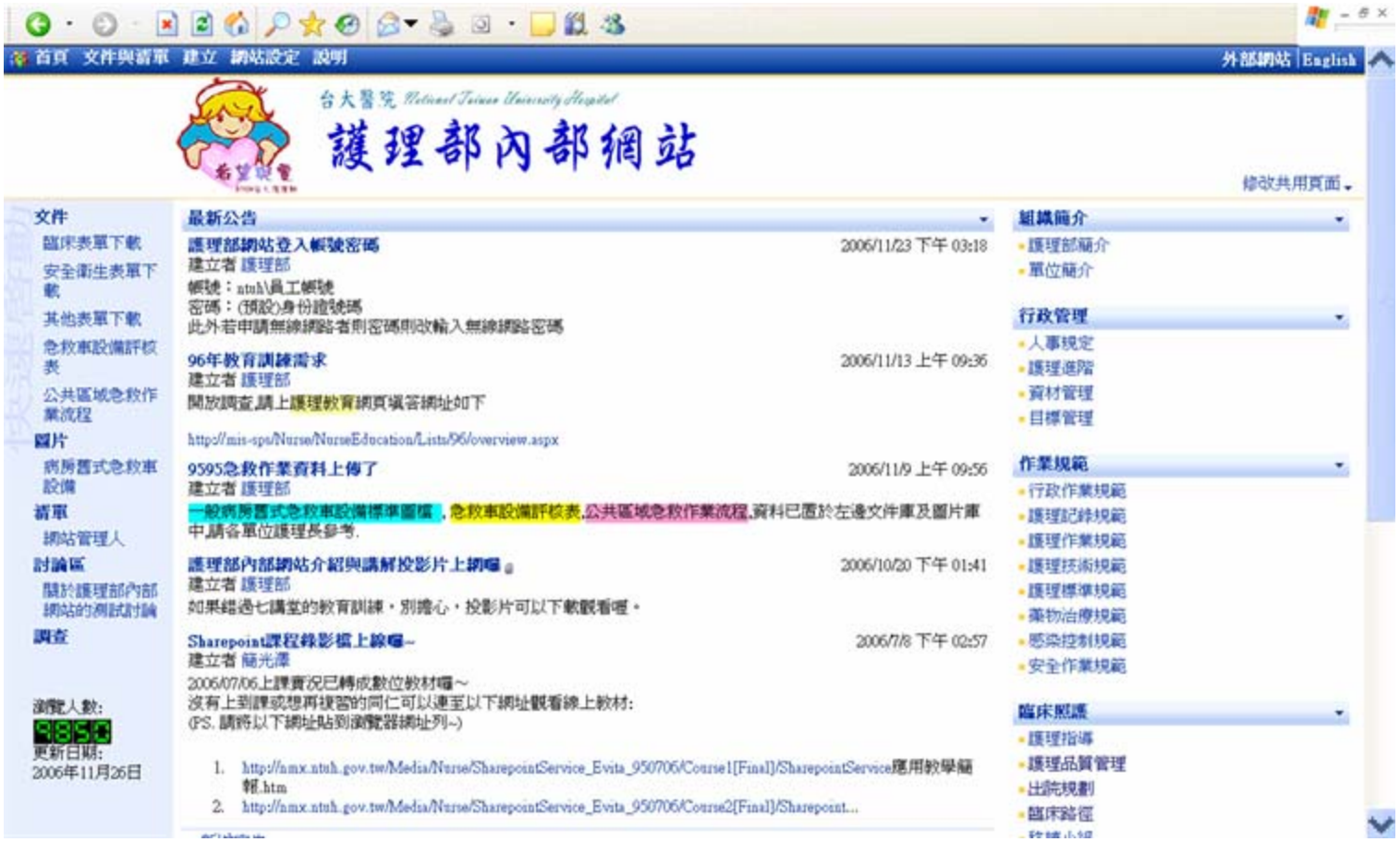


Figure2-
The Nursing Information Portal



Results

- We totally created 28 sub-sites in NIP. There are 24 nursing managers assigned to manage the website, including 13 nurse supervisors, 8 special functional nurses, 3 administrators.
- After the training course, 7 special functional nurses design their assigned website on their own.
- Nurse supervisors were too busy to design by themselves and to supply the materials and to ask the informatics nurse to help them in beginning.
- However, they sometimes needed to collect data form units so they would ask informatics nurse to teach them how to create a survey in NIP. With this regard, the NIP became their useful tool to data collection.
- There were 29 questionnaires returned with a return rate of 36.7%. The result of questionnaire survey is shown in Table 1.

Table 1-

The results of nurses' acceptance of the NIP

Questions	Strongly Agree	Agree	Undecided	Disagree
The history data of website can be kept for a long time.	4(13.79%)	10(34.48%)	15(51.72%)	
The website can save of my total working time	8(65.52%)	19(65.52%)	2(6.90%)	
I feel that the website is easy to use.	6(20.69%)	16(65.52%)	3(10.34%)	1(3.45%)
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I am satisfied with this website	4(13.79%)	20(68.97%)	5(17.24%)	

I feel that the website is useful for my work.	6(20.69%)	21(72.41%)	2(6.90%)	
I feel that the website is friendly to use.	3(10.34%)	25(86.21%)	1(3.45%)	
I feel that the website has improved the working flow.	6(20.69%)	19(65.52%)	4(13.79%)	
I often use the website information.	2(6.90%)	22(75.86%)	3(10.34%)	2(6.90%)
Overall, the website could improve the communication and collaboration .	5(17.24%)	18(62.07%)	5(17.52%)	1(3. 45%)
Overall, the website could increase the care quality to patient.	3(10.34%)	9(31.63%)	**17(58.62%)**	
Overall, the website could increase the efficiency to Department of Nursing.	6(20.69%)	20(68.97%)	3(10.34%)	
Overall, the website could simplify the workflow.	8(27.59%)	20(68.97%)	1(3.45%)	

Discussion &Conclusion

- The NIP appears to be a useful tool for nurses to meet their information needs.
- They could collect the data more efficiently then before.
- Some head nurses even asked informatics nurse to integrate more functions into NIP, like the documentation records. Some nurses did appreciate this website.
- The Web 2.0 concept in nursing information portal appears successful from our study.
- In the future we would also like to teach our head nurses to manage their unit websites to improve their wok performance then before and to increase their acceptance of NIP.

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A Review of the Use of Health Technology Assessment in Relation to the Safe and Effective Use of Diagnostic Imaging Technologies in Health Care

Bernard L Crowe[a] and Peter MacIsaac[b]

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[b]*Principal, MacIsaac Informatics, Canberra, Australia*

Abstract

Health Technology Assessment (HTA) has become the standard methodology use by government agencies for evaluating the role and funding priorities of new Diagnostic Imaging (DI) technologies. A structured literature review of recent HTA reports concluded that there had been no major developments in assessment methods used in HTA and, therefore, no widespread spillover from the development in research methods in general to the field of HTA methodology.

Purchasing decisions of new technology are guided by a DI professional assessment of improvements in image quality, efficiency, safety and capacity for expanded range of diagnostic and procedural interventions. The implementation of a new technology in DI often precedes systematic reviews by HTA bodies of patient outcomes and may be based on data provided by manufacturers and on recent papers presented at professional conferences. This situation often leads to a clash of evaluation cultures between the DI profession and the HTA agencies charged with informing public purchasing and health policy.

As emerging DI technologies sit at the border of computer technology and social interaction between patients and clinicians, a number of authors have concluded that because of the complexities of health systems, both qualitative and quantitative data are required to resolve questions about the appropriate use of diffuse DI technologies. The authors conclude that assessment of DI technologies s should be based on qualitative methods involving surveys of the experience of practitioners and patients rather than only on traditional quantitative methods.

Keywords:

health technology assessment; diagnostic imaging; quantitative assessment; qualitative assessment

Definition of HTA

Health Technology Assessment (HTA) is a scientific and policy domain that has grown rapidly over the past twenty years. HTA is a multidisciplinary field of policy analysis. It studies the medical, social, ethical, and economic implications of development, diffusion and use of health technology. HTA seeks to inform health policy makers by using the best scientific evidence on the medical, social, economic and ethical implications of investments in health care.

HTA and priority setting

The impact of on new Diagnostic Imaging (DI) technologies on health care is seen as a major factor in the improvement in health outcomes in many developed countries. At the same time, DI is seen by critics as a driver of increases in health expenditure. While the various health professions have traditionally managed the introduction of new diagnostic imaging technology, principles of evidence based medicine are being rigorously applied to the introduction process by many government health authorities. New techniques and procedures have to be not only effective and beneficial, but also justify any increased costs and resources. It is a reality that a mechanism such as HTA is required for priority setting in government environments where there are competing calls on limited resources.

Literature review of developments in HTA methodology

A review of relevant literature has been conducted to determine trends in the use of HTA methodology for the assessment of DI technologies. Consideration is being given by academic radiologists to the issues of how to both collect evidence on the impacts of DI as well as how to deal with appraisal of rapidly changing technology [1]. A conceptual framework of a hierarchy of levels of efficacy that could guide thinking about imaging test evaluation has been developed. In particular, the framework relates the key questions; "How well does this test distinguish disease from the non-diseased state?"; "How much does this intervention improve the health of people?"; "What is the cost of that improvement?" The model describes decision analysis and cost-effectiveness analysis, which are quantitative modeling techniques usually used to answer the two core questions for imaging.

However, a structured literature review by Draborg et al [2] of 433 HTA reports from the period 1989 to 2002 by eleven leading HTA institutions worldwide found that lit-

erature reviews were still the most often used method of assessment. The authors concluded that there had been an increase in the number of HTAs but no major developments in assessment methods used and, therefore, no widespread spillover from the development in research methods in general to the field of HTA methodology.

Discussion

As a group of emerging technologies, DI sits at the border of computer technology and social interaction between patients and clinicians and thus calls for a socio-technological approach to evaluation of organizational, cultural and technological factors. An innovative qualitative approach to the assessment of DI technologies is required when seeking new directions for evaluation [3]. The conclusions of a recent workshop, Putting Evidence into Practice in Edmonton, concluded that: "In the end, evidence and information cannot be the determining factor in policy decisions. There will always be world views and values, which will help to determine when a condition becomes a problem and when the political situation is such that a decision can be made."[4]

The ability of HTA systematic reviews to keep pace with technological change in DI technologies is being challenged in environments of limited resources for research and evaluation. While both quantitative and qualitative techniques of evaluation have evolved over the last decade, the HTA paradigm of systematic review has not, yet controlled trial evidence of the outcome of DI technologies is often hard to find. It is suggested that assessment of DI technologies should be based on qualitative methods involving surveys of the experience of practitioners and patients rather than only on traditional quantitative methods.

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Overview 2

This situation often leads to a clash of evaluation cultures between the DI profession and the HTA agencies charged with informing public purchasing and health policy.

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HTA seeks to inform health policy makers by using the best scientific evidence on the medical, social, economic and ethical implications of investments in health care.

HTA and priority setting for DI

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Principles of evidence based medicine are being rigorously applied to the introduction process of DI by many government health authorities.

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Literature review of developments in HTA methodology

A review of relevant literature has been conducted to determine trends in the use of HTA methodology for the assessment of DI technologies.

Consideration is being given by academic radiologists (Sunshine et al) to the issues of how to both collect evidence on the impacts of DI as well as how to deal with appraisal of rapidly changing technology.

A conceptual framework of a hierarchy of levels of efficacy that could guide thinking about imaging test evaluation has been developed. In particular, the framework relates the key questions:

Key questions for HTA

"How well does this test distinguish disease from the non-diseased state?“

"How much does this intervention improve the health of people?" and

"What is the cost of that improvement?”

The Sunshine et al model describes decision analysis and cost-effectiveness analysis, which are quantitative modeling techniques usually used to answer the two core questions for imaging.

Literature review 2

A structured literature review by Draborg et al of 433 HTA reports from the period 1989 to 2002 by eleven leading HTA institutions worldwide found that literature reviews were still the most often used method of assessment

The authors concluded that:

there had been an increase in the number of HTAs

no major developments in assessment methods used

no widespread spill over from the development in research methods in general to the field of HTA methodology.

Discussion 1

As a group of emerging technologies, DI sits at the border of computer technology and social interaction between patients and clinicians

DI calls for a socio-technological approach to evaluation of organizational, cultural and technological factors.

An innovative qualitative approach to the assessment of DI technologies is required when seeking new directions for evaluation

Discussion 2

A workshop Putting Evidence into Practice in Edmonton, concluded that:

"In the end, evidence and information cannot be the determining factor in policy decisions.

There will always be world views and values, which will help **to determine when a condition becomes a problem** and when the **political** situation is such that a decision can be made."

Conclusion

The ability of HTA systematic reviews to keep pace with technological change in DI technologies is being challenged in environments of limited resources for research and evaluation.

While both quantitative and qualitative techniques of evaluation have evolved over the last decade, the HTA paradigm of systematic review has not, yet controlled trial evidence of the outcome of DI technologies is often hard to find.

It is suggested that assessment of DI technologies should be based on qualitative methods involving surveys of the experience of practitioners and patients rather than only on traditional quantitative methods.

References

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Thank you for your attention

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Qualitative Characterization of Query Structure in the Arden Syntax

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Abstract and objective

Context: Arden Syntax is an American National Standard Institute (ANSI) standard used to encode executable knowledge as Medical Logic Modules (MLMs). Consensus is elusive regarding a standard format for database queries in knowledge bases (KB). Objective: Analyze a sample of MLMs in order to characterize the syntax of database linkages. Method: A convenience sample of 331 MLMs drawn from 6 distinct clinical decision support systems (CDSS) was examined. MLM types included 42% lab, 23% clinical assessment and 14% medication. Results: Only half of the systems include the Structured Query Language (SQL) in queries. Only two used standard terminologies. Queries from all six systems contained at least some site-specific content, some of which was included only at run-time. Conclusion: Arden Syntax database linkages vary in format, and significant work remains to converge on a standard for Arden Syntax queries.

Keywords:

decision support systems, clinical; knowledge bases

Introduction

Arden Syntax is an HL7/ANSI standard for procedural knowledge representation, and the medical logic module (MLM) is the unit of representation. Nevertheless, some site-specific changes must occur in order for a KB in standard format to be transferred from one site to another—the "curly braces" challenge, named for the construct that encodes site-specific references in the Syntax. A database query is represented by a READ statement, which may contain site-specific references in the curly braces combined with standard operators such as aggregation and constraints. Key to minimizing the need for KB changes when sharing MLMs is the standardization of these database linkages. The present work qualitatively characterizes the structure of database queries from different institutions and CDSS. This will inform development of a standard for database linkages and estimation of the work needed to converge on the standard.

Methods

MLMs were obtained from six distinct source systems: sample knowledge bases of the 3 principal vendors of Arden-compliant CDSS and three academic medical centers with independently developed CDSS. The READ statements in the collected MLMs were isolated in order to characterize their structure. The analysis focused on these characteristics: the use of ANSI-standard SQL; whether query elements were added at run time that were not encoded in the MLM; the use of coded terminology; and the extent to which the query was represented entirely within the curly braces or partially in the standard component of the READ statement.

Results

A total of 331 MLMs were pooled from the 6 source CDSS, including 19 from 3 vendor KBs and 312 from the 3 academic medical centers. MLMs concerned mainly with lab tests were the most common (138/331 = 42%), followed by clinical assessment or classification (75/331 = 23%) and medication (45/331 = 14%). The remainder addressed administrative and miscellaneous topics. Each MLM contained at least one READ statement. Within the MLM cohort of each CDSS, query structure did not vary by MLM type. Half of the source systems used SQL to link to databases, while the others used proprietary expressions. Four of the six systems included the entire query in the READ statement, while the other two relied on partial run-time inclusion of query elements. Only two of the systems used coded vocabulary terms to refer to data elements. Each of the other four appeared to use a local, controlled terminology that was neither coded nor standard. All six source CDSS used the curly braces to represent at least part of the query; none used the standard parts of the READ statement exclusively. Three of the six included SQL queries in the curly braces, while two others reserved the curly braces for local terminology references.

Conclusion

A sample of MLMs drawn from a variety of Arden Syntax-compliant CDSS demonstrates the absence of a uniform query structure. Other standards such as SQL and controlled terminologies are used but do not predominate. Run-time inclusion of query elements complicates efforts to represent queries in a standard, shareable format. Considerable work remains to achieve convergence on a standard for representing database queries in the Arden Syntax.

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Development of Reference Terminology in Korean Health Domain

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Abstract

To know whether existing terminologies are applicable to our environments or not, we analyzed the structure of health information vocabularies and other terminologies. From this, we knew the necessity of reference terminology suitable for our environment. To make Korean reference terminology in health domain, we made three models— Meta, Conceptual, and Instance model— based on the structure of our terms. And we constructed database based on these models. Our work is expected to be a useful precedent to develop reference terminology appropriate for our environments.

Keywords:

vocabulary, controlled; Korean language

Introduction

Reference terminologies and terminology services permit retrospective and real-time aggregation, and sophisticated decision support. A reference terminology is a formal terminology where each term has a computer-usable formal definition supporting data aggregation and retrieval. Such formal terminologies promise to reduce maintenance and mapping effort [1, 2].

To accomplish and continually improve medical records documentation, improve care quality, promote patient safety, and reduce costs, we made reference terminology models.

Methods and results

Analyses

To know whether existing terminologies are applicable to our environments or not, we analyzed the structure of health information vocabularies which have been collected by National Health Information Standard Committee and other terminologies—UMLS and SNOMED CT.

Collected terms are being used in 12 departments (or domains)— Clinical Findings and Problems, Diagnoses, Operations and Procedures, Nursing, Laboratory, Imaging, Medical Device, Dentistry, Oriental Medicine, Drug, Public Health, and Health Statistics. The structure of these terms was domain specific and had various structures. We also analyzed UMLS and SNOMED CT to confirm applicable to our terms. According to analyses, we think that UMLS and SNOMED CT don't suitable for representing our terms. It is because existing terminologies could not reflect various structures of our terms and include needed terms sufficiently.

Modeling

We made three-level models based on the structure of our terms. The most abstract level is the Meta model. This model consists of Concept, Semantic class, Lexicon, concept relationship, semantic class relationship, term relationship, concept-term relationship (or consist_of relationship), and concept-semantic class relationship (or categorized_by relationship). The conceptual model is more specific than the Meta model. It is divided into the common conceptual model (CCM) and domain conceptual model (DCM). The CCM defines common properties which are applicable to all domains. The DCM defines domain specific properties. The most specific model is the instance model. It generates instances which have properties with real value and consists of skeleton tables and queries. From this model, we can obtain instances and see the integrated vocabulary structure.

DB construction

We made logical and physical schema based on our models, then we constructed DB using Oracle 10G based on these schema. We also developed user interface using Visual Studio C# .NET 2005. Through this, we could confirm our models.

Conclusions

The reference terminology which is used commonly and centrally is a prerequisite for meaningful exchange. For this, we went to work—terms analysis, modeling, and DB construction. In the future, we will develop integrated terminology system suitable for our environment.

Acknowledgments

This work was supported by a research grant of the Korea Health 21 R&D project, Ministry of Health and Welfare of Korea (A050909).

References

[1] Cimino JJ, Clayton PD, Hripcsak G, Johnson SB. Knowledge-based approaches to the maintenance of a large controlled medical terminology. *Journal of the American Medical Informatics Association* 1994;1(1):35-50.

[2] Lau LM, Johnson K, Monson K, Lam SH, Huff SM. A method for the automated mapping of laboratory results to LOINC. *Proc AMIA Symp* 2000:472-6.

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Development of Reference Terminology Model in Korean Healthcare Domain

MEDINFO 2007

Seunghee Kim[a], Yookyung Boo[a], Dongkyu Kim[b], Soyong Yoon[a], Misook Kwak[a], Yoon Kim[a]

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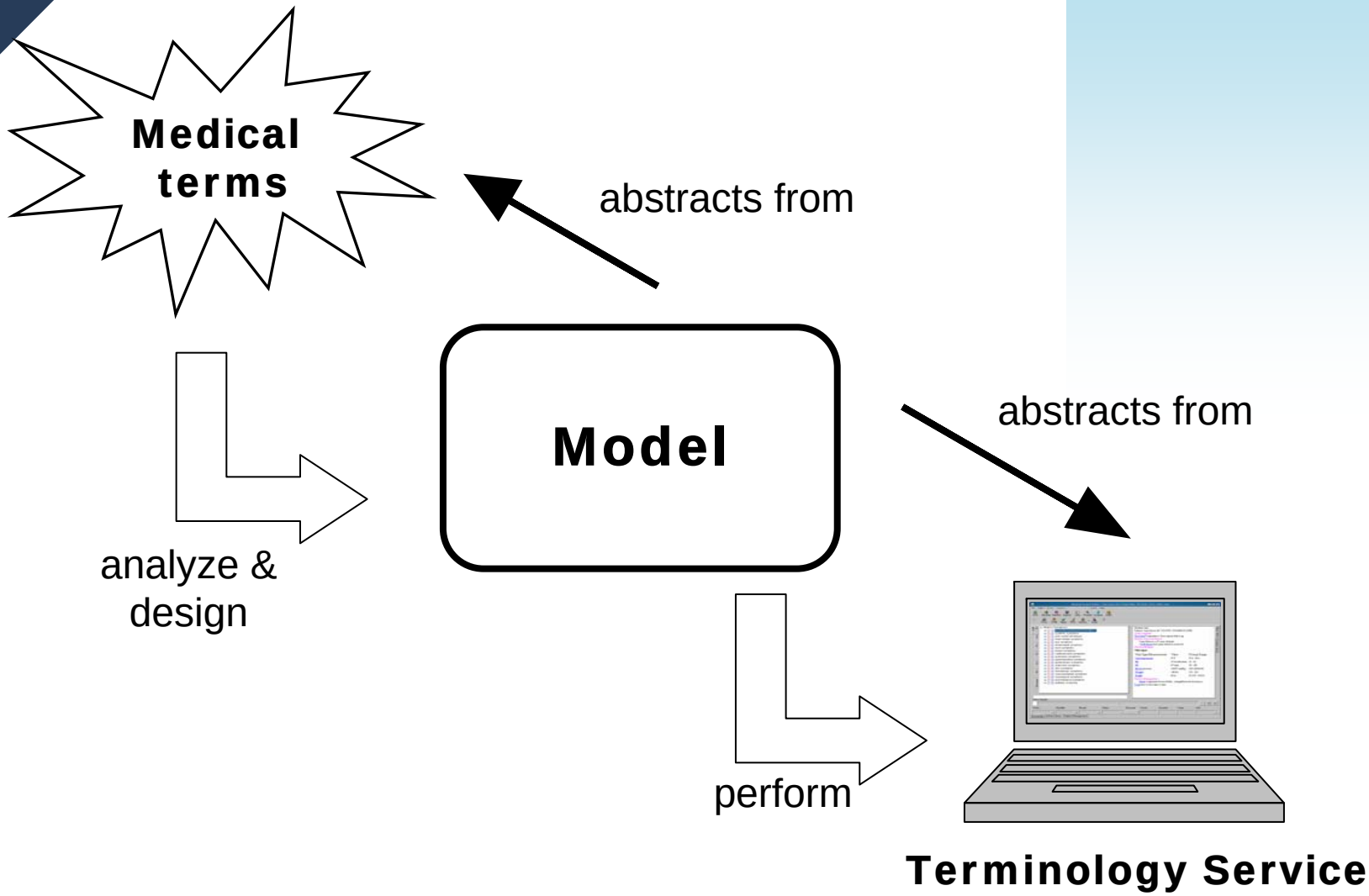
Introduction

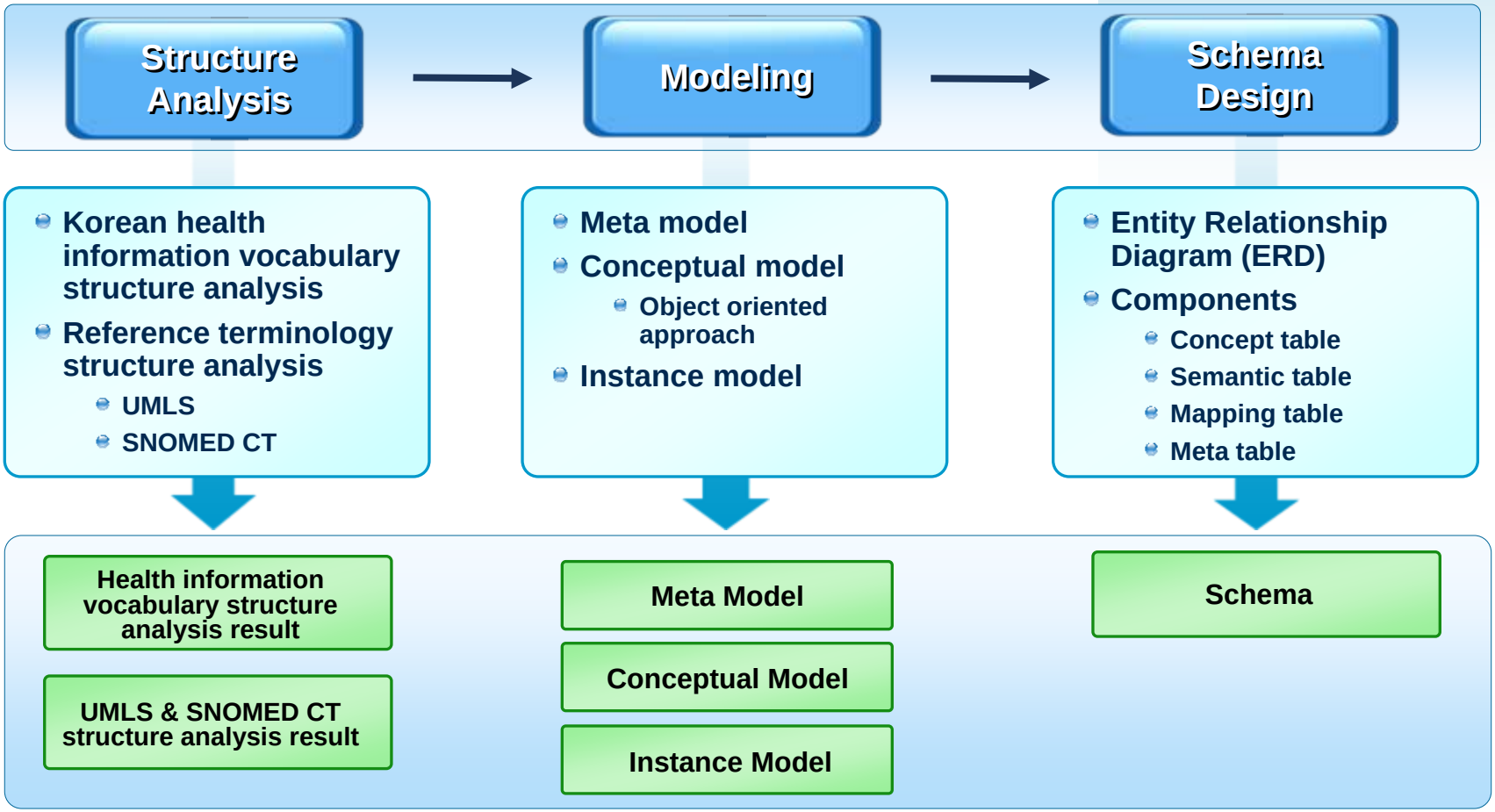
- Controlled vocabulary
  - A terminology intended for clinical use
- Data sharing and re-use
- Common, centralized vocabulary
  - Communication among applications
  - Information processing standardization
  - The overall cost reduction
- Goal
  - Modeling a controlled vocabulary for standardization as core element for interoperable EHR

Role of model



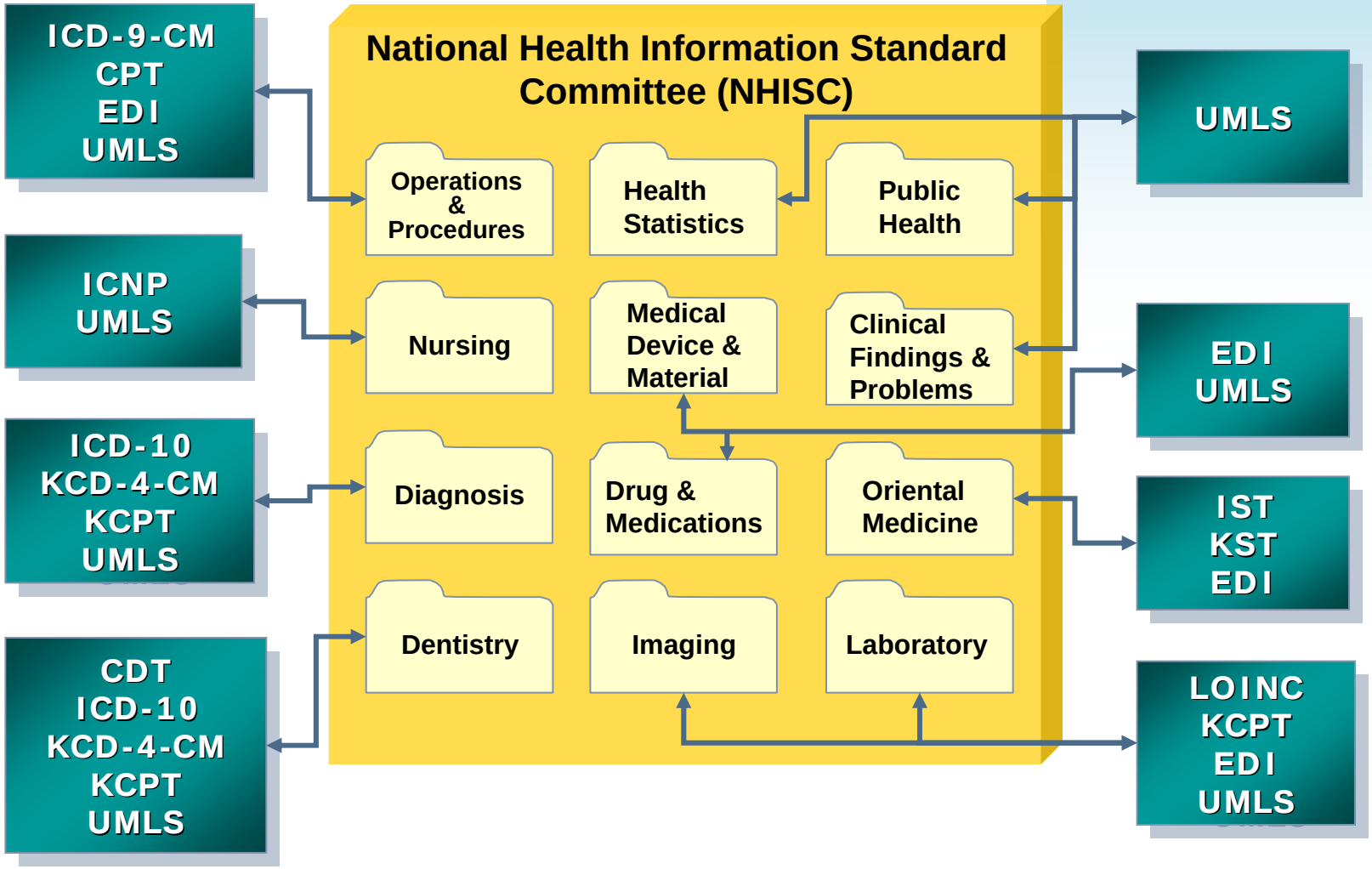
Materials & Methods

Reference terminology model development to integrate various domain vocabularies



NHISC vocabulary → UMLS → SNOMED CT

Results



Results

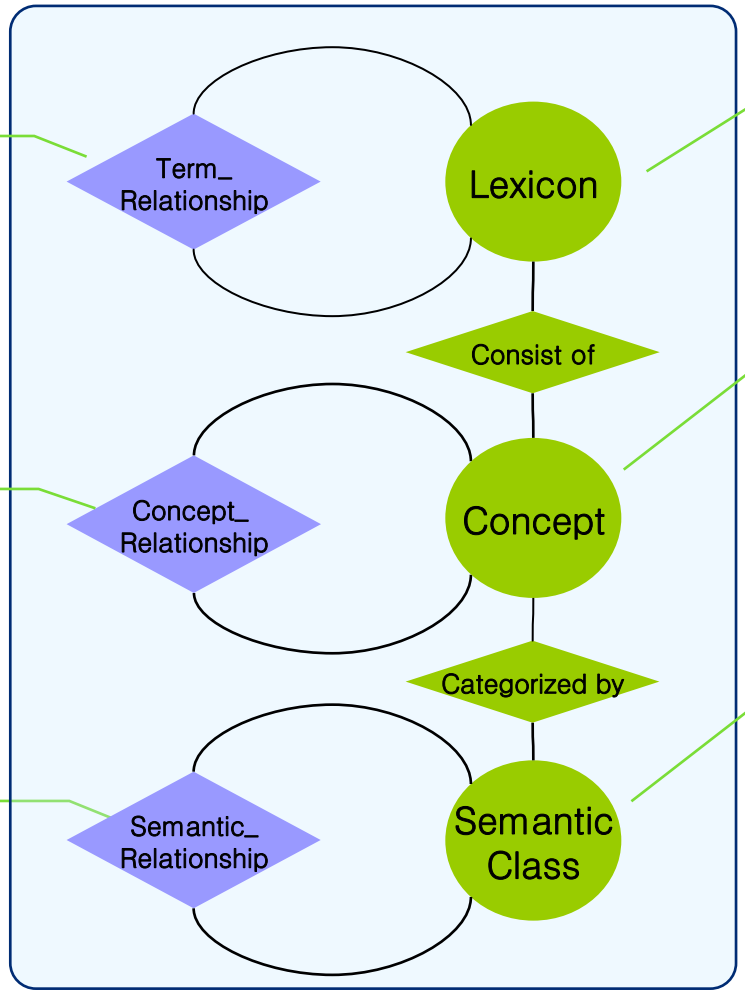
Component	UMLS tables (.RRF)	UMLS group
Metadata	MRFILES, MRCOLS, MRDOC, MRRANK	Data about the MT
Concept	MRCONSO	Concepts, Concept Names, and their sources
	MRSAT, MRDEF	Attributes
Semantic type	MRSTY	Attributes
History	MRHIST	Attributes
	CHANGE/MERGEDCUI, CHANGE/DELETEDCUI, CHANGE/DELETEDLUI, CHANGE/DELETEDSUI, MRCUI	Data about the MT
Relationship	MRREL, MRCOC, MRCXT, MRHIER	Relationships
Mapping	MRMAP, MRSMAP	Relationships
Source	MRSAB	Data about the MT
Ambiguity Concept	AMBIGLUI, AMBIGSUI	Data about the MT
Index	MRXW, MRXNW, MRXNS files	Indexes

Results

Component	SNOMED CT tables	SNOMED CT group
Concept	Concepts, Descriptions	Core Tables
Relationship	Relationships	Core Tables
Subset	Subsets, Subset Members	Subset Mechanism
Mapping	Cross Map Sets, Cross Maps, Cross Map Targets	Cross-Mapping Mechanism
History	Historical Relationships, Component History	History Mechanism
Developer Toolkit	Indexes, Canonical Table, navigation Hierarchies, Subsets, Word Equivalents, Duplicate Terms	Developer Toolkit

Meta Model → Conceptual Model → Instance Model

Results



Relation between two terms

A set of lexical for each spelling or set of spelling variants in a particular part of speech

Relation between two concepts

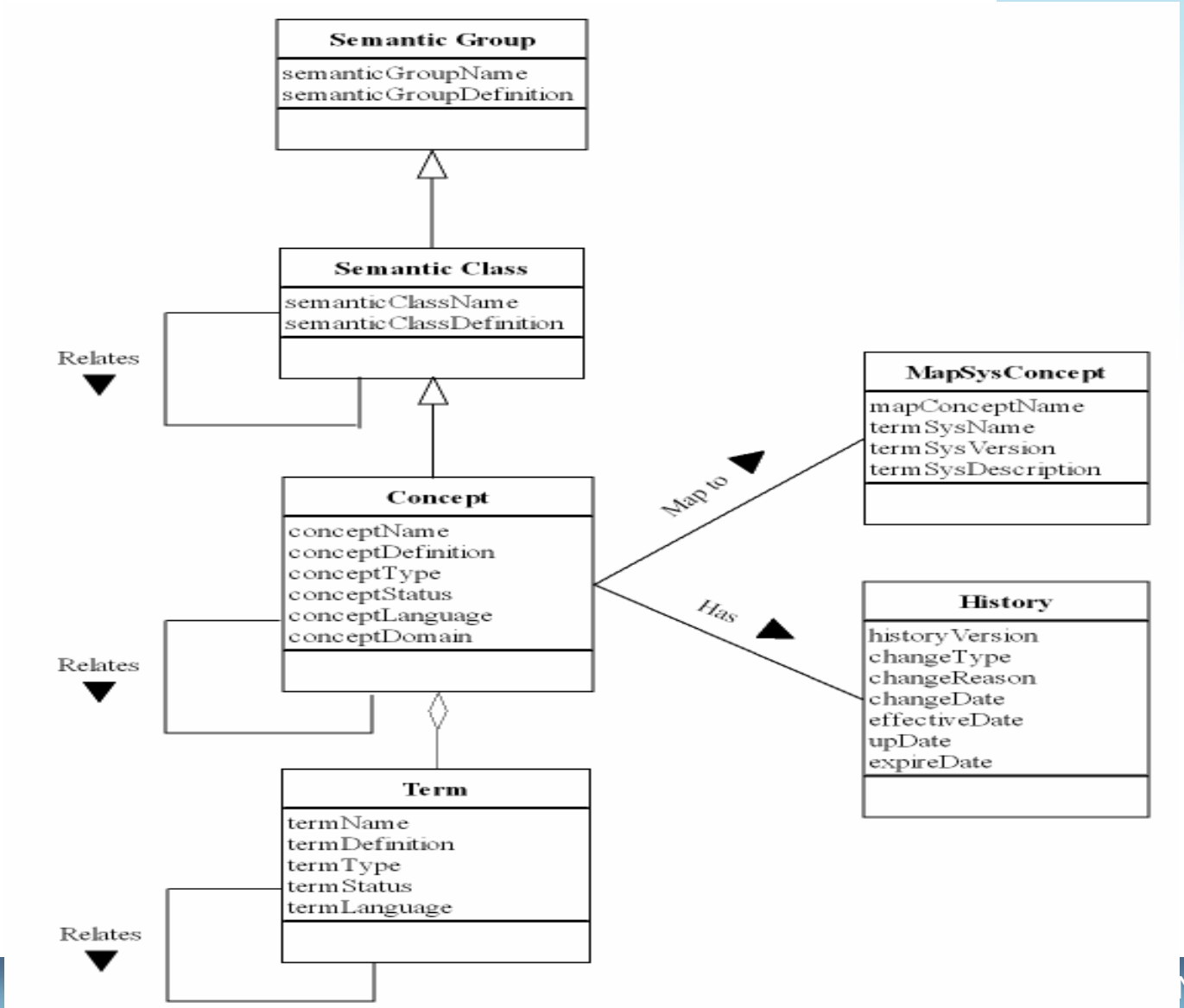
Unit of knowledge created by a unique combination of characteristics

Relation between two semantic classes

Generic concept which corresponds to two or more concepts which form a group by reason of common properties

Results

Meta Model → Conceptual Model → Instance Model



Meta Model → Conceptual Model → Instance Model

Results

Concept	CID	SYID	CNAME

Semantic_Class	SID	STYPE	SDEF	SGID	SGNAME

Concept_Semantic	CID	SID

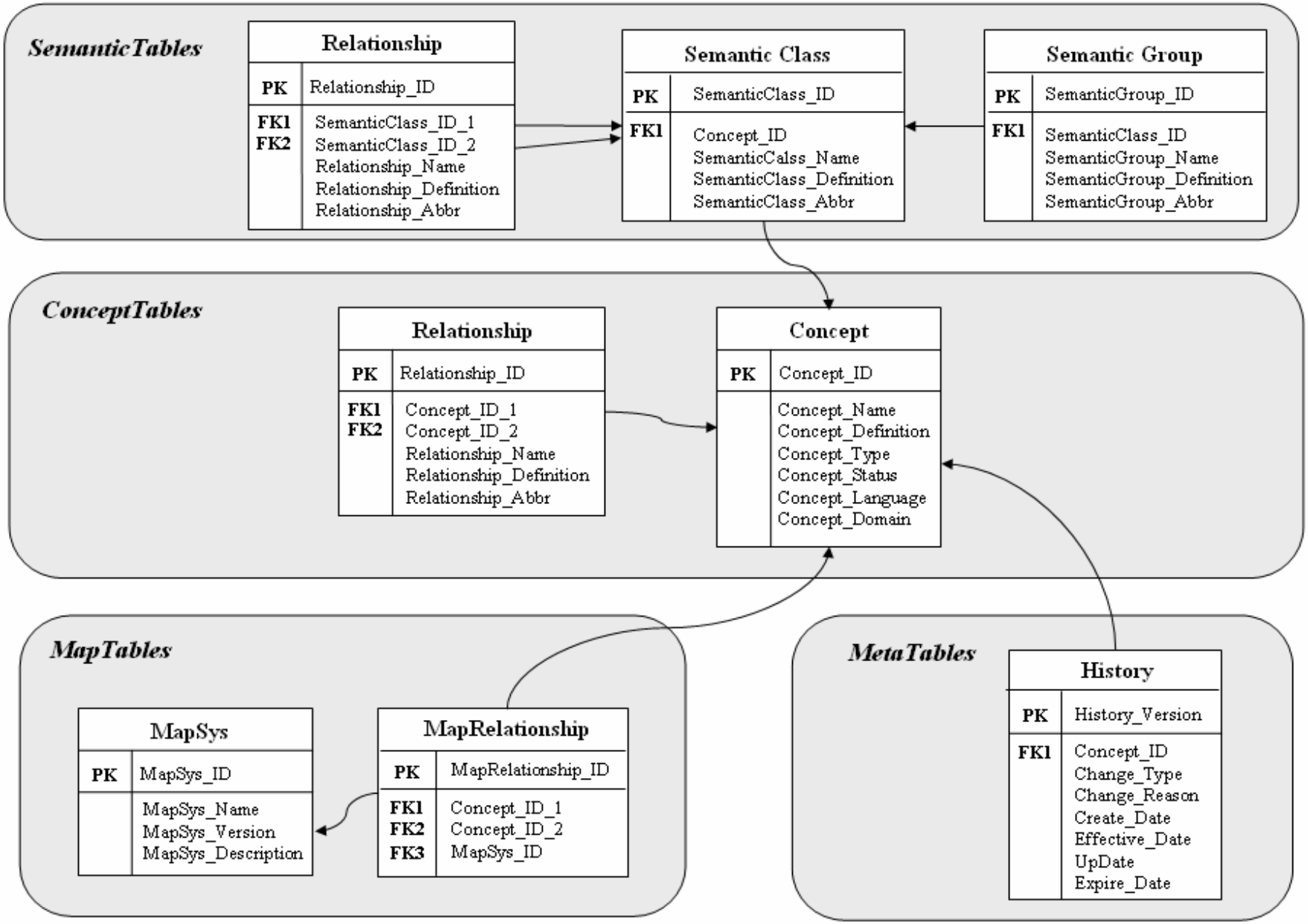
Lexicon	TID	Tense	BAS	SCA	TYP	MOD	SPV

Concept_Lexicon	CID	TID

Concept_Relationship	CRID	CID1	CID2	CREL	CCHRTYPE

⋮

Results


SemanticTables
Relationship
PK Relationship_ID
FK1 SemanticClass_ID_1
FK2 SemanticClass_ID_2
Relationship_Name
Relationship_Definition
Relationship_Abbr
Semantic Class
PK SemanticClass_ID
FK1 Concept_ID
SemanticCalss_Name
SemanticClass_Definition
SemanticClass_Abbr
Semantic Group
PK SemanticGroup_ID
FK1 SemanticClass_ID
SemanticGroup_Name
SemanticGroup_Definition
SemanticGroup_Abbr
ConceptTables
Relationship
PK Relationship_ID
FK1 Concept_ID_1
FK2 Concept_ID_2
Relationship_Name
Relationship_Definition
Relationship_Abbr
Concept
PK Concept_ID
Concept_Name
Concept_Definition
Concept_Type
Concept_Status
Concept_Language
Concept_Domain
MapTables
MapSys
PK MapSys_ID
MapSys_Name
MapSys_Version
MapSys_Description
MapRelationship
PK MapRelationship_ID
FK1 Concept_ID_1
FK2 Concept_ID_2
FK3 MapSys_ID
MetaTables
History
PK History_Version
FK1 Concept_ID
Change_Type
Change_Reason
Create_Date
Effective_Date
UpDate
Expire_Date

Conclusion

References

- Cimino JJ, Clayton PD, Hripcsak G, Johnson SB. Knowledge-based approaches to the maintenance of a large controlled medical terminology. *Journal of the American Medical Informatics Association* 1994;1(1):35-50.
- Lau LM, Johnson K, Monson K, Lam SH, Huff SM. A method for the automated mapping of laboratory results to LOINC. *Proc AMIA Symp* 2000:472-6.

Acknowledgments

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Mapping of Korean Healthcare Vocabulary to the UMLS

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[a] *R & D Center for Interoperable EHR, Korea*

Abstract

The UMLS is used for research and development across wide range of different applications. In this paper, we evaluated the coverage of the UMLS as mapped with healthcare vocabularies in Korea. Of the 216,697 terms, 42% were matched with the UMLS concepts exactly. We then analyzed unmatched terms. There were various reasons why 58% of our terms were unmatched with the UMLS concepts.

Keywords:

vocabulary, controlled; Korean language; UMLS

Introduction

There is an increasing need for successful terminology mapping to achieve compatibility among terminologies and to allow clinicians and researchers familiar with one terminology to search and use other terminology schemes [1]. The Unified Medical Language System (UMLS) has incorporated over 100 sources into one database [2].

In this study, we evaluated the coverage of the UMLS as mapped our terms to the UMLS Metathesaurus (MT) using string matching tool. Then, we analyzed mapping results.

Methods and results

Mapping to the UMLS MT

The National Health Information Standard Committee collected healthcare vocabularies which are used in twelve departments (or domains)—Clinical Findings and Problems, Diagnoses, Operations and Procedures, Nursing, Laboratory, Imaging, Medical Device, Dentistry, Oriental Medicine, Drug, Public Health, and Health Statistics—for standardization of healthcare vocabulary.

We mapped 216,697 healthcare vocabularies to the UMLS MT using string matching tool which was developed by the Vocabulary Server Development team in the Interoperable EHR Center. The mapping results are provided in Table 1.

Analysis mapping results

Of the total terms, 91,056 (42%) terms matched with the UMLS MT exactly. The Diagnoses had highest mapping percentage and the Medical Device had lowest mapping percentage. Un-mapping terms were the Korean alphabets (Hangul), composite concepts, misspellings, and domain specific terms. There were some of un-mapping terms which were included conceptually in the UMLS MT, because we did only string matching. From this result, we could know coverage of the UMLS MT. The UMLS MT has many terms which are related to diagnoses, laboratory, operations and procedures, and clinical findings and problems. On the other hand, the UMLS MT has a few terms which are related to medical device, imaging, drug, and oriental medicine.

Table 1 – Mapping Result to the UMLS MT

Domain	Matched terms (%)	Unmatched terms (%)	Total
Clinical Findings & Problems	39,927 (61.0)	25,523 (39.0)	65,450
Diagnoses	24,453 (84.8)	4,381 (15.0)	28,834
Operations & Procedures	5,661 (74.7)	1,915 (25.0)	7,576
Nursing	93 (12.8)	634 (87.0)	727
Laboratory	13,256 (79.5)	3,412 (20.0)	16,668
Imaging	5 (0.1)	3,888 (99.9)	3,893
Medical Device	0 (0.0)	130 (100.0)	130
Dentistry	5,867 (27.1)	15,763 (73.0)	21,630
Oriental Medicine	76 (2.1)	3,534 (98.0)	3,610
Drug	395 (0.6)	65,045 (99.0)	65,440
Public Health	1,313 (54.0)	1,117 (46.0)	2,430
Health Statistics	10 (3.2)	299 (97.0)	309
Total	**91,056 (42.0)**	**125,641 (58.0)**	**216,697**

Conclusions

The high percentage of medically relevant unmatched terms is attributed to a variety of factors. The UMLS MT has incomplete synonyms and absent concepts. Also, healthcare vocabularies have different term structures to the UMLS MT and misspellings.

Acknowledgments

This study was supported by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare, Republic of Korea (A050909).

References

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[2] UMLS Knowledge Sources. Bethesda (MD): National Library of Medicine, 2006AA.

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Mapping of Korean Healthcare Vocabulary to the UMLS

MEDINFO 2007

Yookyung Boo[a], Seunghee Kim[a], Misook Kwak[a], Soyong Yoon[a], Yoon Kim[a]

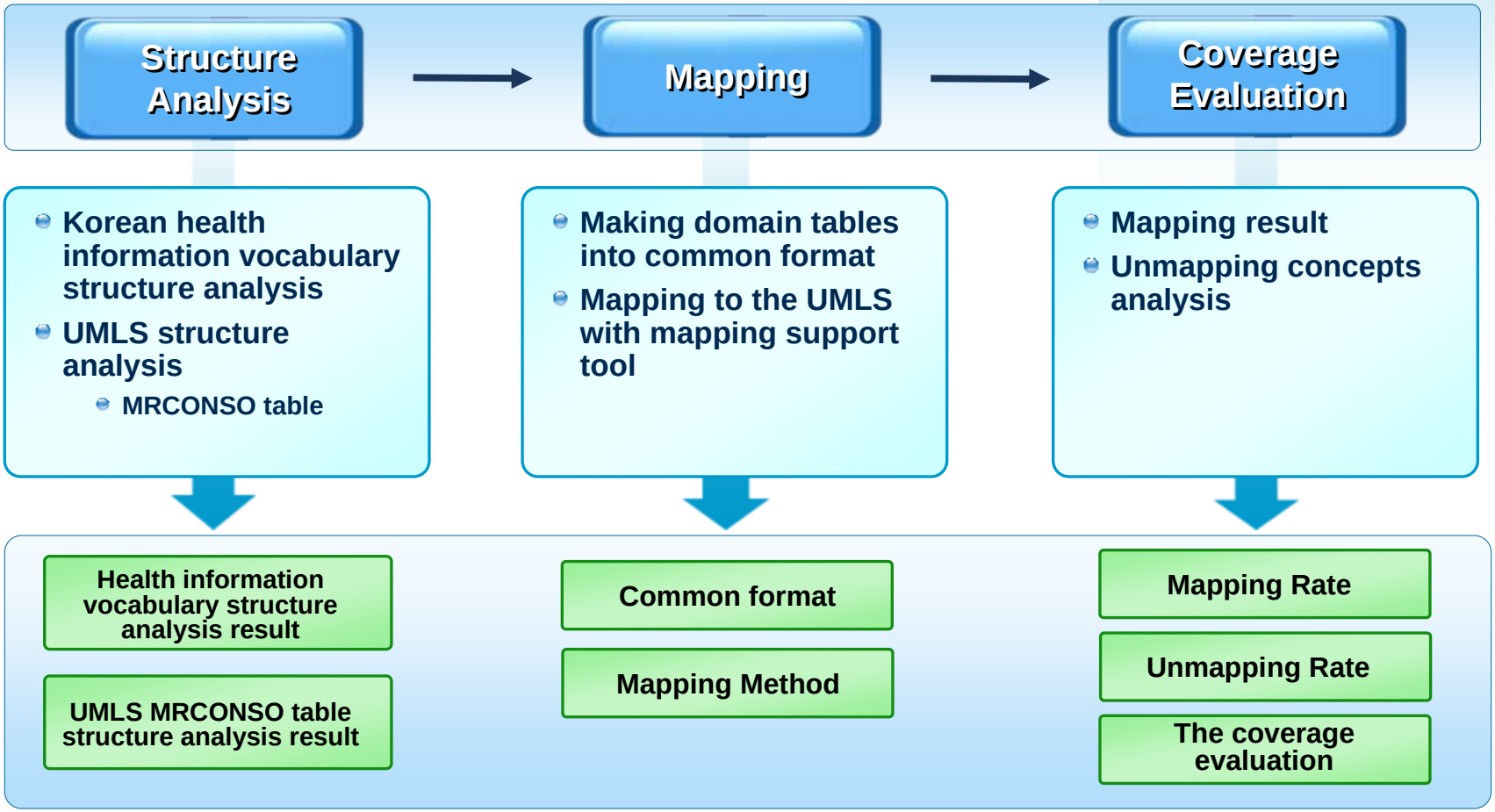
[a] R & D Center for Interoperable EHR, Korea

Introduction

- An increasing need for successful terminology mapping
  - To achieve compatibility among terminologies
  - To allow clinicians and researchers familiar with one terminology to search and use other terminology schemes
- the Unified Medical Language System (UMLS)
  - To facilitate the development of computer systems that behave as if they “understand” the meaning of the language of biomedicine and health
- Goal
  - To evaluate the coverage of the UMLS as compared with medical terms collected by the National Health Information Standard Committee (NHISC)

Materials & Methods

Mapping of Korean health information vocabulary to the UMLS to evaluate the coverage of the UMLS



NHISC vocabulary → UMLS MRCONSO

Results

Number, Concept ID, Concept Name (Korean), Concept Name (English), Semantic Type, Definition, Source of data, Format type, Length, Created date, Expired date, Status

Standard Code, Product Name, Generic Name, Usage, Classified Number, Company, Name, Standard, Material Quality, Insurance Code…

Number, CUI, T classifier, KCD4 code, Concept Name (English), Synonym (English), Abbreviation, Concept Name (Korean), Concept Name (KCD4), Synonym (Korean), Using Domain

National Health Information Standard Committee (NHISC)

- Operations & Procedures
- Health Statistics
- Public Health
- Nursing
- Medical Device & Material
- Clinical Findings & Problems
- Diagnosis
- Drug & Medications
- Oriental Medicine
- Dentistry
- Imaging
- Laboratory

Business Domain, Control Number, ConceptID, Concept Name (Korean), Concept Name (English), Semantic Type, Definition, Source, Source of Data, Synonym

Control Number, CUI, Preferred Name (English), Preferred Name (Korean), Definition, Created date, Expired date, Status

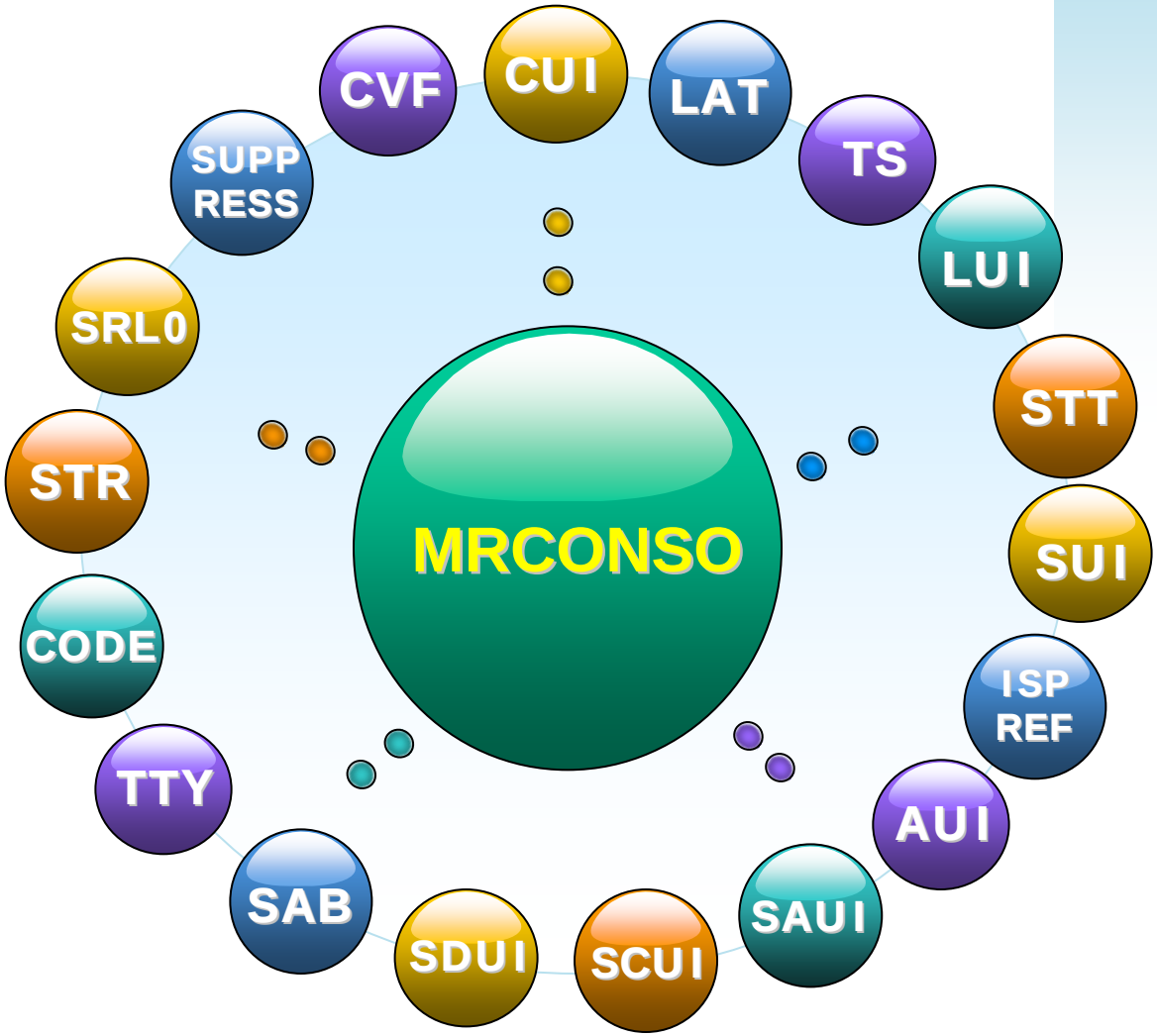
Number, EDI, Concept Name (Korean), Concept Name (English), Classified Name, CUI, Synonym Mapping Identifier

New K code, LOINC_NUM, CUI, Component, Property, Time_aspct, System, Scale_typ, Method_typ, Class, Insurance code, Insurance Name, Short name, Synonym

Very various & complex

Results

NHISC vocabulary → UMLS MRCONSO



Results

Common Format → Mapping Method

Control Number	Concept Identifier	Preferred Name (English)	Preferred Name (Korean)	Semantic Type	Definition
1	K0000726	Abdomen	배, 복부	Body Location or Region	That portion of the body that lies between the THORAX and the PELVIS
2	K0000729	Abdominal Cramps		Sign or Symptom	
3	K0000731	Abdominal distension	복부팽만	Finding	
4	K0000733	Abdominal Injuries	복부손상	Injury or Poisoning	General or unspecified injuries involving organs in the abdominal cavity
5	K0000734	Abdominal mass	복부종괴	Finding	
6	K0000737	Abdominal Pain	복통	Sign or Symptom	Sensation of discomfort, distress, or agony in the abdominal region; generally associated with functional disorders, tissue injuries, or diseases

Common Format → Mapping Method

Results

NHISC common fields

Control Number	Concept Identifier	Preferred Name (English)	Preferred Name (Korean)	Semantic Type	Definition
1	K0000726	Abdomen	배, 복부	Body Location or Region	That portion of the body that lies between the THORAX and the PELVIS
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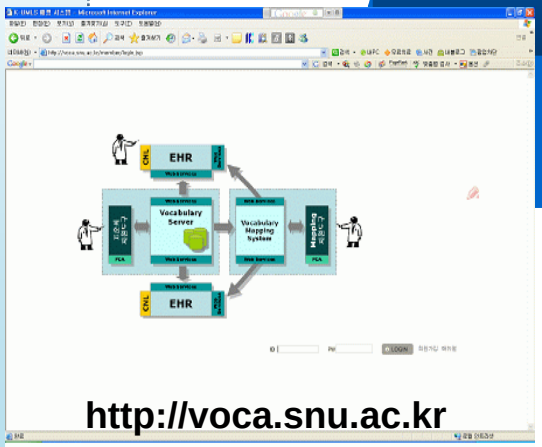
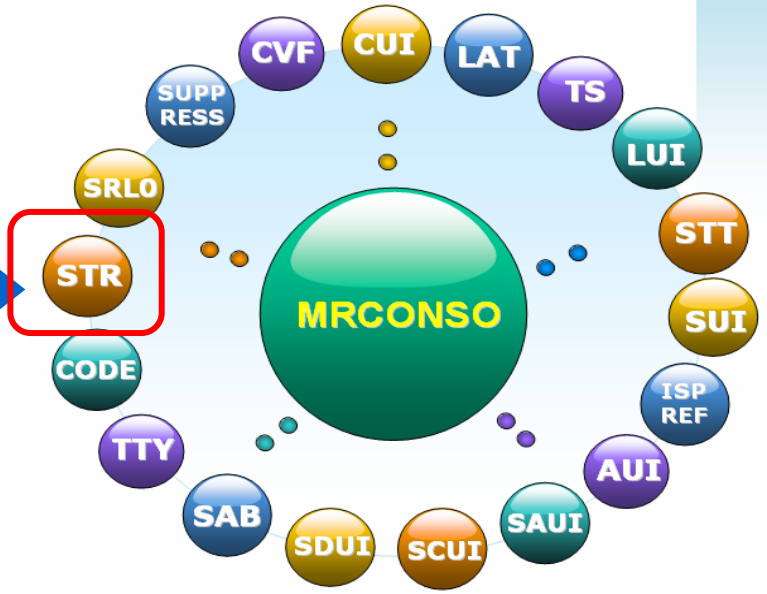
Mapping support tool



http://voca.snu.ac.kr

Exact String Matching



Results

Domain	Matched terms (%)	Unmatched terms (%)	Total
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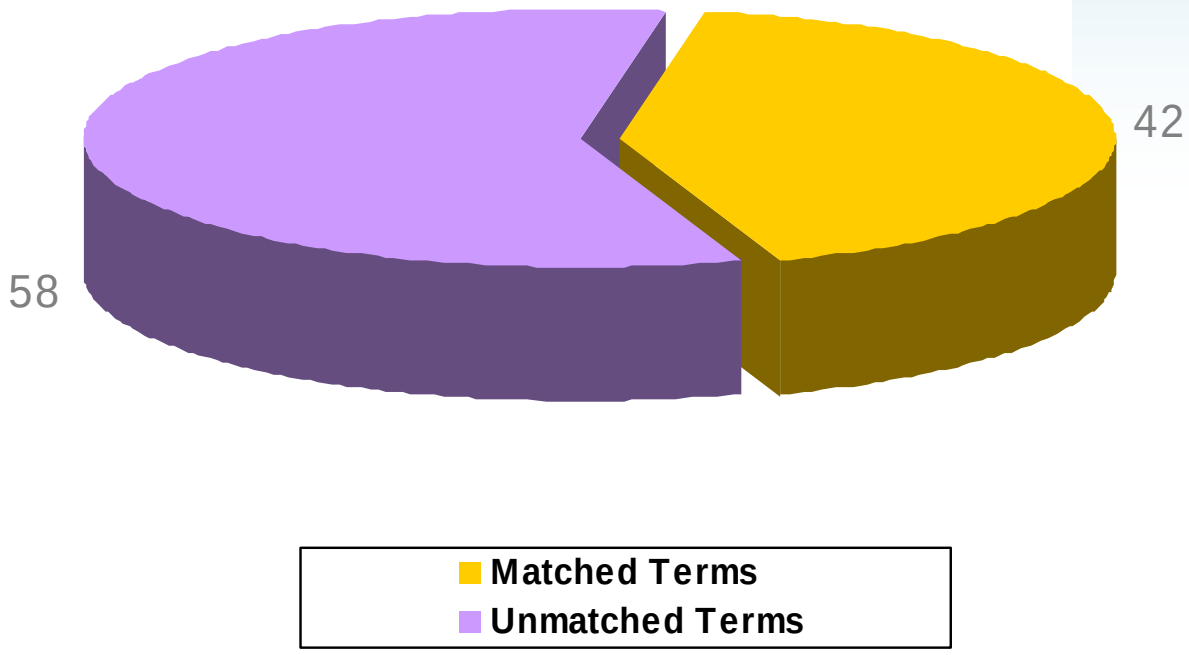
Total	91,056 (42.0)	125,641 (58.0)	216,697

Results



Results

Diagnoses Domain

- The highest mapping rate (84.8%)
- This domain collected concepts based on the UMLS ones

Medical Device Domain

- The lowest mapping rate (0%)
- This domain has product names, but UMLS doesn't have these concepts

Results

- Unmapping concepts analysis
  - Korean Concepts
  - Composite Concepts
  - Misspelling Concepts
  - Etc.
- Because we did only string match, there were some of un-mapping terms which were included conceptually in the UMLS MT
- The UMLS MT has many terms
  - which are related to diagnoses, laboratory, operations and procedures, and clinical findings and problems
- The UMLS MT has a few terms
  - which are related to medical device, imaging, drug, and oriental medicine

Conclusion

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An Analysis for the Automated Mapping of Laboratory Data with Logical Observation Identifier Names and Codes (LOINC)

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Abstract

Logical Observation Identifiers Names and Codes(LOINC) set is the only publicly available universal standard for laboratory test names essential for Electronic Medical Record(EMR) system. Although Regenstrief Institute maintaining the LOINC database provide an automatic LOINC mapping tool (RELMA), It is not sufficient for applying LOINC code set to Laboratory Information System (LIS) of local hospital. LOINC code has up to six attributes and if one of six attributes has the different value, it means different LOINC code is defined. Because many local hospitals have used their own LIS with arbitrary codes witch is not followed by LOINC attributes and some does contain several same attributes, one code of LIS system would match with several LOINC codes. So we cannot help developing protocols and tools to match codes of LIS system to codes of LOINC as one to one. As we have been develop automatic tools to connect LIS system of Pusan National University Hospital (PNUH) with LOINC. Ant it may be valuable as facilities for applying of LOINC code set essential for EMR system to the local hospitals witch has their own LIS system.

Keywords:

logical observation identifiers names and codes; electronic medical record; laboratory information system

Introduction

Development of information technology is bringing many changes to our lives, and such processes of change can also be experienced in the medical environment. Developments are also being made in the public health areas so that data can be automatically retrieved and analyzed, and such data are already being used in the form of electronic documents and being integrated into the Public Healthcare Information System. The Hospital Information System (HIS), enhances information accessibility in the aspects of patient diagnosis, education, research, and heath care management and affects the medical profession in various ways. With Information Technology, HIS surpasses the scope of an automated tool and is evolving as Electronic Medical Record Systems, EMRS.

According to materials that studied status of hospital informationalization at approximately 122 large scale medical facilities including general hospitals, 88.1% are equipped with the Hospital Order Communication System and 9.2% are equipped with the Electronic Medical Records System. As a useful tool that can overcome the restrictions of time and space, access to EMRs is possible anywhere and any time a computer is available, therefore, it is being expanded into various fields such as remote diagnosis and remote education [1].

In order to provide appropriate information that is needed in many areas such as diagnosis and research using the Electronic Medical Records System, the significance and the essence of the data to be used must be communicated accurately to the user or to the user's computer. In reality, however, accurate expression and maintenance of accurate medical records of patients' conditions and their progress of treatment is something that is difficult to accomplish, and exchange of information is also impossible. The main reason is for these difficulties is because majority of hospitals independently operate and manage their HIS or EMRs of medical records. Majority of HIS or EMRs that are being utilized are being operated based on a Relational Database Management System, and because information and data are being expressed based on the relationship between specific key values that are unique to each hospital, accurate communication and transmission of information between disparate systems cannot be accomplished. In addition, since independent systems have been constructed using code switching, message exchange between Disparate Systems are impossible. In order to extract the massive information neglected in independently constructed systems for use as knowledge source and to communicate accurate meaning of medical records through information exchange and sharing between each facility, use of Standard Vocabulary is necessary. Currently, various studies on standard vocabulary systems including Unified Medical Language System (UMLS) [2], Systematized Nomenclature of Human and Veterinary

Medicine Clinical Term (SNOMED-CT) [3], Logical Observation Identifier Names and Codes (LOINC) [4], and International Classification of Diseases Version 10(ICD10) [5] are in progress.

LOINC is a general standard vocabulary system that is used for expressing medical diagnosis results, and of all forms of medical information, a medical diagnosis result is the most objective form of information that expresses and displays the condition of the patient. Also, by providing basic materials with which treatments are made, it is also extremely important in a clinical environment. Standardization of medical diagnosis results not only saves waiting period for patients when transferring to a different hospital or when sharing information between medical facilities it also serves as the basis for Evidence Based Medicine (EBM) [6].

Materials and methods

We have been mapping the LOINC for Local code of 183 blood chemistry in LIS. We need Link code's generation to connect Local code and LOINC code for Automated LOINC mapping.

Logical Observation Identifier Names and Codes

The Logical Observation Identifier Names and Codes (LOINC) code set is the only publicly available universal standard for laboratory test names [7-9]. The current version of the LOINC code set, maintained by the Regenstrief Institute, contains more than 33,000 observations. Each LOINC record corresponds to a single test result and includes fields for specifying component (analyte), property measured, timing, type of scale, and, where relevant, the method used to property measured, timing, type of sample, type of sample, type of scale, and, where relevant, the method used to produce the result. Therefore, each LOINC code has up to six attributes and belongs to a class or group (e.g., Chemistry, Microbiology). The purpose of the LOINC is to facilitate the exchange and pooling of results, such as blood hemoglobin, serum potassium, or vital signs, for clinical care, outcomes management, and research [10,11].

Local Terminology

The Local Terminology (LT) being utilized is organized in the form in which alphabetic code or acronym of classification codes are documented and expanded into a numeric code based on an independent classification system (Figure 1)

Table 1 – LOINC specimen abbreviation to available in LOINC database

Specimen code	Specimen code name	LOINC specimen abbreviation
A0	Blood, Plain tube	SER/PLAS
C0	Body fluid	FLD
C4	Cerebrospinal fluid(CSF)	CSF
C7	Body fluid, gastrointestinal	GAST
C8	Joint(synovial) fluid	SNV
CB	Peritoneal(ascetic) fluid	PRT
CC	Pleural fluid	PLR
Y0	Urine	UR

This is the form most commonly used by majority of HIS being operated based on RDBMS. LT is linked with specimen code more than one in single laboratory code [12]. However, LOINC must recognize by laboratory test that same test is different if specimen is different. Therefore, we created link code so that compose of LT and specimen code. As a result, LT could correspond with LOINC code (Fig. 1).

Lab. Code	Specimen code	Specimen code name	Tube code	tube	unit
LCLDH	A0	Blood, Plain tube	55	SST tube	IU/L
LCLDH	C0	Body fluid	37	Plain tube	IU/L
LCLDH	C4	Cerebrospinal fluid	37	Plain tube	IU/L
LCLDH	CC	Pleural fluid	37	Plain tube	IU/L
LCLDH	Y0	Urine	28	Culture cup	IU/L

LCLDHY0

Figure 1- LT of PNUH and formation of Link code for LOINC

Development tools

For the purpose of this study, in order to map and simulate the LT being used at a university hospital with the LOINC, Oracle 10g DBMS Version 10.0.2, a relational database management system by Oracle was installed on a PC. In addition, for development and management of an efficient database, Toad for Oracle Freeware Version 8.0.5.5 by QuestSoft was used as a Database Managing Tool and for development to User Interface of the application for viewing LIS (Laboratory Information System) results, Visual Basic 6.0 Enterprise by Microsoft was utilized.

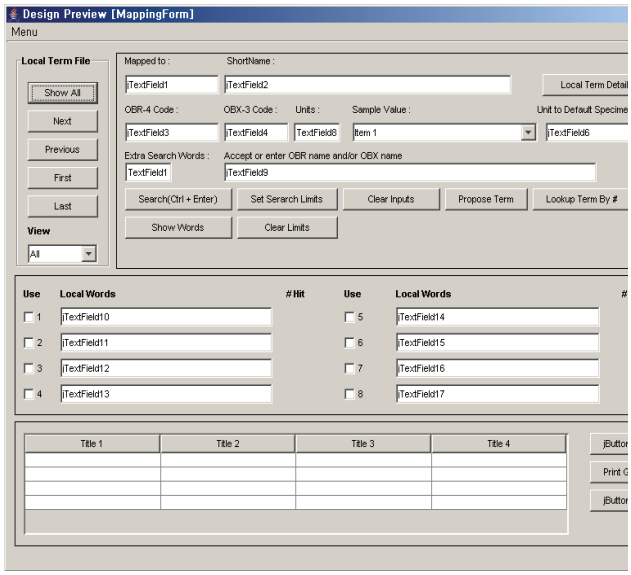

Figure 2- Screen capture of original mapping program, in mapping process

Natural Language Processing

The above figure represents the natural language processing. In this process, there are two steps such as normalization process and words index. Normalization process is get local terminology as input, it convert this string to uppercase string. And then process split string into array of words, and eliminate all of special characters such as ‘, “, ?, etc. Eventually, the process will give array of words as result [12, 13].

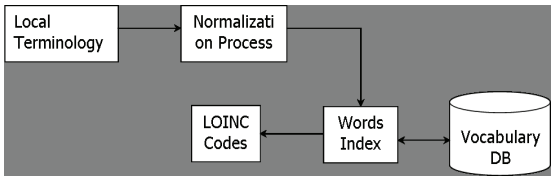

Figure 3- Natural language process

The words Index process gets result of Normalization process as input data. Each word is used in order to look for LOINC within Vocabulary database. Eventually, the output is LOINC that related to LT. In the summary, the natural language processing is used for looking for all of LOINC that related to Local terminologies.

KEYWORD	LOINC_NUM
ABXBACT	91-9
ABXBACT	92-7
ABXBACT	93-5
ABXBACT	94-3
ABXBACT	95-0
ABXBACT	96-8
ABXBACT	97-6
ABXBACT	98-4
ABXBACT	99-2
ABY	1000-9
ABY	1001-7
ABY	1002-5
ABY	1010-8
ABY	1011-6
ABY	1012-4
ABY	1016-5
ABY	1017-3
ABY	1018-1

Figure 4- Results of Natural language process

Vocabulary database includes LOINC table, keywords table, hierarchy data, and so on. The keywords table is called dictionary. The words index process use keywords table in order to look for LOINC.

Results

137 codes (excepted battery item of 183 Link code) did automatic mapping by results of 133 (97%). The failed Link code did Mapping in LOINC manually. Table 2 is result for automated LOINC mapping tools.

Table 2- Result for automated LOINC mapping tools

Specimen code name	**Code Link**	**LOINC**
Body fluid	LCLDHC0	22989-1
Cerebrospinal fluid(CSF)	LCLDHC4	22958-7
Body fluid, gastrointestinal	LCLDHC7	22989-1
Joint(synovial) fluid	LCLDHC8	23141-3
Peritoneal(ascetic) fluid	LCLDHCB	22989-1
Pleural fluid	LCLDHCC	23019-5
Urine	LCLDHY0	22958-7

This study was conducted in order to identify a method for efficient information exchange between disparate systems through informationalization of massive medical data that are stored in independent HIS. For the purpose of the study, 183 chemistry codes being utilized at a university hospital were randomly selected and mapped with LOINC, and as can be seen in Table 2, in a single examining room UI, independent use of LT or LOINC is possible, and mixed use is also possible. At this time, items that are displayed to the user are only partially shown, and because information that are internally hidden includes various types of information as seen possibility of efficient information exchange with a disparate system was verified.

Therefore, user convenience in an independent HIS can be secured by utilizing a LT and information exchange with disparate systems can be accomplished by utilizing the HL7 Interface Engine of the LOINC.

Discussion

In this study, by mapping diagnosis results codes and their expression methods that are currently being utilized in hospitals with standardized codes, a fundamental study for standardized information sharing of medical information and Evidence Based Medicine was conducted. Of all medical records, medical diagnosis result is the most objective information that provides reliable data. LT being independently used in hospitals can be applied and utilized various ways within each hospital, but because the vocabulary system of each hospital are completely different, diagnosis results of one facility cannot be used directly at another facility. In order to extract and exchange the massive amount of information stored within medical information systems as knowledge information, a study on a method for efficiently utilizing a standardized vocabulary system must be conducted.

An applicability of a standard vocabulary system was evaluated by mapping an LT of a hospital system with LOINC, an international standard coding system; and rather than terminating the study at standardization of codes, a database was designed to maintain their 6 axial forms so that the information to be exchanged can remain their compatibility. Driven by development of information technology and specialization of medical technology, importance and need for real time remote diagnosis and exchange of medical information between hospitals are increasing. This study is scientifically significant because it serves as substantial basic work for electronic data exchanges in the medical environment.

Acknowledgments

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RxNav: Towards an Integrated View on Drug Information

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RxNav[1] is a browser for *RxNorm*[2], a controlled vocabulary of normalized names for clinical drugs. *RxNav* displays links from clinical drugs, both branded and generic, to their active ingredients, drug components and related brand names. The current dataset (March 1, 2007) comprises 5,604 ingredients, 11,363 brand names, 13,509 clinical drug components, 17,726 clinical drugs, 14,064 branded drugs, 13,460 branded drug component, 8,311 clinical drug forms, 11,033 branded drug forms and 140 dose forms. *RxNorm* is one of a suite of designated standards for use in U.S. Federal Government systems for the electronic exchange of clinical health information.

RxNav was first developed as an interface to the *RxNorm* database and was thus restricted to displaying relations among drug names. However, besides terminology, other drug-related information could be displayed in and integrated through *RxNav*, including pharmacologic action, drug-drug interactions, indications and contraindications, adverse reactions, etc. RxNav could also provide better integration with other drug information such as the drug labeling resource *DailyMed*[3]. We give a brief review of some of the changes planned for *RxNav* in the near future, with the objective of ultimately providing an integrated view on drug information.

Equivalent names and codes

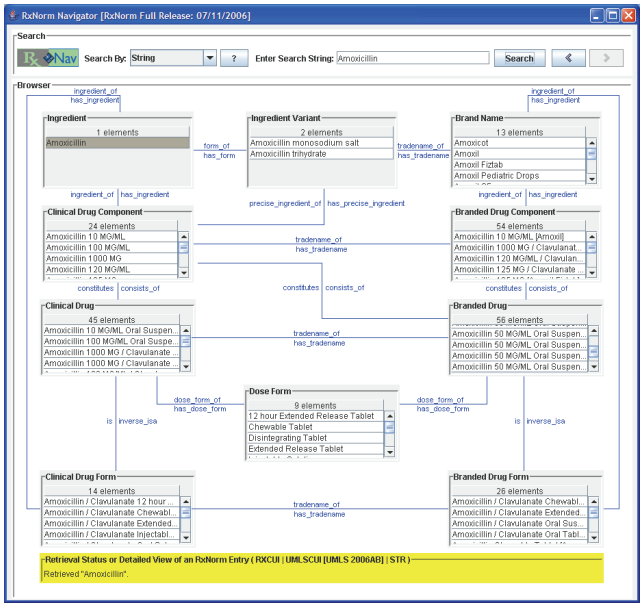
RxNorm covers many of the drug vocabularies commonly used and organizes the different names for a given drug entity into a concept. Because of intellectual property restrictions imposed by some sources, *RxNav* only displays the normalized name created by *RxNorm* for a given entity. A new function will soon be added to *RxNav*, allowing users who have obtained the required licenses to access the name of drug entities in specific sources to find equivalences between drug names across sources. Examples of equivalent names include “Acetaminophen”, “APAP”, and “Paracetamol”, whose corresponding equivalent codes include RXCUI:227257, BRAND_CODE:2177, etc.

Clinical information from UMLS source vocabularies

While most curated clinical information about drugs is compiled in proprietary knowledge bases, some of it is publicly available through resources such as the NLM’s *Medical Subject Headings* (MeSH) and the Veterans Administration’s *National Drug File Reference Terminology* (NDF RT). *MeSH* provides information about pharmacological action and *NDF RT* about indications and pharmacokinetics. Like *RxNorm*, both *MeSH* and *NDF RT* are source vocabularies in the *Unified medical Language System* (UMLS) Metathesaurus, making it easy to integrate the information they provide.

Links from RxNav to applications

Because it already provides an interface to drug names, with services such as specific spelling correction and correspondence between equivalent names, RxNav will provide an excellent entry point to applications such as the drug labeling resource *DailyMed* and medication list applications developed as part of personalized health records (e.g., *MyMedicationList*).



RxNav screenshot for Amoxicillin

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1 http://mor.nlm.nih.gov/download/rxnav/
2 http://www.nlm.nih.gov/research/umls/rxnorm_main.html
3 http://dailymed.nlm.nih.gov/

Semantic Interoperability and SNOMED CT: A Case Study in Clinical Problem Lists

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Abstract

Sharing clinical data between institutions requires a shared semantic model and reproducible metrics for comparing post-coordinated clinical record data. We evaluated the interoperable features of SNOMED CT by merging and comparing SNOMED problem list dictionaries between primary care sites in Nebraska and Argentina.

The two problem subsets had modest differences in semantic content, but differed substantially in frequency of post-coordinated content. 64.3% of the final merged problem vocabulary was post-coordinated. 0.9% of the merged concept set was found to have semantic duplication. Classification employing SNOMED Normal Forms was found to effectively identify semantic equivalency in 65.2% of cases studied.

The most frequent reasons for failure of the classification procedures included: post-coordination not compliant with SNOMED guidelines (28.8% of cases), conflicting guidance presented in SNOMED pre-coordinated content (3.6%), unclear definition of source clinical concepts (1.2%), and limited expressiveness of the SNOMED definitional model (1.2%).

We conclude that interoperable post-coordination employing SNOMED CT is feasible, but that better dissemination of SNOMED editorial guidelines, refinement of the concept model and training of the user community will be required for reproducible and reliable implementation.

Introduction

- Semantic interoperability requires that advanced compositional vocabularies such as SNOMED CT[1] support computation of equivalence between post-coordinated concepts authored at disparate sites
- Advancing to multi-national status with formation of a new international standards development organization[2], SNOMED CT must reliably support interoperability world-wide
- We analyzed the validity of algorithms for testing of semantic equivalence while comparing SNOMED problem lists at two institutions

Methods: Study sites

- University of Nebraska Medical Center; Omaha, NE, USA

  Clinics of the University of Nebraska Medical Center employ the GE Centricity Enterprise record which includes problem list and assessment functions with SNOMED CT as coding reference. Employing "just-in-time" post-coordination[3], UNMC has developed an extension to SNOMED CT which includes 6% post-coordinated concepts within a problem data dictionary of 9800 concepts and 14500 interface terms.

- Hospital Italiano; Buenos Aires, Argentina

  Hospital Italiano is a non-profit university hospital, associated with a large network of ambulatory care services, located in Buenos Aires, Argentina. Hospital Italiano employs a health information system developed in-house including an institution wide electronic medical record supporting all levels of care. Clinical data entry uses a local interface terminology for diagnosis and procedures. This terminology was created from 2 million terms of free text recorded by local users in legacy systems. Every concept from the terminology has been coded with SNOMED CT. Current Hospital Italiano terminology has 24,800 concepts and more than 100,000 interface terms, with approximately 70% post-coordinated content.

Methods

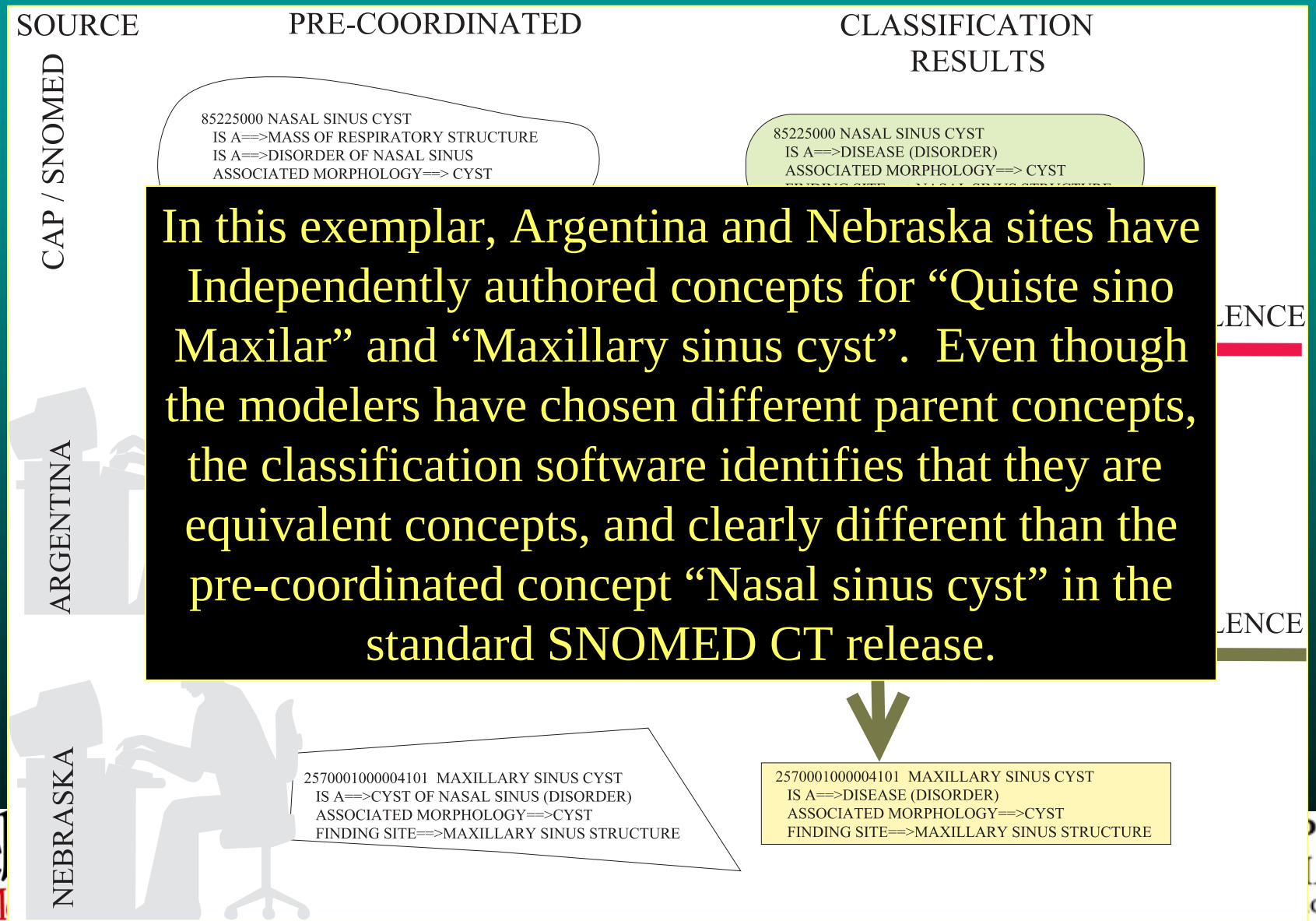
- SNOMED CT problem lists were merged and compared in order to develop a shared problem list vocabulary for primary care
- The merged concept inventory was processed with a classifier compliant with SNOMED guidance[5] in order to compute Long Normal Forms[6] for each concept

Methods

A sample of the classifier output was systematically evaluated by the authors:

1) verifying the intended meaning in the original concept term
2) verifying SNOMED editorial guidance for modeling of the meaning
3) validating the post-coordinated concept against published SNOMED editorial principles[4]
4) verifying true synonymy of content where asserted by the classifier
5) assessing for “hidden synonymy” against concepts classified as unique by intensive review of related concepts and alternative post-coordination strategies.

Classification and comparison of post-coordinated concepts



Results

	Nebraska	H Italiano	Merged
Pre-coordinated	9734 (94.3%)	7666 (23.7%)	14069 (35.7%)
Post-coordinated	585 (5.7%)	24727 (76.3%)	25312 (64.3%)
Total concepts	10319	32393	39381

Problem list subsets at the two institutions were notably different in concept inventory, frequency of post-coordination and semantics. This table summarizes the number of concepts at each institution that were pre- and post-coordinated.

Results

	Nebraska	H Italiano	Merged
Disorders	7467 (72%)	15891 (65%)	20633 (66%)
Findings	1372 (13%)	3516 (27%)	7328 (23%)
Events	30 (0.3%)	82 (0.3%)	104 (0.3%)
Procedures	1098 (10.6%)	112 (0.5%)	1201 (3.8%)
Situation w/ explicit context	339 (3.2%)	864 (3.5%)	1178 (3.7%)
All other	(0.9%)	(3.7%)	3.2%)

This table summarizes the differences in SNOMED semantic inventories between the two institutions and the merged problem list subset. Note that Nebraska employed more procedure history and Hospital Italiano more findings.

Results

Failure of post-coordination	
Vague source concept utterance	3 (1.2%)
Limited expressiveness of SNOMED model	3 (1.2%)
Conflict of SNOMED guidance	9 (3.6%)
Non-compliance with SNOMED editorial guidelines	72 (28.85)
Subtotal of classification errors	87 (34.8%)
Masked synonymy	3 (1.2%)

We sampled 250 concepts classified as unique from the merged subset and systematically evaluated the post-coordination and classification output for accuracy. Our review supported reasonable and accurate performance of semantic equivalency testing in 64.8% of cases. This table summarizes the problems we identified during detailed study of the classifier analysis of post-coordinated concepts.

Discussion / Conclusion

- Studies have demonstrated the limitations of conventional classifications and confirmed the requirements of compositional forms to deal with an ever expanding clinical knowledge base[7]
- Our research supports the utility of SNOMED Normal Forms for comparing disparate data sets, however…
- The greatest deficiency we identified in post-coordination was inconsistent behavior in the data modeling staff at the two institutions
- Furthermore, the SNOMED standards board must extend support for post-coordination by:
  - Addressing consistency within the SNOMED CT data model
  - Document and disseminate SNOMED data model standards
  - Promoting open discussion and training in SNOMED use
  - Providing clear guidance supporting reproducible and understandable post-coordination algorithms

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Semantic Interoperability and SNOMED CT: A Case Study in Clinical Problem Lists

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Abstract

Sharing clinical data between institutions requires a shared semantic model and reproducible metrics for comparing post-coordinated clinical record data. We evaluated the interoperable features of SNOMED CT by merging and comparing SNOMED problem list dictionaries between primary care sites in Nebraska and Argentina. The two problem subsets had modest differences in semantics, but differed substantially in frequency of post-coordinated content. 64.3% of the final merged problem vocabulary was post-coordinated. 0.9% of the merged concept set was found to have semantic duplication. Classification employing SNOMED Normal Forms was found to effectively identify semantic equivalency in 65.2% of cases studied. The most frequent reasons for failure of the classification procedures included: post-coordination not compliant with SNOMED guidelines (28.8% of cases), conflicting guidance presented in SNOMED pre-coordinated content (3.6%), unclear definition of source clinical concepts (1.2%), and limited expressiveness of the SNOMED definitional model (1.2%). We conclude that interoperable post-coordination employing SNOMED CT is feasible, but that better dissemination of SNOMED editorial guidelines, refinement of the concept model and training of the user community will be required for reproducible and reliable implementation.

Keywords:

controlled terminology, Systematized Nomenclature of Medicine, semantic interoperability

Introduction

Semantic interoperability denotes the ability of two different clinical information systems to seamlessly share clinic record content and recognize meaning within and between those records. Semantic interoperability requires standardized coding of conceptual content as well as understanding of the information model employed by the clinical systems. Interoperability requires that the system be able to recognize equivalence between post-coordinated concepts developed at different clinical sites by different authors.

SNOMED CT is an advanced terminology supporting post-coordination. It is demonstrably the most comprehensive and useful clinical reference terminology available to vendors today. Under the governance of a new international standards organization, it is poised to support interoperability of clinical systems within and between those nations where it is deployed.

While organizing and characterizing the semantic features of a shared SNOMED CT problem list for primary care, we analyzed for equivalence in clinical concepts authored by separate clinicians working on two continents. From systematic study of classifier data, we identified similarities and differences in our practices, and discovered issues for the interoperable deployment and use of SNOMED CT.

Methods

Study sites

Clinics of the University of Nebraska Medical Center employ the GE Centricity Enterprise record which includes problem list and assessment functions with SNOMED CT as coding reference. Employing "just-in-time" post-coordination, UNMC has developed an extension to SNOMED CT which includes 6% post-coordinated concepts within a problem data dictionary of 9800 concepts and 14500 interface terms.

The Hospital Italiano of Buenos Aires is a non-profit university hospital, associated with a large network of ambulatory care services, located in Buenos Aires, Argentina. Hospital Italiano employs a health information system developed in-house including an institution wide electronic medical record supporting all levels of care. Clinical data entry uses a local interface terminology for diagnosis and procedures. Every concept from the terminology has been coded with SNOMED CT. Currently Hospital Italiano terminology has 24,800 concepts and more than 100,000 interface terms, with approximately 70% post-coordinated content.

In order to collaboratively develop a SNOMED CT subset to support problem lists for primary care, UNMC and Hospital Italiano merged and compared their SNOMED data dictionaries, evaluating for similarities of content. Frequency of use statistics for concept codes were further compared in order to identify useful SNOMED concepts for inclusion in a standardized problem subset. This merged problem subset comprised the source content used for this study.

SNOMED post-coordination and classifier software

Post-coordination refers to the definition (or modeling) of a concept that is required for clinical recording but which is not found in the standard SNOMED CT release. Post-coordination requires the concept to be compared to the SNOMED CT definitional model. Relationships and attribute values are chosen to encode the required meaning, and the new post-coordinated concept is employed in the vendor SNOMED extension.

Due to the richness of the SNOMED model, two or more alternative post-coordinated expressions are often possible. In order to support equivalence testing between these alternatives,

SNOMED CT provides technical guidance for the development of classifier software which will convert SNOMED expressions to Normal (Canonic) forms for comparison. Comparing the Normal Forms of two user concepts allows for a computable determination whether the two are synonymous or unique. Classification software systematically computes normal forms for all concepts within a set and determines the relationship of concepts to each other within the taxonomy while identifying synonymous content.

Problem list classification

We compared the separate SNOMED CT subsets representing problem list coding at the two institutions, first characterizing the shared pre-coordinated content and then analyzing post-coordination. Classifier software developed at UNMC was employed to compute Normal Forms for all concepts in the merged set. We identified synonymous concepts by comparing classifier results and assessed the validity of post-coordination of concept samples from both sites. We searched for masked synonymy employing exhaustive editorial search within the merged problem set.

Results

Problem list subsets at the two institutions were notably different in concept inventory and frequency of post-coordination. Only minor differences in local problem list recording habits were reflected in the semantics of the SNOMED CT use at the two institutions, reflecting more frequent recording of procedure history at the Nebraska site. Clinical disorders, findings and events were the majority of concepts in use, while "past medical history" and "family history" concepts, occurred regularly at both institutions.

The Normal Form was computed for 31,382 concepts in the merged subset. 293 concepts were identified as duplicating concept meaning with other subset members including 9/578 (1.6%) of Nebraska post-coordination, 281/16807 (1.7%) of Hospital Italiano post-coordination, and 3 cases in which a Nebraska concept was identical in meaning with a concept from Hospital Italiano.

Table 1 summarizes the issues we identified during detailed study of the classifier analysis of post-coordinated concepts.

Table 1 – Analysis of post-coordination / classification errors

Failure of post-coordination	
Vague source concept utterance	3(1.2%)
Limited expressiveness SNOMED model	3(1.2%)
Conflict of SNOMED guidance	9(3.6%)
Non-compliance with editorial guidelines	72(28.8%)
Total classification errors	87(34.8%)
Masked synonymy	3(1.2%)

Discussion

Clinical reference terminologies employing features of ontologies create new opportunities for interoperability of clinical systems, but they also lead to a new set of challenges. Experience at the two sites presented in this paper confirms that the organizational and information science approach of the enterprise can lead to rather different needs for support and maintenance of post-coordination.

Assuring that post-coordinated data sets interoperate requires attention to many details. It is especially challenging at this time when the technology of clinical systems such as SNOMED CT are evolving. While our research supports the utility of SNOMED Normal Forms for comparing disparate data sets, reliable and consistent results require that information system managers have well trained and consistent data modeling staff. This was the greatest single deficiency identified in our analysis and accounted for the largest variation from expected results. The SNOMED standards board must extend support to the enterprise employing post-coordination by addressing consistency within the SNOMED CT data model. But even more important for post-coordinated data management is dissemination and documentation of the SNOMED data model standard, promotion of open discussion and training in SNOMED use, and provision of clear guidance supporting reproducible and understandable post-coordination algorithms.

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Sustainable Health Systems: Using Metadata Registries with Nursing Terminology

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Abstract

Health data and information sharing using a metadata registry promotes cross-system and cross-organization descriptions of common units of health data and allows nurses, health administrators, and hospital systems to make significant strides towards sustaining health system information systems. Metadata registries contribute to patient safety, efficient and successful electronic health record system implementation, and lower of healthcare costs in electronic health record system implementations by avoiding multiple data translations and mapping, data duplication and messaging errors.

Keywords:

Clinical Care Classification; terminology, nursing, metadata, registry, CCC, health systems

Introduction

The online metadata registry with an organization's strategic plan allows healthcare organizations to share data in a common format with descriptions of common units of health data and demonstrate actual resources, cost, patient management and outcomes. Metadata information in the United States Health Information Knowledgebase (USHIK) contains the Clinical Care Classification System (CCC) developed by Saba and Colleagues which encompass assessments, diagnoses, interventions, actions, and the actual and expected outcomes for describing, communicating and evaluating interdisciplinary practice within the electronic documentation of nursing practice.

Materials and methods

In healthcare organizations, with disparate data elements collected for many departments in different presentation formats on various electronic system screens, the ability to provide efficient patient management information that is sustainable in a health system requires standardized data elements. Data standardization increases the cross-system and cross-organization comparison of clinical

information. In an electronic health record (EHR) and in Computerized Provider Order Entry (CPOE) systems; the selection of a common data format, e.g. metadata is the vital component.

As of October 2006, the Health Information Technology Standards Panel (HITSP) sponsored by the American National Standards Institute (ANSI) with funding from

The Office of the National Coordinator for Health Information Technology, United States Department of Health and Human Services mandated by Executive Order 13335 compliance with Health Information Technology Standards Panel standards that includes an initial Nursing Terminology: Clinical Care Classification system; a nursing terminology available in the United States Health Information Knowledgebase (USHIK) (www.ushik.org). In the United States Health Information Knowledgebase public and private organizations have access to Standard Development Organizations data elements about what nurses' chart and manage.

Results

A metadata registry harmonizes information formats even though data needs change. A controlled clinical vocabulary, e.g. the Clinical Care Classification system (CCC) is the key to measuring outcomes, improving patient safety, reducing error rates, and lowering cost. Technology puts nursing at the bedside and nursing terminology promotes evidence-based medicine and sustainable health systems.

Conclusion

A metadata registry allows an organization to review specific disease management practice guidelines by location and decreases the variations in disease screening; 2) allows the comparisons of the process of care delivery and promotes the transformation of a health information system into a unit management information system; 3) consolidates redundant health data and standardizes data elements and attributes with each organization; and 4) supports the 'Magnet' concept of the American Nurses Association for data driven organizations. The United States Health Information Knowledgebase is excellent source to use within multi-hospital systems to compare and harmonize interventions, results and outcomes. USHIK enables the browsing, comparison, synchronization and harmonization of facts about health data in a uniform query and interface environment that allows nurses to identify and manage multiple data elements in an electronic health record.

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USHIK

UNITED STATES HEALTH INFORMATION KNOWLEDGEBASE

Sustainable Health Systems: Using Metadata Registries with Nursing Terminology

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USHIK

UNITED STATES HEALTH INFORMATION KNOWLEDGEBASE

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A metadata registry is a place to keep facts about characteristics of data that are necessary to clearly describe, inventory, analyze, and classify data.

A metadata registry supports data sharing with cross-system and cross-organization descriptions of common units of data.

A metadata registry promotes a common understanding of shared data by unit of data meaning, representation and identification.

Comparison Matrix Aids in Harmonizing Data Elements

Comparison Matrix

Organization:	CMS	NCPDP	X12
Data Element ID:	0060-92-764-5622.65902.v000	0060-02-166-0014.60872.v0	0060-07-329-4837.25320.v0
Data Element Name:	Gender	Gender Code	Gender Code
Definition:	1 = Male; 2 = Female; 3 = Unknown/not stated as recommended by the Uniform Hospital Discharge Data Set and the Uniform Ambulatory Care Data Set.	For eligibility, and identifying the gender of the individual member.	A code indicating the gender of the patient or insured.
Context:	NCVHS Core Health Data Elements	NCPDP Data Dictionary	X12N Health Care Data Element Dictionary
Registration Status:	Incomplete	Incomplete	Incomplete
Status Date:	2002-07-08	2001-11-27	2001-10-17
Comments:			This data element utilizes a sub domain of the X12 data element domain that is based on the its use in a Transaction Set. Please refer to the Transaction Set Implementation Guide for the specific sub domain utilized.
Data Collection Methods:			
Data Type:	N	x(1)	ID
Minimum Size:	1	1	2
Maximum Size:	1	1	2
Representational Layout:	Not Provided	Not Provided	Not Provided
Representational Form:	Not Provided	Not Provided	Not Provided
Unit of Measure:	Not Provided	Not Provided	Not Provided
Precision:	0	0	0
Minimum Range:			
Maximum Range:			
Data Domain:	1 Male 2 Female 3 Unknown/not stated	M Male F Female U Unknown	F Female M Male U Unknown

Value of Lessons Learned to Nurses and Nursing Standards Development Organizations

- Standards have multiple means of versioning (e.g. major / minor numbering, re-release with corrections) and multiple versions available at any one point in time
- Workload entailed in loading different identified items varies widely due to the different levels of standardization
- A large amount of effort required in grooming the metadata to fit into the standard format as most exciting metadata does not exist in any kind of standard format
- Once in USHIK - standards data can be used many times

Value of Lessons Learned to Nurses and Nursing Standards Development Organizations

- New standards versions do not identify a delta (difference) between the versions, so a metadata difference analysis must be determined

- Many points for data errors with a tremendous quality assessment responsibilities to analyze the standard, determining the differences between versions, format the metadata, and enter the health information technology standard data elements

- Metadata analysis reveals standards may require change to correct errors:
  - Changes may be in the structure of the standard
  - Changes may have a cascading affect that may change data meanings
  - Changes must be reviewed to determine if data element still meets the needs of the Nursing Community of Interest

Relationship of Health Metadata Registries

UMLS: National Library of Medicine Unified Medical Language System (UMLS) project develops and distributes multi-purpose, electronic "Knowledge Sources" and associated lexical programs for system developers. Researchers will find the UMLS products useful in investigating knowledge representation and retrieval questions."

Used to: Research terms and phases to use in developing definitions for data element concepts or data elements.

USHIK "The United States Health Information Knowledgebase (USHIK) provides and maintains a metadata registry of health information data element definitions, values and information models that enable browsing, comparison, synchronization and harmonization within an uniform query and interface environment."

Used to: Publish data elements or designate the group of standards that meet functional requirements and that registration organizations want public and private organizations to use for the adoption of health information technology standards

Next Steps

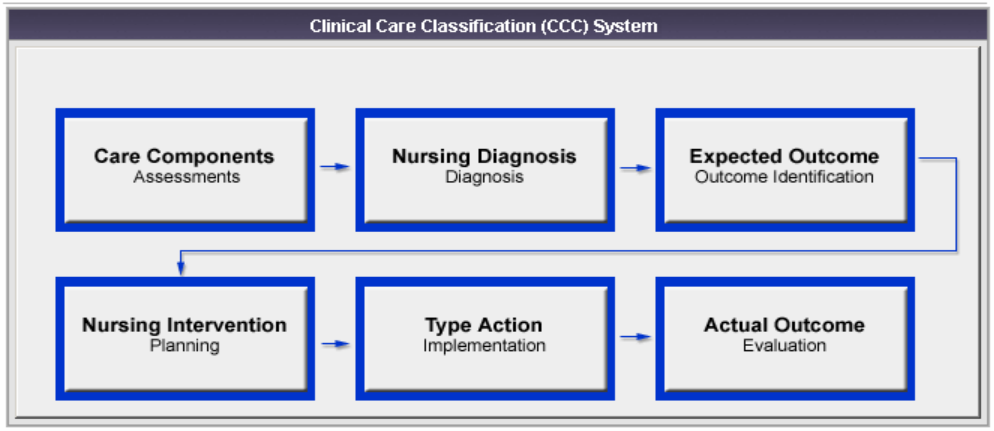
- *Eliminate a barrier to health data interoperability by matrix comparison of nursing data elements for the Customer – Centered Electronic Health Record*

- Educate on the United States Health Information Knowledgebase (USHIK) health metadata standards

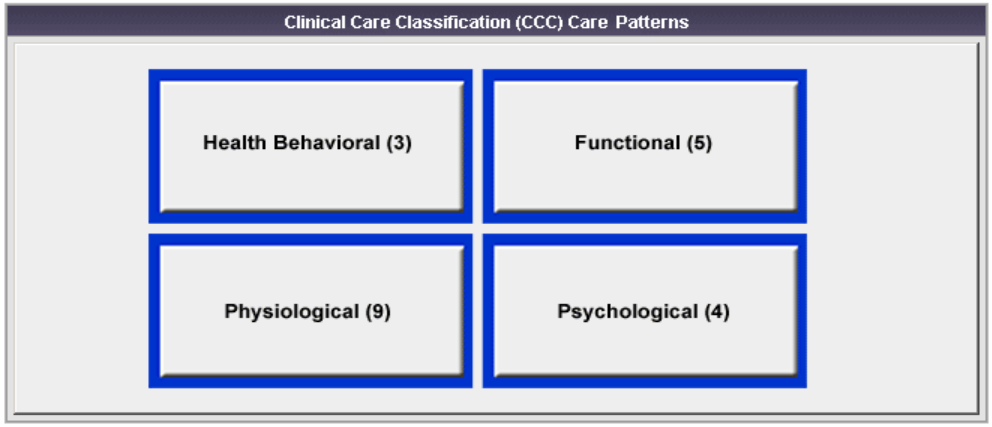
- *Maintains the USHIK document registry of all historical documents of record behind a data analysis (metadata of terms & definitions)*

The Clinical Care Classification (CCC) System (Nursing Taxonomy)

Reference Framework



Care Components



Physiological	
Description:	A cluster of elements that represents a unique pattern of clinical care nursing practice related to Physiology
Model sub views associated with this model view	Bowel Elimination/Gastric (B) Cardiac (C) Metabolic (I) Physical Regulation (K) Respiratory (L) Skin Integrity (R) Tissue Perfusion (S) Urinary Elimination (T)
Concepts associated with this model view	
Data Elements associated with this model view or concept (count follows letter)	[A(0)] [B(0)] [C(0)] [D(0)] [E(0)] [F(0)] [G(0)] [H(0)] [I(0)] [J(0)] [K(0)] [L(0)] [M(0)] [N(0)] [O(0)] [P(0)] [Q(0)] [R(0)] [S(0)] [T(0)] [U(0)] [V(0)] [W(0)] [X(0)] [Y(0)] [Z(0)] [Others(0)] [All(0)]

Listing Created on Jun 6, 2006

Search Results

Data Elements for Model Respiratory (L)

Data Element		Matrix	USHIK ID	Type	Status
L26.0 - Respiration alteration		☐	Sabacare.75181.v1	Data Element	Incomplete
L26.1 - Airway clearance impairment		☐	Sabacare.75184.v1	Data Element	Incomplete
L26.2 - Breathing pattern impairment		☐	Sabacare.75186.v1	Data Element	Incomplete
L26.3 - Gas exchange impairment		☐	Sabacare.75187.v1	Data Element	Incomplete

Run Matrix Report On Selected Items | Select All Items On This Page | Clear All Items On This Page

Add To Matrix Report Saved List | Clear Saved List | Run Matrix Report From Saved List

Search Again

Listing Created on Jun 6, 2006

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The Use of UMLS to Establish a Mediation Terminology for Exchanging Patients' Allergy Profiles between two U.S. Federal Agencies' Electronic Health Records

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Abstract and objective

Recognizing that interoperable health information system can lower costs, reduce medical errors, and improve quality of care, the Department of Veterans Affairs (VA) and the Department of Defense (DoD) are working towards seamless sharing of real-time clinical data between the respective agency's Electronic Health Records (EHR). One strategy to achieve this goal is through the mapping of the two agencies' proprietary terminologies to standard vocabularies. However, the difficulty is that most terminologies are not fully mature to adequately cover the allergy domain. This paper describes the process of using the Unified Medical Language System (UMLS) to derive a mediation code set for exchanging patient's allergy profile. With our initial effort, 84% of allergens sent by the VA are successfully mediated, computed on, and stored in the DoD's Clinical Data Repository (CDR) and 82% of allergens sent by the DoD are successfully mediated by the VA's Health Data Repository (HDR).

Keywords:

unified medical language system, electronic health records, computerized/* terminology standards, allergy and immunology/*standards

Introduction

Having interoperable health information systems has been recognized as a necessary step toward improving the quality of health care, reducing medical errors, and controlling costs. Over the past decade the VA and the DoD have been making great efforts at sharing the health information of their mutual beneficiaries. In 2004, the VA and the DoD successfully prototyped the Clinical Health Data Repository (CHDR) application for the exchange of codified patient data. Through this application, health information can be transferred and stored at the other agency's clinical data repository as computable data which then can be used in clinical decision support applications. In 2006, the two agencies continued to improve upon this prototype to exchange medication and allergy profiles. Patient safety researchers have pointed out that giving patient medication that they are known to have an allergy against is one important and preventable cause of adverse drug events. Since no designated set of standards exist for the allergy domain at the initial start of the CHDR project, the two agencies evaluated the use of UMLS to mediate the two agencies patient's allergy lists.

Methods

The DoD extracted a set of UMLS Concept Unique Identifiers (CUIs) associated with RxNorm concepts. RxNorm alone does not provide adequate coverage of the allergy domain because it does not contain a semantic type for drug classes. However, the DoD used RxNorm concepts as the initial effort to harvest UMLS CUIs already mapped to RxNorm. Automated mapping between the DoD's allergen file and the RxNorm concepts was made through exact string and lexical variants matching. When there were one-to-many matches, terminology subject matter experts manually set a precedence flag. The VA extracted its mapping to CUIs directly from the UMLS metathesaurus. Independent experts reviewed the two mapping tables side-by-side and identified any discrepancies. The System Acceptance Testing (SAT) for CHDR was carried out at William Beaumont Army Medical Center, El Paso Texas during the period of September 11-15, 2006.

Results

The mapping tables contained respectively 7157 and 8358 allergens for the VA and the DoD. The expert review of the 1924 common concepts identified less than 3% discrepancies which were resolved. The majority of the vocabulary differences were due to the use of generics and brand names and ingredient base or salt forms. The SAT indicated that 84% of allergens that are sent from the VA to the DoD are successfully mediated, computed on, and stored in the DoD's CDR and 82% of allergens that are sent from the DoD to the VA are successfully mediated, computed on, and stored in the VA's HDR.

Conclusion

The Consolidated Health Informatics panel has now recommended a set of terminologies to cover the allergy domain: FDA UNII codes for drug ingredients; RxNorm for brand names (which have relationships to generic names), NDF-RT for drug classes. However, the FDA UNII codes are incomplete and not ready for implementation. The VA-DoD patient exchange project has demonstrated that the use of UMLS is an effective mediation standard for the drug allergy domain.

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Interoperability and Security: Design and Development of a Clinical Documents Repository Digitally Signed using CDA Standard

Fernán González Bernaldo de Quirós, Adrián Gómez, Fernando Campos, Jorge Severino, Fernando Plazzotta, Daniel R. Luna

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Abstract

The amount of institutions with hospital information systems has increased. Different technologies and standards available makes possible to satisfy many information exchange needs. HL7's CDA is a marked-up document standard, which specifies the structure and the semantics of a clinical document. Digital Signature is a tool that guarantees the authorship and integrity of electronic documents. The Hospital Italiano of Buenos Aires, has developed and implemented a CDA documents repository along with the creation of its own PKI infrastructure, obtaining then a trustworthy and unique registry of the medical acts, making possible the access to documents in a format that allows full legibility, also allowing process and later inclusion of this information in other systems or applications, guaranteeing its authorship and integrity.

Keywords:

medical records systems, computerized,
computer security, standards, electronic documents, digital signature

Introduction

The growth of hospital information systems, the information exchange needs and the proliferation of technologies implemented on the Internet, allowed medical documents to be shared and exchanged between organizations, hospitals and healthcare providers [1]. This made possible the development of protocols and methods to assure medical information exchange in a standard format, increasing the possibilities of achieving semantic and syntactic interoperability.

One of the main standards families in health information systems setting is Health Level Seven (HL7). CDA stands for Clinical Documents Architecture and is a markup standard, which specifies the structure and the semantics of a clinical document. The present version is 2.0, is part of version 3 of HL7 standard and describes its semantic content in the Reference Information Model (RIM) [3].

On the other hand, paper documents have traditionally guaranteed its authorship and integrity by handwritten signature. In medical settings physicians records in paper and signs at the end of the chart. Each later registry must be signed, indicating the authorship and responsibility of any modification made from the previous signature.

When it comes to digital charts, the use of simple electronic signatures, like "username and password", does not fulfill all the requirements needed to replace the hand written signature.

Digital signature is a technological tool that guarantees the authorship and integrity of digital documents, giving them the same validity of those signed in paper.

In the present work we will describe the design, development and implementation process of a digitally signed clinical documents repository, created from an electronic health record, using CDA standard and the asymmetric key infrastructure (PKI - Public Key Infrastructure).

Materials and methods

Scenario

The Italian Hospital of Buenos Aires (HIBA) is a tertiary care, teaching and research hospital with a 150 year old history. Since 1998 a full scale HIS has been gradually implemented, including ambulatory Electronic Health Record (EHR), several health informatics standards had been implemented, including HL7, CDA 2.0, ICD-9CM, DRG and ICD10 [4].

Digital Signature legislation in Argentina

In 2001, bill number 25506 of "Digital Signature" was sanctioned, it essentially recognizes the use of digital and electronic signature, and its legal validity, allowing the truthfully identification of individuals making electronic transactions. This way, when a document requires a handwritten signature, that exigency is also satisfied by a digital signature.

This bill also describes in its fifth article the figure of electronic signature as an integrated electronic data set, related in a logical way to other electronic data, used by the signatory like his means of identification, which lacks some of the legal requirements to be considered digital signature [5].

Medical information security

Our project includes as a key issue the development of the security mechanisms needed to operate and maintain a decentralized medical record system, knowing that medical information security is based on five fundamental aspects:

- **Privacy**: medical information cannot be accessed by third parties not related to the attention process.
- **No Disavowal**: references the authorship of the document, only the person who possesses the digital signature is in charge of the generated and saved data.
- **Authenticity**: it refers to the character of authentic of a document, that is to say, that is the original one.
- **Integrity**: related to the previous one, talks about the content of the medical information preventing that it original content is altered.
- **Chronology**: directly related to integrity, allows keeping registry of the date and hour of the creation of the original information, thus giving the data a temporary sequence.

CDA documents creation

The information system of our institution, registers all the medical events generated in the health care process. The clinical document generation begins with the medical encounter or "health care event", for the outpatient setting is the aggregation of all the actions made (medical problems, medical progress notes, orders entered, clinical observations, pharmacologic prescriptions, date and hour).

For in patient and emergency settings, clinical document example is the epicrisis; and, in the case of information generated by ancillary services, each procedure inquired is equivalent to a health care event, reason why it generates a document, using the information made in the report system.

Once the health care event is stored into the clinical data repository (CDR), a web service is in charge of generating a CDA document. This service recovers the medical information recorded from the CDR and creates the document (a XML file). Then the user is asked to validate the information through a confirmation process and the document is digitally signed. This signed documents and its control parameters are stored in file data system.

Digital Signature of medical documents

HIBA took the initiative to create its own PKI by developing an "in house" application that makes possible to lead all the process of creation and administration of public and private keys and digital certificates.

In order to guarantee its integrity and authenticity, a digital document must fulfil three basic characteristics:

- Having a HASH to guarantee the document's integrity.
- Been signed with private and public key system, to guarantee its authorship.
- Having a Time Stamping service, that guarantees document's temporality.

In our project, public and private keys are stored in a cryptographic USB E-Token given to providers and it's asked for its insertion at the moment of the signature. The E-Token is an electronic component with USB (Universal Serial Bus) interface.

When a XML clinical document is created, the application calculates a single HASH value and encrypts it using the private key stored in the E-token. This encrypted file maintains its original information and the digital certificate [6].

The exact moment when the primary load of information happened is one of the most important variants, since the medical document existence at a certain moment in time must be determined in a safe way. We chose to generate a process of time stamping, which stores a digitally signed time registry with the document signed by the user.

Discussion

The summary of providers work, documented in a single XML file, adding Digital and Electronic Signature, provided by the E-token, will allow the creation of a trustworthy and unique registry of the medical acts.

On the other hand, current graphical interfaces, although provide improvements in usability and information visualization, does not correspond with the traditional charts in paper. Traditionally the professionals records their observations and findings in documents and then sign them. The implementation of CDA and Digital/Electronic Signature maintains this sequence.

Conclusion

The implementation of this solution allowed users to access laboratory results, imaging reporting, referral notes, discharge letters, progress notes, diagnoses, procedures and medical prescriptions, in a fully legible format and the possibility of information processing for its later inclusion in other information systems or related health care applications.

Documents visualization was personalized using XSL style sheets being able to render styles, typographies and icons recognized and validated by the institution. A time stamping service (also digitally signed), will allow temporality to this unique registry of medical acts.

CDA standard implementation with the aggregate of digital/electronic signature in an electronic health record is a true challenge, since it entails an important technological

and organizational impact. At this moment we are carrying out a pilot test for the completion of the system and the norms and procedures created to such aim.

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Interoperability and Security: Design and Development of a Clinical Documents Repository Digitally Signed using CDA standard.

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Departament of Medical Informatics

Introduction

- Medical documents can be shared and exchanged
  - →Growth of hospital information systems
  - →Information exchange needs
  - →Proliferation of Internet technologies
- Standard formats - semantic and syntactic interoperability
  - →HL7, CDA

Introduction (cont.)

- Handwritten Signature
  - →Traditionally guaranteed authorship and integrity of paper documents
  - →Is written at the end of the document to prove that what is authenticated has not been modified
  - →Medical setting works by this same modality
- Impossibility of physically signing digital documents
  - →Simple electronic signatures can't replace handwritten signature
- Digital Signature guarantees authorship and integrity of digital documents
  - →Giving them the same validity of those signed in paper
  - →Uses mathematical processes to relate the signed document with information from the signing person

Objectives

- Describe the design, development and process of implementation of a clinical electronic documents repository digitally signed, using CDA standard and the asymmetric key infrastructure (PKI - Public Key Infrastructure).

Materials and Methods – Scenario

- Hospital Italiano de Buenos Aires (HIBA)
  - →Tertiary care, teaching and research hospital with a 150 year old history
  - →Since 1998 a full scale HIS has been gradually implemented
    - Including Ambulatory Electronic Health Record (EHR)
    - Several health informatics standards had been implemented, including HL7, CDA 2.0, ICD-9CM, DRG and ICD10

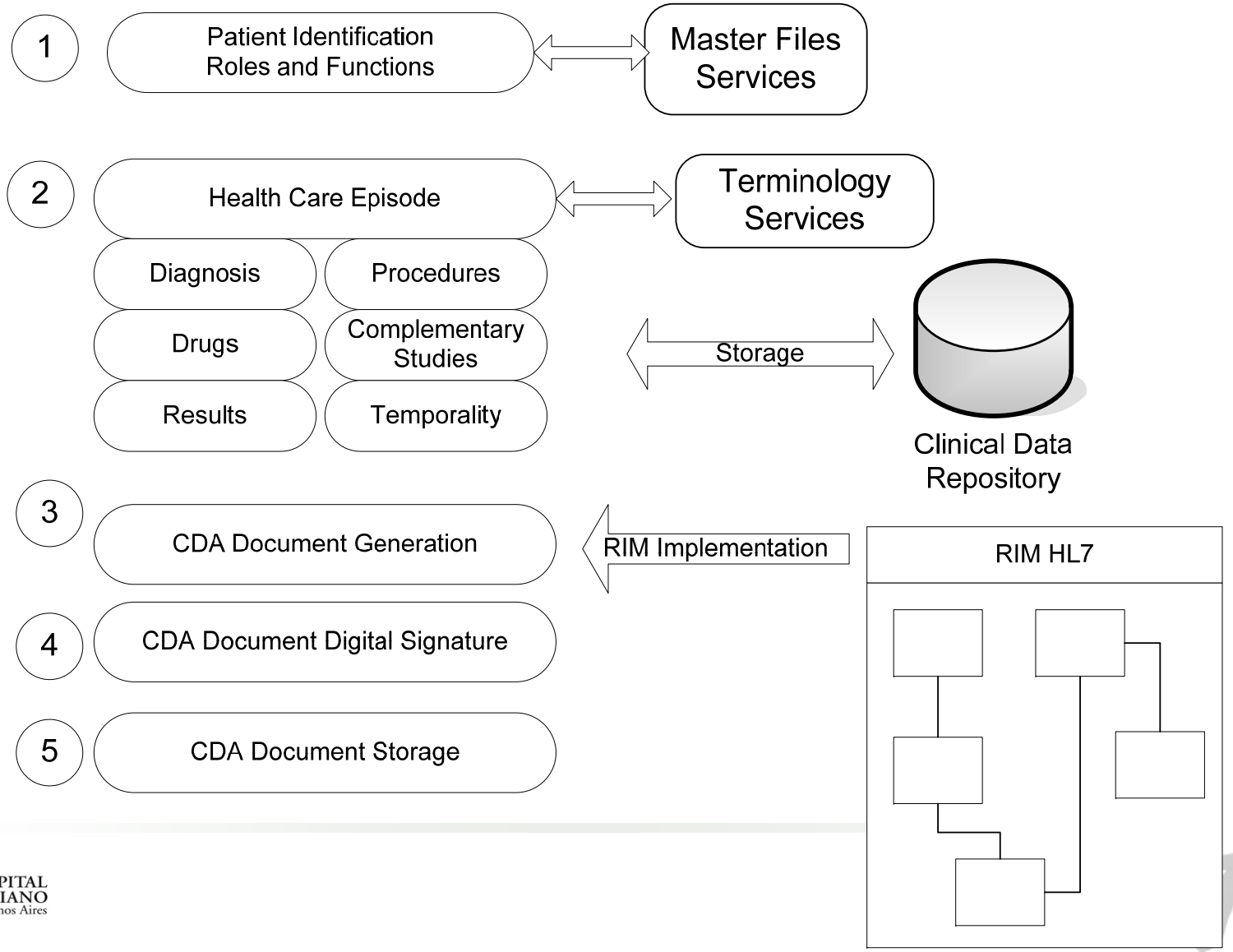
Digital Signature Legislation in Argentina

- In 2001, Bill 25506 of "Digital Signature" was sanctioned
  - →Recognizes the use of digital signature, and its legal validity
  - →Allows truthfully identification of individuals making electronic transactions
  - →When a document requires a handwritten signature, that exigency is also satisfied by a digital signature.
  - →Also describes the figure of electronic signature as an integrated electronic data set, related in a logical way to other electronic data, used by the signatory like his means of identification, which lacks some of the legal requirements to be considered digital signature

Medical Information Security

- Key issue
  - ⟶Development of security mechanisms needed to operate and maintain a decentralized medical record system
  - ⟶Based on five fundamental aspects:
    - Privacy
    - No Disavowal
    - Authenticity
    - Integrity
    - Chronology

CDA documents creation



Signature of Medical Documents

- "In house" application, with own PKI
  → Creation and administration of public and private keys and digital certificates.
- Three basic characteristics of digital documents:
  → Having a HASH to guarantee the document's integrity.
  → Been signed with private and public key system, to guarantee its authorship.
  → Having a Time Stamping service, that guarantees document's temporality.
- Public and private keys are stored in a cryptographic USB E-Token given to providers
- Each XML clinical document created, has a single HASH value and is encrypted using the private key stored in the E-token
  → This encrypted file maintains its original information and the digital certificate
- A process of time stamping stores a digitally signed time registry with the document signed by the user

Discussion

- Trustworthy and unique registry of the medical acts, allowed by:
  - →Documents in single XML files that summarizes providers work,
  - →Digital and Electronic Signature, provided by the E-token
- Current graphical interfaces
  - →Provide improvements in usability and information visualization
  - →But...
  - →Does not correspond with the traditional charts in paper.
- Traditionally the professionals records their observations and findings in documents and then sign them
  - →The implementation of CDA and Digital/Electronic Signature maintains this sequence.

Conclusion

- Users can access laboratory results, imaging reporting, referral notes, discharge letters, progress notes, diagnoses, procedures and medical prescriptions, in a fully legible format…
  - →and the possibility of information processing for its later inclusion in other information systems or related health care applications.
- Documents visualization was personalized using XSL style sheets
- A time stamping service (also digitally signed), will allow temporality to this unique registry of medical acts.
- CDA standard implementation with the aggregate of digital/electronic signature in an electronic health record is a true challenge
  - →it entails an important technological and organizational impact.

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The Brazilian Healthcare Software Certification Process

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Abstract

This paper describes the Brazilian Healthcare Software Certification Process started in 2004. The Brazilian Health Informatics Society (SBIS) and the Federal Medical Council (CFM) have proposed and are conducting the certification process. This paper describes the motivation, the history, the three phases methodology adopted, and its current status. A comparison with other international initiatives of health information systems certification is also presented. To conclude the future plans are presented.

Keywords:

healthcare information systems, standards,
software certification

Introduction

The use of computerized systems in medical offices is increasing worldwide. Brazil has a long tradition of using IT in healthcare. The Brazilian National Health System - SUS adopts electronic standards for hospital and outpatient billing for more than 25 years. All information is available for consultation at the Ministry of Health homepage (www.datasus.gov.br) [1]. More recently, the National Regulatory Agency for Supplementary Health – ANS, responsible for the regulation of the private market, has published TISS, an electronic messaging standard, based on XML schemes, to send billing information to and fro healthcare providers and payers. From May 2007 on, the standard TISS becomes mandatory[2]. There is a national registry with unique identifiers for persons (so far with 116 million persons uniquely identified), healthcare providers (149 thousand) and healthcare workers (1.5 million)[3]. A national PKI (public key infrastructure) - ICP Brasil, based on open standards, gives legal validity to documents digitally signed, ever since 2002[4]. Brazil as well as Mexico is the two countries where the number of Internet hosts grows more in the world according to recent publications [5].

Motivation

Many of the hospitals and large clinics, at least in the larger cities already use health information systems, mostly for billing and patient record purposes. These organizations face the ever growing problem of storing the paper medical record. According to the Brazilian Federal Research Council it is mandatory to store the paper medical record for at least 20 years after the patient's last visit to the healthcare unit. At the same time, physicians in their medical offices are largely using electronic heath records systems. Some of these physician offices, regardless of the regulations, are paperless. As the regulations and legal validity of electronically signed documents evolved in the Country, several physicians motioned their Regional Medical Councils, looking for legal advice on whether they could become paperless. The Regional Medical Councils (there is one for each of the 26 Brazilian States) did not feel comfortable in replying and sent all those requests to the Federal Medical Council, which, in turn, decided to create a specific Technical Committee on Health Informatics and Telemedicine to, with the support of the Brazilian Health Informatics Society (SBIS) try to answer to those questions.

In 2002, due to the large number of requests from the Brazilian healthcare community, CFM and SBIS established a cooperation agreement to define and implement a software certification process that would allow, in the long run, for physicians and healthcare providers to be paperless safely and legally, according to the Brazilian regulations.

The next sections describe the methodology adopted in the certification process, the present status, lessons learned and future plans.

The Certification Methodology

Once the legal aspects of the agreement were established the technical group started to work. By 2002, there was no other international experience of software certification for healthcare, more precisely for systems that dealt with patient identified health information. The Certification Commission for Healthcare Information Technology (CCHIT) was created by the US government only in 2004 and is today a very successful example of healthcare software certification [6].

Legal background

In order to understand what we were dealing with, an extensive bibliographic review on software certification,

as well as on the Brazilian regulations for digital signatures, information security, privacy and confidentiality issues was carried out. In addition to that, the work of the ISO-TC 215 Health Informatics Committee was taken as a prime reference. As our understanding evolved, so were evolving the two basic documents we have used as references for the architecture, content, structure and function requirements of the certification process: ISO/TS 18308:2004 - Health informatics - Requirements for an electronic health record architecture [7] and the ISO/TR 20514:2005 Health informatics -- Electronic health record -Definition, scope and context [8].

The Federal Research Council published, in 2002, two specific regulations on patient records – Resolution CFM 1638/2002, and on electronic health record systems – CFM 1639/2002 [9,10]. These two resolutions together with the ISO-TC 215 documents above mentioned, and the ISO/IEC 17799:2005 Code of Practice for information security management [11] were the key documents used to define the SBIS-CFM certification process.

CFM 1638/2002 resolution defines the patient record as a document that contains text, images and signals related to the patient and that the resulting set of items is a private and confidential piece of information that can only be shared for patient care purposes. According to the Brazilian legislation, all information on the patient belongs to the patient. Physicians in their offices and health care providers in general have the obligation of keeping patient files for a period of at least 20 years (for the paper record). The 1638/2002 resolution also details the minimum content of the patient record. The recommendation is that the patient record (no matter whether electronic or on paper) has to contain the patient identification (it recommends the use of the national person identification registry), patient history, physical examination, ancillary tests and its results, therapeutics planning, diagnoses, evolution, surgical reports (if the case), and all medical orders. Summary discharges in case of hospital admissions with clear patient's recommendations in lay language. If on paper, it's mandatory that all documents be legible and signed by the attending physician. If electronic, the documents must be digitally signed according to the Brazilian PKI otherwise they must be printed and hand signed. The 1638/2002 resolution also deals with exceptions, as when the patient cannot speak, in which case it describes in detail what information has to be written on the patient file.

The 1639/2002 CFM was published a month after the 1638 in August 2002. It establishes the foundations of the SBIS/CFM certification process and describes the first set of technical recommendations for the process. These first recommendations were expanded in a full publication: The EHR systems security, content, and functionality requirements for the SBIS/CFM certification process, as described in the following sections. Among the recommendations, it says that for those who decide to use electronic health records, files must be saved forever, which means to the actual technology limit and that proper mechanisms should be granted to guarantee the compatibility of the storage devices, as technology evolves. That is also a recommendation present in the ISO/IEC 17799:2005 regulations. In addition to that, it is also recommends, and makes it mandatory for those who will have adopted the EHR, the existence of a Patient File Committee. The Head of this Committee is the one legally responsible for the patients file and for keeping its privacy and confidentiality. Should any legal problem occur, this is the person that is going to be implicated. The two resolutions made it clear to the healthcare community that it was possible to move to the paperless environment but it is necessary to improve drastically specially the small offices' *so called* "EHR" systems. Many physicians were already unable to defend themselves in malpractice suits because all they could present to the court was a paper printed from a simple system with no guarantee whatsoever that the specific piece of information was valid.

SBIS-CFM certification scope

Software certification is a rather complex task. It demands that at least two main issues are taken into account: the software product itself and its use in different organizations. For example, the same software product may be complaint with security requirements in one site, while not in others, because users share passwords, for instance. This has to do with the software utilization, rather than with the software product itself.

It was decided that the SBIS/CFM certification scope target any software product that captures, stores, manages, publishes or electronically communicates patient-identified health information, or, in other words, is an EHR. This definition is on purpose similar to the ones described in the ISO TC 215 aforementioned documents [7,8].

It was also decided that the SBIS/CFM certification is a VOLUNTEER process, meaning that only organizations that want to become paperless have to be certified. Recently the Federal Regulatory Agency for Supplementary Health, in its publication of the electronic standard for exchanging billing information, recommended that all systems implementing the communication should be compliant with at least Level 1 Security SBIS/CFM, as explained ahead.

SBIS/CFM certification phases

The SBIS/CFM certification process is composed of two basic phases: Phase 1 – Compliance Declaration; Phase 2 – Auditing and Quality Labeling. A third phase has also been envisioned in which necessarily the Ministry of

Health and ANVISA, the Brazilian Health Surveillance Agency will have to participate.

A Manual with all the Security, Content, Structure and Function Requirements for EHR was elaborated and went into public consultation in 2003, through the Internet[12]. The market reacted promptly considering the requirements too hard. The decision was then to split the process in three phases, based on the need to start with a lighter, educational phase, in which the main objective was to let the market, in special the small players, understand what the requirements were and have enough time to adapt. Brazil IT healthcare market mimics what the healthcare market is: many scattered small players attending the local market. There has always been the concern not to kill the local initiative, but rather to qualify it and make the world of standards, privacy, confidentiality and PKY for digital signature fully understandable even for the very small companies that offer "EHR" systems for the local physicians in the small communities across the country.

Since it had also and educational purpose, the Manual includes a large introduction with references to the CFM resolutions, ISO TC 215 documents, ISO 17799 Security Code of Practice and ICP-Brasil, the Brazilian PKY Infrastructure. The EHR system requirements are divided into the following sections: Security, Content, Structure and Functionality.

The Security chapter is based on the ISO/IEC 17799:2005 Code of Practice for information security management and in the privacy and confidentiality rules of the CFM Ethical Code of Practice. According to the Manual, EHR systems can be classified as Guarantee Security Level 1 or Level 2. The difference is that to be classified as Guarantee Security Level 2, the EHR system has to be compliant with all Level 1 requirements **and** provide digital signature authentication based on the ICP-Brasil.

The Content, Structure and Functionality requirements are an adaptation from the ISO-TC 215 documents. Every requirement is identified as mandatory or optional. Some are identified as "desirable", as is the case of the need to incorporate comments in any data entry or to specify the relevance level of the information. The "desirable" attribute indicates to the community that although not mandatory today, this is an attribute that will probably be mandatory in the near future.

Each requirement is uniquely identified within the Manual, has a description and a reference to the information source. All national standards for patient, healthcare provider and healthcare worker identification and description are part of the mandatory requirements of the Content Section.

Phase I – Compliance declaration

Phase I of the SBIS/CFM Certification Process is FREE and totally online by accessing SBIS's website (www.sbis.org.br). It consists of a self-proclaimed declaration from the software supplier, stating that the specific product registered at SBIS website is compliant with the Requirements Manual at the Security Level 1 or 2.

The process is simple and straightforward as depicted in Figure 1 below.

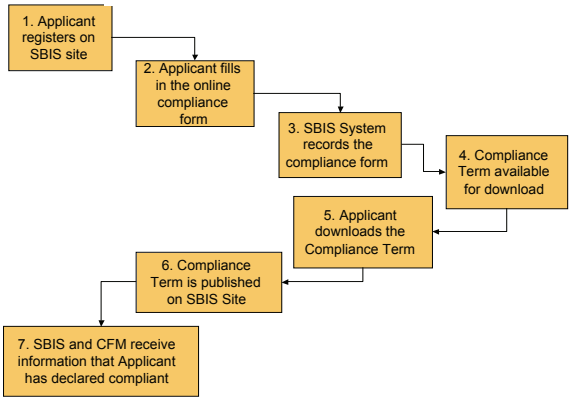

Figure 1 - SBIS-CFM Certification Process – Phase 1

The applicant is the software supplier. It may be a company, an academic institution or even a single person. The first step is the registration of the organization or person responsible for the software product. A brief description of the product is also required, such as operational system used, architecture, category (hospital, outpatient, medical office, laboratory, imaging, public health integrated system, billing). After that, the requirements are presented as a questionnaire to the applicant, to be answered on-line, as shows Figure 2 below. When finished, if all the mandatory requirements are present, the compliance declaration is published at the web site and can be downloaded by the applicant.

Figure 2 - SBIS/CFM Certification Questionnaire

Phase 1 is an educational phase for the market. Neither SBIS nor CFM takes any responsibility on what has been declared. Therefore it's not recommended to become paperless based on this compliance term.

Phase II Auditing – SBIS/CFM quality labeling

The second phase of SBIS/CFM certification process is also a volunteer one, but not without costs, since here there is the need to pay for the systems auditing.

In Phase II, all systems compliant after Phase I can proceed to Phase II and be audited by accredited organizations. The process is also simple and mostly done through the Internet as in Figure 3.

The applicant chooses the accredited certification organization, through by assessing the company's history and available auditors. Each auditor's biography is available, as well as their declaration of interest. The objective here is to have full transparency, avoiding possible conflicts of interest.

The applicant has to approve the commercial proposal for the auditing which triggers the start of the auditing process. The auditing process is objective, with the auditors (always two) having to follow very detailed script and case tests, to check the system compliance with each Manual Requirement.

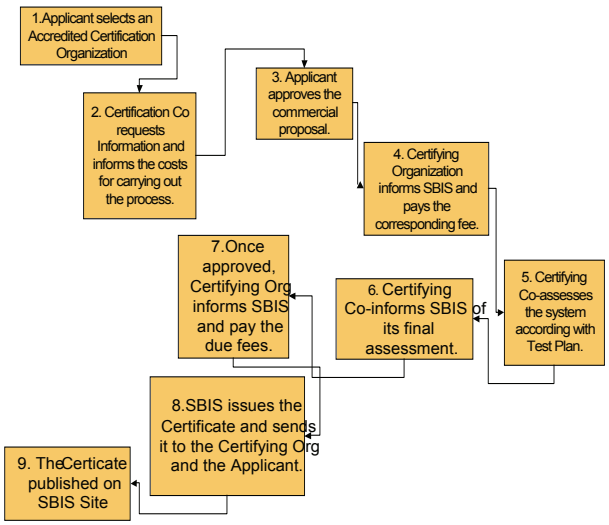

Figure 3 - SBIS-CFM Certification Process - Phase 2

Once the auditing has finished, SBIS receives the report from the accredited certification organization and, should the system be compliant, a Quality labeling is issued to the applicant and the associated certificate is published on SBIS website.

Phase III – Ministry of Health involvement

Phase III necessarily requires that the Brazilian Ministry of Health and ANVISA, the Brazilian Health Surveillance Agency, take part in the process, as those are the organisms with legal power to legislate on these matters. CFM has power over medical doctors. The Ministry of Health and ANVISA have power over all healthcare organizations. Nevertheless, Phase III deals with certification of products and their "on site" implementation. Systems that have survived Phase II are natural candidates for Phase III. Assessing how systems perform after implementation is a more complex process that relates to ISO 9000 series of certificates, and SBIS/CFM must learn from there.

Results

The SBIS/CFM Requirements Manual was first published in February 2004. Phase I of the certification process is operational since October 2004. More than 200 software developers have registered on SBIS website and have downloaded the SBIS/CFM Requirements Manual.

At the moment (December 2006), fifty one (51) software products have self-proclaimed compliance with the Manual. Products are divided in categories, according to the table bellow.

Table 1 – Categories of software compliant to SBIS/CFM requirements

Category	Number of products conformant
Public Health Systems	6
Medical office automation / EHR	17
Billing – health insurance	7
Medical Images	3
Occupational Health / Surveillance	4
Hospital Information Systems	14
Total	**51**

Present status

At the moment, the documents to initiate Phase II are ready: the Auditor Manual with all the scripts and case tests, the Code of Ethics for the auditor and the Term of Reference to accredit Certification Organizations. The training program for the auditors is scheduled for January 2007 and it is our intention to have Phase II operational by March 2007. Hopefully by MEDINFO we will have the first results of Phase II to show.

Conclusions

Certifying software is a very complicated and costly task. The Brazilian process had to start in small steps to accommodate and educate the market. Today there is a consensus that the process will qualify the software suppliers in Brazil and will allow for a secure transition to a paperless environment.

The Ministry of Health participation in this process is desirable since this would guarantee greater investment in the process. So far the work has been sponsored solely by the Brazilian Federal Council.

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Biometrics for Telemedicine Operation and Management

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Abstract

The biometric methodologies and effects on telemedicine are discussed in this paper. In developed nations, the increase of the non member of the health insurance becomes a social problem. Near future, when we had operated telemedicine (especially telehomecare) via broadband circuit, a client's biometrics become more important to confirm whether or not the client is the very person who joins to the health insurance. We feel that the optical sensor (face, iris, and retina) using the videophone system is a promising biometrics system for telehomecare. We propose the inclusion of optimized biometric methodologies and guidelines as a theme of ITU E-Health standardization and/or ISO HL7.

Keywords:

biometrics, certificate of health insurance member, standardization

Objectives

The biometric methodologies and effects on telemedicine are discussed in this paper.

We propose the inclusion of optimized biometric methodologies and guidelines as a theme of ITU's E-Health standardization.

Background

What is biometrics?

Biometrics is an individual identification technology utilizing the unique biological characteristics of humans, and is typically used to identify the owner of forms of identification such as cash cards, driver's licenses, and health insurance ID cards. The conventional technique is to compile information on individuals in the form of a database and then identify individuals using a PIN, password, and ID cards based on the stored information. This technique, however, is vulnerable to illegal acts such as forgery, theft, tapping, and identity theft.

The biometric method measures biological objects having the following three characteristics:

1. Universality (characteristics common to everyone)

2. Uniqueness (characteristics unique to each individual)

3. Permanence (characteristics that do not change over time)

Such individual characteristics--well-known examples include fingerprints, the retina, iris, voice, hand shape, palm print, and face--are stored in a database for identification.

This technique simply analyzes the biological characteristics that are expressed using images and signals, and estimates the probability of pattern matching with the data in the database. As a result, the output is only a positive recognition or negative recognition, as shown in Fig. 1; note that the matching probability is not 100%.

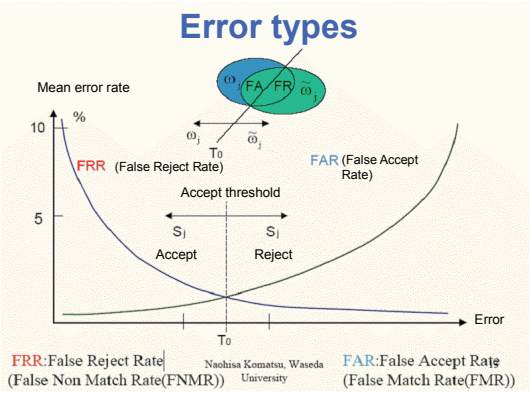

Figure 1 - Error types

Market

Increasing global concerns about terrorist activity and identity have boosted the demand for improved security. Increased media attention has raised end users' awareness of the potential of biometric technologies in security applications. Significant market opportunities are thus emerging in application areas such as physical access control, citizen identity, network security, financial services, entitlement and healthcare. For example, InfoShop-Japan reports that the world market size for access management (keyless entry) alone was USD13 million in 2002 and will reach USD70 million in 2007(Fig. 2). As shown in Fig. 3, 50% of 2004 biometric products are fingerprint sensors. Non-contact sensors are expected to increase in popularity in the near future. If they are used in the areas of telehome care and geriatric care, the market may explode in advanced countries.

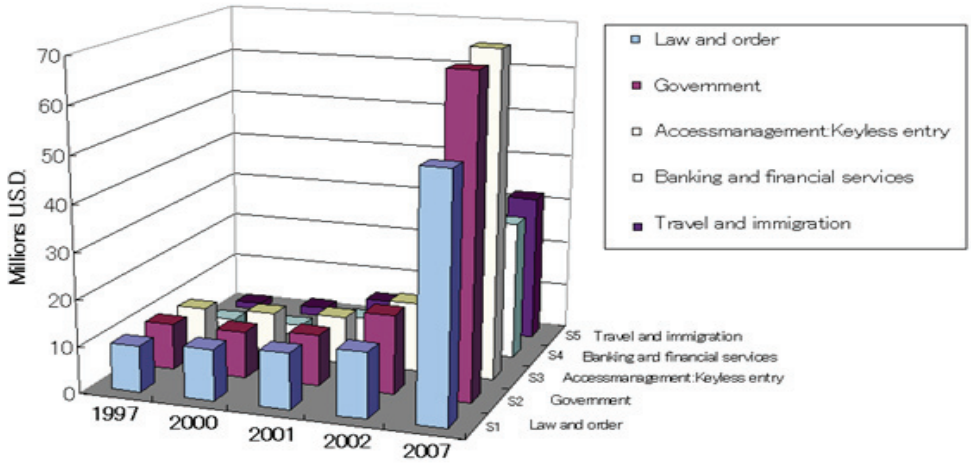

Figure 2 - The world market for Biometrics

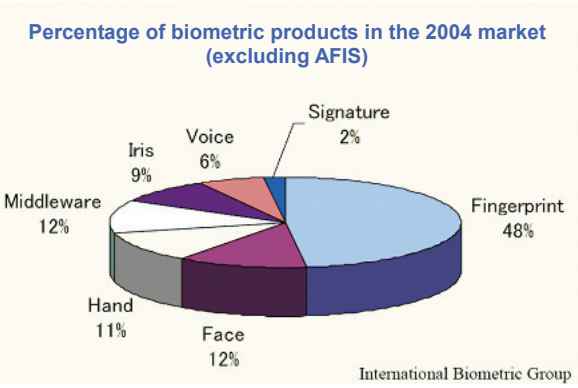

Figure 3 - Percentage of biometric products

Necessity of biometrics in telemedicine

With the increasing importance of the comprehensive management of medical information in our aging society, individual identification is essential not only for telemedicine but for information management for individual information browsing and making insurance payments. Japan is facing the problem of an increase in the number of people who do not pay health insurance fees. As the number of patients who attempt to receive medical services in an illegal manner through identification theft is expected to grow, the importance of individual identification will be enhanced.

We have identified the following needs in telemedicine for individual identification:

1. Health insurance ID certificate (or ID card in some countries)

2. Remote consulting

3. Emergency transport

4. Health check (except for diseases)

5. Return of medical fees

6. Patient chart browsing (for the patient only)

The above six applications require identification accuracy as high as that needed for the online banking system.

Proposal

We feel that the following optical sensor using the videophone system is a promising biometrics system for telehomecare.

Face

A Methodology: We learn the characteristics of each face using CCD cameras and photos in advance, prepare a database, and examine the target face based on the face patch theory (which is totally different from the neural network theory that has already been discussed extensively).

Preliminary learning: Extracts the relative positions of the eyes, nose, and eyebrows, and draws an identification curve using Adaboost Image matching: Extracts the eye, nose, and eyebrow characteristics of the target face, and matches them with data in the database

B Advantages: A videophone system using a PC-based or dedicated terminal device is used in telehome care. Thus, compared with other applications, it is easy to capture the patient's face image from the front each time with almost the same size under uniform illumination conditions that are close to ideal. Because the high-quality CCD device allows the doctor to see the symptoms of anemia, icterus, spider angioma, and nerve damage, the visual check and

face identification can be performed simultaneously. It is, however, difficult to maintain consistent identification accuracy, as the face characteristics may change over time. False identification as a result of plastic surgery on the eyes, nose, and jaw may also be possible. Thus, it is preferable to use another identification technique in addition to face identification.

Iris

A Methodology: Individuals can be identified based on the iris pattern, which is unique to each person. The iris pattern is formed within six months after birth and stabilizes within one year after birth, and does not change until death. Two devices can be used to measure the iris pattern, as follows.

1. If the videophone system is equipped with a zooming function, it can work as an iris identification device.

2. A dedicated light-reaction device can measure the speed of light reaction and examine the iris pattern simultaneously.

In the identification process, the analysis zone is selected from the iris pattern sampled using the CCD, its profile is extracted using a Gabor filter and then coded. This code is used to select the closest iris code in the database based on the Hamming distance value. The error rate is 2^{-244}, the same probability of a coin toss ending with the same result 244 times in a row.

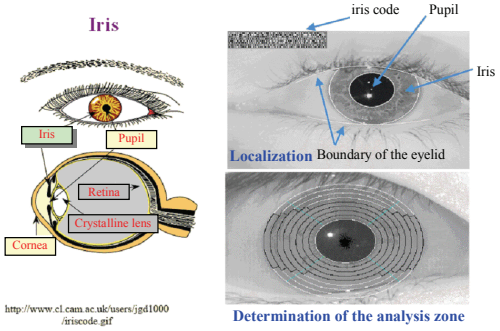

Figure 4 - Analysis of the iris

B Advantages: Non-contact, easy to use, and accurate. It would be very difficult to fake an iris, even with advanced plastic surgery and eye operation techniques. In combination with the light-reaction device, it can measure the iris reaction speed (which aids in diagnosis of problems with the brain stem and oculomotor nerve) and identify the iris pattern simultaneously.

Retina

A Principle: The vessels pattern of the retina can be used for identification. This vessels pattern remains unchanged unless the veins shrink due to diabetes or other illness. It is normally difficult to see the vein pattern without expanding the iris using chemicals (e.g., Mydrin). In recent years, however, a device has been developed that can see the vein pattern without the use of iris-opener chemicals. As dedicated equipment is necessary in both cases, it is not possible to conduct retina identification using a normal videophone system alone.

B Advantages: Non-contact and accurate, but not easy to use. The biological origin of the retina is the same as that of the brain. In fact, it is possible to estimate the condition of the blood in the brain from that in the retina, and the brain pressure from the optic papilla on the retina. Some easy-to-use devices are expected to be developed in the future. We should focus on the retina device as a promising telehomecare device.

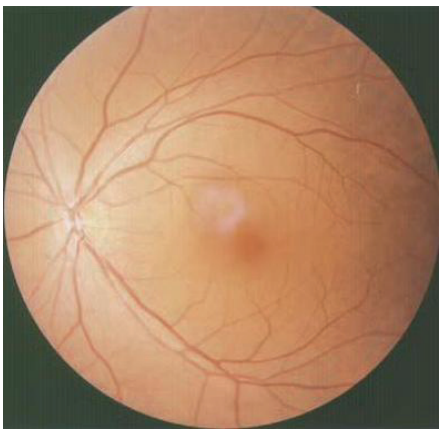

Figure 5 - The pattern of retinal blood vessels (Artery and Vein)

Prospects

Reluctance to use fingerprints

The U.S. Visit Program employed by the immigration authorities in 2004, which uses fingerprints for individual identification, has been poorly evaluated by those visiting America. This is due to the fact that this FBI technique, known as AFIS (Automated Fingerprint Identification System), has been used to identify criminals in the United States. Many people may not accept the use of such a criminal identification system for totally different medical use. Most users may prefer non-contact-type biometric techniques that do not use fingerprints. Diagnosis using the videophone system provides information on the patient's physical characteristics. Thus, it is natural to use such physical information for user identification.

Three accuracy levels

A number of biometrics companies have developed a variety of identification techniques using fingerprints, vein patterns of the palm, face, iris, and retina characteristics. These techniques are completely unrelated to each other.

Although more than one algorithm and measurement device are available, the identification result can only be one for each individual. As in the case of mathematics, there is only one correct answer. If the identification accuracy is not sufficiently high, users will be inconvenienced. Unless an identification system is shared by many users, as many sensors and devices as the number of such systems will be necessary. This is unreasonable for users. Since the 9/11 terrorist attacks, homeland security has been focused on, so it is currently difficult to establish an international standard for individual identification. However, at least objective accuracy guidelines should be considered. We feel that the following accuracy evaluation should be included in such guidelines.

1. Accuracy evaluation of the matching algorithm: Numeric degree of pattern matching between two input images

2. Accuracy evaluation of the matching device: Accuracy of hardware, including sensors

3. Accuracy evaluation of identity matching: Accuracy of identification of the correct person

Without these three accuracy evaluations, no identification technique can be objectively evaluated. Objective evaluation is the first step toward international standardization.

Efforts for standardization

The standardization of biometrics is underway in ITU-T SG-17 Telebiometrics and ISO/IEC SC37/SC17/SC27. However, there is no forum for discussing applications to telemedicine. If E-Health is standardized by ITU-T SG-16 Q-28 in 2004-2007, discussions on the standardization of biometrics for telemedicine should be kicked off as early as possible jointly with SG-17. As mentioned above, the medical needs are diverse and the telemedicine market is growing faster than expected. We feel that biometrics for telemedicine should be included in the ITU scope. If we lose this opportunity, the importance of telemedicine standardization by ITU will fall drastically. This is due to the fact that the ICT technology will involve the elderly, who often do not go out for medical care, and to the fact that the biometric market is expected to explode. If there is no international standard, the market may be driven by a de facto standard. Although de facto standards are acceptable for applications in a free market, they may cause many problems in medical applications that should be under national control. As a result of such problems, many developing countries and the weak and elderly will be left behind. Therefore, ITU is required if standardization is to be achieved in a timely manner.

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Nationwide Standard Electronic Health-Document-Exchange based on HL7CDA - Rel.2 in the New National Health-Checkup-Program for Preventing Metabolic Syndrome in Japan

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Abstract

We have developed the standard electronic format based on HL7CDA-Rel.2 in the nationwide standard electronic health-document-exchange that is the indispensable infrastructure of the new national health-checkup-program (NHCP) in Japan. HL7CDA-R2 was proved to be an applicable message standard to the NHCP in Japan. The exchange has been under the test phase since F.Y.2006 and the real phase is supposed to start in the beginning of F.Y.2008. This is the first nationwide standard health-document-exchange based on HL7CDA-R2 and the estimated number of participants is between 10 million and 50 million citizens.

Keywords:

health checkups, Metabolic Syndrome,
public health informatics, HL7 CDA,
information standard

Introduction

In recent years, life-style related diseases such as diabetic mellitus, hypertension and hyperlipidemia are greatly increased in Japan. This situation is criticized as one of the causes of ballooning healthcare cost. For this reason, the Japanese government formed the policy which aimed at a 25% decrease of the prevalence of the life-style related diseases and the number of pre-disease state person by F.Y.2015[1].

In accordance with the above policy, the Ministry of Health, Labor and Welfare, Japan (MHLW) has decided to start the new national health-checkup-program (NHCP) which is specific for preventing metabolic syndrome from F.Y.2008 because metabolic syndrome is proved to be a key pre-stage followed by the life-style related diseases. All the health insurers that support the universal health insurance system in Japan shall be obligated to provide all the insured persons and their dependent family members aged between 40 and 74 with the routine health-checkup. They also have obligations to conduct the health consultation program which is specific for preventing metabolic syndrome in the standard method.

In NHCP, all the stakeholders (i.e. health-checkup providers, health consultation providers, insurers, and so on.) are required to exchange the health checkup and consultation data in a standard electronic format. Therefore, we developed the standard format and the guideline of its application under the special working group sponsored by the MHLW. The purpose of this project is to show problems and its solutions in applying HL7 Clinical Document Architecture, Release2 (CDAR2)[1] to the standard data format in NHCP.

Methods

In NHCP, there will be 4 major events such as health checkup, first-time consultation, mid-term evaluation and final evaluation consultation. Since the information to be exchange are different in each events, specified message formats are required for each message exchange.

In order to reduce development and management costs, we have developed a standard message model based on the HL7 CDAR2 specification [2]. The message format and XML schemas are derived from the model we have developed.

Results

Figure 1 shows the NHCP standard message model based on the HL7 CDAR2. Message schemas dedicated to each NHCP events are generated from this message model. Each message has basically one section to describe each health checkup and consultation events. Additional sections will be occurred to describe optional information, such as health insurance policy holder specified health checkup results.

The checkup results and the performance of the consultations are described in structured format conformant with

CDAR2L3 for automated data processing on the recipient side.

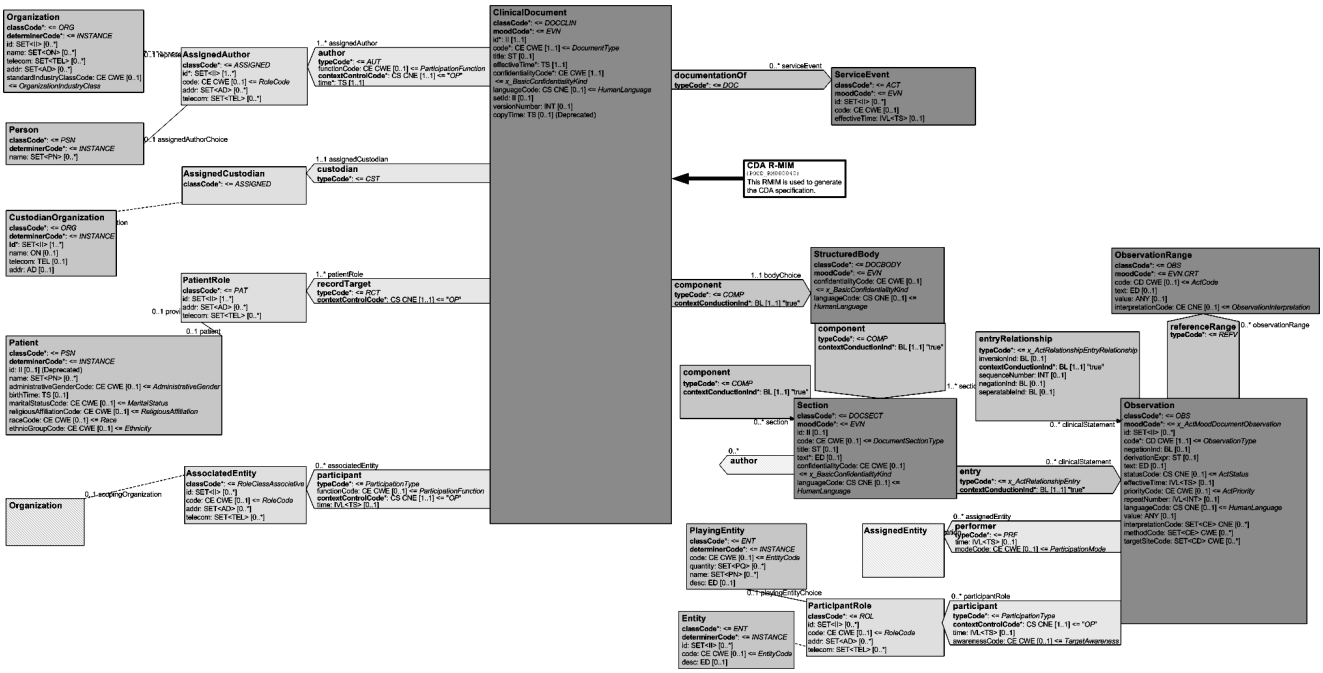

Figure 1 - The NHCP message model. This model is derived from original CDAR2 message information model

Discussion

In the NHCP, although it was found that the author, the custodian and the participants-information elements in the CDA message header have to be rewritten as the exchanging phase progresses, the HL7CDA-R2 was proved to be an applicable message standard to the NHCP.

However, since the CDA is originally an adaptable standard for the various medical documents, plural message notation exists to the identical contents. In addition to it, the NHCP requirements may be changed in the future. To guarantee the interoperability, development of a new mechanism to verify the message conformance to the standard is required.

The real phase of using the proposed standard is supposed to start in F.Y.2008. This is the first nationwide standard health-document-exchange in Japan. The estimated number of participants (i.e. the insured) is nearly 50 millions in the near future.

This message model and message format will be used for information exchange of the Health Checkup for Labors under the Occupational Health and Safety Law of Japan, and Health Checkup and Management Program for School workers under the School Health Low of Japan, as well. The authors believe that the proposed HL7CDA-based exchange program will not only contribute on the success of the NHCP in Japan but also serve as a useful reference for health document exchange in other countries.

Conclusion

In this paper, we described an outline of the new national health-checkup-program and brief structure of the NHCP message model. The exchange has been under a test phase since F.Y.2006 and the real phase is to start in the beginning of F.Y.2008. It will be the first nationwide standard health-document-exchange in Japan.

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OpenECG: Promoting Interoperability Through the Consistent Implementation of the SCP-ECG Standard in Electrocardiography

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Abstract and objective

The OpenECG Network (www.openecg.net) has been created to promote interoperability in electrocardiography with tutorials, specifications, open source tools, data sets, converters, and interoperability testing. ECG vendors, members of professional organizations, researchers, and other stakeholders participate in the OpenECG network to exchange views and receive assistance in implementation. In 2006, members are more than 700 individuals from 58 countries. A specific focus area for OpenECG that concerns diagnostic quality resting electrocardiograms (ECGs) is SCP-ECG, the European standard (EN1064:2005). An online interoperability testing service assists members in consistently implementing SCP-ECG and effortlessly integrating electrocardiographs with eHealth systems. OpenECG is a case of best practice in interoperability that should be followed by medical devices and sensors for effective personalized health monitoring.

Keywords:

interoperability, standards, telemedicine, eHealth services, medical devices, electrocardiography

Methodology

Electrocardiography is the most frequently applied non-invasive examination for early detection of heart disease, a leading cause of morbidity and mortality in western countries. It is estimated that more than 100 million ECGs are recorded annually in Western Europe. The ECG allows early detection and follow-up of heart disease, but today the operation of most ECG devices is still based on proprietary protocols and file formats.

SCP-ECG is a standard communication protocol that specifies the interchange format and a messaging procedure for ECG equipment-to-computer communication and for retrieval of ECG records from the computer to the ECG equipment (if needed). Since March 2005, SCP-ECG (EN1064:2005) is the European standard for high quality diagnostic ECG exchange and if consistently implemented ensures interoperability. Nevertheless, it is rather difficult for integrators to implement SCP-ECG correctly and there are variations in implementations, which can be a barrier to interoperability. Although a number of ECG device manufacturers and integrators have implemented the SCP-ECG standard, most implementations are not fully accurate. This is due partly to misconceptions and partly to the lack of widely publicized conformance levels and IHE-like integration statements that exist for modalities in radiology.

In 2003, OpenECG established an online conformance testing service to support the OpenECG community at large in implementing interoperable eHealth systems with SCP-ECG support. A member may submit an ECG file in an alleged SCP-ECG format and receive a list of errors and warnings. If no errors are detected, the submitter may request a certificate that is granted after thorough manual review of the file.

Results

The SCP-ECG conformance testing service has been used extensively by members and in many occasions an interoperable solution was achieved with support from the help desk. In the period 2003-2006, more than 1700 ECGs were submitted for conformance testing by members in more than 20 counties worldwide. Leading is Italy with 11 members, who have submitted 37.3% of the tests. After Italy, most ECGs have been submitted by Greece (17.74%) and Hungary (11.89%). ECG devices and eHealth services have been tested, improved, and validated using online tools and support from the OpenECG helpdesk. In 2005, a web service variant of the conformance testing service was integrated to the ECG viewer that won the first prize in the OpenECG programming contest. After certain limitations of the software were identified and amended, a new version of the ECG viewer was released and is currently available at the OpenECG open source repository.

Conclusions

The OpenECG network promotes best practice in interoperability for ECGs. Innovative eHealth services capable of managing personal wellness profiles call for plug-interoperability of medical devices, which is an issue of patient safety, key to advancing quality and cultivating consumer trust in the next generation of ambient intelligent working and living environments.

OpenECG

www.openecg.net

Poster #394

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Promoting interoperability through the consistent implementation of the SCP-ECG standard in electrocardiography

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ECG Interoperability portal

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Abstract and objective

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- Electrocardiography is the most frequently applied non-invasive examination for early detection an follow-up of heart disease.
- The operation of most Electrocardiographs is based on proprietary protocols and data formats!
- What is OpenECG?
  - The OpenECG network promotes interoperability in electrocardiography through the consistent implementation of standards
  - OpenECG members are 845 individuals from 60 countries in June 2007, representing different stakeholders.
  - An online SCP-ECG (EN1064:2005, 2007) conformance testing service assists integration of electrocardiographs with eHelath systems.

ECG interoperability portal

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What is OpenECG?

www.openecg.net

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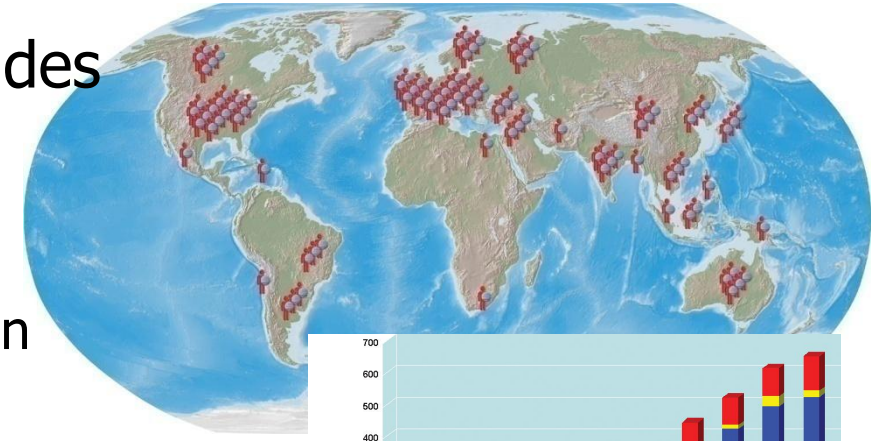
- OpenECG is a European initiative with world-wide impact that actively promotes interoperability and open standards in electrocardiography since 2002.
- 845 members from 60 countries worldwide in June'07
- all stakeholders represented, 30% manufacturers
- The OpenECG portal provides
  - world-wide experience
  - up-to-date information
  - assistance in implementation
  - open source tools
  - specifications and data sets
  - online conformance testing



	Oct-02	Feb-03	Jun-03	Oct-03	Feb-04	Jun-04	Oct-04	Feb-05	Jun-05	Oct-05	Dec-05
Refused	0	2	3	7	19	30	48	72	87	87	107
Under Evaluation	1	2	4	8	8	10	5	18	12	33	21
Members	55	66	91	121	178	235	290	352	422	493	523

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Increasing impact worldwide

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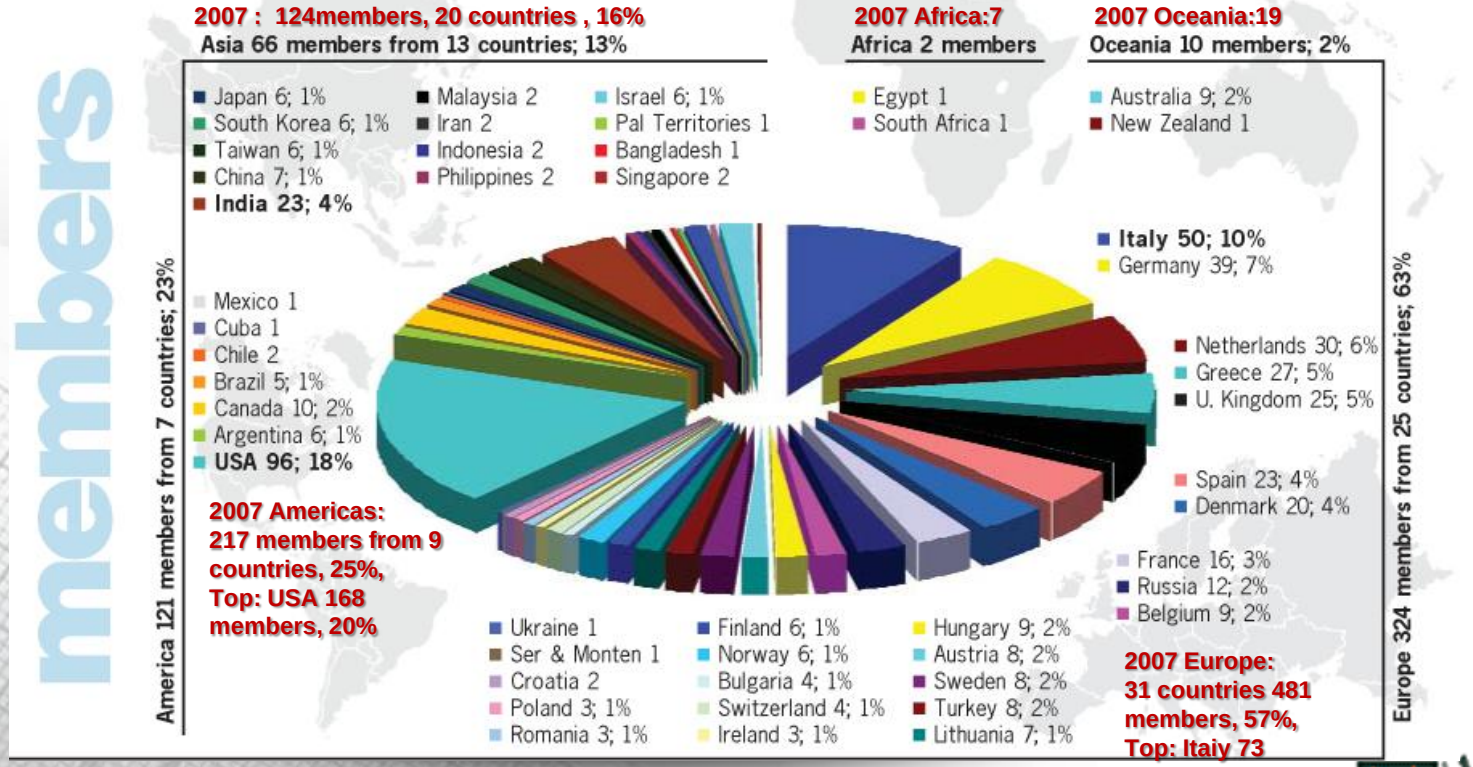
523 members from 49 countries worldwide [Jan 2006]

845 members from 60 countries worldwide [*June 2007*]



60% increase in members since January 2006!
Mostly outside Europe…

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OpenECG services

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- online services: specifications, data sets, tutorials, converters, SCP-parsing by email
- open source SW repository: download tools in open source, peer-reviewed by the OpenECG community
- help desk: contact helpdesk@openecg.net to receive assistance on implementing ECG interoperability standards
- mailing list: discuss developments and practical problems with ECG interoperability standards
- **interoperability testing: conformance testing of SCP-ECG records and ECG devices, SCP-ECG validation web service**
- liaison with standardization bodies: provide practical feedback from implementations
- open source programming contest: check out award winning software at the open source SW repository.

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Resting Electrocardiograph (ECG)

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- The most common frequent non-invasive examination for early detection of heart disease is the Resting ECG where the ECG in supine position is acquired with 12 leads (I, II, III, aVR, aVL, aVF, V1, V2, V3, V4, V5, V6) for a short time (usually 10 sec)
- The CSE project (1980-1990) identified some minimal requirements for diagnostic ECG
  - duration of acquisition (10 sec), sampling rate (500 Hz) and resolution (5 μV) for assuring diagnostic quality to the acquired ECG signal
- The European standard EN1064:2007 (SCP-ECG) up as an ISO NWI, specifies an interchange format to assist the integration of electrocardiographs to eHealth services & EHR systems.

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SCP-ECG structure and compliance levels (EN1064:2007)

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Status	Content
Mandatory	2 bytes- Checksum CRC - CCITT over the entire record
Mandatory	Pointers to data areas in the record [0]
Mandatory	Header Information – Patient data/ECG Acquisition data [1]
Optional	Huffman tables used in encoding of ECG data [2]
Optional	ECG lead definition [3]
Optional	QRS Locations (if reference bits are encoded) [4]
Optional	Encoded reference beat data if reference beats are stored [5]
Optional	Residual signal after reference beat subtraction or encoded rhythm data [6]
Optional	Global measurements [7]
Optional	Textual diagnosis from the "interpretive device" [8]
Optional	Manufacturer specific diagnostic and over reading data.. [9]
Optional	Lead measurement results [10]
Optional	Universal statement codes resulting from the interpretation [11]

SCP-ECG: Compliance Levels

Category	Data Sections Required	Content Description
I	**0, 1, 7, 8**	**Demographics, global measurements and interpretation**
II	**0, 1, 2, 3, 6, (7), (8)**	**Demographics and ECG rhythm data**
III	**0, 1, 2, 3, 5, (7), (8)**	**Demographics and reference beats**
IV	**0, 1, 2, 3, 4, 5, 6, (7), (8)**	**Demographics, ECG rhythm data, and reference beats**

- SCP-ECG is a European standard for 12 lead ECG interoperability
- Includes
  - Demographics
  - Rhythm data (waveforms)
  - Diagnostic report
- Option for ECG specific compression
- Quality control characteristics
- Specific for Short-term conventional "Resting" not:
  - Body surface ECG
  - Intracardiac potentials.
  - Medium and long-term ECG (exercise ECG, Holter ECG or ECG monitoring).

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METHOD: SCP-ECG compliance testing and OpenECG certification

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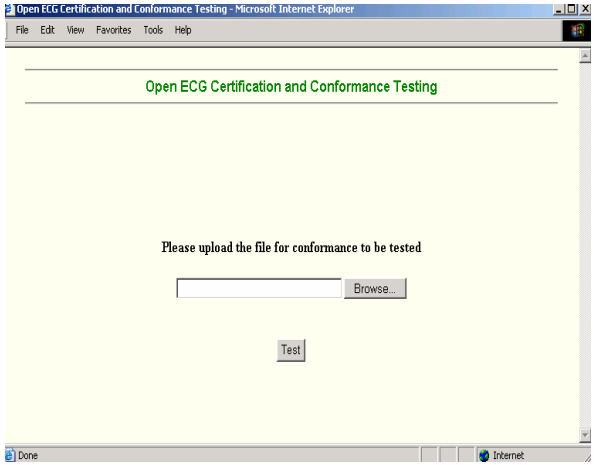

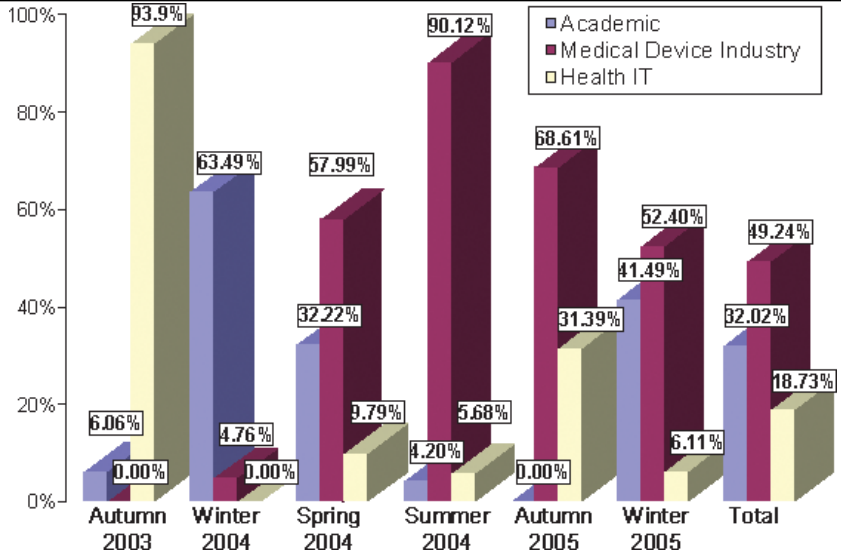

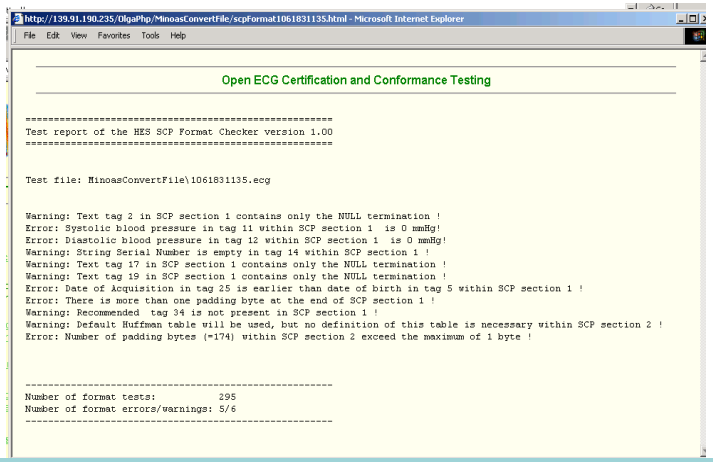

SCP-ECG testing also as a web service: a programming interface to access the SCP-ECG conformance testing service from 3rd party software

RESULTS: Who is using conformance testing?

OpenECG www.openecg.net

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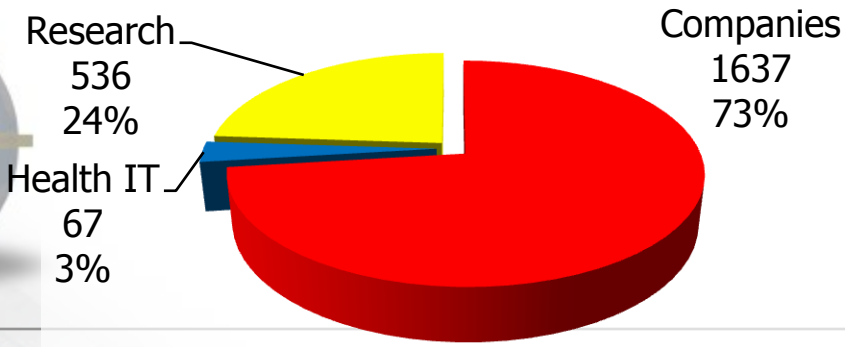
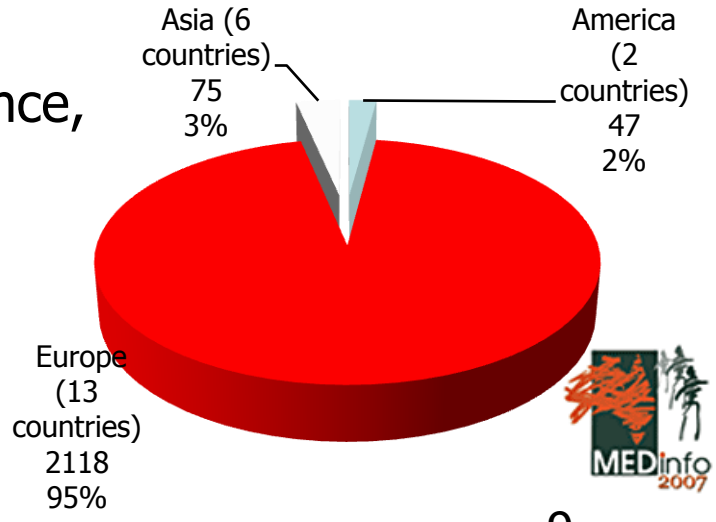
- 49 organizations, 21 countries world wide [June 07]:
  - From September 2003 to June 2007, a total of **2235 ECGs** were submitted by 64 members (8% of the community)
    - Top in Europe: Italy 12 members with (560) 22,5% ECGs
    - USA, 3 members (38 ECGs submitted)
    - Top in Asia: Japan, 2 members (21 ECGs)
  - 23 companies (italy, poland, russia, hungary, us, spain, germany, finland, france, greece, austria, netherlands, japan, china, turkey)
  - 20 research organizations, 2 freelance, 4 healthcare facilities/authorities





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FUTURE WORK: Harmonization Open ECG formats

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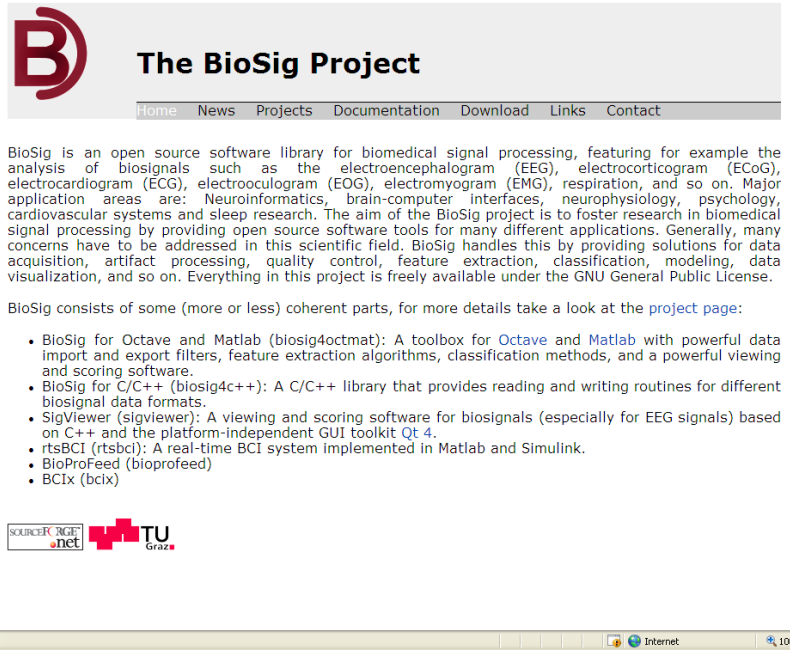
- SCP-ECG to HL7 aECG two-way converter
  - Using Biosig (www.biosig.sf.net)

Ref: Schloegl el al. Computers in Cardiology 2007

- MFER to SCP-ECG mapping (available from the creators of MFER)
- SCP-ECG to DICOM waveform converter (since 2004 in the openECG website)
- MIME types for ECG format



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The VISION: plug-n-play operation of medical devices with Personal Health Records

845 members from
60 nations world wide
In June 2007

- Billion devices connected, some managing our health: are they trusted?
- mobile and wearable "health devices"
- Smart textiles recording biosignals
- patient safety/ reduction of errors
- Intelligence, reliability, robustness
- plug-n-play operation
  - ECGs and biosignals in EHR

    Acquired, processing

    Analysis, managing alarms

For OpenECG interoperability is:
"A patient safety issue,
a quality label for eHealth innovation!"

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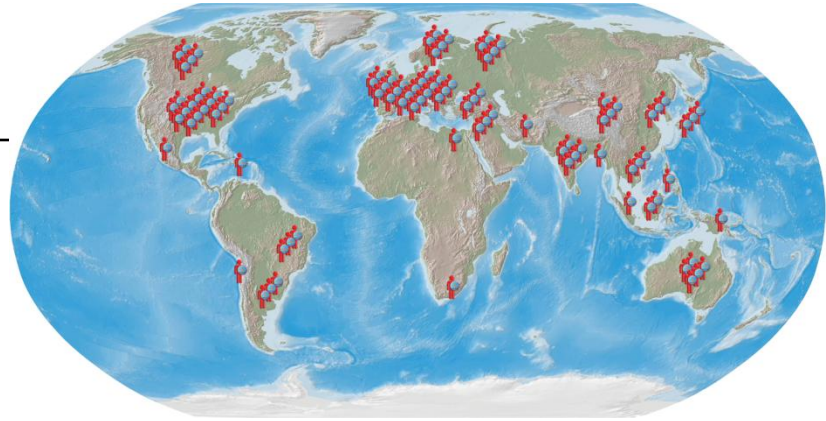
ECG interoperability portal

If you think it's time for

- plug-n-play ECG devices/ biosensors
- personal health monitoring
- lifelong electronic health records
- analysis of high quality health data



Be part of the effort!

join us!

Promoting interoperability through the consistent implementation of the SCP-ECG standard in electrocardiography

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Increasing the Sustainability of a Web-Based Virtual Patients System by Applying the Emerging Medbiquitous VP Standard

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Abstract

The Web-SP is a web-based Virtual Patient system developed at Karolinska Institutet with the aim to easily author, run and manage Virtual Patients (VP) for training and assessment purposes. Web-SP was successfully implemented at several universities world-wide. Our presentation will focus on the findings and experience acquired while adapting Web-SP to comply with the MedBiquitous VP XML emerging standard. An important outcome was the rethinking of the lifecycle of VP's to improve their accessibility and reusability. A new VP import/export tool was developed to support the exchange of VP learning content between universities, either as complete packages or via web services.

Keywords:

patient simulation, standards, computer assisted instruction, problem based learning

Introduction

The Web-based Simulation of Patients (Web-SP)(1, 2) project was initiated in order to facilitate the use of realistic and interactive virtual patients (VP) in medicine and healthcare education. Web-SP focuses on moving beyond the technology savvy teachers, when integrating simulation-based education into health sciences curricula, by making the creation and use of virtual patients easier. The project strives to provide a common generic platform for design/creation, management, evaluation and sharing of web-based virtual patients. Web-SP was successfully implemented at several universities world-wide. The aim of this study was to further improve the sustainability of Web-SP by remodeling the case import/export tool to comply with the Medbiquitous XML standard.(3)

Material and methods

We actively participated into the specification of the Medbiquitous Virtual Patient Schema. A remodeling of the architecture of the vp import/export tool was performed, based on the emerging XML standard published by the Medbiquitous.

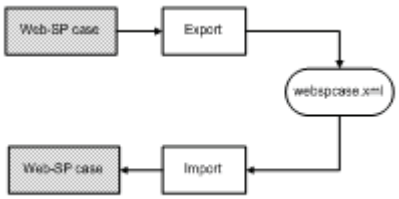

Figure 1 - shows an implementation of a proprietary Virtual Patient exchange, only allowing instances of the same system to exchange cases

Results

The Web-SP system takes advantage of the standard during export and import of a virtual patient case. Thus allowing for cross platform exchange of Virtual Patient Data.

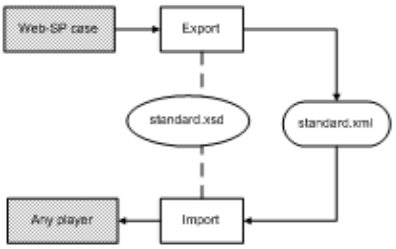

Figure 2 - shows an implementation of Virtual Patient exchange using the MedBiq standard

Acknowledgments

We wish to thank all the members and invited experts of the Medbiquitous Virtual Patient group for their valuable contribution. A special acknowledgment to Robin Eklund for his contribution to the development.

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Evolutions of the Brazilian Permanent Council of Health Standards

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National Supplementary Health Agency (NSHA), Rio de Janeiro, Brazil

Abstract

The Brazilian Permanent Council of Health Standards, COPISS in portuguese, consists of 21 stakeholders representing every part of health care system in Brazil: healthcare organizations and clinicians, patients, payers, government agencies and researchers. This council has been working on the evolution of the TISS standard, which establishes rules for data structure, terminology, communication and security policies between health plans organizations and health providers. The main evolution in TISS standard has been the design of web services to be adopted between their softwares to implement the electronic messages already defined. A reference implementation, called TISSNet, is a powerful JAVA solution for this. The COPISS results have been relevant in order to make achieve interoperability in private health care information systems.

Keywords:

medical informatics, standards

Introduction

Even though Brazil has achieved universal or near-universal cover through a national public health system, large population segments (25%), estimated as 180 million of people, are covered by private health plans. National Supplementary Health Agency, NSHA, (*"Agência Nacional de Saúde Suplementar"*) created in 2000, is responsible for regulating and assisting the private health plans organizations (HPOs), around 2000, and their integration with the health care providers (HPs).

The lack of health care data standards has led NSHA enact the federal normative resolution (RN no. 114), October 25, 2005, establishing the supplementary health information exchange standard (*"Troca de Informação em Saúde Suplementar", TISS*, in Portuguese*)*. Based on the structure of the American Health Insurance Portability and Accountability (HIPAA)[1], it establishes a set of standards for data exchange between HPOs and HPs, and also creates the Brazilian Permanent Council of Health Standards (*Comitê de Padronização de Informações em Saúde Suplementar*, COPISS, in Portuguese), which manages the implementation and evolution of TISS standard.

As a matter of fact, the COPISS has significantly contributed to achieve all stakeholders' consensus and even their recognition for the value of the interoperable data exchange. Through many debates and a collaborative methodology the stakeholders have considered the TISS standard the main project in the supplementary health market for the last years.

Methods

NSHA started the TISS standard development in 2002 as a research, sponsored by the Inter-American Development Bank (IDB). At the beginning it was a software development project based on any market health information standard. So NSHA decided to analyze some national and international standards and then developed a real national one. The software would be a reference implementation.

After disseminating the results of the research to all stakeholders through several seminars around the country, the market asked for a mandatory standard published in a resolution, which was finally enacted in October 2005. In fact, the TISS standard will be mandatory from May 2007, between HPOs and hospitals/laboratories; from November 2007 between HPOs and odontological clinics; and from November 2008 between HPOs and medical and dentist offices.

In order to improve the TISS standard, the resolution created the Brazilian Permanent Council of Health Standards, called COPISS, in Portuguese. This council has been working intensively since April 2006 and has accelerated the adoption of more standards in order to facilitate true interoperability on a national scale.

Results

Twenty-one organizations representing HPOs, HPs, federal agencies and academic and research institutions participate in COPISS. It has a coordinating committee and other four committees divided in the same way the normative resolution (RN no. 114) divides the TISS standard: data structure, terminology, communication and security.

The Data Structure Committee defines the data to be exchanged between HPOs and HPs either by paper forms

or electronic media and the terminology committee defines the semantic domains the data must adhere to.

The communication committee defines the possible transactions and protocols to be used; and the security standards define requirements to protect classified health information. The TISS communication committee is aimed at assuring interoperability between HPOs and HPs to the maximum possible extent.

It is important to mention that some significant results have been recently achieved mainly related to the communication standards. The communication committee has agreed upon a couple of rules defining a standard directory structure for batch file exchange, based on the inbox / outbox model, and a well defined set of web services in WSDL for on line transactions. NSHA has developed a reference implementation for the agreed and proposed communication standards, called TISSNet, available at the ANS web site: www.ans.gov.br, which implements each and every defined requisite. Developed entirely in JAVA 5, it can be used under Windows, Unix and MacIntosh unchanged, and is offered for free to the market, to be enhanced and improved by the players themselves. So far, it supports HTTPS, digital certification, zip compression, RIJNDAEL encryption and the JSR-181 (EJB-3.0) standard for web services, and can be wrapped into an ActiveX DLL to become a component for WINDOWS applications. Table 1 shows an example of the input / output TISS messages and web services between them.

Table 1 – TISS electronic messages and Web Services

Input Message	Web Service	Output Message
Claims/ encounter data	TISS-Claims/ encounter	Claims/encounter data response
Referrals and authorizations	TISS- Authorizations	Referrals and authorizations response
Claim status inquiry	TISS- Claim status	Claim status response
Eligibility inquiry	TISS- Eligibility	Eligibility response

Web services are a powerful tool to integrate disparate health care applications and will certainly bring many advantages to the Brazilian health care domain [2]. As can be seen, a set of web services will certainly address the functional interoperability, in other words, the ability of two or more system to exchange information. Even though it will be necessary to conform to the exact specification by calling Web Services with the names that have been specified, it may achieve a certain degree of semantic interoperability. So all information shared by systems will be understood by the receiving system. But authors consider that much has been done considering interoperability advances by COPISS. Soon NSHA intends to evaluate the use of the TISSNet software through a set of indicators and interviews and also the use of web services between the private health information systems.

Discussion

The creation of a council called COPISS has been fundamental to the evolution of health care standards in Brazil. Its members, both public and private, have been working all together in a collaborative way and have been disseminating the results for all health care organizations around the country. However, there are still relevant issues not discussed yet like vocabularies, unique drugs terminology, demographic services, reference model for data architecture, medical equipment, protocols for medical equipment and also standards for electronic prescribing and laboratory results. More studies should be done comparing the TISS standard and some international standards like ISO/ TC215, CEN/TC251 and HL7 [3], [4], [5].

Conclusion

COPISS is really a democratic forum, where standards are developed through an open-door consensus process and achieve their credibility by the participation of the stakeholders, often with contrasting or even opposing interests.

Only through this council, interoperability in health care systems will be achieved. The design of web services to change messages between HPOs and HPs is a good example. Another excellent example is the reference implementation, TISSNet, that will implement the proposed communication standards by all players since it is free and available on the web.

In such a huge market, as private health care is in Brazil, it is very important that government, HPOs and HPs work together.

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Evolutions of the Brazilian Permanent Council of Health Standards

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•Some Facts about Brazil

- 9th Largest Economy in the World
- 190 million Inhabitants
- Larger than Continental USA
- It is a Country of Huge Contrasts:
  - some top quality institutions and
  - a very bad income distribution, though improving
- 22 million Internet users today, some 5M with broadband access
- e-business:
  - 5th largest market in e-business
  - U$15Bi in e-commerce in 2005
- 95% of IRS Tax Return Forms on the Web
- Voting System is 100% Electronic
  - More than 100 million voters
  - Recent National Election Results in Less than 12 hours

Brazil – Geo-political Perspective

- The largest country in Latin America
- The only Portuguese-speaking country in LA (52% of South America speak Portuguese)
- The 5th most populated country in the World
- The 2nd country in number of Internet hosts in America

SUS – The Brazilian Health System

- **Universal Access**
  - Health is a Right for All (~ 145M individuals)
- **Full Coverage , Free of Charge**
  - All service and Procedures
- **SUS principles:** Equity ; Universality; Integrality
- **National standards:** health plans carriers, providers and individual unique identifiers – vocabularies: ICD-10
- **Funding and Management are Shared**
  - Federal, State and Municipal Levels

Brazilian National Standards for the private sector

- **Suplementary Health for Those Wiling to Pay**
  - ~ 2,000 HMOs (~ 45M individuals)
  - National Agency for Supplementary Health – NASH ("*Agência Nacional de Saúde Suplementar*", ANS, in portuguese) regulates the Sector
- **"TISS" project – Private Health Information Exchange – since October 2005**
  - Content, Vocabularies and Data Transmission XML based
  - Enforces Data Confidentiality and Privacy
  - Simplifies Data Exchange Between Providers and Health plans
- **COPISS: Brazilian Permanent Council of Health Standards**

National Standards for the private sector: messages and Web Services

Input Message	Web Service	Output Message
Claims/encounter data	TISS- Claims/encounter	Claims/encounter data response
Referrals and authorizations	TISS- Authorizations	Referrals and authorizations response
Claim status inquiry	TISS- Claim status	Claim status response
Eligibility inquiry	TISS- Eligibility	Eligibility response

COPISS - Brazilian Permanent Council of Health Standards

- Twenty-one organizations representing:
  - Health plans carriers
  - Healthcare providers
  - Federal agencies
  - Research institutions

COPISS - Brazilian Permanent Council of Health Standards

- Meetings:
  - Every month
  - Discussion:
    - data structure of billing forms;
    - Terminology;
    - electronic data interchange (messages);
    - and security/confidentiality.

COPISS - Brazilian Permanent Council of Health Standards

- COPISS is really a democratic forum, where standards are developed through an open-door consensus process and achieve their credibility by the convening of different stakeholders, traditionally opponents

- This council is the way to achieve interoperability of independent health care information systems.

- The design of web services for changing messages among health plans carriers and healthcare providers.

- In such a huge market, as private health care is in Brazil, it is essential that government, health plans carriers and healthcare providers work in a collaborative way

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ANS Agência Nacional de Saúde Suplementar

Ministério da Saúde

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Developing An Automated Mapping Algorithm for the ICNP in Japanese

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Abstract

OBJECTIVES: The purpose of this study is to develop the mapping method from terms which are used in clinical settings to the Japanese Translation of the ICNP version 1. METHOD: We used n-grams for approximate matching and calculated the similarity scores between terms by the length of the n-grams and the frequency of n-grams in the ICNP. Using this method, we were able to create the lists sorted by the similarity scores. RESULTS: The proposed method seems to be useful in the mapping process.

Keywords:

ICNP, translating, terminology, International Council of Nurses

Introduction

The Japanese translation of the ICNP version 1 (International Classification for Nursing Practice) was published in July 2006. But one of the reason is that the concepts in ICNP is that some translation terms are rarely used in clinical settings.

In order to use the ICNP as a reference terminology, it is necessary for users to find the ICNP concepts from Japanese terms easily.

The simple word matching algorithm was not appropriate if the results suggest more than 20 terms.

Methods

At first, we extracted 20838 n-grams from the Japanese translation of the ICNP. To calculate the similarity scores between a query string and terms in the ICNP, we used following equation.

$$\sum_{n \in Q} \frac{Length(n)}{Freq(n)} \quad (1)$$

where
Q are the N-grams made by a query string

Length(n) is the length of the N-gram

Freq(n) is the number of documents containing the N-gram

To evaluate the method, the Japan Nursing Practice Standard Master (JNPSM) that includes the names of nursing activities and is built by the Medical Information Center Development Center (MEDIS-DC);

There was not full agreement in the mapping between the experts. We used 48 sets of the mapping as a gold standard.

Conclusion

The proposed method seems to be useful in the mapping process.

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Nursing Minimum Data Set: A Literature Review

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Abstract

Essential information for nurses may be obtained from information technology systems, for this reason it is fundamental the adoption of standard language which translates the essence of nursing. The Nursing Minimum Data Set and Nursing Management Minimum Data are relevant in description, register and retrieval of these data. A literature review on the use of these data sets for research on the subject, the trends and nurses' practice was accomplished. Method: Selected articles from the index of Medical Literature and Analysis and Retrieval System on Line (1993 - 2005), from the integrated library archives of Regional Medicine Library, in English and Portuguese. Final considerations: The findings permitted the identification of the total number of publications which show the necessity of dissemination and discussion of the subject among the Brazilian nurses; description of current health trends, the elderly and chronic disease patients care; nursing home care evaluate trends, justifying costs, comparing and evaluating cares. The increasing interest on the use of these data sets can be explained by the necessity of consistent and available information at the shortest length of time possible.

Keywords:

nursing minimum data set management,

nursing informatics, nursing, terminology, medical records systems

Introduction

Nowadays information has become a more significant power much than any other one. This power is frequently measured by the mastery and use of information provided by new technologies. Everyday, new technology resources are developed to enable new forms of relationship in the work, either for facilitating or creating new opportunities.

Several benefits from the use of information technologies have been incorporated by health professionals through development of more efficient medical equipment which can be interlinked, enabling professionals to access the necessary information for decision making. On the other hand, scientific and technological advance also brought more data and information.

The information volume generated by health institutions is enormous which demand the use of information technology to sustain process and management of necessary information for caring with the quality level that is demanded and deserved by the clients.

This reality brings many challenges to health professionals, mainly for nursing, which is responsible for continuous care of clients/patients. In this context it is expected from nursing professionals an adaptation to the new roles which answer the social and institutional demands, with knowledge, quality and competitiveness to attend clients who are more conscious and demanding about their rights, in a supplier/costumer relationship. Therefore, it is understood that an efficient use of information is critical for a contemporary health assistance of high quality by the professionals who are directly involved with the clients/patient care.

The use of information technology in health care has evolved from a situation where the computer was used in the accomplishment of single and isolated tasks to the level of integration of information, whose objective is to integrate diverse points of information and their use on the services.

At the beginning the use of information technologies was directed to the accomplishment of management activities with the development of financial and managerial systems. However, there is an increasing interest in development of information systems towards the registering of nursing clinical care.

The introduction of computer systems in the care environment enabled an approximation with the client.[1] Through these systems, the nurse can access more consistent and uniform information about procedures, responses to performed cares, and how clients perceive the received care.

A nursing information system focused on client must be specific to the complexities of nursing care and it needs to project the activities, interventions and outcomes for the client, which represents a great challenge since the nursing care outcomes do not occur isolated, but into a multi-disciplinary context.

In order to develop a nursing system the responses to the needs above mentioned it is fundamental the adoption of a

standardized language which can translate the essence of nursing as a profession. Therefore, several attempts have been seek out by nurses throughout the world to develop a standard list for the classification and documentation of nursing practice.

In 1984, the North American Nurses Association (ANA) started adopting a series of definitions in order to build an agreement about the necessity of defining a Nursing Minimum Data Set (NMDS) so that it would be possible the aggregation of data in a large scale. Since then, many efforts have been realized and they produced a vast knowledge throughout the years.Therefore, many nursing terminologies were developed to support the operation of nursing diagnosis, interventions and outcomes of nursing practice.

In 1988, based on the concept of Uniform Health Data Set (UMHDS) Werley and Lang built a Nursing Minimum Data Set which can be defined as set of uniform elements and information with definitions and categories related to nursing specific dimensions, with the location of necessary information to a variety of users in the health care system.[2] This data set has the following purposes: (1) describing the nursing care for the clients and their relatives in a variety of situations, (2) establishing comparisons on nursing data, (3) showing or projecting trends according to nursing care and distribution of nursing resources to clients according to health problems or Nursing Diagnosis, (4) stimulating the research in nursing through the use of detailed data present in a Nursing Information System and in other Health Care Information Systems and (5) supplying data about nursing care that can influence heath policies and decisions.

The Nursing Minimum Data Set defined by Werley[2] includes three major data categories: (a) the nursing care, (b) patients or clients demographics, (c) about the service.

In the data category abou*t nursing care* it is included: nursing diagnosis, nursing interventions, nursing results and intensity of nursing care.

The data category *patients or clients demographics* is composed by: personal identification, date of birth, sex, race and ethnics, and residence.

And, in the data category *about the service* we find: unique number of facility and service, patient's or client's health register number, nurses register number, admission episode or date, discharge or discharge date, patient's or client's location, and identification of paying source or responsible for payment.

In 1989, Huber and Delaney (.ref..) initiated, based on the work developed by Werley and Lang, the development of a data structure. The development project of the conceptual structure was based on Donabedian's[3] ideas related to structure, process and results as components for quality; from Iowa's[4] nursing management model and the nursing minimum data set by Werley and Lang[1], since the last identifies the service and demographics data as well as three important elements about nursing care: diagnosis, interventions and outcomes.

Tthe nursing management minimum data set is composed of 17 elements, grouped in three great categories: environment, nursing resources and financial resources.[5]

The use of these data sets may bring many benefits to Nursing: (1) Obtaining comparable essential data about nursing care essence and local, regional, national, and international resources. (2) Pointing out in the patient record the provided nursing care. (3) Identifying trends related to patient's or client's problems and the provided nursing care. (4) Providing Parameters to improve nursing services costs. (5) Data for quality improvement. (6) Additional stimulus for the development and refining of health information systems and electronic healthrecord. (7) Comparative research about nursing care, including research on nursing diagnosis, interventions, outcomes, and intensity. (8) Contributions to promote nursing as a discipline.[6]

Understanding the relevanceof nursingdata sets to support nurses in describing, registering and retrieving data about their activities, either assisting or managerial,; this study was developed by a review of publications which approach the use of nursing minimum data sets to better understand the subject and trends in research and practice developed by nurses.

Objectives

Identifying in national and international periodicals from 1993 to 2005, those referring to Nursing Minimum Data Set (NMDS) and the Nursing Minimum Managerial Data Set (NMMDS) and characterize the production related to some characteristics as language, origin of articles, most common periodicals, authors' performance location and the main themes approached.

Material and methods

The criteria established for the selection of periodicals were: articles that approached the subject Nursing Minimum Data Set, articles into MEDLINE (Medical Literature Analysis and Retrieval System on Line) within 1993 and 2005, articles located in the integrated library archives in theBIREME - the(Latin American and Caribbean Sciences of Health Information Center), in the English language.

The key words used for the bibliographic search in MEDLINE were: "nursing", "minimum", "data", "set", "management". The first results of this search were the

obtainment of 160 articles and the studied sample had 130 articles. The articles which were not in English or could not be found in the archive were refused.

The variables chosen for analysis of articles were: publication language, articles origins, most common journals, authors' performance location and main themes approached.

A quantitative analysis was performed in order to characterize the sample according to the chosen variables through the use of a data basein MicrosotfAccess ®. The categorization was accomplished after reading the article and filling up a script for data collecting.

Results and discussion

From the 160 articles found in MEDLINE, 155 (97%) were written in English, 3 (2%) in Dutch, 1 (1%) in French and 1(1%) in Norwegian. From the 155 articles written in English it was possible to retrieve 130 (81%) articles which constituted the sample for this study. Therefore, the analysis was accomplished using the sample of 130 articles which correspond to the described criteria.

Distributing the sample according to country of , wepublication found that they were from seven countries as it shows on table 1. The greatest number of publications are in the United States of America totalizing 101 (78%) of articles, followed by England 15 (12%), Canada 5 (4%), Holland 4 (3%), Italy and Finland with 2 (2%) articles each and Australia 1 (1%). This survey showed that within the 13 years analyzed, the United States of America was the country that produced articles more constantly.

Table 1 - Distribution of sample according to publishing country

Country of Publication	N	%
The United States	101	78%
England	15	12%
Canada	5	4%
Holland	4	3%
Italy	2	2%
Finland	2	2%
Australia	1	1%
Total	130	100%

In table 2 it can be verified the distribution of articles according to the publication year. The year 2003 was the one which showed more publications 23 (18%), followed by 2004 with 22 (17%), 1997 with 14 (11%), 2002 with 13 (10%) published articles.

It was verified an increase in thescientific production in a more constant way from the year 2002.

Table 2 - Distribution of sample according to the publication publishing year

Publishing Year	N	%
1993	3	2%
1994	8	6%
1995	8	6%
1996	3	2%
1997	14	11%
1998	6	5%
1999	10	8%
2000	11	8%
2001	8	6%
2002	13	10%
2003	23	18%
2004	22	17%
2005	1	1%
Total	130	100%

Regarding to the publishing means it was found that the sample was distributed among 67 journals which were grouped by publication area: 66% (86) of the articles were divided in three areas: 29% (38) were published in journals specialized on geriatrics, 24% (31) in journals on nursing and 13% (17) in medical journals.

This distribution may show a trend in health assistance, since the elder population has been increasing in the last decades.

Table 3 - Distribution of sample according to thematic area of journal

Journal Thematic area	N	%
Specialized on Geriatrics Journal	38	29%
Nursing Journal	31	24%
Medical Journal	17	13%
Health Journal	9	7%
Congresses Proceedings	8	6%
Quality Journal	7	5%
Neurology Journal	7	5%
Informatics Journal	4	3%
AIDS Journal	2	2%
Others	7	5%
Total	130	100%

The distribution of articles concerning to the thematic category presented on table 4 show that most of them focus on describing 'Trends related to patient's or client's problems 38% (49), followed by 'Parameters for cost improvement' 16% (21), 'Obtainment of comparable data' 15%, Data for quality improvement 12%.

Therefore, it is possible to verify that a nursing minimum data set is useful for improving nursing services, since anticipating patient's/client's needs, improving costs, comparing data and verifying quality improvement opportunities, the possibility of offering and controlling care is more concrete.

Table 4 - Distribution of sample according to thematic categories

Thematic category	N	%
Trends related to patient's or client's problems	49	38%
Parameters for cost improvement	21	16%
Obtainment of comparable data	19	15%
Data for quality improvement	15	12%
Comparative research on nursing care	11	8%
Development of Health Information Systems	10	8%
Contributions promoting nursing as a discipline .	5	4%
Total	130	100%

The distribution of articles regarding author's affiliation-shows that 68% (88) worked in Universities, 19% (25) in Health Associations or Institutions, 2% in hospitals and 11% (14) of the articles did not mention author's affiliation. From this survey it is evident the importance of educational institutes on the knowledge production. The Universities are located in the U.S.A., United Kingdom, Japan, Korea, Italy, Belgium, Taiwan, Iceland and Germany. The health associations and institutions are also concerned with knowledge production; however, much investment is still needed. It is necessary to convinceprofessionals to become integrated to these academic institutes on the accomplishment and mainly the use of research results to design and redirect . The concern is increasingly frequent for through the aforesaid, it will be possible to plan and evaluate the offered services, however, there are still much to be done.

Final considerations

This work has originated from the interest in studying the standards for the documentation of nurse care in order to incentive the development of computerized nursing systems that may register and retrieve nursing data, generating information that show the nursing contribution for health care. In other words information that supports nurses in different locations and type of nursing performance.

The search for publications about the subject was a way of identifying the nursing minimum data set related studies, verifying the benefits achieved from this use.
The findings allowed the identification of important facts as the totality of English language publications and international journals, displaying the necessity of spreading and discussing the theme among Brazilian nurses, making the language barrier less evident.

It was also possible to identify that the articles describe the current health trends and care has extrapolated the hospital, the assistance of elders and patients with chronic diseases. A variety of articles was found related to nursing home care, which use the nursing minimum data set to evaluate the nursing care trends necessary, justifying costs, comparing and evaluating these cares.

It was evidenced the growing interest by nurses on the use of those minimum data sets which may be explained by the need of consistent and available information at the shortest time length possible to guarantee high quality and optimized use of human and material resources.

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Current Approaches to Secure Health Information Systems are Not Sustainable: an Analysis

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Abstract

This paper proposes a viable IT-based solution for ensuring the privacy and security of sensitive information in contemporary Health Information Systems (HIS).

Keywords:

trusted systems, information assurance, privacy, MAC, HIS

Introduction

In today's society Information, Computer and Telecommunications technologies (ICT) are increasingly entrenched as information infrastructures for the majority of essential services in leading countries such as Australia, the UK and the USA. ICTs are being designed and deployed to process, transmit and store health information in various e-health systems globally. These systems play a significant role in the potential improvement of quality and productivity in the health sector.

In order to manage healthcare stakeholders' expectations of these systems, governments have initiated e-health blueprints which provide guidelines to the developers of HIS. These guidelines take into account the interests of all stakeholders in the health sector.

This paper is particularly interested in the implementation of HIS from an information security aspect: the protection of personal privacy and security of electronic patient records. Current approaches to information security in HIS are, in the opinion of the authors, not sustainable. This paper proposes a viable ICT solution which can reliably provide appropriate levels of secure access control for the protection of sensitive health data in HIS.

Access control in ICT

Access control is one of the fundamental security mechanisms used to protect computer resources; in particular in multi-user and resource-sharing computer environments such as contemporary HIS. The lack of adequate access control management in such systems has been demonstrated on numerous occasions in recent history: the privacy invasion scandal at Australia's Centrelink [1], the lack of adequate safeguards in the UK NHS patient records system [2], and the significant IT security weaknesses identified in the USA HHS information system [3]. These types of breaches have the potential for inflicting, and do inflict, major harm on consumers and providers alike. The issue of providing suitable access control in such systems is not an insurmountable one. This paper proposes a viable solution to this issue.

The two traditional types of access control modes are Discretionary Access Control and Mandatory Access Control:

The **Discretionary Access Control (DAC)** mechanism allows the owner of information to grant access permissions to other users or programs at his/her discretion without the system administrator's knowledge. Such a policy does not provide the actual 'owner' of the system fully centralised access control over the organisational resources. DAC mechanisms are fundamentally inadequate for strong system security because the owner of the system does not have access control over the objects (files) on the system.

The **Mandatory Access Control (MAC)** mechanism provides the ability to limit access to only legitimate users. Ferraiolo et al [4] underscore that MAC is necessary when the provision of a truly secure system is required. Access permission to information is determined by the user's security clearance compared to the security level of information determined by the system. This is also known as a multi-level security (MLS) policy, which was first introduced by Bell and LaPadula (BLP) [5] .

Role-Based Access Control (RBAC) is complementary to both DAC and MAC techniques. RBAC enables easier management by ensuring finer granularity in the access system.

The majority of current information systems which manage access control are DAC-based allowing for wide implementation of commodity software and hardware. Examples are Microsoft Corporation's Windows systems, open-source systems such as Linux and the original Unix system. These are general-purpose systems intended for use in as many applications as possible. In the healthcare sector, HIS MAC-based systems are more appropriate to, and capable of, satisfying the specific requirements of privacy and security of information.

In technical computing terms an application program resides atop a number of sub-systems, one of which is the

operating system (OS) which effectively controls what the hardware does. The security of an application program is restricted by the strength of the security that the OS allows. DAC and MAC mechanisms are enabled at the OS level as well as higher levels including data network management and the database management systems for the application.

Our approach

ICT is now sufficiently advanced that a MAC-based electronic healthcare management system is feasible. Our research to date has indicated that current OS structures need to be updated for HIS needs. The Health Informatics Access Control (HIAC) model is our approach to overcoming many of the privacy and security issues which have plagued previous attempts at electronic health management systems. The HIAC is based on the MAC type of OS which primarily satisfies the requirement for confidentiality of records (this is a major impediment in current and previous systems). The HIS is then developed atop the trusted OS.

For general applications, currently available products that support the MAC principles of trusted OS include "Red Hat Enterprise Linux (RHEL) Version 5, "Fedora Core 6", and "Sun Microsystems Solaris 10 with Trusted Extensions Software". The HIAC model exploits the privacy- and security-enhancement features of such trusted OS in the healthcare environment. The end result is a dedicated trusted HIS which satisfies all privacy and security requirements.

To determine the practical viability of a HIAC model for HIS a demonstrator, based on the Security Enhanced Linux (SELinux) OS with MAC and RBAC approach, was built [6] The HIAC model is necessarily MAC-based accompanied by RBAC properties for flexibility and a refined level of granularity. This degree of simultaneous control and flexibility is not achievable with DAC, RBAC or MAC individually.

The MAC-based system can provide the ability to limit access to only legitimate authorised users. The HIAC profiling mechanism allows for the system administrator to configure the organisational access policies defined and determined by the CEO/CIO and the data custodian. With MAC the access privileges of all users are equally bound by the policy, not set by the discretion of the file/program owners as with DAC. The internal adversary or disgruntled employee will not be able to access health information inappropriately or even through feeding information to an external adversary.

The MAC mechanism can protect the system from malicious or flawed applications which can potentially damage or destroy the system and its information. This can prevent an external adversary penetrating the system by exploiting Trojan Horse attacks, viruses, malware, social engineering or other illicit means to gain total access control or to tamper with audit systems. The HIAC model includes the principle of least privilege and also enforces domain separation through the use of the protected zones known as 'sandboxes' within Redhat's SELinux. These help prevent applications interfering with each other such that an unauthorised user cannot gain overall control of the system as with DAC.

HIAC incorporates RBAC which complements contemporary MAC systems by ensuring more flexibility over the more traditional MAC standalone systems. With RBAC Doctor X and Nurse Y are appointed into a role-type, for example Doctors and Nurses respectively. Access permissions are associated with these roles. In practice this approach gives more flexibility than in the traditional MAC where accesses are granted to individual persons.

In general HIAC provides for maximum flexibility within a strongly secure environment. This means achieving a balance between security needs and flexibility of implementation, which is primarily determined from a privacy risk assessment. For example HIAC provides the flexibility of having an emergency override function by switching to the emergency policy in emergency circumstances. Full auditing of the system deters potential abuses of this flexibility.

Conclusion

Current moves toward Web-based identity and authentication structures present major challenges where such structures are not based on highly trusted OS. The majority of OS in use today are DAC-based in which there are no inherent privacy and security features. All applications and supporting software which necessarily reside atop these untrusted operating systems are also untrusted and therefore vulnerable from a privacy and security viewpoint.

This paper contends that it is both timely and desirable to move electronic HIS towards privacy- and security-aware applications that reside atop trusted computing-based OS. Such systems have the real-world potential to satisfy all stakeholder requirements including modern information structures, organizational policies, legislative and regulatory requirements for both healthcare providers and healthcare consumers (privacy and security), and flexible operational demands in HIS.

This paper emphasises the need for well-directed research into the application of inherent privacy- and security-enhanced operating systems to provide viable, real-world trusted HIS. The authors propose an HIAC model which has the potential to fulfil these requirements.

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Current Approaches to Secure Health Information Systems are Not Sustainable: an Analysis

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Queensland University of Technology, Brisbane, Australia**

Research Question

Are the current approaches to secure health information systems viable and sustainable?

Are there any cases related to health information privacy violations or weaknesses?

Privacy Invasion at Australia's Centrelink [1]

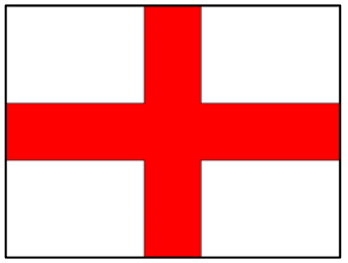
- Centrelink deploys spyware software to detect inappropriate access to client records
  - **790** cases of inappropriate access to client records since 2004
    - 19 staff were fired, 92 resigned,
    - More than 300 staff faced salary deductions or fines,
    - 46 were reprimanded, and
    - the remainder were demoted or warned.

Access control management issue

Inadequate Security Measures at UK's NHS System [2]

- 50 million patient records may be made accessible by 250,000 NHS staff
- To access patient records is on a "need-to-know" basis.
- Does not allow patients to selectively protect particular parts of their health information

Access control management issue



Security Weaknesses at HHS Information Systems [3]

- Significant security weaknesses, e.g.
  - network management, user rights and file permissions, and the auditing and monitoring of security related events
- The potential to expose clients' sensitive information to serious privacy invasions

Access control management issue

HHS : Health and Human Services

Access Controls

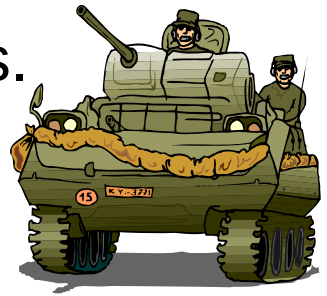
- A set of rules that specify which users can access what resources with which types of access restrictions
- **Applications**
  - Operating systems,
  - Network control systems, and
  - Database management systems
- **Access Models**
  - Mandatory Access Control (MAC)
  - Discretionary Access Control (DAC)
  - Role-based Access control (RBAC)

Discretionary Access Control (DAC)

- Most mainstream operating systems are based on DAC
- DAC enforces security by ownership
- DAC allows the owner of information to grant access permissions to other users/programs at his/her discretion, for example, in Unix/Linux
  - chmod 777 spy
- It is vulnerable to “Trojan horse” attacks

Mandatory Access Control (MAC)

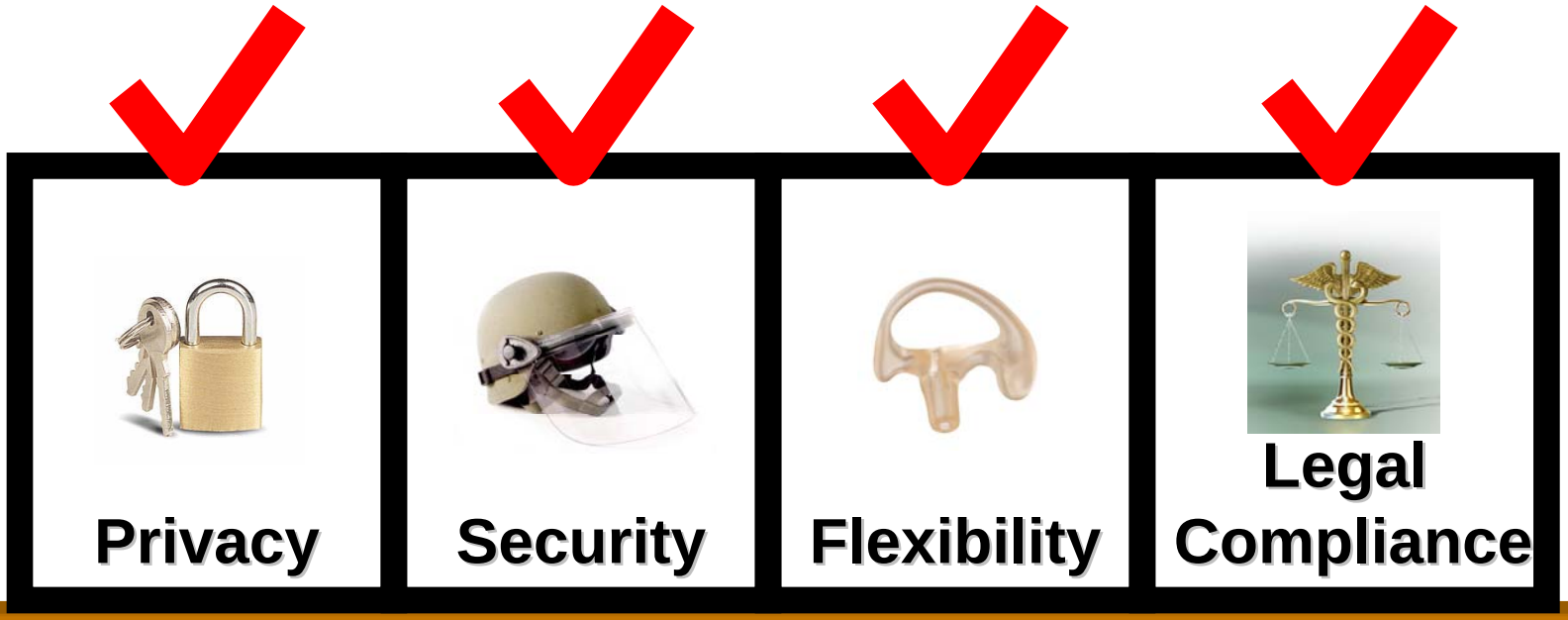
- MAC can be use to prevent some types of Trojan horse attacks. 
- The traditional MAC was originally designed largely for a military environment based on the MLS hierarchical structure.
- MAC focuses on data confidentiality
- MAC can provide the ability to limit access to only legitimate users 
- In MAC-based system, it is more difficult for an external adversary to tamper with audit systems.



Role-based Access control (RBAC)

- To simplify the management of authorisation
- Policy-independent and policy neutral i.e. not enforcing any particular protection policy
- RBAC does not efficiently support access policies in the way of general consent qualified by explicit denials

Health Informatics Access Control (HIAC)



HIAC {MAC, RBAC}

Health Informatics Access Control (HIAC)

- The HIAC system is necessarily MAC-based, incorporating RBAC properties.
- The HIAC profiling mechanism allows for health professionals to specify their requirements to a refined level of granularity.
- This degree of simultaneous control and flexibility is not achievable with either DAC or MAC individually.
- In a HIS environment, the flexibility feature is required to allow for emergency override.

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[1] Leigh D and Evans R, Warning over privacy of 50m patient files, Guardian News and Media Limited, issued on 01/11/2006, http://society.guardian.co.uk/health/news/0,,1936403,00.html accessed 01/11/200

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Snomed CT Survey: An Assessment of Implementation in EMR/EHR Applications

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Abstract

A much-needed start to facilitating the linkage between vendor willingness to adopt SNOMED CT and actually implementing it in electronic medical record (EMR)/electronic health record (EHR) systems is to gain knowledge about the current use of SNOMED CT in applications. A descriptive study on the status of adoption and implementation of SNOMED CT in EMR/EHR systems by health information technology (HIT) vendors was conducted in late 2006. This study consisted of a Web-based survey of 25 questions. Results revealed that 42 or 58.3% had obtained a SNOMED CT license. The most common reason given for not making plans to obtain a license was no market demand. In addition, only 14 or 19.4% of the respondents had SNOMED CT currently operational. Twenty, or 27.7%, of the respondents indicated SNOMED incorporation into applications is currently being developed, is planned for 2007, or is planned for 2008 or beyond. All told, less than half, 47.2%, of the respondents have incorporated or plan to incorporate SNOMED.

Keywords:

SNOMED CT, computerized patient records, terminology, standards

Introduction

The new millennium ushered in the unprecedented national consensus that the widespread use of technology for the electronic health record (EHR) will lead to reduced medical errors, higher quality care, and improved efficiency in the healthcare industry.[1] To accomplish this it will be necessary to move beyond the administrative data currently accepted as the standard for clinical data in many health services research projects.

The National Committee on Vital and Health Statistics (NCVHS) study identified SNOMED CT as one of the core set of Patient Medical Record Information terminology standards.[2] SNOMED CT was also adopted as a Consolidated Health Informatics (CHI) standard for the following domains: lab result contents, non-laboratory interventions/procedures, anatomy, diagnosis/problem lists, and nursing.[3] In May of 2006 SNOMED CT was identified as one of the preferred terminologies in the American Society for Testing and Materials (ASTM) Continuity of Care Record.[4]

Also in 2006, the Healthcare Information Technology Standards Panel (HITSP) recommended SNOMED CT in their Interoperability Specifications.[5] Then in January, Secretary Mike Leavitt, Department of Health and Human Services, accepted the standards recommended by HITSP for the Electronic Health Records, Biosurveillance, and Consumer Empowerment use cases.[6] One of the terminology standards named was SNOMED CT.

Four years ago SNOMED CT became available to U.S. users at no cost through the National Library of Medicine's Unified Medical Language System®. However, the enablers or impediments regarding implementation of SNOMED CT into EHR systems are relatively unknown. A NLM representative, upon questioning during the July 2005 NCVHS Subcommittee on Standards and Security, recognized the need to find out what the barriers are to EHR vendors adopting SNOMED CT.[7]

With the U.S. government acknowledging the need to gain a better understanding of vendor concerns regarding integration of SNOMED CT into their clinical information systems, identifying the barriers to SNOMED CT adoption is critical. Learning what prompts vendors to include SNOMED CT in EHR systems could help draw up strategies to accelerate use and encourage implementation.

Methods

The Foundation of Research and Education of the American Health Information Management Association (AHIMA) conducted a descriptive study. This study was designed to determine the status of adoption and implementation of SNOMED CT in EMR/EHR systems by health information technology (HIT) vendors and discover the available applications for SNOMED CT in EHR systems. An additional objective included learning what prompts vendors to include SNOMED CT in EHR systems.

A list of HIT EHR vendors was created from the following sources:

- HIMSS EHR Vendor's Association

- EHRs certified by CCHIT
- Winners of TEPR awards for the past five years
- AC Group's 2006 EHR/PMS survey
- EHR/EMR category of the Healthcare Informatics 2006 Resources Guide
- EMR category of the Health Management Technology Online Resource Guide
- 2006 13th annual Healthcare Informatics 100
- Exhibitors at the 2006 HIMSS Exhibition
- AHIMA vendor director
- Commercial sites

A survey consisting of twenty-five questions was developed. Face validity was performed by AHIMA and FORE staff in order to ensure the items addressed the important aspects of determining SNOMED CT implementation in EMR/EHR systems. A group of nursing informaticians conducted content validity.

Results

The survey was e-mailed to 408 HIT vendors. Out of 408 HIT vendors who received the survey, 72 were returned with a response rate of 18%. Forty-two or 58.3% had obtained a SNOMED CT license. Thirty or 41.7% stated they have no current plans to obtain a SNOMED CT license. The most common reason given for not making plans to obtain a license was no market demand.

To address the survey's objective of identifying the prevalence of SNOMED CT integration in EHR products, recipients were asked about their plans for implementation of SNOMED CT in their product. Implementation was defined in the question to mean SNOMED CT is a part of or used in the EMR/EHR application. As shown in figure 1, only 19.4% of the respondents had SNOMED CT currently operational. Twenty, or 27.7%, of the respondents indicated SNOMED CT incorporation into applications is currently being developed, is planned for 2007, or is planned for 2008 or beyond. All told, less than half, 47.2%, of the respondents have incorporated or plan to incorporate SNOMED CT.

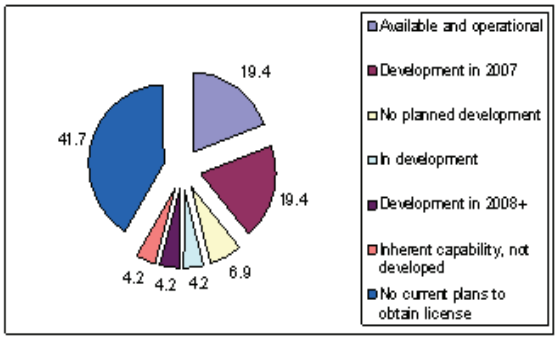

Figure 1 - Prevalence of SNOMED CT Integration

Discussion and Conclusion

Obtaining a complete a representation of HIT vendors is made difficult by the enormous volatility in the field. An additional complicating factor is finding the knowledgeable person within the company to receive the e-mail. Both of these factors may have accounted for not receiving a response to the request for survey completion.

In order for SNOMED CT to be successfully adopted and implemented, vendors need a business reason (mandate or end-user demand) to deploy it. Ultimately, adoption and implementation of SNOMED CT depends upon its ability to address very practical needs. Without incentives or drivers finding less than half of the respondents to this survey having incorporated or planning to incorporate SNOMED CT in EMR/EHR applications is not surprising. The most common reason for not making plans to obtain a SNOMED CT license was no market demand. Ways in which this demand could be created is through the inclusion of terminology for certification of electronic health records and use case requirements.

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SNOMED CT Survey: An Assessment of Implementation in EMR/EHR Applications

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FORE Foundation of Research and Education of AHIMA

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Introduction

- Electronic health record (EHR)
  - Component – the source or clinical information systems (CISs) that capture data to directly support patient care and the EHR infrastructure
    - CISs use a number of applications often focused on clinical function to enable the collection, storage, and processing of **discrete or structured** data for various purposes
      - Terminologies supply the **discrete or structured** data
        - » SNOMED CT is a reference terminology which can be used to encode discrete clinical information

Objectives

- Identify the universe of HIT vendors working with SNOMED
- Determine the prevalence of SNOMED CT integration in EHR products
- Learn what prompts vendors to include SNOMED CT in EHR systems
- Identify the available and potential future applications for SNOMED CT in EHR systems

Methodology

- Descriptive study
  - Study sample
    - Health Information Technology (HIT) vendors
  - Study tool
    - Web-based survey

Methodology: Study Sample

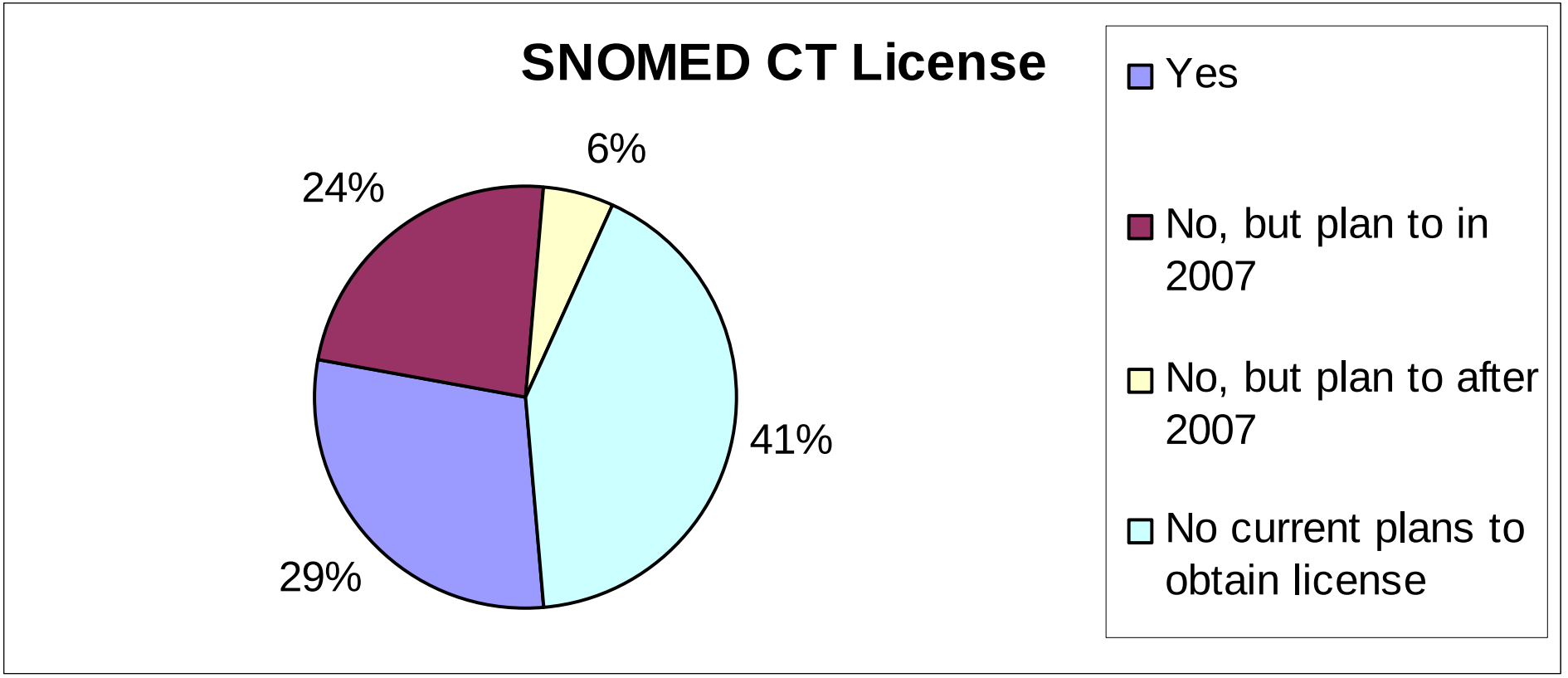
- Sources for HIT EHR vendors
  - HIMSS EHR Vendor's Association
  - EHRs certified by CCHIT
  - Winners of TEPR awards for the past five years
  - AC Group's 2006 EHR/PMS survey
  - EHR/EMR category of the Healthcare Informatics 2006 Resources Guide
  - EMR category of the Health Management Technology Online Resource Guide
  - 2006 13th annual Healthcare Informatics 100
  - Exhibitors at the 2006 HIMSS Exhibition
  - AHIMA vendor director
  - Commercial sites

Results

- Number of surveys sent: 408
- Number received: 72
- Response rate: 18%

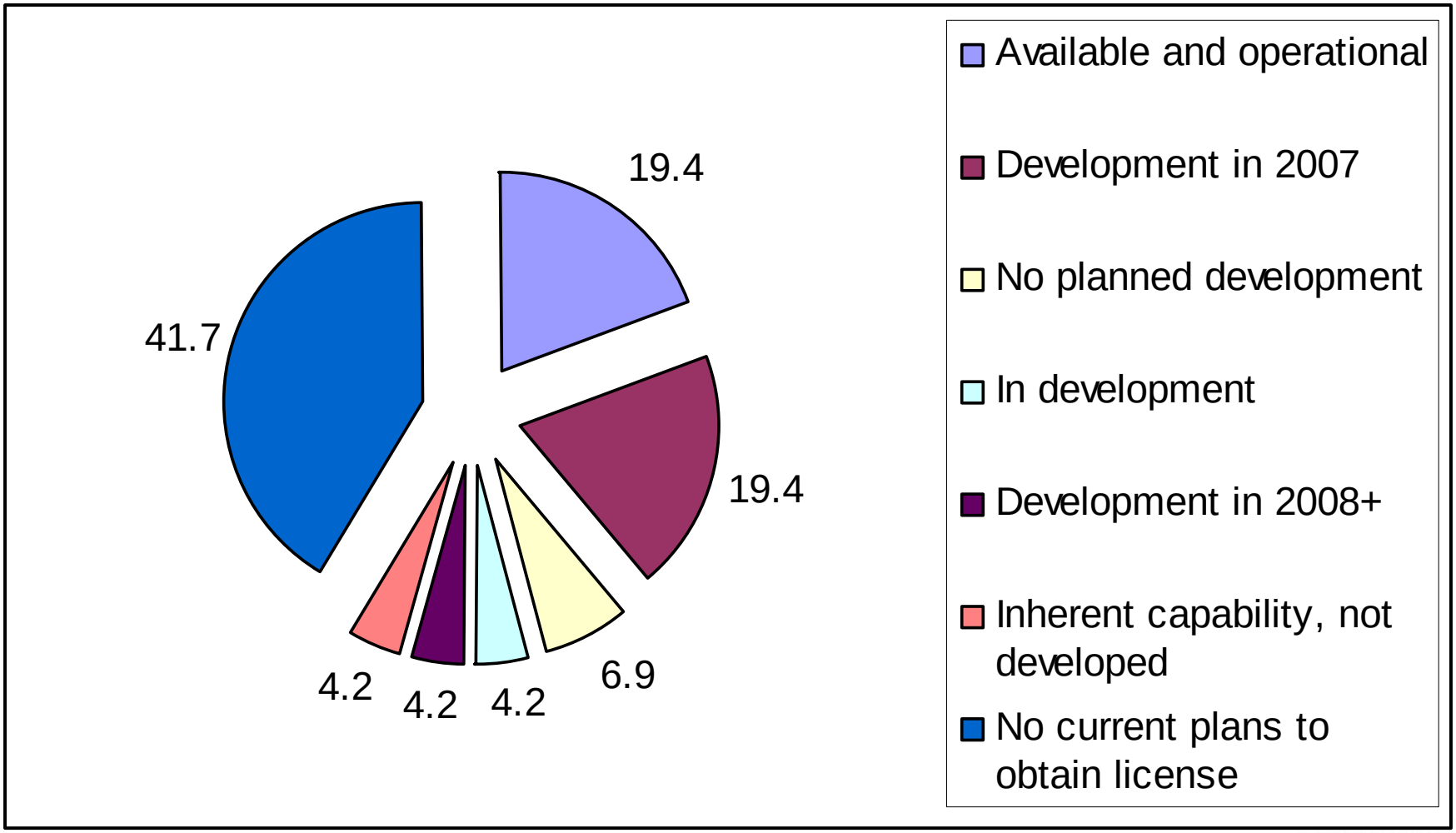
Results

Universe of HIT vendors with SNOMED CT License



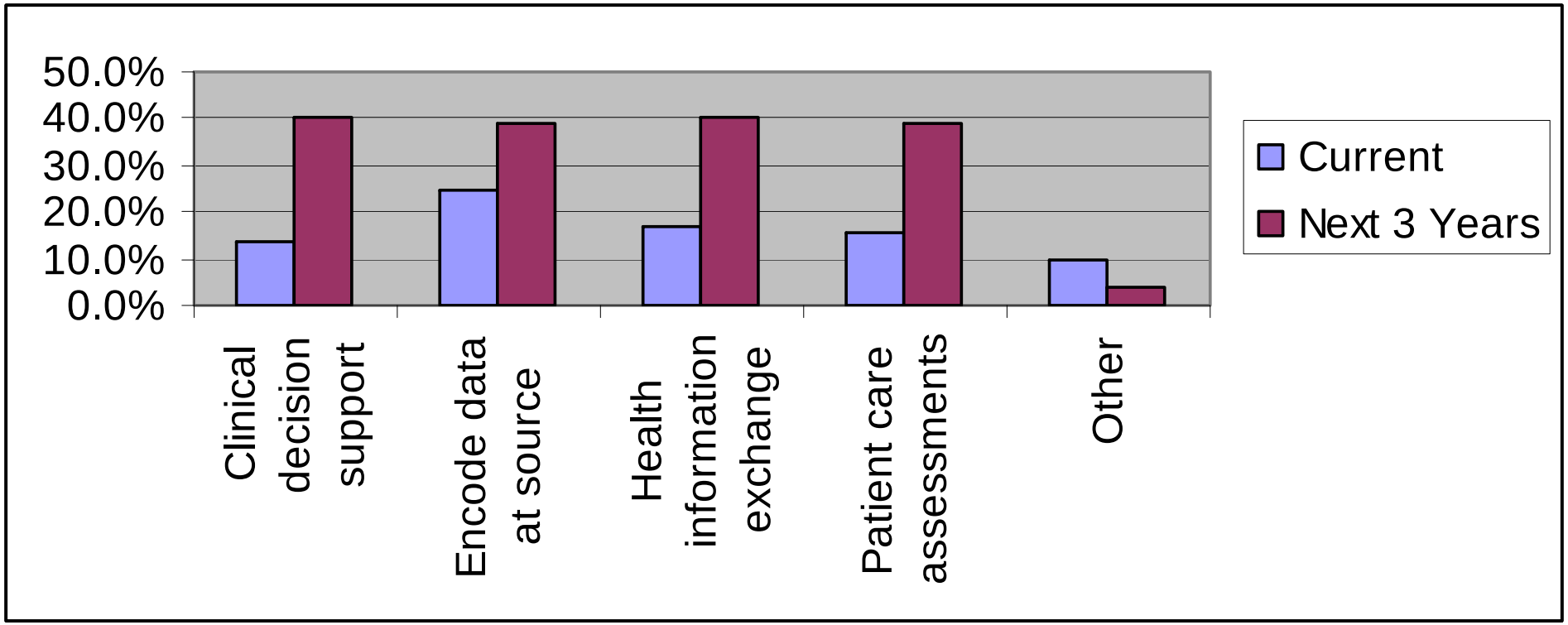
Results

Prevalence of SNOMED CT Integration



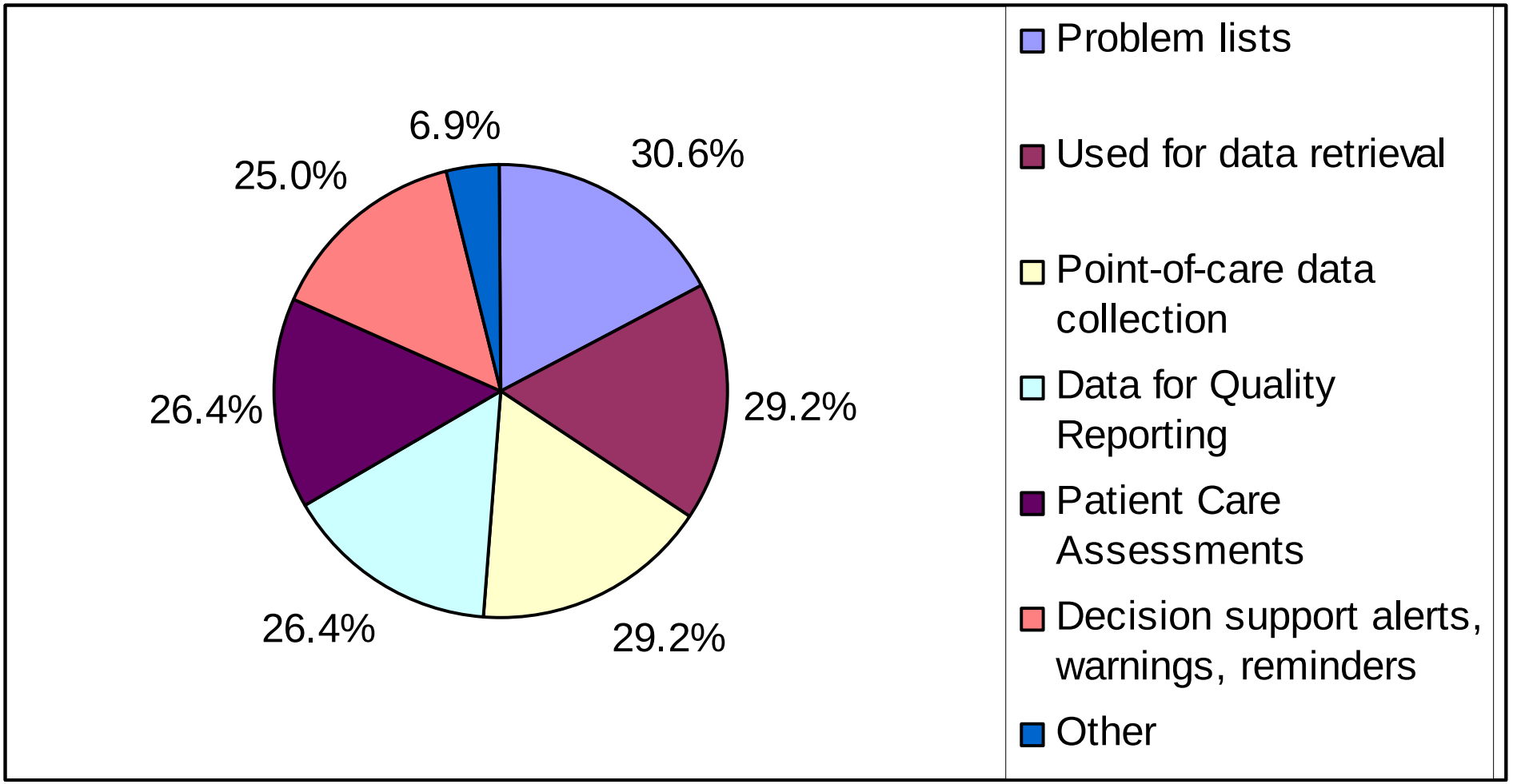
Results

Applications for SNOMED CT in EHR Systems



Results

SNOMED CT Uses in EMR/EHR Applications



Discussion

- Less than half, 47.2%, of the respondents have incorporated or plan to incorporate SNOMED CT
- Lack of incentives or drivers to implement
  - Most common reason for not making plans to obtain a SNOMED CT license
    - No market demand
- Vendors need a business reason (mandate or end-user demand) to implement SNOMED CT
  - Certification requirement, e.g., CCHIT
  - Named as a terminology standard for specific use cases, e.g., HITSP

Questions, concerns, additional information contact:

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Computer-Assisted Coding Software Standard Recommendations from a Workshop

Susan H. Fenton, Sandy Fuller, Kathy Giannangelo, Rita Scichilone, Mary Stanfill, Sue Bowman, Allison Viola

American Health Information Management Association, Chicago, Illinois, United States of America

Abstract

Standards for computer-assisted coding (CAC) software development are important while CAC is used for administrative purposes and are crucial when CAC is utilized in clinical care applications and clinical decision support. A workshop of CAC vendors and other stakeholders convened in September 2006 to begin a dialogue about these standards. The stated intention of the program was and is to promote a future state where automated tools are used to capture discrete coded data that can be mutually understood and shared for multiple uses within the healthcare industry. Following presentations on current CAC research the attendees divided into 5 workgroups: Software Management and Use, Audit Mechanisms, Metrics and Evaluation, Certification and Test Suite. The participants were asked to discuss issues and develop recommendations. The synthesis of the workgroup discussions revealed a series of next steps requiring input from a wide variety of stakeholders. They are presented here for discussion with interested parties.

Keywords:

software validation, information management

Introduction

Purpose of the conference

This conference was organized by the Foundation of Research and Education (FORE) of the American Health Information Management Association (AHIMA) to prepare for the future of coding and classification. The goals included: 1) raising the awareness of the need for computer-assisted coding (CAC) software standards, 2) delineating the scope of the challenge, 3) gathering input from a variety of stakeholders, 4) recommending a framework for CAC software standards, and 5) determining the necessary and desired next steps.

Methods

Conference content

The first day of the conference consisted of technical papers solicited via a call for participation. The titles are the papers presented are as follows:

1. Assessing Coder Change Rates as an Evaluation Metric by *Michael Nossal, MA; Philip Resnik, PhD; and Jean Stoner, CPC, RCC -CodeRyte, Inc.*
2. Computer-Assisted Auditing For High Volume Medical Coding by *Daniel T. Heinze, Peter Feller, Jerry McCorkle, Mark Morsch - A-Life Medical, Inc.*
3. Using Intrinsic and Extrinsic Metrics to Evaluate Accuracy And Facilitation In Computer Assisted Coding by Philip Resnik, PhD, Michael Niv, Michael Nossal, Gregory Schnitzer, RN, CCS, CCS-P, CPC, CPC-H, RCC, Jean Stoner, CPC, RCC; Andrew Kapit, and Richard Toren - CodeRyte, Inc.
4. Software Engineering of NLP-Based Computer Assisted Coding Applications by *Mark Morsch; Carol Stoyla; and Ronald Sheffer, Jr .- A-Life Medical, Inc.*
5. Computer Assisted Coding For Inpatients - A Case Study by *Cheryl Servais, MPH, RHIA - Precyse Solutions, LLC.*
6. How Does the System Know It's Right? Automated Confidence Assessment for Compliant Coding by *Yuankai Jiang, PhD; Michael Nossal, MA; and Philip Resnik, PhD, - CodeRyte, Inc.*
7. Computer Assisted Coding Software Improves Documentation, Coding, Compliance and Revenue by *Sean Benson, - ProVation Medical.*
8. Automated Coding and Fraud Prevention by *Jennifer Garvin, Ph.D. - Medical Informatics Postdoctoral Fellow, Center for Health Equity Research and Promotion; and Valerie Watzlaf, Ph.D., RHIA, FAHIMA - University of Pittsburgh.*

The second day consisted of 5 workgroup breakouts:

1. Software Management and Use – including implementation issues. CAC must interface with other systems to provider adequate Return on Investment for its use. Quality checks on CAC data will be required for the foreseeable future.
2. Audit Mechanisms – also called Quality Assurance. These checks are integral to all healthcare data, not just data coded with a computer. Sample size and acceptable accuracy rate issues remain to be resolved for all coding.

3. Metrics and Evaluation – how to determine the accuracy of CAC software. There are multiple levels of evaluation requiring different types of metrics. This group believed it to be vital to have a reference or "gold" standard for evaluation purposes.
4. Certification – possibly needed to promote user acceptance. Different possible certifi-cation models were discussed and a list of desirable certification criteria constructed. This group felt it was too early in the standard development process to discuss certification.
5. Test Suite – a standard source for testing functionality and accuracy. The group felt that development of a test suite would not only require a high level of government involvement and cooperation, but would also be very expensive. Overall, while this might be a desirable objective, the group felt the industry needed to understand the issue more thoroughly before beginning on a project like this.

A more detailed summary of the breakout group results can be found in the proceedings.

The final morning featured a reactor panel whose purpose was to present different perspectives on the issue of CAC software standards.

The entire proceedings can be found at http://www.ahima.org/perspectives/conference_papers.asp.

Results

Next steps for beginning the CAC software standards development process emerged over the course of the conference. Short term next steps included:

1. establishing a public forum for continued dialogue and development,
2. benchmarking current U.S. coding processes in order to better understand the impact of CAC,
3. begin an education process with all stakeholders,
4. reconvene in 2007 (in Philadelphia, PA on October 5, 2007), and
5. develop a consensus on a standard U.S. coding process as a precursor to a best practice and metrics.

Long-term steps were also discussed including:

1. fully defining a coding gold standard for accuracy – dependent upon consensus and benchmark results,
2. determining what combination of testing, certification and conformance are the best, correct choices to achieve standardization,
3. educating current and future coding professionals to ensure they can effectively use CAC software, and
4. continued pursuit of the "right" code – assigned with 100% certainty.

Conclusions

CAC is an emerging technology having an effect on all purposes for which coded data is used. AHIMA/FORE will continue to sponsor the development of consensus standards as the technology matures. We welcome opportunities for discussion with all interested parties.

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Computer-Assisted Coding Software Standard Recommendations from a Workshop

Susan H. Fenton, Sandy Fuller, Kathy Giannangelo, Rita Scichilone, Mary Stanfill, Sue Bowman, Allison Viola

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ABSTRACT

- Standards needed for computer-assisted coding software
- FORE/AHIMA convened a workshop for vendors and other stakeholders in September 2006.
- The results are presented here as a basis for continued discussion with interested parties.

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INTRODUCTION

- Goals:
  1. Raising awareness of the need for CAC software standards
  2. Delineating the scope of the challenge
  3. Gathering input from a variety of stakeholders
  4. Recommending a framework for CAC software standards
  5. Determining the necessary and desired next steps

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METHODS – FIRST DAY

- Presentation of solicited technical papers in the following areas:
  - Evaluation methods and metrics
  - Software development
  - Implementation testing
  - Regulatory Issues

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METHODS – SECOND DAY

- Working group breakouts
  - Software Management and Use – including implementation issues
  - Audit Mechanisms – AKA Quality Assurance, this is integral to all healthcare data
  - Metrics and Evaluation – determining the accuracy of CAC software

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METHODS – SECOND DAY

- Working group breakouts (con't)
  - Certification – possibly needed to promote user acceptance
  - Test Suite – standard source for testing functionality and accuracy. Very complex and expensive undertaking.

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SHORT-TERM NEXT STEPS

1. Establish a public forum for continued dialogue and development
2. Benchmark current U.S. coding processes to better understand the impact of CAC
3. Begin an education process with all stakeholders

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SHORT-TERM NEXT STEPS

4. Reconvene in 2007 (now scheduled for October 5-6, 2007 in Philadelphia, PA)
5. Develop a consensus on a standard U.S. coding process as a precursor to a best practice and metrics

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LONG-TERM NEXT STEPS

1. Fully defining a coding gold standard for accuracy
2. Determining what combination of testing, certification and conformance are best for standardization
3. Educating current and future coding professionals to effectively use CAC
4. Continued pursuit of the “right” code – assigned with 100% accuracy

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CONCLUSIONS

- Computer-assisted coding is an emerging technology having an effect on all purposes for which coded data are used.
- FORE/AHIMA welcomes the comments and involvement of all interested parties.

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CAC SOFTWARE STANDARDS WORKSHOP PROCEEDINGS

The entire proceedings, with technical papers, can be found at http://www.ahima.org/perspectives/conference_papers.asp.

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ACKNOWLEDGEMENTS

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- Questions, concerns, additional information contact: Susan H. Fenton, PhD, RHIA at 312-233-1532 or susan.fenton@ahima.org.

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What Health Influences Are Caused By EMR Working? - In Case of Japanese Nursing Situation

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Abstract

The purpose of this study was to determine how nurses used visual display terminals (VDT) and whether the use of VDTs had any influence on their health. In our study, the use of the EMR and the health influences of introduction of the EMR were surveyed using a questionnaire in a general hospital. The results indicated that VDT works were conducted in nurse stations rather than at the bedside. Only about 10% of nurses did exercises to prevent neck, shoulder and back pain before starting work. Since more than half of the nurses remained standing while inputting, extra guidelines should be developed for this aspect as the MHLW guidelines currently only deal with seated operations. Health influences after introduction of the EMR, more than half the subjects complained of worsened symptoms including eye strain, stiff shoulders and neck, and general fatigue, all of which are signs of VDT syndrome.

Keyword:

nurses, VDT works, electronic medical record system(EMR), health influences

Introduction

Currently in Japan, the use of EMR and digital ordering systems in hospitals is increasing. Since medical service is one of the seven main fields of the e-Japan priority policy program, it is assumed that digitalization will be promoted in medical facilities. Accordingly, appropriate workplace health measures should be taken in response to changes in the working environment of nursing personnel.

Methods

1) Study period: March 8 to 29, 2005. 2) Subjects: Nursing care personnel (378 individuals) working at a private general hospital (477 beds) in Japan which had introduced an EMR around a year previously. 3) Method and contents of study: Self-reported questionnaire study. A questionnaire was delivered to the subjects and was recovered on completion under ethical cares. It consisted of questions regarding the VDT working situation of EMR((1)posture, (2)place, (3)adjust materials around PC, (4)input device, (5) time per one use of EMR, (6)brightness around PC on each shift, (7)setting-up exercise before working) and the health influences (eye strain, low vision, dried eyes, stiff neck and shoulders , numbness of fingers, back pain, fatigue, headache, stress, gloomy) after using the EMR.

Results

323 questionnaires delivered were recovered (85.4% recovery). 193 subjects (59.8%) were in their 20s, 80 (24.8%) were in their 30s, 27 (8.4%) were in their 40s and 19 (5.9%) were in their 50s. Four subjects (1.2%) did not reveal their age. The average number of years working at the hospital was 5.67.

1) The VDT working situation of EMR

VDT works were conducted in nurse stations rather than at the bedside. Since more than half of the nurses remained standing while inputting records.

2) The health influences after introduction of the EMR

Only about 10% of nurses did exercises to prevent neck, shoulder and back pain before starting work. More than half the subjects complained of worsened symptoms including eye strain, stiff shoulders and neck, and fatigue, all of which are signs of VDT syndrome (Figure 1).

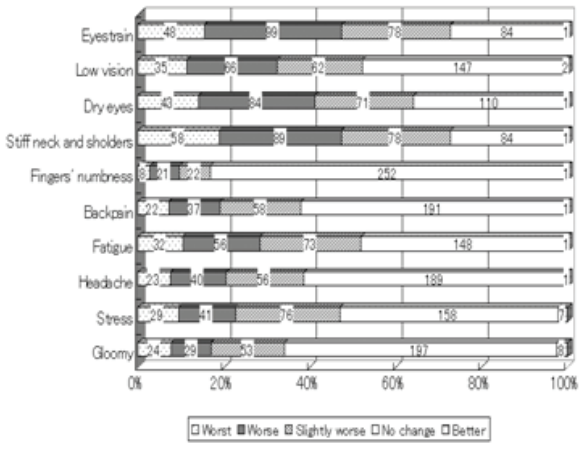

Figure 1 - Subjective signs of health influences after using EMR

Conclusion

Nurses' VDT working situations are different form those of office workers etc. Workplace health measures for VDT operations by nurses should be urgently revised based on the results of this study.

M. D. Anderson Cancer Center: Gaining Capacity by Improved Patient Throughput

Gerard J. Colman, Vice President and Chief of Clinical Operations
Frank R. Tortorella, Vice President, Clinical Support Services
Renee T. Konstanzer, Project Director, Clinical Operations

THE UNIVERSITY OF TEXAS
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CANCER CENTER
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M. D. Anderson Cancer Center

The mission of The University of Texas M. D. Anderson Cancer Center is to eliminate cancer in Texas, the nation and the world through outstanding programs that integrate patient care, research and prevention, and through education for undergraduate and graduate students, trainees, professionals, employees and the public.

512 Beds

$409 million in research funding in FY06

16,000 Employees

1367 Faculty

4366 Trainees

FY06 Clinical Activity	5-year Growth
21,221 Admissions	14%
155,551 Patient Days	15%
27,340 New Patients Served	28%

8.8 million square feet

Capacity Issues at M. D. Anderson

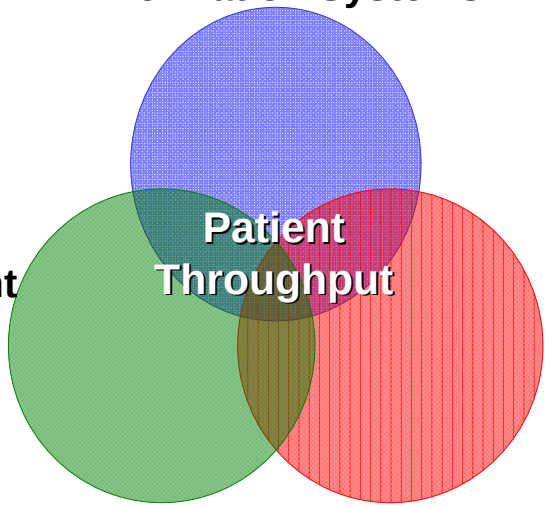
- In 2005, census overwhelms capacity and patients wait for beds in following areas:
  - Emergency Center
  - Operating Room/Post-Anesthesia Care Unit (PACU)
  - Admissions
- Limited space available to create or build additional beds
- Construction projects very expensive to plan and undertake
- Demand for oncology services will continue to increase as population ages

Goal of Project BED
Bringing Efficient Discharge

By focusing on short- and long-term solutions related to the discharge process, teams in Clinical Operations will make hospital beds available more quickly and gain capacity by improving patient throughput.

Administrative Team*
Admissions, Housekeeping
Patient Transportation
Information Systems

Teams:
- **Measured discharge process steps**
- **Targeted specific steps to improve**
- **Eliminated process flow obstacles**

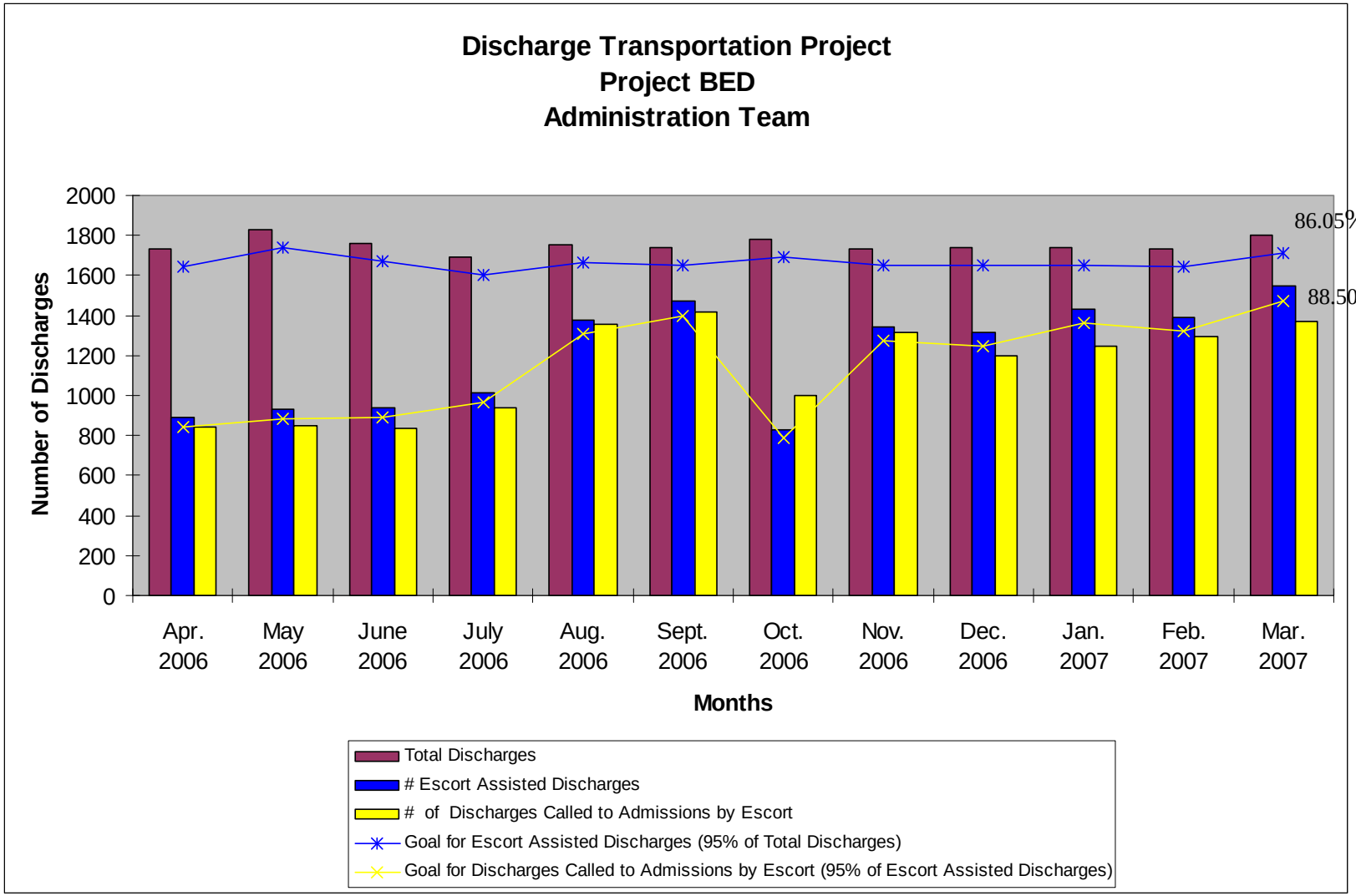


Clinical Team
Nursing
Case Management
Pharmacy

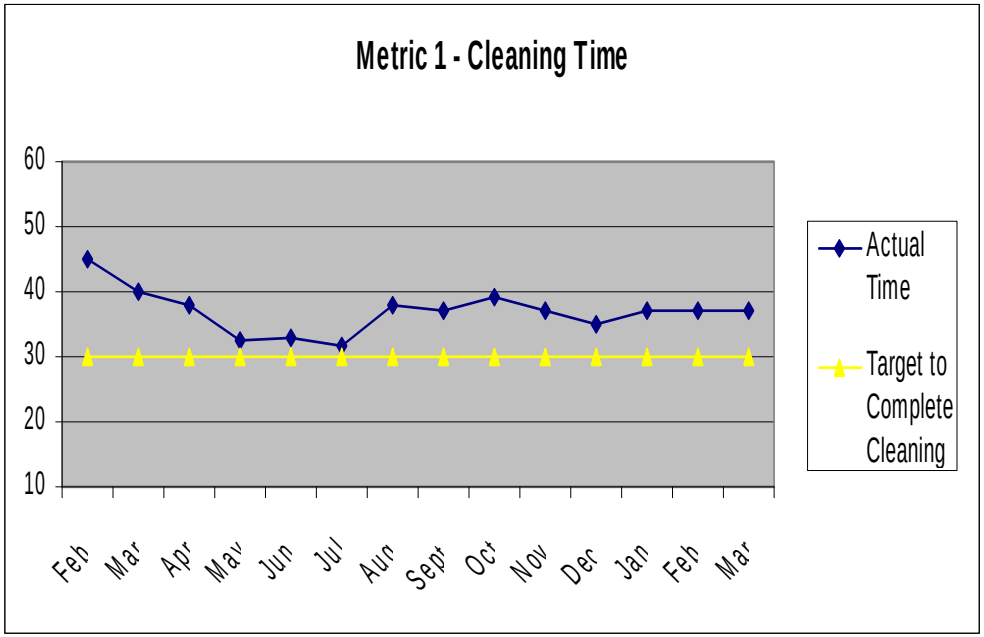
Medical Team
Medical Staff
Leadership

*This presentation focuses on the efforts of the administrative team, while recognizing the efforts of all involved.

Escort-Assisted Discharges



Housekeeping Room Turnaround Times 06 - 07



Goal for blue line

March 2007
Highest Cleaning Time 44 min
Lowest Cleaning Time 23 min
Mean Cleaning Time 37 min

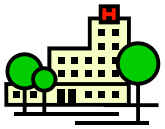
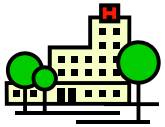
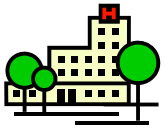
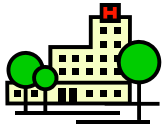
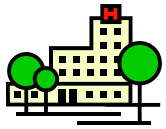
EFFORT	OUTCOME
Design the process to meet institutional bed initiative goals	Alignment to institutional goals
Involve the customer in defining process	Customer satisfaction
Received historical data from customer	Alignment
Change work schedule to match customers needs	Alignment
Write new Work Instructions (WI)	Constancy and consistency
Added mechanical and electrical checks to WI	Constancy and consistency
Involve infection control in WI review / approval	Alignment to institutional goals

Discharge Nurse Role Created
Ongoing Projects

- Discharge Assessment
  - Establish expected discharge date based on historical length of stay (LOS)
  - Assess patients for resources and services needed after discharge
  - Standardized checklist
- Identify learner(s) and apprise unit staff of those to engage
- Medication Reconciliation – review maintenance meds and anticipate
- Application of Acute Care Criteria
- Hand-off Communication – provide summary to next provider
- Discharge Preparation Checklist
- Transition Home Measures – apply acute care criteria daily

Improved Throughput Adds Incremental Capacity

"Effective" Beds Gained from Length of Stay (LOS) Reduction[1]

LOS Reduction \ Hospital Size	 200 beds	 300 beds	 400 beds	 500 beds	 600 beds
0.25 day	8	12	16	20	25
0.50 day	16	25	33	41	49
0.75 day	25	37	49	61	74
1.00 day	33	49	65	82	98
1.25 days	41	61	82	102	123
1.50 days	49	74	98	123	147

At M. D. Anderson, for the month of October 2006, a half-day reduction in LOS would translate into $4.5 million.[2]

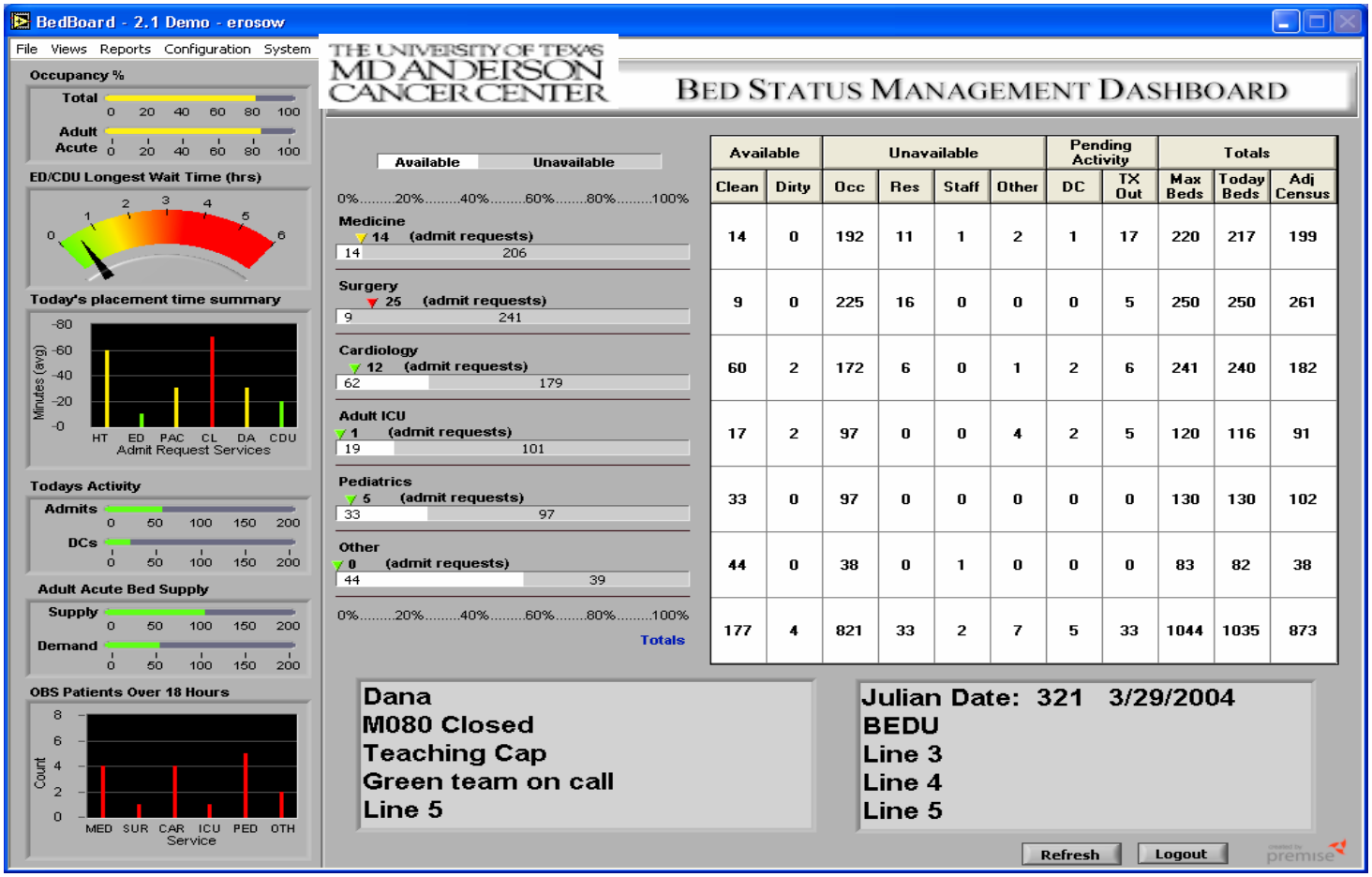
For the average 500-bed hospital, reducing LOS by a half day is the equivalent of adding 41 new beds to the facility.

[1]Assumes initial LOS of 5.2 days, 85 percent occupancy; savings based on simple LOS reduction. Source: Health Care Advisory Board, 2006.
[2]M. D. Anderson Cancer Center Institute for Performance Excellence, 2006.

Electronic Bed Management Project Timeline

Phase	Go Live	Impact
Phase I – Transportation **Transport Dashboard**	4/30/07	All users call to request patient escort, and dispatchers use Transport Dashboard to enter job requests and dispatch escorts.
Phase II – Transportation and Housekeeping **Transport Dashboard & BedXpress**	6/13/07	All users input requests for transport jobs; bed turnover notifications automated. All inpatient units use BedXpress for room turnover. Housekeeping receives dirty bed pager notifications and views bed status.
Phase III – Electronic Bed Management **Bed Management Dashboard**	8/22/07	Nursing and Admissions will use for patient placement and pending discharges. Electronically tracked patient room status will provide automatic notification to Housekeeping, Transportation, Admissions and Nursing. Bed status information will be immediately accessible to leadership.

Electronic Bed Management
Bed Status Dashboard



Select Project BED Metrics

Effort	Goal/Benchmark	Actual Performance	Status
Short-Term: Patient Transportation would provide **escort-assisted discharges** to transport all discharged patients from rooms	95% of discharges would be escort-assisted	86% achieved in March 2007	Increased from initial measure of 52%, efforts continuing
Short-Term: Housekeeping developed room turnaround teams to standardize process, clean and make minor room repairs	30 minute cleaning time, 10 minute travel time, quality score 90%	37 minute cleaning time, 3-5 minute travel time, quality above 90%	Continuous improvement in cleaning time, exceeding goals on other measures
Short-Term: Evaluation and selection of **Electronic Bed Management System**	Selection of a electronic solutions partner	Criteria reviewed and vendor selected	Institution currently in go-live status, will be fully implemented in August of 2007
Long-Term: Reduce institutional **length of stay (LOS)**	Sustained reduction in LOS	Preliminary reduction in LOS at clinical division level	Anticipate institutional LOS reduction with full implementation of long-term strategy, including electronic bed management

References and Contacts

References:

Health Care Advisory Board, 2006.

M. D. Anderson Cancer Center Institute for Performance Excellence, 2006.

Premise Corporation, (Dashboard), 2007.

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M. D. Anderson Cancer Center: Gaining Capacity by Improved Patient Throughput

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[b]*Clinical Support Services, The University of Texas M. D. Anderson Cancer Center, United States*

Abstract

As demand for services increases, healthcare organizations must be able to efficiently diagnose and treat more patients utilizing fewer resources. By focusing on the inpatient discharge process, M. D. Anderson Cancer Center developed short- and long-term solutions: formation of housekeeping room turnover teams, creation of a patient-escorted discharge process, assignment of discharge nurses and selection of an electronic bed management system. The first three solutions as listed resolved the immediate issue of patient boarding time in the Emergency Center, Admissions and the Operating Rooms; in combination, all solutions show promise in achieving a longer-term reduction in length of stay (LOS) and a capacity gain.

Keywords:

capacity, patient throughput, patient discharge, bed management

Methods

Increasing demand requires faster patient throughput, optimally allowing for more admissions with the same scarce staff; this faster throughput provides the hospital with additional "free" beds [1]. Beginning in 2004, M. D. Anderson Cancer Center faced a critical bed shortage as patients boarded for several hours in the Emergency Center, Operating Rooms, and Admissions while beds became available. As bed space and staff were limited, the institution focused on developing innovative short- and long-term solutions to meet demand.

In 2005, Clinical Operations initiated Project BED (**B**ringing **E**fficient **D**ischarge) to improve patient throughput. The Administrative, Clinical, and Faculty teams identified and measured each step in the current discharge process, targeted specific steps to improve, and eliminated process flow obstacles.

Results

In September 2005, patient escorts began to transport all discharged patients from their rooms to reduce turnover time. Patients waiting on external transportation were relocated to a central holding area. In the initial eleven months of operation, escort-assisted discharges increased from 52 percent to 85 percent of discharges.

In December 2005, Housekeeping standardized its processes and established room turnaround teams on nine inpatient units in order to quickly inspect, clean and make minor repairs to each room. Since February 2006, cleaning time was reduced by five minutes to 40 minutes per room; the goal is 30 minutes per room. Quality scores hover between the 90% target and 100%, and response time is three to five minutes, exceeding the original goal of 10 minutes.

Nurses were realigned to ensure efficient, timely, and appropriate discharge of patients. Currently, 70 nurses have been trained in discharge nurse functions - coaching bedside nurses, rounding with clinical teams, and coordinating 23-hour observation. The program goal is to reduce LOS by 0.5 days. In a 500-bed hospital, a reduction in LOS by 0.5 days translates into 41 additional beds [1]. For M. D. Anderson in October 2006, this 0.5 reduction equates to over $4.5 million in net revenue [2].

Team members evaluated and recommended purchase of an electronic bed management system to enhance productivity of and interconnectivity between Admissions, Nursing, Housekeeping and Patient Transportation. Functional requirements included an electronic bed board, electronic notification system, assignment of work, and reporting capability. Currently, M. D. Anderson is in the go-live stage and anticipates data analysis within the next quarter.

Other solutions included ordering discharge medications and writing discharge orders the day prior to discharge to reduce patient wait time. Generally, the shift toward outpatient and minimally invasive surgery has also positively influenced M. D. Anderson's ability to provide capacity.

Conclusion

Project BED efforts have added capacity and decompressed patient boarding. While some results are preliminary, these efforts show promise in longer-term reduction in LOS.

References

[1] Health Care Advisory Board CEO Roundtable. The Advisory Board Company, Washington, D.C., 2006.
[2] M. D. Anderson Cancer Center Institute for Performance Excellence, 2006.

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Telehealth Trends in Pacific Islands and Solutions for the Sustainable Operation

Isao Nakajima, Muhammad Athar Sadiq, Koredianto Usman
Yasumitsu Tomioka, Hiroshi Juzoji

Nakajima Laboratory Tokai University School of Medicine, Japan

Abstract

We are reporting our recent study and investigation concerning about telehealth activities in pacific islands and provide some support to keep self-sustainable operation. In pacific, three major telehealth operations are performed. However, all of them are facing strong obstructs sense for the following reason, 1) problem of running cost 2) lack of the social structure for the human resource development 3) limitation of the data speed. Based on this investigation, we are providing solutions (Universal service policy, ITU training course, and ETS-VIII satellite) in order to keep self-sustainable operation in Pacific Islands.

Keywords:

universal service fund, human resource development, isolated islands, ETS-VIII satellite

Purpose

We are reporting our recent study and investigation concerning about telehealth activities in pacific islands and provide some support to keep self-sustainable operation.

Investigation

Health professionals in various Pacific Island countries, particularly those working in rural and remote areas, have less opportunity than their peers in developed and even some developing countries to keep abreast with both technical and technological advancements in medicine and healthcare.

POLHN (Pacific Open Learning Health Network)

For their continuing education and professional development, distance education using a variety of media is an option that has been supported via funding from the Japanese Government.

In general, POLHN is a successful initiative based on actual web-based operation via internet with package media, like CD-ROM, the evaluation report, and the meeting discussions. The pilot open learning courses are well received by health professionals and the learning centers in each country, equipped with information, communication, technology (ICT) for open learning and health educational resources, are being used by countries for their health professional training and continuing education, including ICT skills trainings. There was a strong interest among the participating countries to contribute to the long-term sustainability of the POLHN and a desire for greater ownership by the countries, of the open learning centers. There was also consensus that it would be important to integrate POLHN as a component of national human resources for health programmes of the ministries of health, and that the network's coverage should be expanded to include other countries and to make it a Pacific regional learning network. There are two phase projects in the POLHN.

Phase One: the establishment of computer laboratories as resource centers for the health professionals (HPs) in ten countries in the Pacific (Cook Islands, Fiji, Kiribati, Marshals, Federated States of Micronesia, Palau, Samoa, Solomons, Tonga and Vanuatu) has been completed. Computer laboratory equipped with computers, servers, networked printers, data projectors, web cams and Internet connectivity. Various learning and reference materials are also available in the resource centers including the blue trunk library kit.

Phase Two: using the computer laboratories as resource centers for the continuing education of professional health workers of the Pacific started in later 2003.

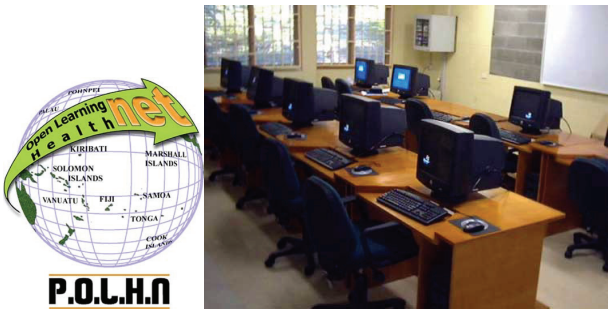

Figure 1 - PLOHN operation room in Solomon

Pacific Basin Telehealth Initiative

The U.S.-affiliated Pacific Islands jurisdictions represent over 2,200 small volcanic and coral islands stretching across 4,500,000 square miles, with about 400,000 inhabitants living on a landmass smaller than the state of Rhode Island. Due to their geography and isolation, coupled with limited finances, poorly developed infrastructures and lack of skilled staff, these islands provide an ideal environment for developing and implementing telehealth applications.

In 1999, the Health Resources and Services Administration (HRSA) launched a multi-year Pacific Basin health initiative to bring telemedicine to the region. This initiative came out of recommendations from two events the previous year: a HRSA-sponsored summit meeting in Rockville, Maryland with the health ministers from the six U.S.-affiliated Pacific Basin jurisdictions and the publication of the Institute of Medicine's report "Pacific Partnerships for Health: Charting a New Course." Both the report and participants at the summit identified telehealth (i.e., telemedicine and distance education) as a key strategy for improving primary care delivery, enhancing prevention activities and supporting the training of health personnel. This telehealthnet work has been funded by the OAT(Office for the Advancement Telehealth) of the U.S. Government.

PPHSN (Pacific Public Health Surveillance Network)

“Training in applied epidemiology and public health surveillance” is one of the five strategies of Pacific Public Health Surveillance Network (PPHSN). It aims to develop a regional pool of experts in public health surveillance and responsefor the Pacific Islands. The PPHSN was created in 1996 under the joint auspices of SPC (South Pacific) and WHO. The Goal is to improve public health surveillance and response in the Pacific Islands in a sustainable way. In 1996, the idea of a modular training programme with field-based components, involving universities, health development agencies and professional associations came up. This programme should be accredited by a training institution. From 1998 to 2001, SPC made a first move in that direction and ran two different series of subregional training sessions in surveillance, outbreak investigation and the use of Epi Info 6 software for surveillance activities. The overall objective of these training sessions was to build a critical mass of health professionals who share a common set of tools and methods for public health surveillance. SPC can also provide attachment and hands-on field training opportunities for trainees in public health practice. A memorandum of understanding was signed between SPC and FSM in 1999. The article suggests the areas of future FSM/SPC collaboration in public health surveillance: the accreditation of SPC courses by FSM; the addition of a microbiology component; the identification of opportunities for field training; and the evaluation and harmonisation of the training programme(s).

Considerations and our solutions

Based on these investigation, we understand that all of them are facing strong obstructs for the following reason, 1) problem of running cost 2) lack of the social structure for the human resource development 3) limitation of the data speed. So we are willing to provide solutions (an idea of Universal Service Policy, ITU telemedicine expert training course, and ETS-VIII satellite with free of charge) in order to keep self-sustainable operation in Pacific Islands.

Universal Service Fund

In order to reduce running cost of the operation, and to assist continuous self sustainable operation of tele-health in developing nations, especially remote island and isolated area, we have to consider a universal service fund.

The Universal Service Principles in the United State[3] are:

(1) Quality and rates.--Quality services should be available at just, reasonable, and affordable rates.

(2) Access to advanced services.--Access to advanced telecommunications, broadband and information services (Internet) should be provided in all regions of the territory.

(3) Access in rural and high cost areas.--Consumers in all regions of the territory, including low-income consumers and those in rural, insular, and high cost areas, should have access to telecommunications and information services, including interexchange services, broadband and advanced telecommunications and information services, that are reasonably comparable to those services provided in urban areas and that are available at rates that are reasonably comparable to rates charged for similar services in urban areas.

(4) Equitable and nondiscriminatory contributions.--All providers of telecommunications services should make an equitable and nondiscriminatory contribution to the preservation and advancement of universal service.

(5) Specific and predictable support mechanisms.--There should be specific, predictable and sufficient public mechanisms to preserve and advance universal service.

(6) Access to advanced telecommunications services for schools, healthcare and libraries.--Elementary and secondary schools and classrooms, health care providers, and libraries should have access to advanced telecommunications services.

(7) Additional principles.--Such other principles as the Joint Board and the Commission determine are necessary and appropriate for the protection of the public interest, convenience, and necessity.

Universal telecom service is implemented by the Universal Service Administrative Company. While contributions to the Universal Service Fund are required by telephone, wireless and VOIP service providers, these carriers generally recover this cost by passing on a surcharge to retail customers as a billing line item -- often labeled as USF charge. A surcharge of approximately 10% of interstate usage currently appears on telephone, wireless and VoIP bills. The Universal Service Administrative Company cur-

rently administers four distinct programs as authorized in the federal telecommunications Act of 1996.

Rural health care division of the Universal Service Administrative Company (USAC) is responsible for ensuring for health care providers in rural areas to obtain the benefits of the internet and current communications technology as provided for by the United States Congress and the Federal Communication Commission (FCC) through universal service support. The FCC established program funded 56 million U.S.D. in 2003(Fig.2), 400 million U.S.D. in 2004 to rural health care providers so that they don7t need to pay move than their urban counterparts for the communication services.

In addition to USF, another organization support telehealth in the U.S., it is the the OAT(Office for the Advancement of Telehealth) under the umbrella of the U.S. Department of Health and Human Services. This organization is promoting the use of helehealth technology for health care delivery, education, and health information services, and providing the funds more than $34.9 million U.S.D.

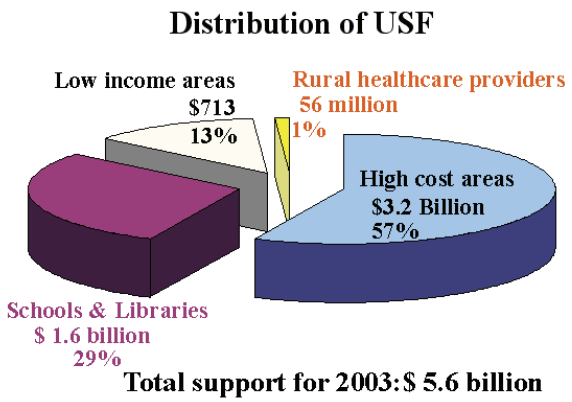

Figure 2 - Distribution of the Universal Service Fund in the US in 2003

Human resource development

The objectives of our cooperation related Pacific Island through ITU, APT, NICT, Sasakawa Fund, and other private sectors in developed nations is to bring research teams in health care field, governments sectors in island, and other stakeholders in the region to discuss the different applications of telecommunication and information technology in the health care sector. Based on our investigations, we intend to invite some researchers from Pacific Islands to provide an opportunity to study more advanced telehealth at the ITU Telemedicine Expert Training Course in the Shonan Campus, Hiratsuka Japan from 2006 to 2009.

To familiarize themselves with the specifications and implementation details of telehealth;

To assist in the management of the transition process from IPv4 to healthcare specialist to end user(client); and

To share information on the development and deployment of telehealth to other countries and regions.

WINDS satellite for broadband network

WINDS is currently under joint development by JAXA and the National Institute of Information and Communications Technology, as part of the e-Japan Priority Policy Program of the Japanese government's IT strategy headquarters. WINDS will be launched by an H-IIA Launch Vehicle in the fiscal year 2007 to establish the world's most advanced information and telecommunications network (the broadband transponder of Ka-band). It is expected that this information and telecommunications network's speed and capacity will be much higher than anything achieved previously. The WINDS satellite communication system aims for a maximum speed of 155Mbps (receiving) / 6Mbps (transmitting) for households with 45-centimetre aperture antennas (the same size as existing Communications Satellite antennas), and ultra-high speed 1.2 Gbps communication for offices with five-meter antennas. In addition to establishing a domestic ultra high speed Internet network, the project also aims to construct ultra high speed international Internet access, especially with Asian Pacific countries and regions that are more closely related to Japan. We believed that the WINDS can support the infrastructure of the tele-halth network in pacific.

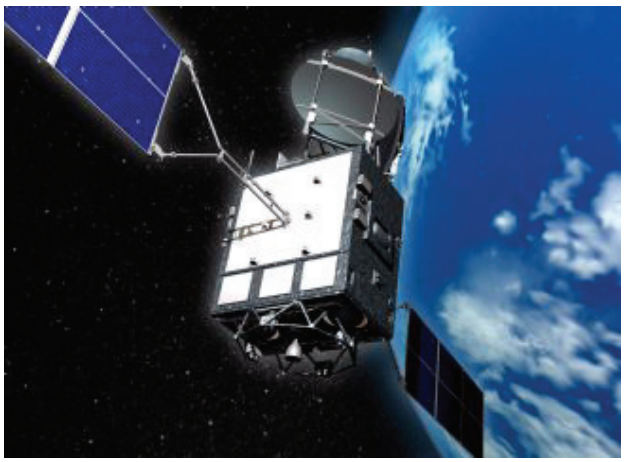

Figure 3 - Ka-band broad band circuit for the Pacific with WINDS satellite

Acknowledgments

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Regional Health Information Networks: Towards Sustainable Health Systems Globally

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Abstract

There has been tremendous growth in regional health information organizations (RHIOs) in the US. There has been emergence of similar networks in the UK, Australia, Singapore, Greece, and New Zealand.

Keywords:

community health networks; regional health planning; information networks; collaboration

Background

Globalization has had an impact in accelerating the development of regionalism in the delivery of health services throughout the globe. There has been tremendous growth in regional health information organizations (RHIOs) in the US. There has been emergence of similar networks in the UK, Australia, Singapore, Greece, and New Zealand.

The value of networks arises principally from the enrichment and extension of the social frameworks that motivate human behavior by creating social capital. Such features of social capital in networks are knowledge sharing and trust, that facilitate coordination and cooperation for mutual benefit. Mutual knowledge can be characterized as shared experiences or close mutual understanding of the respective contexts of individuals. This allows network participants to identify shared problems and communicate solutions and individual experiences in a meaningful way.

Trust is necessary to pass on tacit knowledge from one network member to another. Accepting the contributions and suggestions of other network members require trust in each individual's expertise. Sharing one's expertise with other network members requires trust that shared knowledge will be used appropriately. Trust in networks is built through repeated rounds of interaction that allows network members to make judgments about the trustworthiness of others.

There are a number of examples throughout the globe where regional health information networks are emerging. In Australia in New South Wales, the Greater Metropolitan Transition Taskforce has programs networking sixteen specialty services, enabling the coordination of activities over a population of at least 5 million (Braithwaite, 2004). These networks enable different types of clinicians to work with management and community representatives over many administrative boundaries. The taskforce has demonstrated the ability of institutions to learn from each other in comparing practices, benchmarking performance, developing innovations and testing alternative systems. (Southon, 2005). Such a structure has worked in conjunction with regional bodies, maintaining and developing standards for integrated health services with the local Boards responsible for local coordination of the different services, and for addressing local issues.

There has been development of a regional health information network in Greece in the island of Crete. (Constantinides & Barrett, 2006). A Greek initiative urged all healthcare regions in Greece to develop regional networks. This regional network received the European eHealth award for technologically advanced design.

In the US, the Indianapolis Network for Patient Care links major hospitals, physicians, and public health sharing information such as lab results, medications and immunizations. (McDonald, 2005). The Utah Health Information Network (UHIN) grew out of a coalition of health insurers, hospitals to create value for all participants and is comprised of providers who pay an annual fee.

Methods

We utilized a brief information gatheirng of the emergence of regional healthh networks throughout the globe. Then we conducted a series of key informant interviews with key health care decisionmakers in the US and UK. These individuals were selected based on knowledge of regional networks. Multiple interview formats were used with the key informants.

Conclusion

Sustainable health systems involve shaping and adapting health information networks to a given regional context. This means cultivating regional learning processes and embedding collaborative and knowledge sharing that persist over time. Establish such networks create opportunities for sharing of experience, knowledge, technologies between the various nodes of the network. Embediing these change processes over time requires

understanding, engaging with the specific dynamics around sensemaking and knowledge sharing.

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Is Sustainable Health a Paradigm Based in Reality?

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Abstract

This paper considers the factors affecting the technical drive and political intent to bring about transformational changes in health care investment and delivery, from sickness to health

Keywords:

transformational change, economics,

Introduction

It is doubtful that anyone could foresee the transformational changes in delivery that technology has brought about in industries such as banking and international travel. That it has happened is evident so why hasn't the same transformational, customer oriented change happened in the health industry?

This article puts forward a view that paradigm changes in delivery requires more than technology and political imperatives and that social and cultural acceptance are also essential.

Technology has a history of both acceptance and rejection, not just because of cultural fit, or social acceptance, but due to leadership, entrepreneurialism and plain luck. For example VHS v Betamax. Beta max was perceived as the better technology and more economic to produce. The VHS format's defeat of the Betamax format is now identified with the verbal phrase "to Betamax", wherein a proprietary technology format is overwhelmed in the market by a format allowing multiple, competing, licensed manufacturers [1].

Technology is on occasion very rapidly embraced. The young, and young at heart, have instigated a new way of purchasing and listening to music, and brought about the resurgence of an old one. UK records are sold on line and downloaded straight to an MP3 player [2]. This has transformed the industry and supply chain – pop groups, including the Arctic Monkeys [3], are using the internet and MySpace

Sustainable transformation

How much technology is being used at the coalface? In England some 99.9% of GP's use clinical information systems on a daily basis to undertake tasks which are routine and common in general practice, for example recording observations and clinical notes, through to writing prescriptions.

However the use of technology to change behavior in a fundamental way is not evident. There are some GP practices who provide a telephone service for registered patients, some use email. However work by Malec & Wright [4] indicate that these services are more prevalent in US, mainly due to differences in the economic/ financial reward model where primary care physicians do not act as gatekeepers.

So what is it that is it about health that is intended to be transformed? We know that the population is ageing, globally and within specific countries. Some countries face more acute problems of healthcare crises as a result, in terms of supply of healthcare facilities and affordability of healthcare. Healthcare levels of expenditure in the USA according to Gingrich [5]

"Healthcare consumes 26% of all federal spending and growing, dwarfing every other priority."

But will transformational change happen because; policy makers and consumers want it, or because technology is driving it, or are other factors key to success?

So how does this impact on the shift in health care focus, from cure to prevention?

Politically in countries from England to Australia, most government agencies and health care providers are already recognising the need for capital investment in health information technology infrastructure to reduce expenditure and improve the quality of patient outcomes. Some, such as England, are using consumerism under the banner of patient choice to challenge the acceptability of waiting times, poor conditions and service. Future health service priorities will intend to bring about improving access and increasing the knowledge base, while infrastructure such as buildings and other resources will continue to be downsized per head of population. Information technology and 'Labour-saving" technology will consolidate and expand key services with Governments driving the need optimise return on ICT investment

The political drive is largely led by economic imperatives. There is a growing staff shortage internationally, and in most first world countries there are less children being born, and therefore less future tax payers and healthcare workers coming through. Outsourcing is becoming more

usual in healthcare; letters in the UK, Los Angeles or Brisbane typed up by staff in India, even basic x-ray reporting has been outsourced by some countries [6].

Social

The earlier major causes of death and disease, from trauma and infection, are being tamed in the first world, through planned interventions. But chronic disease is now the problem at both individual and national economic levels [7]. Historically chronic disease has been treated rather than prevented (asthma, diabetes) with professions and specialisms such as podiatry and opthalmics evolving on this basis. Everybody gets inoculation for smallpox etc, but for diabetes and HIV there is currently no immunisation possible and the causal factors and impact of the disease itself are heavily influenced by lifestyle choice at an individual level. Chronic disease management (CDM) will requires personalisation but the technological support for CDM at the moment is generic. Given that each age group and societal strata readiness to accept or adopt change may differ there is a need for different methodologies to be adopted.

Is this where healthcare can learn from banking? Are health and lifestyle coaches the way to meet individual need and manage whole population problems? Will generic tools allow clinicians time for more personalised treatment? Can you move to preventative care if no technical infrastructure in place?

With the next 5 –10 years seeing integrated systems across healthcare boundaries and electronic health record and point-of-care support. Mobile clinical support will include fully integrated medication management systems. Computing will be ubiquitous and incorporate decision support and communications with knowledge management capabilities and comprehensive, searchable knowledge bases at the point-of-care. But who will pay for these cross boundary solutions, and who will reap the benefit? Which organisations will be so altruistic, or is entrepreneurialism to be the luck factor?

Integrated technologies, such as internet enabled digital video phones, will increasingly find their way into use in health care and teleHealth could be used successfully to improve healthcare delivery, delivering in circumstances where it was previously difficult or impossible, and in a way that is cost-effective. This will enable entrepreneurial delivery of services whether from an acute care hospital or primary care will be dependent on the technology available, and on social and geographical constraints.

Technology has developed so quickly that legalisation and policy development are lagging behind and in some areas projects are being implemented before trials have finished. Smart homes which can detect what is used, who is in the house, and provide dietary advice informed by sensors in the toilet already exist. Will the location of our new homes in the future be based on genomic data, because the individual has a genetic marker for osteo-arthritis or malignant melanoma?

Conclusion

It is not always possible to foresee social change – Bob Geldorf and Liveaid brought about subsequent celebrity use of their own status to influence and the impact of entrepreneurialism is often just as much an accident as planned, for example – friends reunited

People and technological infrastructure are needed in combination to make transformational pilots successful on a scaleable way in healthcare but at a way that is meaningful and desirable to the individual, whether they be involved in the delivery, or the recipient of healthcare services. Systems need to target lifestyle if chronic disease is to be avoided, and better managed but do people want health portals or do they really want health chat rooms or is this likely to be heavily influenced by their age and experience in IT use?

The health professions may not look anything like they do now in ten years time. In England a new role has already emerged that may result in a new professional group –the Emergency Care Practitioner. The drive to keep people out of institutions and in the community will grow and result in multi-disciplinary teams working across traditional structures, or continue to create new roles and new professions? What will happen to the old ones?

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Is sustainable health a paradigm based in reality?

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Introduction

- Could the transformational changes in delivery that technology has brought about in industries such as banking and international travel be forseen?

  This presentation puts forward a view that paradigm changes in delivering healthcare requires more than technology and political imperatives and that Social and cultural acceptance are also essential.

- Technology has a history of both acceptance and rejection, not just because of cultural fit, or social acceptance, but leadership, entrepreneurialism and plain luck. For example VHS v Betamax. Beta max was perceived as the better technology and more economic to produce but the entrepreneurs who created film libraries chose VHS. They led a new market which found a stronger demand than technological robustness; a social appetite for a new service and cultural acceptance of libraries.

- Technology is on occasion very rapidly embraced. UK records are sold on line and downloaded straight to an MP3 player [1]. transforming the industry and supply chain

Why hasn’t health made same strides?

- Is it because it isn’t possible to anticipate the extent of change? In banking concerns about closures and accessibility have long been surpassed by a plethora of contact and accessibility mechanisms.
- Governor Olson, Before the First Annual Convention of the Ohio Bankers League said that “In the process, we also spawned a new generation of more sophisticated and rigorous risk-management practices. “ [2]
- Is the eHealth story one of bad luck despite good technology or just that we are only on the first page? Arguably no health service anywhere in the world has yet managed to bring teleHealth into the mainstream of service delivery.
- Picture Archiving and Communication Systems (PACS) [3] has been heralded as bringing significant patient benefit, but fundamentally it too is a replacement technology for film, although some institutions still print film for orthopaedic consultants. An attraction for purchasers is that the cost benefits that occur in introducing PACS largely do so within an organisation [4].

What healthcare transformation is needed?

- Globally the population is ageing, with specific countries facing acute problems of healthcare crises as a result - according to Gingrich [5]

  "Healthcare consumes 26% of all federal spending and growing, dwarfing every other priority."

- UK demand for change in delivering patient, community based preventative care rather than high spend on hospital based curative measures.

- Will transformational change happen because; policy makers and consumers want it, or because technology is driving it, or are other factors key to success?

The people factor

- Political drive and technology capability are inevitably generic in approach, however there exists differing experiences and expectations of technology within age groups.

- Using a simple PEST (political, economic, social, technical), framework we consider why health has not undergone a transformation in service delivery by looking at 3 age groupings, albeit no group is homogenous.

Current mid-teens to 20-somethings

Technical

- Early adopters of technology.
- Always in communication with their peers
- Most, not least, have a mobile phone
- Some with asthma receive high risk SMS warnings
- Some update their health record, upload physiological data, receive health care education, access to health providers directly
- Convergent technologies allow multi media through single devices
- Communication Technology standards increase interoperability possibilities, breadth of coverage and security

Political

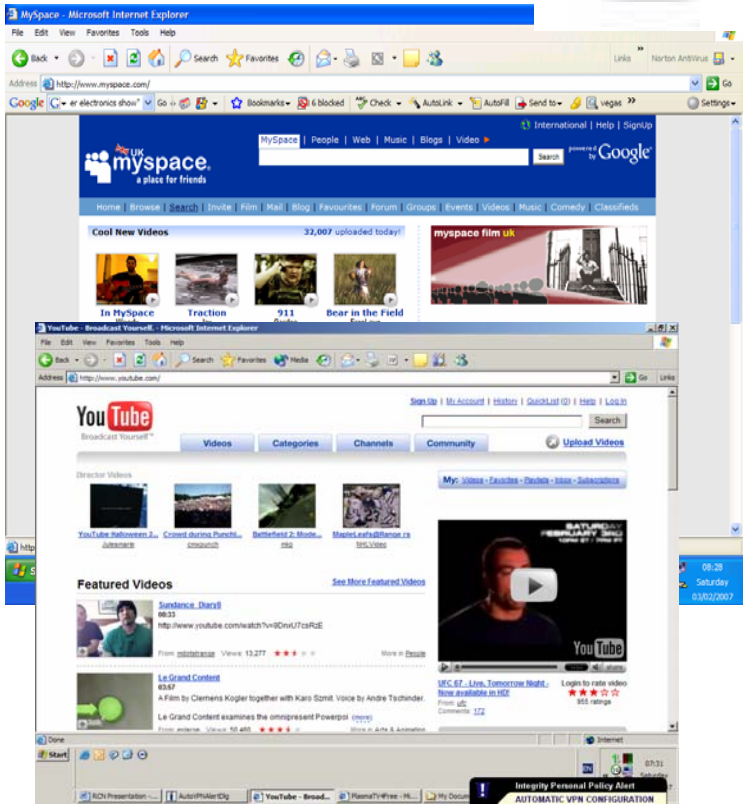
- Concerned about the environment, but less interested in actually getting out in it.
- Not exposed to the competing interests of curative v preventative care

Economic

- Likely to have to work longer, with a fragmented career path
- Stay at home longer than their parents did, and buy homes later
- Expect service, for things to happen when they want it to in a way and time that they want. They are not used to queueing

Social

- Their communication is fragmented, abbreviated language, one line of text with long gaps between and use computers for communication far more than for data processing .
- interact any time, any place anywhere, allowing more collaborative working too.
- seamlessly alternating between channel-hopping and 150% focus.
- intolerant of having less access to knowledge and real-time mentoring
- lifestyle and health choices are heavily influenced by friends and family



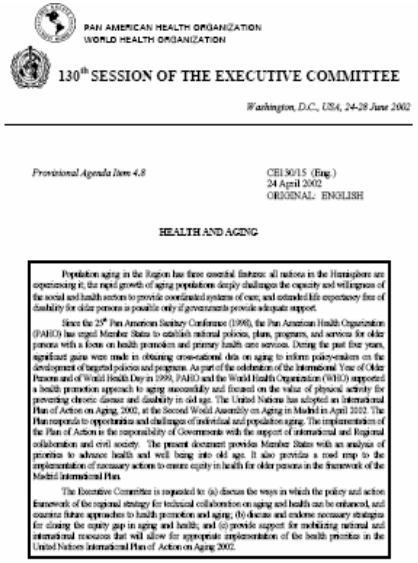
What of that of the 75+

Technical

- A generation of letter writers, but also the first users of the telephone and television but less dexterous fingers cannot readily send text, and aged eyesight finds small font size even on keyboards difficult
- They use sensors in the home to identify changes in their routine, with alarms to instigate a response

Political

- The Age discrimination act is too late for them, many are already to old to work or already out of the workplace
- They have seen some Acts, such as Sunday shopping introduce significant social change (only in some countries)



PAN AMERICAN HEALTH ORGANIZATION
WORLD HEALTH ORGANIZATION

130th SESSION OF THE EXECUTIVE COMMITTEE

Washington, D.C., USA, 24-28 June 2002

Provisional Agenda Item 4.8

CE130/15 (Eng.)
24 April 2002
ORIGINAL: ENGLISH

HEALTH AND AGING

Economic

- The demographic changes will result in less people working (including nurses), and paying taxation to support those who are retired
- Pensions have not kept up with cost of living expenditure, causing many to suffer financial hardship.

Social

- Communication is a whole conversation, a social time or phone call in a place and often appointed time
- Longer life expectancy
- Lifestyle will be dependent on their income, social network and relationship with their families
- Healthcare choices influenced by their community pharmacist, GP
- They are used to, and continue to, wait for their turn

Providers for all 25 - 65

Technical

- Technology is used to make life easier and to maintain status quo overall rather than changing what they do
- Growing use of on line shopping and internet banking
- Communication technology overload – email
- Those working in health have concerns of technology output overload of telehealth – who is going to look at the output of telemonitoring, home sensors?

Political

- Terrorism has impacted on travel both in where they go, and the experience of travel itself
- These are the active policy makers, organisational and government managers, clinicians, technicians with vested interests at national, local and familial level

Economic

- Busy looking after younger and older generations leaves them time poor and economically strained

Social

- For those in health there is insecurity as to what the workforce will look like, and is what they became a professional for?
- Will they need new skills that are more technical and what are their expectations of social interaction with the patient and at work?
- They expect queues and waiting times which are somehow seen as fair
- Heath visitors and midwives came to the house but you go to a surgery to see a doctor
- shopping as a social event, and growth of coffee shops

how does this impact on the shift from cure to prevention?

- Consumerism challenging acceptability of waiting times, poor conditions and service.
- Improving citizen access and increasing the knowledge base
- Healthcare buildings will downsize per head of population.
- ICT and ‘Labour-saving” technology will consolidate and expand key services with Governments optimising return on investment
- Traditional notions of organisational boundaries will need to give way to a concept of ‘health care without walls’.
- Economic imperatives; staff shortage internationally, less children being born, less future tax payers and healthcare workers. s
- Importing expertise v recruitment from overseas

Chronic Disease

Previous causes of death and disease, are tamed through planned interventions. But chronic disease is now the problem at both individual and national economic levels. with causal factors and impact of the disease heavily influenced by lifestyle choices. Chronic disease requires personalisation not generic IT support. Given that each age group and societal strata readiness to accept or adopt change may differ there is a need for different methodologies to be adopted.

Technology

- Computing will be ubiquitous and incorporate decision support and communications with knowledge management available at the point-of-care. But who will pay for these cross boundary solutions, and who will reap the benefit? Which organisations will be altruistic, or is entrepreneurialism to be the luck factor?
- Integrated technologies will increasingly find their way into use in health care enabling entrepreneurial delivery of services.
- Technology is developing so quickly that legalisation and policy development are lagging behind.
- Traditional notions of organisational boundaries will need to give way to a concept of 'health care without walls'.

Enabled applications

Conclusion

- It is not always possible to foresee social change
- People and technological infrastructure are needed in combination to make transformational pilots successful on a scaleable way in healthcare but at a way that is meaningful and desirable to the individual. Systems need to target lifestyle if chronic disease is to be avoided, The health professions may not look anything like they do now in ten years time.
- The social expectations of those manning the organisations at the moment has yet to be adressed - Several teleHealth projects have used nurses within specialised call centres but do nurses want to work this way
- Perhaps it's just too soon to know what patients really need
- "Experience suggests that if the investment requires integration of information and processes across these systems and business units in order to be cost-effective, then re-organising processes, changing responsibilities, re-training large numbers of staff, and finding additional funding can be an incredibly complex undertaking."

  Professor Denis Protti (6)

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Model Driven Realization of Business Processes in Care Paths Based on a Service-Oriented Architecture in a Hospital Infrastructure

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[c] *The Foundation for Scientific and Industrial Research at The Norwegian Institute of Technology, Norway*

Abstract

This presentation will share work from my ongoing master thesis.

At Ullevål University Hospital there is a major challenge in integrating different IT systems in core processes, i.e. patient treatment.

The challenge is a two-way street. It is hard to embed these systems in the treatment processes (care paths) giving optimal value for patients, clinicians and the hospital. Treatment processes are not straightforward and the systems need to be flexible to align the processes.

At the same time complexity is emerging as a result of the way the systems are integrated. New technologies come and go, increasing heterogeneity and lowering flexibility in the way these systems interacts.

The focus in the master thesis is on realizing flexible computer-support in business processes by using concepts from OMG's MDA framework and investigating the use of BPMN and BPEL in this context. The use of reference ontologies are also investigated.

Keywords:

Integration, Model Driven Architecture, Service-Oriented Architecture, Modeling Language, BPEL, BPMN, Ontology, Logistics, Interoperability, Sustainable Development.

Introduction

In my master thesis I will investigate the framework of Model Driven Architecture (MDA) and Service-oriented Architecture (SOA) with the intention to realize flexible system integration aligned with core processes.

The main objective is to find a suitable modeling language(s) to map business processes to IT-infrastructure. Business processes, e.g. treatment processes and care paths, will be captured and used as input to a computational independent model in MDA.

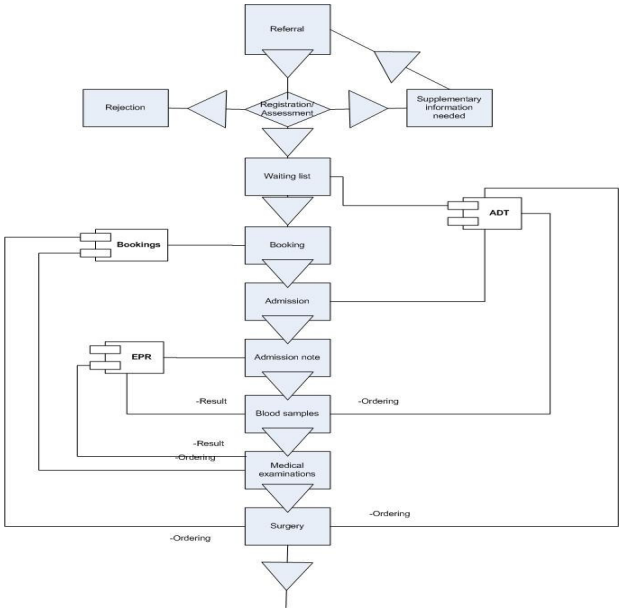

Figure 1- A subset of the treatment process

Methods

The capturing of business processes will be done by conducting structured interviews at a hospital department and modeled informally by the use of simple flow charts. Methods used to capture this and the results are not evaluated.

The captured business processes are modeled in BPMN. Further, models for realizing service chaining and service oriented architecture are made. A platform specific model conforming to BPEL metamodel is made in an attempt to realize service chaining using a specific technology.

Mappings between models are made experimentally revealing the abstraction levels that are needed.

An ontology is also made conceptually and mapped to the MDA stack.

Discussion

In the discussion, the BPMN-BPEL-chain, reference ontologies and the MDA framework is evaluated, raising the following questions:

- What is lost in abstraction to the different technologies?
- Are the technologies suited for integration of health information systems?
- Do the technologies fit into the MDA framework?
- Where do reference ontologies fit in the MDA framework and how should it be realized in a hospital setting?
- How should a reference ontology for semantic mappings of clinical and organizational data in EDI standards, like EDIFACT and HL7, be realized and what are the profits to expect?
- Identifying pitfalls in realization of the conceptual frameworks?

Results and Conclusion

The master thesis is due August 2008.

Model Driven Realization of Business Processes in Care Paths Based on a Service-Oriented Architecture in a Hospital Infrastructure

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Introduction

- The IT-portfolio at Ullevål University Hospital is growing larger and more complex:
  - making it harder to reconciliate systems to business processes.
- Integration of systems are typically done ad-hoc and is lacking structured semantic mappings from business domain to corresponding technical artefacts:
  - Making system integration expensive, rigid and error-prone.
- Manual maintenance of documentation:
  - Not to be trusted – changes demand reverse engineering.
- Need to compose services (service chaining) to composite processes, e.g. patient logistics

Objective

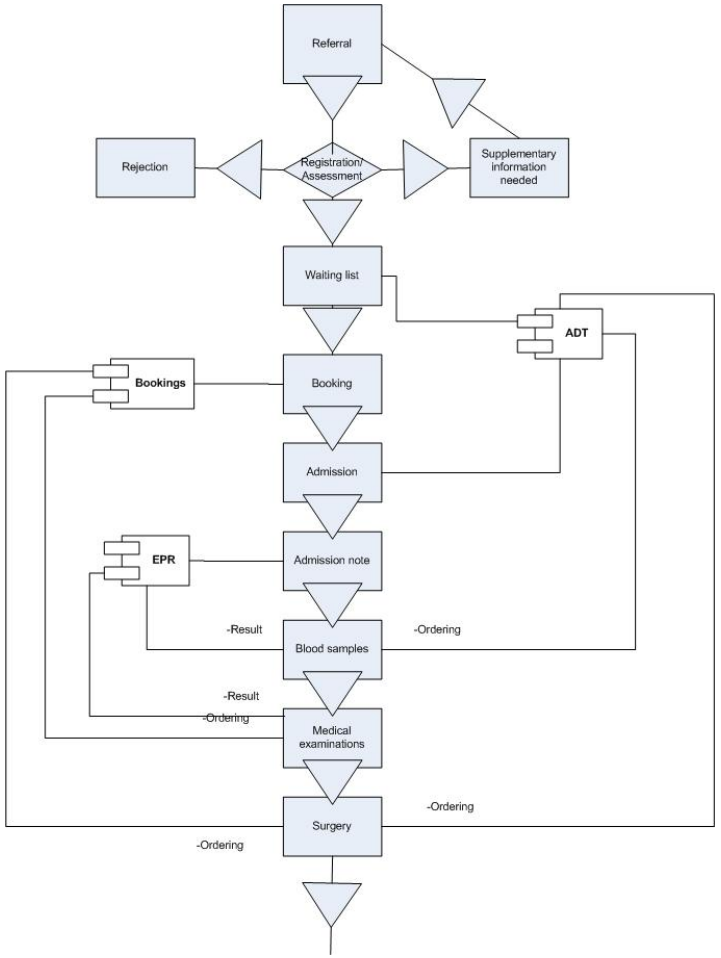
- Improve reconciliation of business processes and IT-portfolio at Ullevål University Hospital by applying MDA /MDD principles.
- Assessment of BPMN and BPEL as technolgies to map business processes (Computational Indepent Model - CIM) to IT-infrastructure (Platform Independent Model /Platform Specific Model – PIM/PSM).
- Assessement of reference ontologies as tools for improving semantic mappings in system integration and in interoperability with external partners.

Methods

- Capture business processes by structured interviews and informal modeling. The methods used and results will not be evaluated or discussed.
- Realizing models for business processes in a BPMN-tool
- Realizing models for service chaining by the use of BPEL metamodel. Map and transform BPMN to BPEL either directly or through a PIM model to constrain implementation to SOA paradigm and further to a PSM model of BPEL.
- Realizing a reference ontology conceptually in a hostpital setting.
- Map MDA CIM and PIM layers to reference ontologies

Methods: Capturing Business Processes

- Structured interviews
- Informal modeling, e.g. simple flow charts
- The accuracy of the captures is not important
- The captures are input to BPMN-models



CIM/PIM Modelling (BPMN /SOA)

- Realizing BPMN models.
- Investigate the need to map BPMN-models to a SOA model in order to achieve a Service Oriented Architecture.

PSM Modelling (BPEL)

- Make a BPEL model that conforms to BPEL metamodel and map it to the CIM model (directly or indirectly)
- Do we need a BPEL model? Is a direct transformation of CIM/PIM model to BPEL the way to do it in real life?

Evaluation of Reference Ontology (RDF and OWL)

- Evaluation of Reference Ontology in the MDA / hospital context
- Evaluation of existing technologies, RDF and OWL, in order to create a reference ontology for integration of health information systems.

Research questions

- Evaluating the BPMN-BPEL-chain:
  - What is lost in transformation from BPMN to BPEL?
  - Is the technologies suited for integration of health information systems?
  - Where does referance ontology fit in the MDA framework and how should it be realized?
  - What are the profits to expect using a reference ontology in semantic mappings of clinical and organizational data in, e.g. EDIFACT and HL7

Research questions: Integration of Health Information Systems

- Does an MDA /MDD approach with BPMN and BPEL:
  - Make integration cheaper,simpler, faster and less error- prone?
  - constitute a platform for configuration and control of the IT-portfolio – making it easier to tailor service chaining and user interfaces for specific needs?
- Pitfalls and criticism?
- Considerations in the health Information systems domain

Discussion and Conclusion

- The master thesis is due August 2008…

References and Contact Details

Supervisor:

Professor Dr. Arne-Jørgen Berre (SINTEF)

- OMG's MDA framework
- OMG's BPMN specification
- OASIS group's BPEL standard
- Athena MDI framework

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Social Construction of the Patient Through Problems of Safety, Uninsurance, and Unequal Treatment, a Discourse Analysis of IOM Executive Summaries

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Abstract

This is a second preliminary report from a larger research project. The purpose of the larger research project is to study how the Institute of Medicine discourse promoting the health information technology may reproduce existing social inequality in healthcare. Subject position is a concept from critical theory which is used to study social justice through such approaches as discourse analysis. Social constructionist and critical discourse analysis combined with corpus linguistics methods has been used in methods testing to study the subject positions constructed for receivers of health care across the executive summaries of three different Institute of Medicine reports. Preliminary data analysis revealed differences in the way receivers of health care are constructed in the three texts selected for this study.

Keywords:

corpus linguistics, critical theory, discourse analysis, health information technology, social constructionism, inequality, social justice

Introduction

The 2003 American Medical Informatics Association Spring Congress outlined a social justice agenda for health informatics by calling for the development of health information technologies (HIT) that bridge the digital divide and support improved health care outcomes for both vulnerable and underserved populations. The white paper reporting on this Congress outlined barriers for HIT development for vulnerable and underserved populations and offered policy, funding, research, and education and training recommendations to overcome these barriers.(Chang et al., 2004)."

This is the second report from a study of how the Institute of Medicine (IOM) discourse promoting the deployment of health information technology and the development of the proposed National Health Information Infrastructure (NHII) may reproduce social inequality in health care. This research is in progress using critical discourse analysis of two Institute of Medicine report series: the Quality Chasm, and the Insuring Health series, as well as the standalone report on the unequal treatment of racialized populations, Unequal Treatment (Institute of Medicine & Board on Health Care Services, 2005; Institute of Medicine & Committee on the Consequences of Uninsurance, 2004; Smedley, Stith, Nelson, Institute of Medicine, & Committee on Understanding and Eliminating Racial and Ethnic Disparities in Health Care, 2003). The overarching goal of this research is to examine these texts for their contribution to the social justice agenda outlined by the 2003 AMIA Spring Congress using a study of the construction of subject positions in the textual data.

Methods

Data. A detailed description of the data selection for this research was outlined in the first preliminary report (Trigg, 2006). Briefly, each of the reports was published by the IOM between 2000 and 2005. To Err is Human of the Quality Chasm series was selected for its strong recommendations for HIT in the interest of improving health care safety and quality (Institute of Medicine et al., 2005) Coverage Matters, from the Insuring Health series (Institute of Medicine et al., 2004) and the standalone report Unequal Treatment (Smedley et al., 2003) were selected because they outline specific social justice problems in United States health care—those associated with uninsurance and the unequal treatment of racialized populations (racialized populations are persons grouped together solely based on the construct of 'race'). The executive summaries were selected for the preliminary data analysis in order to limit the scope of the project for methods testing.

Data Management & Processing. All texts were purchased from the National Academies Press (National Academy of Sciences, 2006) in both paper book and digital .PDF formats to facilitate comparison of surface features of all texts and random checking of agreement between the text versions. Data was cleaned using ConvertDoc™ (Softinterface, 2006) in preparation for analysis using corpus linguistics computer analysis tools. Oxford WordSmith™ Tools 4.0 (Scott & Oxford University Press, 2006) was used initially to create KWIC concordances for the three separate executive summaries for the truncated keyword patient*. Subsequent keyword concordances for the words person* and consumer* were created based on analysis of the results of the initial patient* concordances.

Results

In this section only, Coverage Matters = CM, To Err is Human = TEH, and Unequal Treatment = UT. Table 1 shows the results of the KWIC searches and includes number of tokens in executive summary.

The most notable result of the keyword in context concordancing was the small number of times that the word patient* is used in CM, compared with the number of times it is used in the other two texts.

Table 1 - Word Frequencies

KWIC	CM	TEH	UT
Patient*	2	81	129
Person*	27	2	3
Consumer*	3	7	1
Total word tokens	4764	5139	7729

*Table 1 - This table shows the number of times each truncated keyword appears in each text according to the KWIC concordance. Each line represents a set of concordances. The words person, patient, and consumer are all used to refer to receivers of health care in these executive summaries. Each carries a somewhat different connotation. * = truncation*

The sentence from CM quoted in the last paragraph actually distinguishes between "uninsured persons" and "patients with coverage," reporting that uninsured persons often pay more for medical care than patients with coverage. This distinction is curious and contradictory, given that if "uninsured persons" are "paying more than others for medical care," they must at some time have also been "patients."

Discussion

Exploration of definitions of these words yields interesting distinctions of meaning and therefore social action through language. One of the top current definitions for "person" in the Oxford English Dictionary Online™ (Simpson, 2006) (OED) is "an individual human being." A top OED definition for the word "patient" is "a person receiving or registered to receive medical care." Earlier and currently archaic OED definitions for the word "patient" are "a sufferer" and "a person who suffers from injury or disease." OED defines a "consumer" as "he who or that which consumes, wastes, squanders or destroys." OED definitions of "consume" include "to make away with, use up destructively," "to destroy," "to decompose," and "to spend, especially wastefully, to waste, to squander." American Heritage™ provides another definition for "consumer" as "someone who purchases a good for personal use" (Trefil, Kett, & Hirsch, 2006). Each variation suggests different requirements of an information system.

Given the limited corpora used in this study, little can be made of this distinction. However if this distinction between uninsured persons and patients pervades the Insuring Health texts, and enters the policy level requirements specification for the NHII, the needs of receivers of health care who are uninsured may not be adequately represented in a NHII which is designed for "patient safety."

Conclusion

The combination of critical and social constructionist discourse analysis with corpus linguistics methods has proven to be adequate for investigating textual data for discursive signs of the social action of language in creating subject positions in the selected IOM report executive summaries. It should prove useful in the larger study, which will use a much larger corpus, and make a closer interrogation of the textual data. The automation of corpus linguistics methods doesn't replace human interpretation in discourse analysis, but provides systematic ways to find language use patterns of interest to this research.

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Social Construction of the Patient through Problems of Safety, Uninsurance, and Unequal Treatment, a Discourse Analysis of IOM Executive Summaries

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Abstract Larger Research

- Question: Does the Institute of Medicine discourse promoting HIT/National Health Information Infrastructure reproduce existing social inequality in healthcare?
- Methodology:
  - Analyze social action of language in selected Instititute of Medicine reports using
    - Social constructionist and critical discourse analysis
    - Computer Assisted Corpus Linguistics methods
- Corpus/Data:
  - IOM reports: Quality Chasm, Consequences Uninsurance, Unequal Treatment

Abstract
Methods Testing Studies

- # 1: broad strokes; textually oriented discourse analysis
- # 2: social constructionist & critical discourse analysis; study of subject positions for receivers of health care
- Corpus linguistics used for both
- Same texts used

Background

- ↑Promotion of HIT/NHII in US to improve patient safety & quality through Quality Chasm reports
- Proposal of NHII, now called NHIN
- AMIA 2003 Spring Congress white paper--social justice agenda for HIT
- Unequal treatment of racialized populations
- Uninsurance problem

Rise in Interest in Discourse

- Fairclough (2001):
  - "...a 'knowledge-based economy'....entails a discourse-based economy:

knowledge is produced, circulates, and is consumed as discourses...which are operationalized as new ways of acting and interacting."

(Fairclough, 2001. CDA as a Method in Social Scientific Research, in Wodak & Meyers, Methods of CDA, p 127.)

Existing Social Inequality in Health Care

- **Interlocking nature of oppression (Collins, 1986)**
  - **Intersection of multiple structures of oppression**
- **Social circumstances & health care outcomes mutually constitutive:**
  - **Social position affects health care outcomes**
  - **Health status also affects social position (Blane, 1999)**
- **No universal health care in US, resulting in "uninsurance" problem**

(Collins, 1986. Learning from the outsider within. *Social Problems, Vol 33, No 6: Blane, D. 1999. The Life Course, the Social Gradient, and Health. In M.G.Marmot & R. G. Wilkinson (Eds.), Social Determinants of Health (pp. 64-80). New York: Oxford University Press.)*

Methods: Data

- For methods testing studies:
  - Executive Summaries, abbreviated for Table 1:
    - TEH = Err is Human, (2000)
    - CM = Coverage Matters, (2002)
    - UT = Unequal Treatment, (2003)

Methods: Processes

- IOM reports purchased in digital & book format
- ConvertDoc^{tm}: .pdf converted to .rtf
- KWIC searches:
  - First search patient*
  - Then person* and consumer* based on results of first search

Results

Table 1. Word Frequencies			
KWIC	**CM**	**TEH**	**UT**
Patient*	2	81	129
Person*	27	2	3
Consumer*	3	7	1
Total word tokens	4764	5139	7729

Discussion

- OED (Online 2006):
  - Patient = person receiving or registered to receive care; sufferer (archaic); person who suffers from injury or disease
  - Person = an individual human being
  - Consumer = he who or that which consumes, wastes, squanders or destroys; to make away with, to use up destructively, to squander

Discussion

- Three separate subject positions for a ‘receiver of health care’
- Each has different connotation
- Each connotation may reflect differently in a requirements specification
- Subject positions may conflict

Conclusion

- Social constructionist & critical discourse analysis combined with corpus linguistics are sufficient study subject position in even in small corpora
- Further research should facilitate planning to prevent the reproduction of social injustice in the NHII/NHIN

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INDICATOR: A Comprehensive Cyberenvironment For Infectious Disease Surveillance, Modeling, and Response

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Abstract

Infectious diseases continue to be a major factor in public health and emerging diseases threaten to cause a pandemic. To combat these threats it is necessary to detect outbreaks and determine the most efficient response as quickly as possible. Information technology can give health professionals the tools they need to do this, but these tools must be integrated, effective, scalable, and user friendly. NCSA is currently developing INDICATOR, an infectious disease informatics cyberenvironment, to address this need.

INDICATOR will accept data from a wide variety of sources, including hospitals, public health departments, veterinary—medicine clinics, and remote sensor networks. It will use established spatial and temporal analysis algorithms, e.g. SatScan, to combine these data sources and identify outbreaks. INDICATOR will also support epidemiological modeling with programs, e.g. EpiSims, to help develop preparedness plans and determine the most effective remediation strategies for controlling an existing outbreak. In addition it will provide collaborative, visualization, social networking, and workflow management tools. Once in production INDICATOR will provide a major new resource to the surveillance, modeling, and response communities.

Keywords:

infectious disease informatics, cyberenvironments, public health, surveillance, modeling, response

Introduction

An effective response to an outbreak of an infectious disease, whether routine or rare, naturally occurring or deliberately caused, requires the coordinated effort of healthcare providers and public health officials. To be able to respond effectively, these groups need to have rapid access to information about the outbreak including its location, size, and spread. They also need to have access to models that correlate this information with potential remediation strategies and determine how likely each strategy is to successfully contain the outbreak.

There are currently a number of software solutions available to assist in the detection of an outbreak, including the US Center for Disease Control's (CDC) National Electronic Disease Surveillance System (NEDSS) [1], Early Aberration Reporting System (EARS) [2], Laboratory Response Network (LRN) [3], BioWatch [4], and BioSense [5]; John's Hopkins' Essence [6], the Open Source Realtime Outbreak and Disease Surveillance (RODS) from Pittsburgh [7], Health Canada's Global Public Health Information Network (GPHIN) [8], and the SatScan algorithm from Harvard [9]. There are also a number of formalized surveillance systems relying on communication between physicians such as the International Society for Travel Medicine and CDC GeoSentinel group [10] and the CDC Emerging Infections Network (EIN) [11]. Most of these systems, however, work with a single type of surveillance data, such as syndromic data, mandatory reporting data, or laboratory data and focus almost exclusively on human surveillance.

There are far fewer options for planning the response to an outbreak. Developing these plans is not a simple exercise and requires conducting significant numbers of simulations based on complex modeling studies such as those being carried out by the U.S. National Institutes of Health (NIH) MIDAS (Models of Infectious Disease Agent Study) team using tools such as EpiSims [12], and EpiCast [13]. These modeling studies require the handling and processing of very large, diverse datasets and multiple complex models in a heterogeneous large scale computing environment. Ready access to high performance computers, and datasets that include biological, population, behavioral, and geographic databases requiring a significant information technology infrastructure are also necessities.

Coordinating the computing and IT resources for surveillance and modeling and integrating them into an effective system for decision makers and responders is challenging. Adding the time critical nature of a response to an outbreak, the dynamic nature of the models (where parameters need to be modified in real time), and the need to

share the results quickly and visually makes for a frontier problem that must be addressed quickly. We are working to develop a cyberenvironment to address this need.

Cyberenvironments

Today's scientists spend too much of their time moving data from place to place and format to format—time that could be better spent generating new knowledge. In the infectious disease and bioterrorism community this leads to planners working with obsolete data and modelers lacking access to real time infectious disease information from sentinel systems. What is needed is the next generation of tools to make the research process more efficient—tools that truly integrate data, models, and communities.

Cyberenvironments are this next generation. They are an integrated set of tools and services tailored to a specific discipline community that allow these communities to realize the full potential of the national cyberinfrastructure in their research, development, and teaching activities. They provide an interface to local and shared instruments and sensor networks, data stores, computational capabilities, and analysis and visualization services within a secure framework enabling management of complex projects, automation of processes, and collaboration with colleagues both near and far.

The National Center for Supercomputing Applications (NCSA) is currently working with a number of scientific and engineering communities including earthquake preparedness, atmospheric sciences, and environmental sciences to produced cyberenvironments MAEviz [14], LEAD [15], and ECID [16] respectively. These environments are aimed at revolutionizing scientific practice at the scale of communities, enabling deep collaboration within disciplines and the linking of research with application of that research. Having accurate outbreak detection algorithms and good models of the spread of infectious disease agents is of limited use if the information cannot be shared quickly and easily with all members of the wider preparedness and response community.

In these projects and others in which NCSA is involved, strong support from domain researchers, and their desire to tackle very challenging problems, is driving the development and deployment of technologies. In many of these projects there have already been clear scientific successes enabled by the new capabilities, leading to requests for additional infrastructure. Cyberenvironments involve more than the simple application of new technologies to current science and engineering practice; they enable new ways of organizing, performing, and applying research that will ultimately be shaped by the evolution of community processes.

INDICATOR

The authors together with partners from NCSA's cyberenvironments and technologies division, and external collaborators from the surveillance, modeling, and public health communities are applying the concept of cyberenvironments to infectious disease informatics to produce INDICATOR, Figure 1.

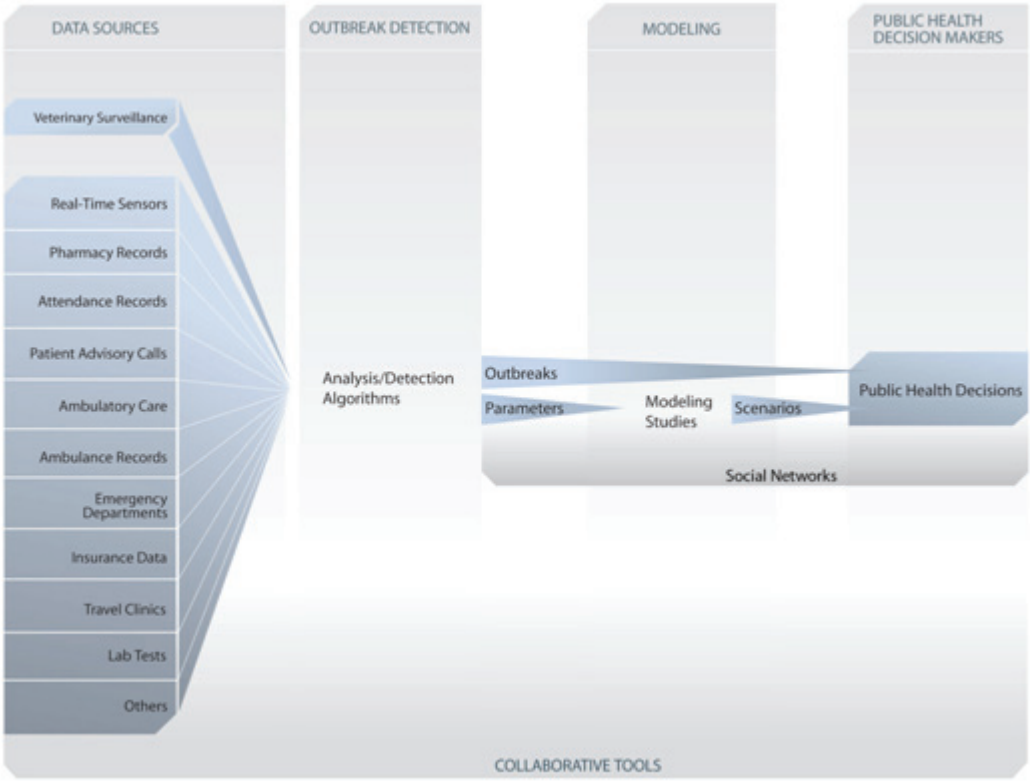

Figure 1 - Conceptual inforation flow for INDICATOR

Figure 1- Conceptual information flow for INDICATO is designed with a focus on the information needed by public health officials to make informed decisions on how best to respond to an outbreak. In most routine outbreak situations, such as the annual influenza season, it will be sufficient to detect the outbreak quickly and present the information to public health authorities in a format that they can quickly interpret. In more serious outbreaks, however, it will be essential to use parameters estimated from the outbreak detection, such as mortality and reproduction number to enable accurate modeling studies to be performed.

Effective surveillance requires the integration of multiple types of surveillance data, including syndromic, laboratory, real-time sensor networks, mandatory reporting, and veterinary data. The inclusion of veterinary data is of particular significance given the ability of wildlife monitoring to provide an early warning on the emergency of zoonotic diseases such as avian influenza and West Nile virus. Combining all of these data sources to provide a coherent picture of the health of a population is an ongoing research problem but one that INDICATOR can help algorithm developers such as Kulldorff (SatScan) address more easily. Recognizing that the data needed to identify an outbreak and model it for public health is the same data needed to advance research in surveillance INDICATOR will also provide the workflow tools needed for efficient management of algorithm testing and ensemble calculations. This will enable large numbers of computer experiments to be submitted to remote compute resources, such as NCSA supercomputers, automatically.

INDICATOR has the potential to facilitate collaboration among multiple organizations using heterogeneous technology. Users may include researchers and practitioners from many different fields, including medicine, public health, environmental science, geography, and veterinary medicine. This offers the opportunities for innovative cross-disciplinary research, but it also poses significant challenges.

Implementation

INDICATOR uses the concept of "workflow" to describe processes at multiple levels. This allows us to describe the technologies and processes in a way that can be analyzed, shared, and reused. Workflow encompasses the high-level graphical user interfaces that domain scientists use, the

low-level job execution, and the data storage and movement. Linking between views requires semantic descriptions, provenance tracking, scalable execution engines, and interfaces for managing workflows.

The workflow for an infectious disease cyberenvironment will involve heterogeneous data, including proprietary formats, processed data, and metadata. Additionally, there will be a need to support different levels of data sharing. Participants will be allowed to identify the part of their own workflows they choose to share, e.g. raw data, results, or abstract descriptions of protocols. INDICATOR will also support provenance tracking to maintain information about the origin of data.

To address these issues, we plan to develop a secure collaborative cyberenvironment and metadata/data repository, leveraging existing components created by NCSA's MAE-Viz team. Users can automatically email, upload their data, or provide an HL7 feed and INDICATOR will parse and process it as necessary. Metadata, including provenance information, will be generated and stored in the repository along with the original data. Spatial and temporal analysis software, e.g. SATSCAN [9] and WSARE [17], will be available as services.

The cyberenvironment will allow users to browse available data sets and metadata, control how their own data is shared, and select data sets and services to run. The resulting data is also stored in the repository and INDICATOR will support visual analysis, e.g., GIS maps and graphs. Users will be able to anonymize their data with FLAIM [18], a tool originally developed by NCASSR to anonymize computer security logs.

To support workflow management, we will be leveraging ECID, Environmental Cyber Infrastructure Demonstration Project, also developed at NCSA. ECID introduces the concept of "meta-workflow" which provides users with the following capabilities [16]

1. Browsing registries of data, tools, and computational resources
2. Creating meta-workflows for batch processing
3. Reuse and repurposing of meta-workflows
4. Executing meta-workflows locally or remotely
5. Incorporating heterogeneous tools and transparently linking them

For example, a user looking at emergency room chief complaint data might suspect a zoonoses-related outbreak, and want to look at veterinary data to see whether there have been unusual patterns with animal illness. The user would either browse the data or perform a metadata-based search. They could then create a new workflow using multiple services, execute it, and view the results. These results would then be stored, and the user could decide whether to share his results.

We also plan to leverage social network analysis to help users discover relevant data and services. ECID is currently exploring this technology as it develops a "dashboard" that provides a dynamic overview of the activities within the current environment [19]. This would also be useful for INDICATOR. For example, someone investigating an outbreak in one county would be able to discover recent results of a similar analysis of a neighboring county.

The LEAD (Linked Environments for Atmospheric Discovery) cyberenvironment allows the user to dynamically control real-time streaming feeds from weather sensors [15]. INDICATOR plans to leverage this technology for its remote sensing data. Weather and environmental data are often linked to infectious disease outbreaks, but the sheer volume of information has often been a problem for researchers analyzing remote sensor data. Allowing the user to dynamically choose real-time feeds would provide a solution to this problem.

Preliminary work has focused on detection of outbreaks from chief complaint data obtained from calls to a local patient advisory nurse. Having evaluated many of the available syndromic surveillance systems and algorithms SatScan and WSARE were selected for initial implementation as services based on their portability and functionality. The evolving nature of a cyberenvironment means that others may be added without disruption to the existing services and in fact INDICATOR provides an ideal platform for comparison of different algorithms.

Conclusions

Cyberenvironments have been employed successfully in multiple scientific and technical domains. These include the earthquake preparedness domain that uses data feeds to detect an earthquake, computational modeling to predict structural damage, and high end visualization to present results to emergency response authorities. The knowledge and experience gained with other cyberenvironments will be applied to the infectious disease domain to develop INDICATOR which will have analogous capabilities to use data feeds to detect an outbreak, computational modeling to predict disease spread, and high end visualization to present results to emergency response authorities. Over the next year we expect to implement workflows for SatScan and EpiSims, implement a cybercollaboratory for EIN, and move our chief complaint surveillance component into production.

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Future Market Expectation for Korean u-Health by Analyzing Demand Forecast and Adoption Factors

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Abstract

With progress in ICT and health care and medical technology providing capability, the introduction of u-Health has been propelled by an increasing demand from both service providers and users. The benefits expected from u-Health are enormous. In addition to the tremendous contribution to the welfare of health care users, it is projected to entail huge economic effects, bolstering the growth of the health care industry as a whole, as well as the ICT industries. In this paper, we, predict demand for both the services and related equipment based on the results of a consumer survey, identify factors affecting the diffusion of this new service system, and, finally, suggest market development strategies for it.

Keywords:

u-Health, ICT, adoption, forecast, market

I. Introduction

The advent of ubiquitous networking promises to bring about dramatic changes at all levels of our life. Ubiquitous networking, by interlinking computers, consumer electronics, automobiles, home appliances, medical equipment, transportation systems, animals and plants through an overlapping of electronic spaces and physical spaces, is expected to provide an environment that enhances our lives through improved convenience, efficiency and safety in all areas. This paper is concerned with strategies to accelerate the diffusion of u-Health services in Korea. In the rest of this paper, we examine the concept and characteristics of u-Health, forecast demand for both services and equipment, and identify factors influencing the adoption and diffusion of these services, using the results of a consumer survey, and finally, based on this analysis, propose development strategies for the u-Health market.

II. Concept and characteristics of u-Health

u-Health, the short form of "ubiquitous health," refers to a health care system making use of ICT to provide preventive care, consultation, treatment, and follow-up care to patients from anywhere and at any time. While e-Health is an electronic information sharing system between patients, the general public, health care institutions and solution providers, u-Health goes one step further to integrate the physical spaces of health care users and providers with electronic spaces, operating cutting-edge medical technologies.

To explain the emergence of u-Health, one must invoke, first of all, progress in ICT and medical technology, and then the desire and willingness on the part of health care institutions to adopt the new service concept and increased health care demand. The extended business areas covered by telecom operators and software solution providers and support from government authorities have been contributing factors as well.

III. Demand forecast and factors influencing on adoption of u-Health

To estimate demand for the u-Health market and identify factors influencing the diffusion of related services, ETRI's Network Economic Research Team conducted a survey between September and October 2005, on a sample population of 800 adults in their 30s and 40s. The market research was preceded by a FGI (Focus Group Interview) on target group [1], from which generic needs relating to u-Health among health care users were determined. The FGI results were further used as a basis for designing a structured survey questionnaire. A leading Korean research firm was contracted to conduct the survey, in the form of one-on-one, face-to-face interviews. Information cards were used to help survey respondents' understanding of the service [2].

1. Adoption intention of u-Health

Consumers appeared to be all in all favorably disposed toward u-Health. 71.8% of respondents perceive u-Health as an exciting service formula, followed by 63.6% finding it interesting, 58.2% preferring it to standard health care services and 55.8% considering it indispensable.

The overall intention to adopt u-Health services appeared to be rather high, amounting to 56.9% of respondents. The intention of adoption was higher among women than men, among respondents residing in metropolitan cities or other small and medium-size cities than those based in Seoul and among stay-at-home wives than people in other occupational categories.

2. Factors influencing on adoption of u-Health

Consumers perceive the level of investment of resources and capabilities on behalf of medical institutions and government policy as more important factors in the achievement of a u-Health environment than a ubiquitously-networked health care infrastructure.

The biggest obstacle to the creation of a u-Health environment was the poor level of informatization in medical facilities (23.0%), followed by insufficient public information efforts concerning u-Health services (20.4%), lack of knowledge (21.0%) and inadequate ICT infrastructure in health care institutions (14.8%).

3. Demand forecast of u-Health

The survey found that the global intention to adopt u-Health in consumers in their 30s and 40s stands at about 46.9%. The intention to adopt health care institution-provided services was measured at 40.9%, and the intention to adopt subscription-based services, 9.1%.

The size of the u-Health market in number of users aged 30 to 49 is estimated at 7,026,000, which breaks down to 6,128,000 for health care institution-provided services and 1,352,000 for subscription-based services.

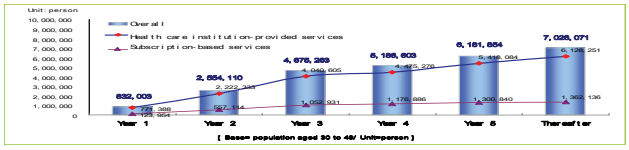

Figure 1- Forecasted number of u-Health users

Total sales in u-Health services and related equipment are projected to amount to an approximate KRW 1,075.6 billion (1,036 million dollars)[1], which breaks down to KRW 562.4 billion (494 million dollars) for health care institution-provided services and KRW 513.2 billion (542 million dollars) for subscription-based services.[2] The high estimation for sales generated by subscription-based services, used by a much smaller projected number of users, is a result of taking into account the high willing-to-pay price indicated by potential users of this type of service, and costs of equipment and devices.

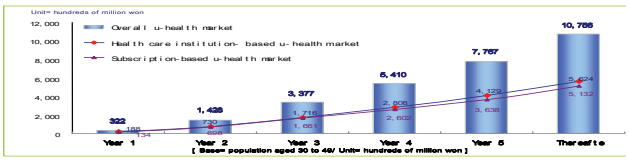

Figure 2- Projected sales in u-Health services and equipment

IV. Conclusion

In this paper, we explored the background to the emergence of u-Health, and examined its concept and characteristics. Based on a consumer survey, we predicted future demand for u-Health, and identified factors accelerating the creation of a u-Health environment and factors hindering it. Finally, we presented success factors and issues for market development efforts in u-Health. The following is implications for participants of the u-Health market.

First, the survey used in this study was limited to a population segment aged 30 to 49. Therefore, if one includes other age groups and takes into consideration forward and backward linkages, both the size of the u-Health market and its economic effect are likely to be substantially greater.

Second, the in-depth analysis revealed that interest in u-Health services was significantly higher among people who were less interested in health than the average, or not all interested, than among the rest. This means that u-Health will be able to generate new demand and create new markets.

Third, introducing necessary revisions to related health care laws and regulations is an urgent task.

Finally, the national government and local authorities must work to actively promote u-Health.

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1 The predicted sizes for the u-Health service and equipment markets are based only on transactions between service providers and users. In estimating the size of sales, the calculation took into account willing-to-pay prices of potential users.

2 Exchange rate is that 1 dollar equals 1,038 KRW(October, 2005)

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Challenges to the Regional Comprehensive Electronic Health Record (rcEHR) - the Experiments in Koriyama -

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Abstract

This paper reports on our efforts and the further challenges that we are having in our experiments in Koriyama. We have been developing electronic medical charts and health examination databases for medical and healthcare facilities, as well as eHealth cards and computer network systems on a regional basis. By integrating all of these functions, we have developed the Regional Comprehensive Electronic Health Record (rcEHR) in Koriyama. This paper explains the solutions to common problems generated in EHR development on a regional level, and upcoming challenges.

Introduction

In Japan, the sharing of health checkup results and medication information on a regional basis began as the eHealth Card system around 1995. The Japanese government has experimented with numerous business models using the electronization of health insurance cards as its ultimate goal. However, there are just a few regions where the operations are still currently available. In regard to regional healthcare via computer networks, even though the government initially poured a sizable budget into the development of the system, an issue remains regarding its sustainability because of lack of personnel and economical reasons due to the elimination of the subsidy.

Without relying on the national budget, we have developed such systems as electronic medical charts, electronic health cards, regional medical computer networks, and a database of health checkup results. In these systems, operability, economical efficiency and interoperability have all been taken into consideration. The systems have been used for the past 20 years, and are well-established in many regions. This paper reports on the sustainable systems we have developed by integrating these operations in Koriyama in Fukushima Prefecture.

Methods (1/2)

We are providing patients with their medical records and health data via electronic media used in digital cameras or cellular phones. We have named these systems My eChart and My eHealth Card respectively.
For medical and healthcare service providers, computer systems are needed to improve the efficiency of each operation at their facilities. Thus, we have developed electronic medical charts for medical facilities, an information system to record health checkup results and issue notifications for health examination clinics. Additionally, we have also developed a health checkup results database and an information system to support health guidance for the facilities. Moreover, from these systems, My eCharts and My eHealth Cards can be downloaded onto personal electronic media systems

Methods (2/2)

In regard to sharing health information between regionally-based medical and healthcare service providers, there are many restrictions in terms of time and amount of data when using patients' portable media systems. Since Internet communication is more convenient, we provide regional medical information sharing systems via highly encrypted networks.

In June 2006, we began using the electronic medical charts and My eCharts at Koriyama Medical and Nursing-care Hospital. Figure 1 shows an example of the medical imaging displayed on My eCharts. In September, we began using My eHealth Cards for workers that contain the data for physical examinations, physical fitness tests and nutritional assessments at the Health Promotion Foundation of Koriyama. We also began My eHealth Cards to provide elderly people with their general health checkup data at the Public Health Center in Koriyama. Figure 2 shows an example of the time-line graphs of the health checkup results in My eHealth cards. In April 2007, we started regional medical network to share patients' data.

Figure 1, 2

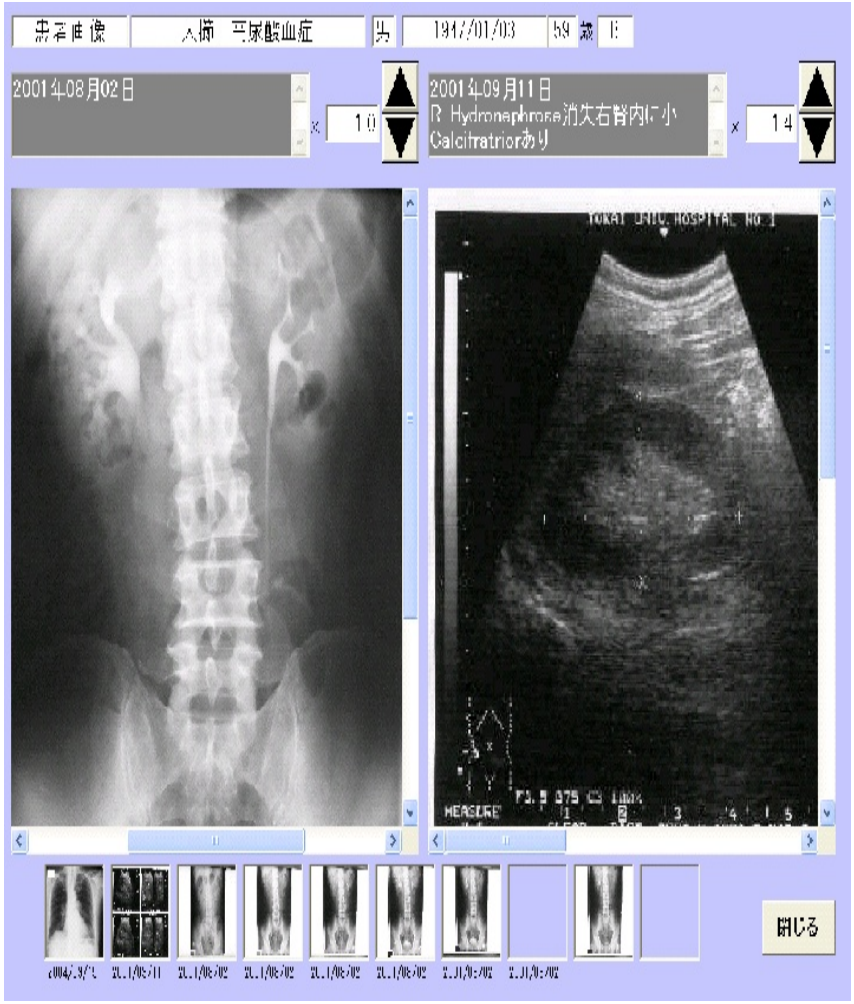

Figure 1- An example display of My eChart medical imaging

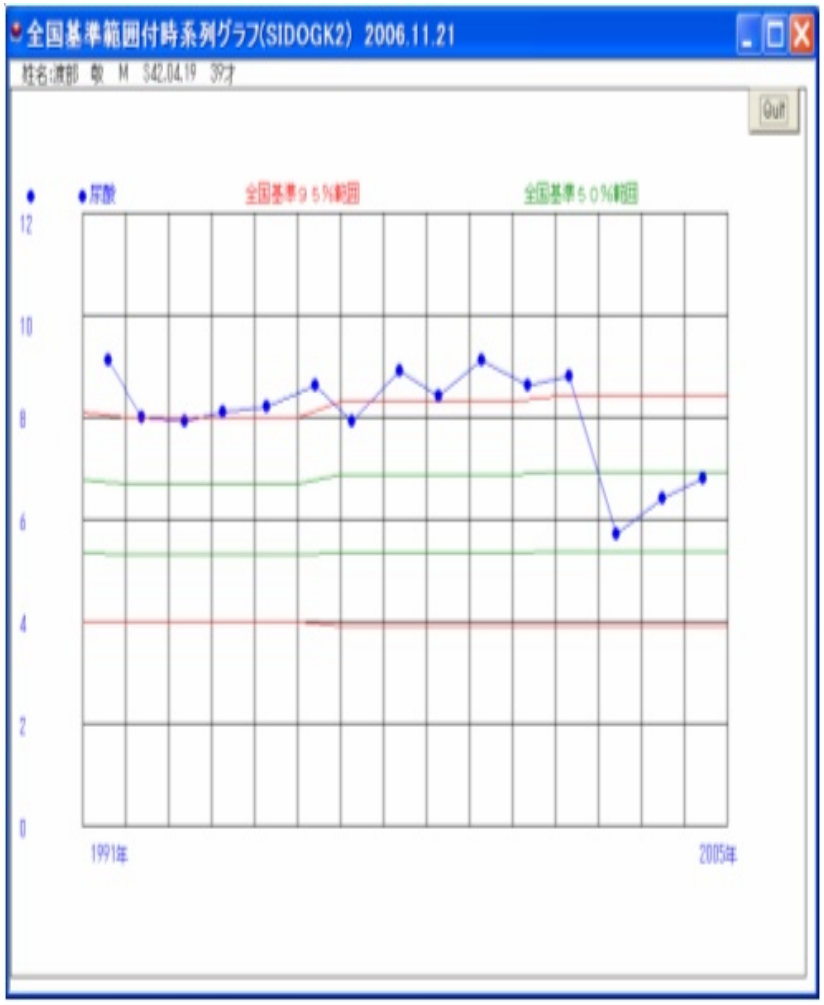

Figure 2- An example of My eHealth Card time-line graphs

Results (1/3)

1. **Operability**
   We applied the touch-screen system to our electronic medical charts. The terms, phrases and illustrations used by each doctor are programmed into the system as a table beforehand, and this reference table will be displayed on the entry screen so that the doctor can enter data with the touch-screen. For My eCharts and My eHealth Cards, the patients will see the same screen that the doctors or health nurses do. These systems enable the patients to refer to their personal health information at home or at work without going through any special training on its operations.

Results (2/3)

2. Easiness to provide My eChart or My eHealth Card

By just clicking the data-providing button on the guidance screen for the patients, personal data will be downloaded automatically onto their My eChart or My eHealth Card. The access program, the execution environment such as DLL or OCX files, and the operation manual in the HTML format are also transferred all at once. This process takes only a few seconds and hardly affects day-to-day operations.

3. Security

The regional medical networks can be accessed only by the registered medical or healthcare specialists. An encrypted password is issued for each user as personal authentication in accessing the networks. SSL is used for communication to prevent interception. Since the data is encrypted and registered in the database in real time, it cannot be decoded through unauthenticated access(Figure 3).

Figure 3

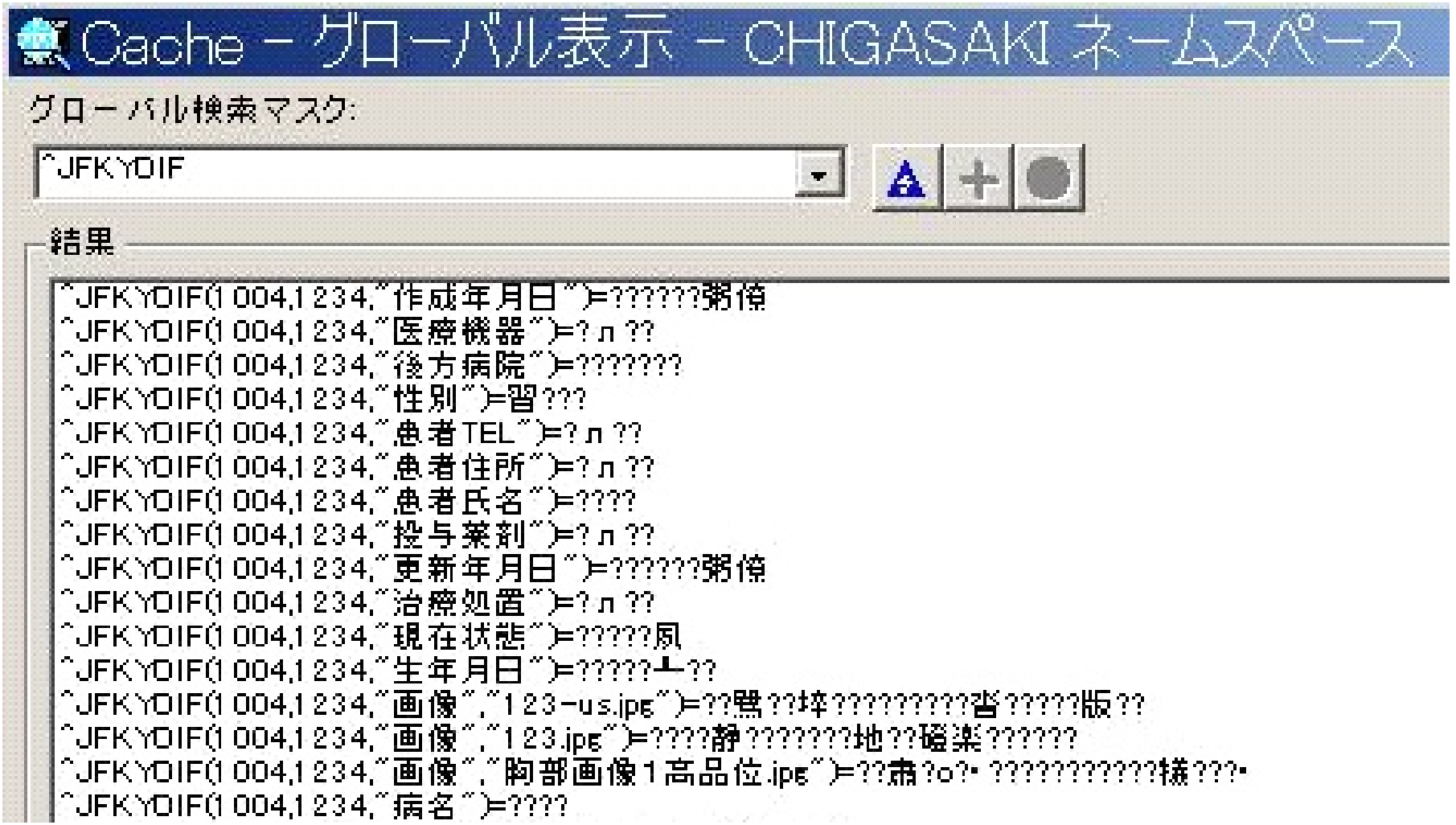

Figure 3- The database encrypted in real time

Results (3/3)

4. **Coexistence of applications among facilities**
   Coding schemes, examination methods and reference intervals, screen designs, and development environments often vary from facility to facility or from region to region. We are providing health data to the patients' media systems along with the programs and the execution environment. On the patients’ media systems, we create folders for each facility, put their data, programs, tables and execution environment in them, and use each folder for one object. By using this method, even the systems developed by other manufacturers or vendors will be able to co-exist in a single patient’s' media system.

Discussion

The interoperations are considered to be the key element, and the standardization of communication protocols and coding schemes is in progress. Moreover, it is not easy to integrate information systems that have been developed and operated by each facility and organization. But, especially with the rapid increase of medical accidents and expenses, EHR is in such a high demand as measures against them that there is no time to wait for standardizations.We are aiming to create interoperations by implementing applications as objects although this is still on a regional basis. The sustainability of the systems is not proportional to the amount of money invested. Sustainable systems are the ones that have gradually been developed and have had functions added to them based on the needs and practical uses in the region. The foundation to support the sustainability of EHR systems can be seen in the prerequisite of the systems. It is believed that the interoperation of the EHR systems will lead to medical safety and the reduction of medical costs through the reduction of duplicate checkups, the prevention of dangerous drug interactions, support for doctors' treatment policies, effective healthcare guidance, and self health care. Having experienced further challenges in Koriyama, we are planning to assess these outcomes quantitatively and clarify the overall effects including extension of healthy lifetime.

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Evaluating Designs Against Users' Requirements in Latin America: An Experience of Human-Centred Methods, Techniques and Tools on a Low Budget

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[a] *Department of Medical Informatics, Hospital Italiano de Buenos Aires, Argentina*

Abstract and objective

Informatics designs centered on the human being are multidisciplinary activities which demand a knowledge of the human factors related to human-computer interaction, the ergonomics of the work and of different evaluation techniques. The Medical Informatics Department of the Italian Hospital of Buenos Aires has gradually implemented a full-scale HIS since 199 and is also responsible for periodically evaluating user interfaces. Using qualitative techniques, diverse problems in the problem management interfaces were found and led to multiple modifications in this section of the HER. Using The Questionnaire for User Interaction Satisfaction we evaluate the new interface. The results show that the doctors found the new Problem Administrator easy to use, and there was high overall user satisfaction.

Keywords:

user-computer interface; consumer satisfaction; questionnaires; medical records systems

Introduction

ISO 13407, the standard for human-centred design (HCD) processes for interactive systems, describes human-centred development as "An approach to interactive system development that focuses specifically on making systems usable. It is a multi-disciplinary activity, which incorporates human factors and ergonomics knowledge and techniques. Applying ergonomics to the design of systems involves taking account of human capabilities, skills, limitations and needs."[1]

The Italian Hospital of Buenos Aires is a tertiary care, teaching and research hospital with a 150 year-old history. Since 1998 a full-scale HIS has gradually been implemented. This includes an ambulatory Electronic Health Record (EHR), is a problem-oriented record, Web based, that generalist physicians use in their routine practice to take care of patients[2].

Since 2002, the hospital has had physicians in a residency program in medical informatics. During our daily work, we perceive problems with the utilization of the EHR. Then we make proposals for the improvement of the problem management system. We began with this part of the system because all interaction with the EHR implies the creation of a new problem or the modification of an existing one.

Background

One of the purposes of the HCD process is to establish and maintain a focus on stakeholder and user issues in each part of the organization which deals with system markets, concepts, development and support. To achieve this first stage we conducted a previous study using qualitative techniques based on ethnography[3]. This evaluation allowed us to clarify how information is communicated and used, as well as to identify the causes and consequences of inadequate information flows and to meet users' needs, their tasks, expectations and problems with the information resource.

In the second place we set up a multi-disciplinary team (medical informatics, nurses, sociologist) and developed a plan specifying how to solve the problems seen and to improve the overall system development process[4]. We are now at stage known as "Evaluate designs against requirements". The purpose of this process is to collect feedback from end users on the developing design.

This study was undertaken to measure user interaction satisfaction with the redesigned EHR in routine clinical practice in order to begin to understand which aspects of the system meet the users' requirements and which do not.

Materials and methods

To accomplish the HCD, we focus on Usability testing, in particular on one method; the Questionnaire for User Interaction Satisfaction (QUIS). In addition to the use of the QUIS, one investigator observed and listened to the clinicians during the evaluation of the interface, to answer questions, to document user comments made during data entry and to observe any difficulties met. Five general practitioners participated in the first study[3].

Setting

This study was carried out in a clinician's office. We used mock patient data to ensure that all items of the problem list administration module were included.

Instrument

Version 7.0 of the paper format of the QUIS was used for the study. The QUIS uses Likert scales and a hierarchical approach in which overall usability is divided into 12 sections of 4 to 6 questions each. We used sections from 1 to 8 because sections 9 to 12 were not applicable to the interface[5].

Data analysis

Data from the returned questionnaires were double entered on an Excel spreadsheet. SPSS 11.00 was used for quantitative data analysis.

Results

A total of five general practitioners agree to participate, one woman and four men, ranging in age from 30 to 44, with a mean age of 38.8. Users spend at least 10 hours per day with the EHR for more than 3 years. All were familiar with computer hardware, word processor, database software, e-mail and the Internet. Table 1 shows the mean user response to each section of the QUIS.

Table 1 - Mean user response for each section

Object	Mean	St. Dev.
Overall user reactions	7.5	0.7
Screen Design and layout	7.5	0.8
Terminology and System information	7.6	0.6
Learning	7.2	1.4
System capabilities	7.1	0.8
Online Help	8.2	0.5

Discussion

In this evaluation study, the problem list administration module scored high in all areas. The score for overall user reactions is consistent with the score of the rest of the sections.

The highest score was in "Screen design and layout" and in "Terminology" and the lowest in the areas of "Learning" and "System capabilities". These findings were not too surprising because most of the clinicians' requirements in the first study were met by a terminology server after they had made some suggestions on user interface, that were taken into account when rebuilding the problem list administration module. In addition, based on extensive user feedback, screen designs and quality of terminology had improved significantly.

Interface satisfaction studies have been conducted successfully because we meet users needs on the EHR redesign.

Conclusion

People and organizations used to think that usability testing is very costly and complex and that it should be reserved for the big project with a huge budget and a lavish time schedule. Not true. The best results come from testing no more than five users and running as many small tests as you can afford. This study allowed us to evaluate redesign in the context of users' requirements and to empower users and motivate them.

Future directions

To undertake evaluation studies on the effect or impact of information resources on users, to find out whether these changes increase productivity, enhance the quality of work, and improve health and safety.

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Evaluating designs against users' requirements in Latin America: an experience of human-centered methods, techniques and tools on a low budget

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HOSPITAL ITALIANO de Buenos Aires

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Introduction

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Introduction (cont.)

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- To achieve this first stage we conducted a previous study using qualitative techniques based on ethnography.
- This evaluation allowed us to clarify how information is communicated and used, as well as to identify the causes and consequences of inadequate information flows and to meet users' needs, their tasks, expectations and problems with the information resource.
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- This study was undertaken to measure user interaction satisfaction with the redesigned EHR in routine clinical practice in order to begin to understand which aspects of the system meet the users' requirements and which do not.

Materials and Methods

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- Five general practitioners agreed to participate, one female and four males, ranging in age from 30 to 44, with a mean age of 38.8.
- Users spend at least 10 hours per day with the EHR for more than 3 years.
- All were familiar with computer hardware, word processor, database software, e-mail and the Internet.

Results (cont.)

Object	Mean	St. Dev.
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Mean user response to each section of the QUIS.

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An Innovative Approach to Large Scale Community Health Program Monitoring and Evaluation through the Internet: PROMS and PMDES

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Abstract

Although internet technology and management information systems are frequently used in health promotion activities and health assessment in individual worksite, school, or clinic settings, their use in community settings for program monitoring and evaluation is much less common. The purpose of this paper is to examine the process and technology used in two internet-based applications (PROMS and PMDES) intended for monitoring, data collection, and evaluation of a large scale health promotion programs in New York State. Using the fundamental concepts of program evaluation, we developed a comprehensive Web-based application that used MS Windows Server, MS SQL Server, .NET framework, and Crystal Reports. The end product enables users across New York State to collect and report standardized data, retrieve information, and generate a variety of reports. Program managers in the state capital Albany can monitor individual projects' progress on a regular basis and generate statewide or project specific reports. This initiative has already proven to be user friendly, cost effective, fast, and accurate.

Keywords:

program evaluation, health promotion, internet

Introduction

According to the Centers for Disease Control, program evaluation involves useful, ethical, feasible, and accurate procedures that help improve and account for public health actions [1]. Furthermore, through successful evaluation procedures, health program managers can make decisions on: the best use of time and resources, determining if the program is achieving its stated goals, demonstrating the effectiveness of a program to funders and other stakeholder groups [2]. In the last few decades, program evaluation has gained prominent position as a key component of public health research. Social programs have become increasingly complex with multiple intervention sites, multiple intervention levels, and multiple audiences [2, 3]. In response, program evaluation theory, intervention designs, and methods have improved to reflect these changes. Government Performance and Results Act (GPRA) has also contributed to the proliferation of community health program evaluation efforts with its requirement that agencies set performance targets and track their progress against these benchmarks. It is, however, surprising that despite all the importance that computer and internet technology play in the 21st century, examples of internet based data collection tools and monitoring systems are only occasionally mentioned in the evaluation of community health programs [4].

At its best, the use of technology by large scale community health programs for data collection consists of electronic compilation of data on individual PCs, either in a template in Excel, Access, or in another data base program. Each project site then transfers their data to a central administration office through e-mail.

This process is not only inefficient and time consuming, but also generates less than reliable and consistent data. Individual projects that submit the data ordinarily do not have access to the data submitted by other projects or have the ability to retrieve and edit their own data. Any modifications or updates to the system would require dissemination of new software and training.

In contract with the New York State Department of Health, we developed two internet-based applications (PROMS and PMDES) that streamlined program monitoring, data collection, and report generation activities in sites across New York State.

STEPS to a Healthier New York Program

Steps to a Healthier US is an initiative from the U.S. Department of Health and Human Services (HHS) to implement chronic disease prevention efforts with the goal of helping Americans live longer, better, and healthier lives. Through this 5-year program, states, cities, and native tribes receive funds to implement chronic disease prevention efforts. The focus areas are diabetes, overweight, obesity, and asthma and address three related risk factors—physical inactivity, poor nutrition, and tobacco use [5]. In New York State 13 projects in four counties received funding. Program administrators are required by the U.S. Federal Government to monitor, evaluate, and report on the progress of projects.

NYS Healthy Heart Program

In 2004, New York State Department of Health released "Cardiovascular Health in New York State: A Plan for 2004 — 2010." "This plan has 19 objectives to promote healthier behaviors, further enhance the quality of care and reduce known disease risks. It promotes interventions in four sectors: communities, schools, worksites, and health care settings. Funds are provided to local communities to conduct physical activity and nutrition interventions in schools, worksites and the community, and to ensure people receive appropriate health care for risk factors for cardiovascular disease" [6]. Currently, 27 sites in four counties administer projects. Program administrators are required by New York State to monitor, evaluate, and report on the progress of projects.

Methods

The need for a new system of data collection for evaluation purposes for both projects was clear. The existing paper and a flat, Access data base driven systems and reporting tools were not efficient, effective, or useful. Project managers were frustrated with the rigidity of the system and the lengthy narratives they had to provide; the administrators at the central office were unhappy about the quality of the data. They were spending inordinate amounts of time integrating data from many sites into a single data base and then extracting data for their reports. Satisfied that an internet-based system could fill an important void, the state level administrators provided the funding to the team at Binghamton University to develop the new system.

The technical team consisted of two software engineers and one system administrator. The project lead was a faculty member in the Decker School of Nursing.

To ensure that the monitoring and data collection system could capture the breadth and depth of local intervention projects, all stakeholders provided feedback on content through program managers at the central office. Hardware and software decisions were made on the basis of recommendations from the computing services of Binghamton University and the expertise of the technical team, resulting in SQL server running on Microsoft Windows Server.

For both systems, the initial prototype went through a number of transformations over a two year period. As the program managers and local project managers realized the possibilities with the systems, many components and additional functionalities were added.

System specifications

The system consists of server and client sides. The first layer of the server side is the operating system. We used Microsoft Windows Server. We deployed a back-up Windows Server that has all functionalities of the main server. In case the server ever goes down, the back-up would immediately take the role of the main server. The second layer is the data base. For the data base we used Microsoft SQL Server and designed a relational data base which contains many tables and view. For example, the PMDES consists of 63 tables, 24 views and over 200 fields. The use of SQL Server provided us additional features such as an easy back-up process, replication, and export of data into other applications such as PDF, Access and Excel.

The third layer of the server side is the application layer. This layer consists of .net framework and Crystal Reports. The .net framework includes web forms, xml, ADO.NET, and ASP.NET. ASP.Net provides the commands to show various text, labels, pictures, checkboxes, radio buttons, tables, and graphics in web forms. Behind all these components, we used C Sharp (C #) to connect all applications and to maintain system functionality.

For the report functions of the system, we used C Sharp and xml to extract data. The data was then passed to Crystal Reports for the end user reports. Finally, the clients access the system through the internet. A graphic representation of the technical specifications of the system is in Figure 1.

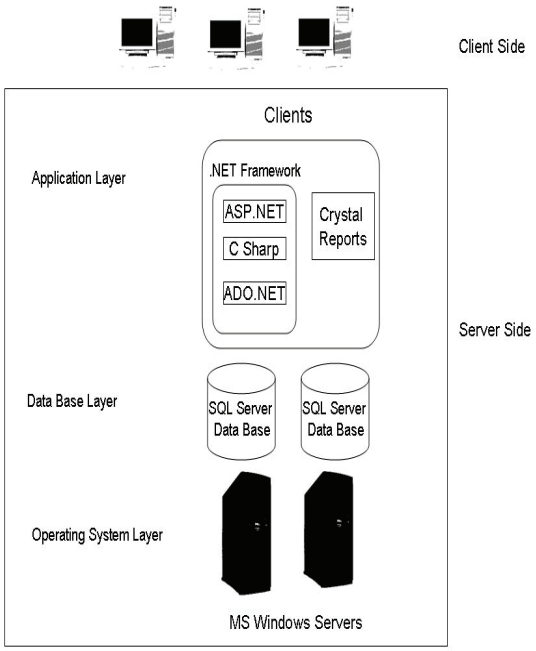

Figure 1 – Technical specifications of the system

Results

User interface

Prior to the full launch of the system, a manual was prepared and on-site training sessions were conducted with clients. The manual was also included on the web page.

Users log-on to the secure web site with their pre-assigned user id's and passwords. All screens following the log-on process are customized for the specific user and project. Since there are different types of roles among the clients, the system is able to recognize the user and his/her role and provide the functions that are appropriate for the specific user.

The decision tree for the user interface is in Figure 2. The users can insert new data into the system or update previously entered data. Alternatively, they can view previously entered data or generate reports for their particular projects.

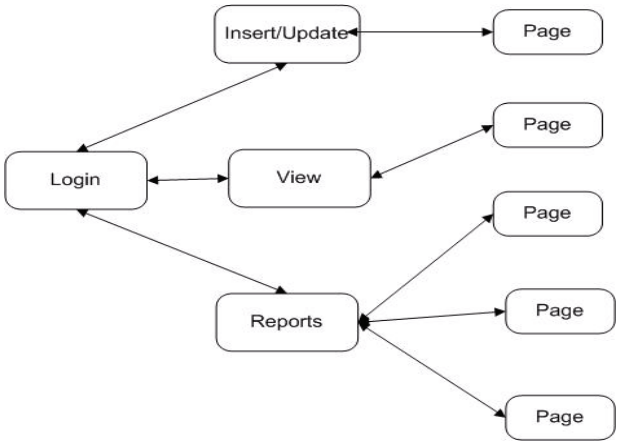

Figure 2 – User interface decision tree

An example of one of the initial screens for PMDES is presented in Figure 3.

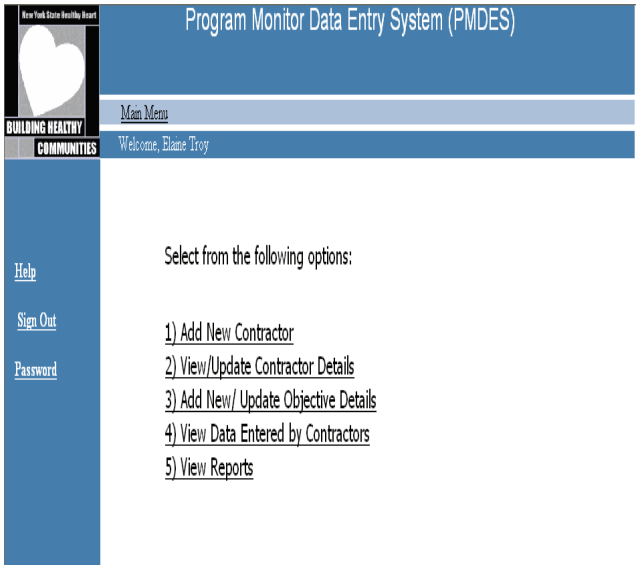

Figure 3 – An initial screen from PMDES

The complexity of the interventions is evident in the number of web forms created for the users. PMDES has over 100 web forms and PROMS has 175 web forms. The following figure (Figure 4) is as sample screen shot from PMDES.

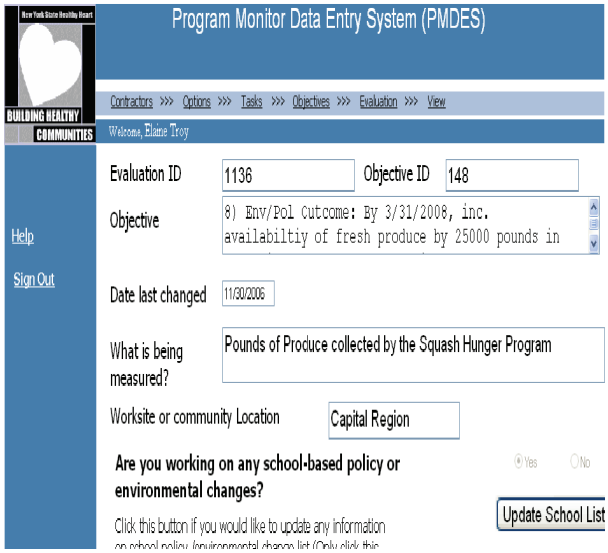

Figure 4 – A sample screen from PMDES

Reports

We used Crystal Reports for the report functionality of the system. PMDES has 20 and PROMS has 30 reports. Different access privileges to the system allow different types and number of reports for various client groups. For example, program managers in STEPS using PROMS can generate statewide or individual project reports, while the

project managers in counties can only generate reports for their own projects. In some reports, data from other counties is presented in an aggregate for comparison purposes. Despite the ease of use for the clients, report generation is a complicated procedure that involves extracting data from the SQL Server feeding it into xml and then into Crystal Reports. The following figure is a graphic representation of this process.

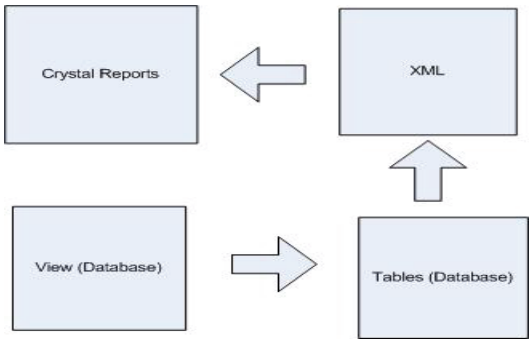

Figure 5 – Report Generation Process

Crystal Reports provides both text and graphics based reports that are presented with a user friendly interface. Through the web interface, clients can select from a variety of parameters to generate highly customized reports. We again use C Sharp in the background for all essential processes. Any report can be printed or exported into a number of file formats including PFD or Word. Figure 6 is an example of a report generated by the PMDES system.

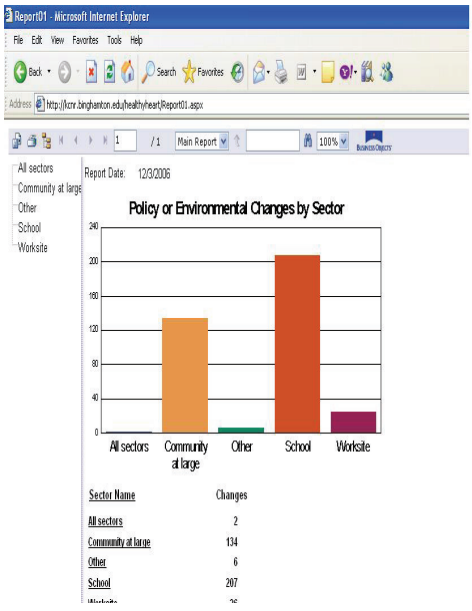

Figure 6 – An example of a report

Conclusion

The applications we developed enable users across New York State to collect and report standardized data, retrieve information, and generate a variety of reports. Program managers in the state capital Albany can monitor individual projects' progress on a regular basis and generate statewide or project specific reports. This initiative has already proven to be user friendly, cost effective, fast, and accurate and met the key requirements of program and project managers with minimum technical assistance. Regardless of the location of individual projects, with internet access, PROMS and PMDES are designed to handle many more clients and potentially go national.

Large scale community health programs that have multiple sites may wish to consider collaborating with nearby academic institutions that can offer the required technical expertise, hardware, and application development.

Some of the lessons we learned through the development of the systems are listed below:

- No system is able to meet all data collection, program monitoring and evaluation requirements for complex community health programs.
- It is not easy to find employees who have the technical expertise to develop a quality system.
- Modifications and additions to the system after initial development should be avoided. Written agreements with funders specifying each field, web form, and reports are highly recommended.
- It is a mistake to assume that anybody can operate a computer and access the internet. We realized during our training sessions that a number of our clients required additional technical support.

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PMDES: http://kcnr.binghamton.edu/healthyheart/
PROMS: http://kcnr.binghamton.edu/steps/

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An Innovative Approach to Large Scale Community Health Program Monitoring and Evaluation through the Internet: PROMS and PMDES

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Introduction

- In the last few decades, program evaluation has gained prominent position as a key component of public health research. Social programs have become increasingly complex with multiple intervention sites, multiple intervention levels, and multiple audiences
- In response, program evaluation theory, intervention designs, and methods have improved to reflect these changes.
- In contract with the New York State Department of Health, we developed two internet-based applications (PROMS and PMDES) that streamlined program monitoring, data collection, and report generation activities in sites across New York State.

Steps to a HealthierNY Program

- Steps to a HealthierUS is an initiative from the U.S. Department of Health and Human Services (HHS) to implement chronic disease prevention efforts with the goal of helping Americans live longer, better, and healthier lives.
- Through this 5-year program, states, cities, and native tribes receive funds to implement chronic disease prevention efforts.
- The focus areas are diabetes, overweight, obesity, and asthma and address three related risk factors—physical inactivity, poor nutrition, and tobacco use.
- In New York State four counties received funding. Program administrators are required by the U.S. Federal Government to monitor, evaluate, and report on the progress of projects.

NYS Healthy Heart Program

- NYS Healthy Heart Program has 19 objectives to promote healthier behaviors, further enhance the quality of care and reduce known disease risks. It promotes interventions in four sectors: communities, schools, worksites, and health care settings.
- Funds are provided to local communities to conduct physical activity and nutrition interventions in schools, worksites and the community, and to ensure people receive appropriate health care for risk factors for cardiovascular disease. Currently, 26 sites in 55 counties administer projects.
- Program administrators are required by New York State to monitor, evaluate, and report on the progress of projects.

Methods

- To ensure that the monitoring and data collection system could capture the breadth and depth of local intervention projects, all stakeholders provided feedback on content through program managers at the central office.
- Hardware and software decisions were made on the basis of recommendations from the computing services of Binghamton University and the expertise of the technical team, resulting in SQL server running on Microsoft Windows Server.
- For both systems, the initial prototype went through a number of transformations over a two year period. As the program managers and local project managers realized the possibilities with the systems, many components and additional functionalities were added.

System Specifications

- The system consists of server and client sides.
- The first layer of the server side is the operating system. We used Microsoft Windows Server. We deployed a back-up Windows Server that has all functionalities of the main server. In case the server ever goes down, the back-up would immediately take the role of the main server.
- The second layer is the data base. For the data base we used Microsoft SQL Server and designed a relational data base which contains many tables and view. For example, the PMDES consists of 63 tables, 24 views and over 200 fields. The use of SQL Server provided us additional features such as an easy back-up process, replication, and export of data into other applications such as PDF, Access and Excel.

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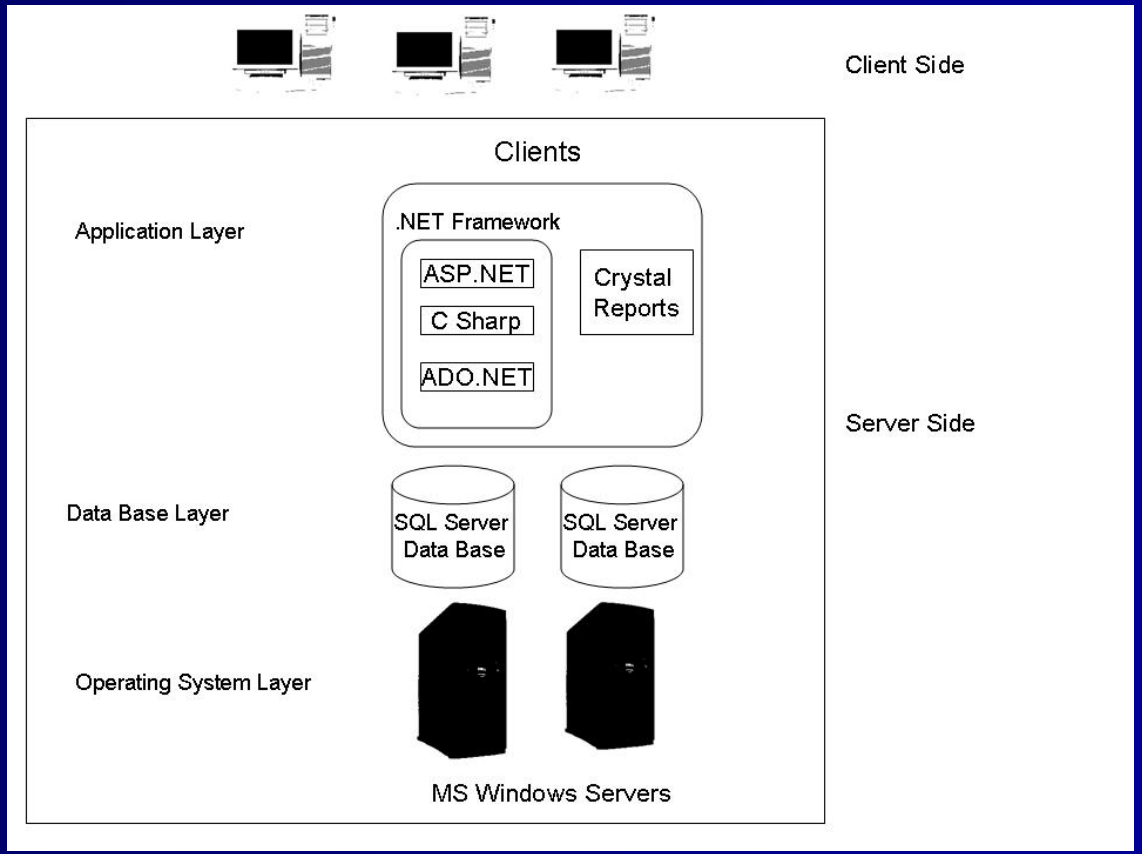
Technical Specifications of the System



User Interface

- Users log-on to the secure web site with their pre-assigned user id's and passwords. All screens following the log-on process are customized for the specific user and project. Since there are different types of roles among the clients, the system is able to recognize the user and his/her role and provide the functions that are appropriate for the specific user.
- Users can insert new data into the system or update previously entered data. Alternatively, they can view previously entered data or generate reports for their particular projects.
- The complexity of the interventions is evident in the number of web forms created for the users. PMDES has over 100 web forms and PROMS has 175 web forms.

Conclusions

- The applications we developed enable users across New York State to collect and report standardized data, retrieve information, and generate a variety of reports.
- Program managers in the state capital Albany can monitor individual projects' progress on a regular basis and generate statewide or project specific reports.
- This initiative has already proven to be user friendly, cost effective, fast, and accurate and met the key requirements of program and project managers with minimum technical assistance.
- Regardless of the location of individual projects, with internet access, PROMS and PMDES are designed to handle many more clients and potentially go national.

Lessons Learned

- No system is able to meet all data collection, program monitoring and evaluation requirements for complex community health programs.
- It is not easy to find employees who have the technical expertise to develop a quality system.
- Modifications and additions to the system after initial development should be avoided. Written agreements with funders specifiying each field, web form, and reports are highly recommended.
- It is a mistake to assume that anybody can operate a computer and access the internet. We realized during our training sessions that a number of our clients required additional technical support.

Acknowledgements and Correspondence Information

- **Acknowledgements:**
  - PROMS is funded by Steps to a HealthierNY through the U.S. Department of Health and Human Services as part of Steps to a HealthierUS.
  - PMDES is funded by New York State Department of Health Healthy Heart Program through the U.S. Department of Health and Human Services.

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A Knowledge Portal for the Illawarra Community Mental Health Rehabilitation Services Community of Practice

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1.Introduction

"Every person with mental health problems and their carers should have access to services that promote hope, help find meaning in life and support the individual in taking responsibility for their own recovery, enabling a collaborative working towards their goals, for the best possible quality of life" [1].

Rehabilitation is the component of the mental health service that focuses on these areas of a person's life[1] .

To guide service development and recovery, five goals have been identified in the Illawarra Mental Health Rehabilitation Services Strategic Plan. These are:

1. Provide recovery focused rehabilitation services and promote a recovery orientation throughout the mental health service;
2. Deliver best practice quality rehabilitation services
3. Ensure rehabilitation services are accessible and coordinated across the Area Health Service
4. Develop and maintain effective partnerships with key service providers and community organizations
5. Ensure rehabilitation services are effective and achieving positive outcome

This paper describes a new and ongoing research project in collaboration with the Illawarra Area Community Mental Health Rehabilitation Services, referred to in this paper as the Mental Health Rehabilitation Services (MHRS), based at Fern Hill in Wollongong NSW[1]. The aim of the project is o develop a knowledge portal and service oriented architecture for community mental health rehabilitation services. It is hoped that once the portal becomes operational, it will enable all members involved in mental health rehabilitation – clients, professionals, carers, advocates, educators, etc. to evolve into a more effective community of practice by providing a collaborative infrastructure for knowledge sharing. It is anticipated that the portal will enhance cross-domain integration and strengthen and support multidisciplinary teamwork in relation to mental health issues. The project is funded by the Faculty of Commerce Social Innovation Networks Program at the University of Wollongong.

2.Communities of Practice

A Community of Practice (CoP) is a voluntary network of people who share information, build on existing knowledge, develop expertise and solve problems for a common purpose, driven by the interest of the community involved. The CoP portal for MHRS is intended for clients and carers, as well as health care professionals involved in the delivery of rehabilitation services, so that they can share their knowledge and expertise to help close evidence practice gaps and improve services. The benefits of Communities of Practice have been researched by Fontaine and Millen [2] and are sumarized in Table 1 below.

Type of Benefit	Impact of Community *It has improved or increased the following*	% Agree
Individual Benefits *What does participating in the community do for individuals?*	Skills and Know How	65%
	Personal Productivity	58%
	Job Satisfaction	52%
	Personal Reputation	50%
	Sense of Belonging	46%
Community Benefits *How does collective participation benefit others?*	Knowledge Sharing, Expertise and Resources	81%
	Collaboration	73%
	Consensus and Problem Solving	57%
	Community Reputation and Legitimacy	56%
	Trust Between Members	50%
Organization Benefits *How does participating in a community increase organizational efficiency, better serve customers and partners, and provide insights for the future of the firm?*	Operational Efficiency	57%
	Cost Savings	51%
	Level of Service or Sales	46%
	Speed of Service or Product	42%
	Employee Retention	24%

Table 1 - Individual, Community and Organizational benefits of CoPs [2].

The concept of a community of practice comes from the work of Wenger and Snyder [3] who define it as "a group of people informally bound together by shared expertise and passion for a joint enterprise," or similarly, as a collection of individuals bound by informal relationships that share similar work roles and a common context. Examples

of communities of practice are found in many organizations and have been called by different names at various times, such as "learning communities" "family groups" , "thematic groups" , and "knowledge networks", but they remain similar in general intent [3].

2.1The evolution model of CoPs

According to Gongla and Rizzuto [3], the creation of a Community of Practice can be summarized in five distinct stages, according to an evolution model, as illustrated in Figure 1 below.

Table 1 Community evolution model definition

	Potential	Building	Engaged	Active	Adaptive
Definition	A community is forming.	The community defines itself and formalizes its operating principles.	The community executes and improves its processes.	The community understands and demonstrates benefits from knowledge management and the collective work of the community.	The community and its supporting organization(s) are using knowledge for competitive advantage.

Figure 1 - The CoP Evolution Model

These are the characteristics that distinguish COPs at each stage of their development. The Evolution model recognizes formative and growth stages of development but unlike Wenger's model, it is not a lifecycle model. Communities may stay at certain stages and not evolve to another level; communities may move "backward and forward" between the stages; communities may have some characteristics of one stage while they are still primarily at another stage; communities may "rest" for extended periods at one stage and suddenly evolve quickly to another stage. At each stage CoPs have defining characteristics and functions [3], as shown in Figure 2 below.

Table 2 Fundamental functions for the stages of evolution

	Potential Stage	Building Stage	Engaged Stage	Active Stage	Adaptive Stage
Fundamental Functions	Connection	Memory and context creation	Access and learning	Collaboration	Innovation and generation

Figure 2. Functions of each stage of the evolution model

2.2 The Influence of people process and technology on COP evolution

According to Fontaine and Millen[2], there are four types of resources required to enable effective CoPs. These are *People* – to fill certain community roles and manage the community's activities; *Activities*- to bring the community together in meetings and events; *Technology* – to facilitate the flow of knowledge and information between activities; and *Content* – to manage and share the explicit knowledge that the community creates. The next section will focus on the generic technology – the service-oriented knowledge portal.

3.Service Oriented knowledge portals

This research is proposing that the mental health rehabilitation service delivery be implemented as an ecology of e-business services providing services for all members of the MHRS community and enabling collaboration with global partners as well. What is presently manual (with desktop support) will become Internet based as a service. The services will be implemented as web services.

3.1Service Oriented Architectures

A Service Oriented Architecture views every application or resource as a service implementing a specific, identifiable set of (business) functions that are identified during business process analysis. The services may be fine- or coarse-grained depending upon the business processes. Services are defined by interfaces that allow them to be published, discovered and invoked. An enterprise can choose to publish its services externally to business partners or internally within the organization. A service can also be composed from other services. Services communicate with each other by exchanging structured information—messages or documents (sometimes called business objects). A Service Oriented Architecture views every application or resource as a service implementing a specific, identifiable set of (business) functions. Thus Service Oriented Architectures are a convenient way to achieve application integration by allowing new and existing applications to be quickly combined into new contexts. Existing applications are "adapted" to service declarations. The interaction of services can be direct, or can be mediated through an intelligent infrastructure, called an Enterprise Service Bus (ESB)[4].

3.2Web Services Architecture

A web services architecture (WSA) is a service oriented architecture that has implemented its services as Web Services, as is the case with the proposed research. The advantage of the web service oriented architecture is that it is based on global internet standards and protocols for all business application. This makes the application truly integrated across organizations. Web Services utilize the WS – I standard services.

3.3 Portals

Portals are commonly used to provide people with access to information and applications in a condensed form. Typically, portals display personalized information from various sources in a single page, thus allowing the user to efficiently access this information instead of visiting vari-

ous Web sites one after the other [5]. Depending on customizable user settings, various portlets usually rectangular areas that display information are included in the web page. Portals and portal development tools allow for integration of web services as data sources. An example of this integration can be illustrated by a news feed scenario. A news portlet that allows the user to configure the news categories to track and then gets the news for these categories live from a Web service whenever it is displayed. In this case, the portlet code runs locally on the portal and uses the Web service to access information. The rendering of the content is done by the portlet itself (see Figure 4 below)[5].

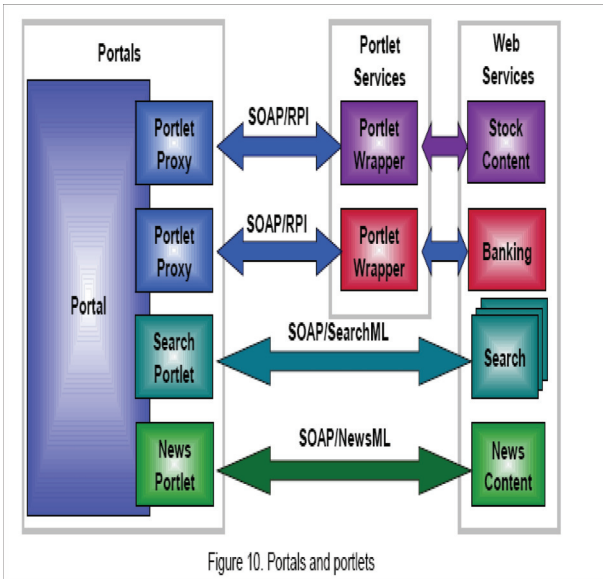

Figure 10. Portals and portlets

A portal should support the following desirable functions and features:

- Allowing different information- and service-providing departments to set up and update their own information and services tailored specifically for different user groups according to the common user profiles (such as grades, departments associated, etc.) and the specific needs of these user groups at specific times.
- Presenting automatically the information and services that a user would need according to his profile at the appropriate time.
- Allowing a user to select the information and services that are his interests and to customize their presentation.
- Setting up information and services from users' perspective rather than from the angle of convenience of the services providers.
- Supporting the "Single-sign-on" feature so that a single sign-on step would enable the user to gain access to the different information resource and services that are supported by different application systems provided by different departments and/or communities.

The Service Oriented Portal Architecture proposed for MHRS is illustrated below in Figure 4.

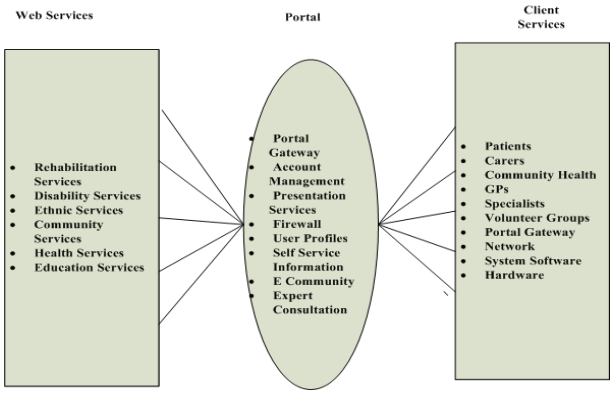

Figure 4 - MHRS Service Oriented Portal Architecture

4.The MHRS project progress

The MHRS project is in its initial stages of evolution – the *Potential* Stage. Several initial concept prototypes were developed last semester by students at the UoW in the Information Systems Project class. These prototypes were based on initial ideas by the author and staff members at Fern Hill rehabilitation centre. At the end of semester projects were presented to a larger audience at Fern Hill and permission was given to go ahead with the project.

Referring further to the evolutionary model, the enablers for moving forward are discussed below.

People: The project must now identify all stakeholders in the core community group, that is potential individual and group members

Activities: Location of potential community members.

Facilitate bringing members together. Establish roles of members of core group.

Perform stakeholder analysis and establish the requirements of the of individuals and groups in the CoP.

Technology: Technology at this stage will be electronic messaging, email, lists, teleconferencing, online forums and directories, and electronic document management.

Content: Information

5. Summary

This paper has described the initial stages of the MHRS project, which began in July 2006 and the proposed next 6 months of the project. The benefits to Mental Health Rehabilitation will be enormous from the carer, client, health

professional, and consultant perspective. It will provide an 'application aware development framework' for all mental health services. At present many basic point of care health services are implemented in individual applications and cooperation between different applications is difficult. By providing an infrastructure such as the service oriented portal architecture, a common standardized service can be provided. The portal architecture will also support the mapping of services to different clients based on their profiles delivered to their mobile devices. The model will also support location based service applications. The potential for location based community support is another component of this project and is described elsewhere [6].

Acknowledgements

[1] The author would like to thank the ongoing collaboration and support of the Fern Hill Rehabilitation centre staff, particularly Ms Kerry Searle and Ms Gaye Richardson.

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[2] Fontaine and Millen (2004). *Understanding the Benefits and Impacts of Communities of Practice.* IDEA Group Inc.

[3]Gongla, P. and Rizzuto, C. (2001). *Evolving Communities of Practice.* KM Review, 3(5).

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E-learning to Support Acquiring Nursing Practice Ability –CanGo Project

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Abstract

We were selected to work with "Development of e-Learning Program to help enhance human resource ability based on needs," which is a government supported program of fiscal year 2005 to address modern education needs (Modern GP). The program has therefore been underway since 2005. The objectives of the program are to use e-Learning to further improve education and teaching practices qualitatively for nursing education, to supply high-level nursing practice capabilities, and provide a new environment in which students can study independently in an efficient manner. The main targets to achieve the program goals are: i) to produce e-Learning training materials that include examples of nursing to use for the study of nursing practice and support students' acquisition of problem-solving abilities during nursing operations; and ii) to construct an environment to support ubiquitous on-demand studies in which students can study for themselves easily, at any time, and anywhere on campus or on the actual practice site using this e-Learning methodology. This paper presents a report of an actual lecture class conducted in 2006 using such training materials.

Keywords:

education of nursing, nursing practice ability, e-Learning, ubiquitous on-demand study, human resource improvement

Introduction

As medical treatment levels are becoming more advanced and patients' requirements become increasingly diverse, what is requested now by every organization that is taking part of nursing education is the need to better cultivate human resources to work in nursing positions so that they can gain proper proficiency in nursing practice, which means the ability to assess a patient's situation correctly, then understand and provide the most appropriate nursing care to that patient. To respond to that social need for human resources, we believe that it is necessary to improve the education and instruction of nursing more qualitatively, and to provide students with a new environment in which they can study efficiently.

Among all educational activities, the most effective way for students to acquire actual nursing capabilities is to have the learner join on-site practice training, which is a required part of the nursing education curriculum. Through on-site practice, students can learn comprehensively by communicating directly to patients or those who require nursing care. However, such practicing facilities are spread out in various locations. For that reason, the situation available on site is not necessarily as good a study environment as that available on campus. The campus might provide facilities such as libraries, Internet capability, and IT equipment. By making e-Learning available at every on-site practice location, we believe that we can not only improve the study environment situation, but also help to raise the quality level of the study itself.

Under these circumstances, the School of Nursing at the Osaka Prefecture University was selected to work with "Development of e-Learning Program to help enhance human resource ability based on needs," which is a government-supported program of fiscal year 2005 to address modern educational needs (Modern GP). The actual title is "e-Learning to help acquire nursing practice ability –Construction of a ubiquitous on-demand study supporting environment–." The program began activities last year as the "CanGo" project. "CanGo" stands for "Communication", "Art", "Nursing", "Good practice", "Osaka prefecture university".

This paper reports the actual classes taught in 2006 using materials that were developed specifically for this project based on project activities undertaken in 2005, and of the results obtained from on-site training support we gave to students.

CanGo project summary

The CanGo project objective is to fill the gaps that are readily noticeable from one study method to another, to improve the efficiency and usefulness of every study activity on-campus or off-campus, and to improve students' attitudes toward study more aggressively. This objective must be achieved so that students can acquire the ability to solve study-related problems that might often occur in lectures, or during practice sessions made on-campus or on-

site, all of which are conducted in the regular curriculum of nursing education.

To introduce an e-Learning program in education curricula of our school starting in 2008, we are making a three-year project plan (Figure 1) and establishing a new organization in our department (Figure 2) to accomplish that plan.

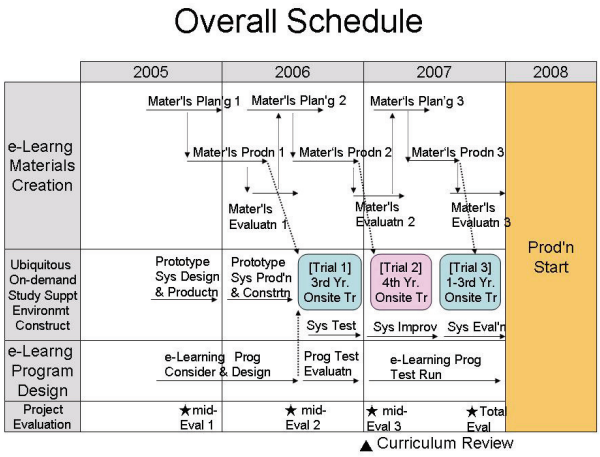

Figure 1 - Overall schedule of the CanGo project

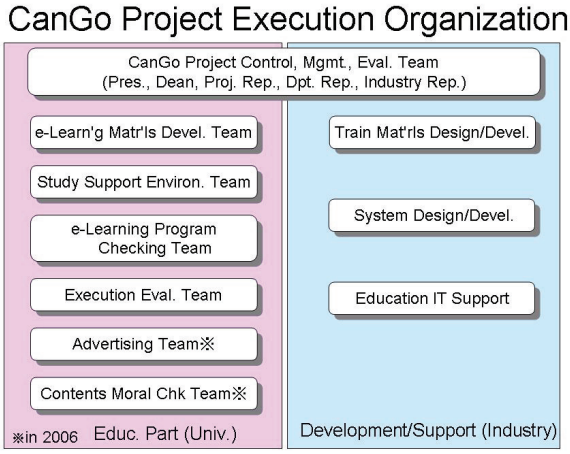

Figure 2 - CanGo project organization

The backbones of our activities are: i) to produce e-Learning materials for the study of nursing practice and examples for use by students to acquire problem-solving ability; and ii) to construct a ubiquitous on-demand study-supporting environment in which students can study independently through e-Learning at any time, anywhere, and without any difficulty whatsoever. Through these four-year studying opportunities on and off campus, we are hoping to help students acquire capabilities to solve all kinds of nursing problems efficiently and aggressively so that, eventually, we can produce in our society good human resources with full proficiency in advanced nursing practice capabilities.

Specifically, the following three unique environments are available to support students' study.

Utilizing USB memory that stores the recorded study history, anyone can easily download examples of nursing from the nursing training materials server machine. Each student is allowed to compile a digital nursing dictionary by downloading the necessary sub-training materials before the on-site practice starts. We believe that any student can study independently while compiling such a "personal digital nursing dictionary." During that study process, a learner would be able not only to review and summarize the contents of past study, but also to proceed with meta-recognition that would point to further study or related activities, and what knowledge and nursing technology must be acquired before the on-site practice starts. Finally, to support self-study, a bi-directional study support environment would be prepared in which a student can receive guidance from the instructor through e-mail that might be available using a cell phone or other media equipment.

Figure 3 depicts the overall structure of the CanGo project. Table 1 shows its targets and accomplishments of 2005.

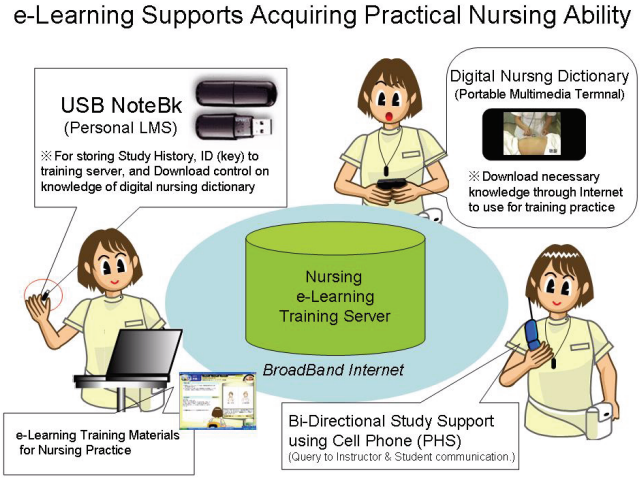

Figure 3 - Overall structure of CanGo project

Table 1- CanGo project targets and its accomplishments in 2005

[Targets] 1) Develop 100 examples of nursing by re-structuring the existing nursing examples documents, and construct a training-material database 2) Construct a ubiquitous on-demand study support environment that is openly available to students [Accomplishments of 2005] 1) Development of 57 examples in four specialized nursing areas, and a total of 641 references for the digital nursing dictionary 2) Supplying equipment for study support environment 22 portable multimedia terminals 14 laptop PCs to support lecture classes 1 wireless attachment for a projector

e-Learning Materials For Nursing Examples

We produced nursing training materials with examples for each specialized nursing area based on prototype training frames for e-Learning of nursing, developed by Majima et.al. [1]–[5] and Seta et. al.[6]–[7] to improve nursing students' problem-solving abilities.

Training frames (Figure 4) consist of two study modes. In study mode 1, a series of nursing processes can be studied through "Understanding patients' examples", "Problem studies on nursing", and "Evaluation of analyzed results". Study mode 2 is available for each example of a patient, in which the student can self-study, when necessary, through the contents of basic and required knowledge of specialized nursing practices, nursing techniques, and national-examination-related materials. Training materials were produced using multimedia techniques incorporating sound effects, animation, and illustrations. Contents that are organizing the training materials can be reorganized and reused for other digital sub-training materials, allowing the creation or addition of any new training materials without difficulty. Moreover, after downloading, they can be used to create a new digital nursing dictionary (Figure 5).

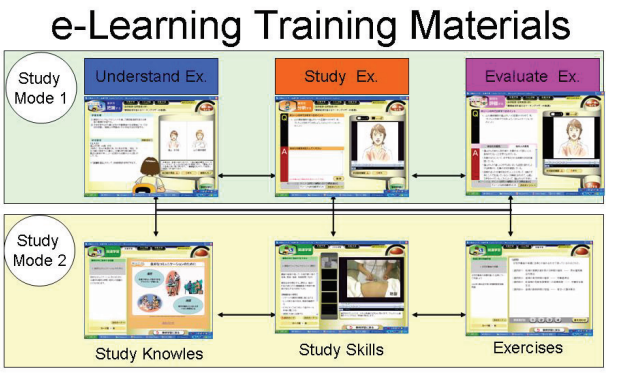

Figure 4 - Training frames on nursing examples

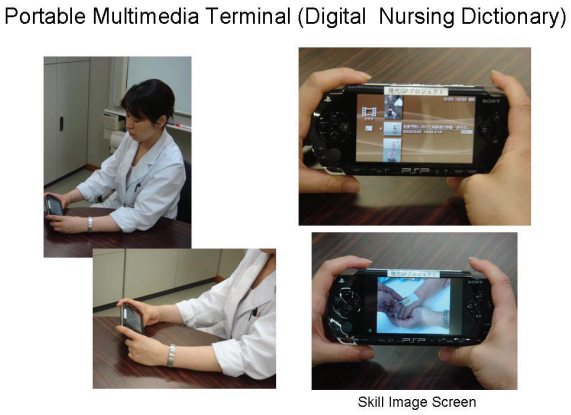

Figure 5 - Digital nursing dictionary

Results

Practice and example in nursing education

During the first half of 2006, we hosted a series of lectures using training materials developed in 2005, and used portable multimedia terminals for on-site practice. Following are the ideas and opinions given to us after that on how to improve practices, as well as other useful advice.

Lectures using training materials with nursing examples

Instructors who joined in the creation of training materials actually used them in their classes. We asked them to report about how they used the training materials in their classes in addition to the responses they received from their students. To have them conduct such training in their classes, the study-support environment development team of the project organization (Figure 2) supplied the training

materials, computers and assemblies, and other materials to instructors who requested them. The execution evaluation team helped create questionnaires for students and the reporting formats to be used by the instructors.

The actual lectures were intended mainly for third-year nursing department students (about 120–140) studying for work in five different nursing fields.

Following are some examples of how training materials were used: i) Starting with the introduction of the patient starring in the training materials of examples on nursing (giving self-introduction narration by the patient), the patient subsequently presented scenes in which nursing problems are described; then the students were separated into work groups and each was expected to make a nursing care plan, and to present it before others, which were finally evaluated by the instructor with appropriate comments provided. ii) Introduction of some nursing examples and scenes of nursing care problems were posed. iii) Providing the students with some nursing care problems beforehand to use them in later work to be done by every group. Therefore, different approaches seem to have been taken by each instructor. Figure 6 shows photographs of the classes conducted using each approach.

Figure 6 - Class photographs

Some opinions from the students are as follows: "It was easy to grasp the images of the examples," "It was easy to read the patient's emotions shown in the examples," "It was realistic, so it was easy to understand," "It was realistic and practical," "It was good from a visual perspective with the image pictures provided," "It was easy to know the necessary information," "It was good to hear the information given by voice," and "I was able to understand the priority of the nursing care problems." Additionally some students pointed out not only about how to collect information, but also about the methodology of how nursing-care assistants should recognize situations to move forward to create opportunities to educate patients.

The following are opinions and impressions elicited from instructors based on their reports.

(1) Impacts on using the training materials

i) It was recognized that understanding every nursing example by image is important to learn processes of nursing care (i.e. processes of solving nursing problems).

ii) Students seem to have a special interest in the contents of the images and the training materials given.

iii) The nursing example training materials were useful to communicate reality to the students even if they were something to be expected for use in learning beforehand.

(2) Information equipment operations by students

Students soon became accustomed to using the training materials in general: no chaos occurred.

(3) Information equipment operations by instructors

i) The fact that it takes time for PC manipulation causes students to wait for a long time, resulting in stopping the smooth lecture flow and losing students' concentration.

ii) That idle time, when it happened to be created during the equipment manipulation, seemed to cause the students to engage in private conversations.

(4) Class environment support

i) I appreciate all the equipment setup done by teachers of the study support environment team.

ii) Being supplied with PCs, CD-ROMs and such equipment was very helpful and appreciated. However, it must be very hard to do it alone, all by myself.

iii) All the instructors should become accustomed to using equipment before using the training materials.

(5) Others

i) I think not only the students, but also I, as an instructor, had a good time in the class.

ii) It takes time to prepare for printing materials and to set up PCs. Therefore, it would be nice if a group work could be done all through a computer network.

On-site practice support by portable multimedia terminals

We prepared portable multimedia terminals (PSP, Play Station Portable; Sony Corp.) loaded with training material contents prepared for the associated nursing practice areas, and lent them each to students who agreed to monitor them. Subsequently, we requested that they use them during the entire practice period. We requested them to give us opinions regarding the operability of the training mate-

rials and other information when they had to return the terminal. Following are some of the comments.

(1) Portable multimedia terminal

i) It was good to be able to find and view the necessary document without taking much time.

ii) Because it is basically a game machine, its operability is good.

iii) It was easy to use the training materials in this way.

iv) The images in the training materials are useful, as if we were playing a game.

v) It is easy to carry because it is small and light.

vi) The screen was easier to see than I thought.

vii) The battery power duration time is too short.

viii) It would be nice if there were a search function available everywhere in the training materials.

(2) Training materials' contents

i) They were helpful in the practice class. It would have been nice if they had been available before.

ii) What we wanted to see out of the training materials was restricted for our practice class.

iii) It was very convenient to be able to see technically related pictures close at hand. It was helpful to understand things using images.

iv) We can see it anytime anywhere. Therefore, it is helpful when we study at home after the nursing technique practice is over.

After having had the training materials and the contents we produced used in the actual classes, we found that the students' evaluations were good partially because it is something new to them. Nevertheless, their comments and opinions accurately reflected their experience, and helped us to determine the issues clearly and work continuously to correct and improve them in future versions of the system. Some instructors were not very happy with manipulation of information equipment, which underscores the importance of support them during use in actual classes. Through the process of having the training materials used in actual classes, we can continue to search for the most appropriate training materials. In so doing, we can review previous teaching methods and adapt and reconstruct them, if necessary. Additionally, using such training materials in actual classes, we can review the class proceedings and teaching methods the classes with the materials combined. Above all, the fact that the instructors felt that teaching a class was fun should create a positive impact on future educational activities resulting in leading to develop of our faculty.

Summary

This report described our introduction of e-Learning in the School of Nursing at the Osaka Prefecture University (as the CanGo project), and reported comments and opinions given when we had the nursing practice example materials and sub-material contents we produced during 2005 used for the actual classes of the first half of 2006. In addition, we reported those comments and opinions given from the experiences we had when supporting the actual on-site practices.

Future studies will further introduce e-Learning techniques based on the plan, along with regular and constructive review. We would be happy if the knowledge and experience we received were referenced and used anywhere else.

Acknowledgments

This project was conducted through the aid of the Modern Education Needs Supporting Program of the year 2005 offered from the Ministry of Education, Culture, Sports, Science and Technology.

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E-learning to Support Acquiring Nursing Practice Ability -CanGo Project-

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Background

- As medical treatment levels are becoming more advanced and patients' requirements become increasingly diverse, what is requested now by every organization that is taking part of nursing education is the need to better cultivate human resources to work in nursing positions.
- They can gain proper proficiency in nursing practice, which means the ability to assess a patient's situation correctly, then understand and provide the most appropriate nursing care to that patient.
- To respond to that social need for human resources, we believe that it is necessary to improve the education and instruction of nursing more qualitatively, and to provide students with a new environment [1] in which they can study efficiently.

CanGo Project Summary

- Our University was selected to work with “Development of e-Learning Program to help enhance human resource ability based on needs,” which is a government-supported program of fiscal year 2005 to address modern educational needs (Modern GP).
- The program began activities as the “CanGo” project. “CanGo” stands for “Communication”, “Art”, “Nursing”, “Good practice”, “Osaka prefecture university”.

Purpose of CanGo

- The CanGo project objective is to fill the gaps that are readily noticeable from one study method to another, to improve the efficiency and usefulness of every study activity on-campus or off-campus, and to improve students' attitudes toward study more aggressively.
- This objective must be achieved so that students can acquire the ability to solve study-related problems that might often occur in lectures, or during practice sessions made on-campus or on-site, all of which are conducted in the regular curriculum of nursing education.

Backbones of CanGo

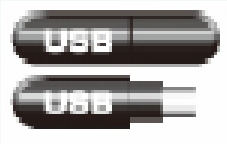
I. To produce e-Learning materials for the study of nursing practice and examples for use by students to acquire problem-solving ability.

II. To construct a ubiquitous on-demand study-supporting environment in which students can study independently through e-Learning at any time, anywhere, and without any difficulty whatsoever.

Overall structure of CanGo project

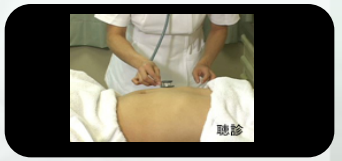
e-Learning Supports Acquiring Practical Nursing Ability

USB Notebook
(Personal LMS)

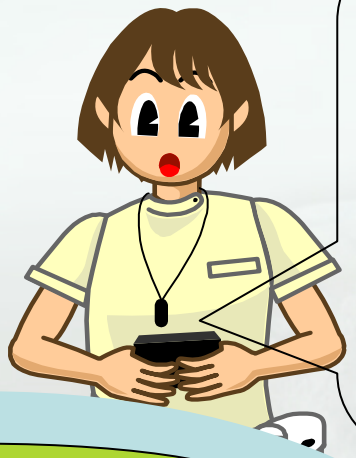


※For storing Study History, ID (key) to training server, and Download control on knowledge of digital nursing dictionary

Digital Nursing Dictionary
(Portable Multimedia Terminal)

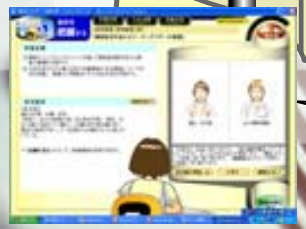


※Download necessary knowledge through Internet to use for training practice



Nursing
e-Learning
Training Server

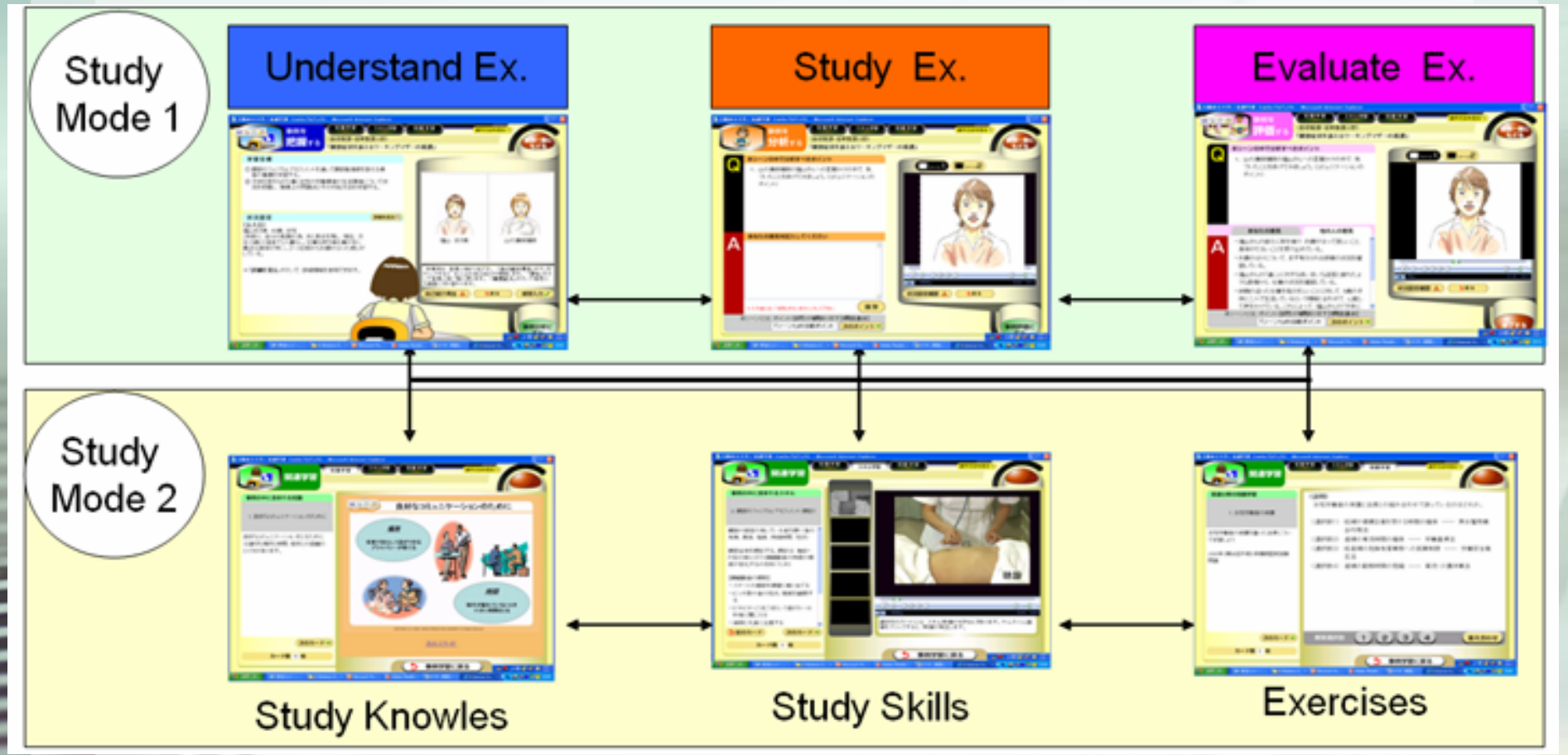
Broad Band Internet



e-Learning Training Materials
for Nursing Practice

Bi-Directional Study Support using Cell Phone (PHS)
(Query to Instructor & Student communication.)

e-Learning Training Materials



Nursing Practice Examples (Nursing Process) of "Basic Nursing Knowledge", "Basic Nursing Techniques" and "National Examinations" are studied through e-Learning.

Practice and Evaluation(2006)

- We hosted a series of lectures using these training materials, and used portable multimedia terminals for on-site practice.

Lectures using training materials

Portable Multimedia Terminal (Digital Nursing Dictionary)

Lectures using nursing examples materials

- Method:
  - Instructors who joined in the creation of training materials actually used them in their classes.
  - We asked them to report about how they used the training materials in their classes in addition to the responses they received from their students.
  - The actual lectures were intended mainly for third-year nursing department students (about 120–140) studying for work in five different nursing fields.
- Some opinions and comments from the students
  - It was easy to grasp the images of the examples.
  - It was easy to read the patient's emotions shown in the examples.
  - It was realistic, so it was easy to understand.
  - It was realistic and practical.
  - It was good from a visual perspective with the image pictures provided.
  - It was easy to know the necessary information.
  - It was good to hear the information given by voice.
  - I was able to understand the priority of the nursing care problems.
  - Some students pointed out not only about how to collect information, but also about the methodology of how nursing-care assistants should recognize situations to move forward to create opportunities to educate patients.

On-site practice support

- Methods:
  - We prepared portable multimedia terminals loaded with training material contents prepared for the associated nursing practice areas, and lent them each to students who agreed to monitor them.
  - Subsequently, we requested that they use them during the entire practice period.
  - We requested them to give us opinions regarding the operability of the training materials and other information when they had to return the terminal.
- Some opinions and comments from the students
  - It was good to be able to find and view the necessary document without taking much time.
  - Because it is basically a game machine, its operability is good.
  - It was easy to use the training materials in this way.
  - The images in the training materials are useful, as if we were playing a game.
  - It was easy to carry because it is small and light.
  - They were helpful in the practice class.
  - It would have been nice if they had been available before.
  - It was very convenient to be able to see technically related pictures close at hand.
  - It was helpful to understand things using images.

Conclusion

- We introduced our CanGo project, and reported students' comments and opinions given when we had the nursing practice example materials and sub-materials contents used for the actual classes.
- We reported those comments and opinions given from the experiences we had when supporting the actual on-site practices.
- Future studies will further introduce e-Learning techniques based on the plan, along with regular and constructive review.

References & Acknowledgments

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Translation, Implementation and Evaluation of a Medical Informatics Distance Learning Course for Latin America

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Abstract

There is a growing need and interest worldwide for healthcare professionals trained in medical informatics. Distance learning technologies are increasingly used to deliver such education, but mainly limited to the English language. We describe the implementation of a medical informatics course delivered in Spanish for a Latin American audience. The course was based on the 10x10 program of the American Medical Informatics Association and Oregon Health & Science University and translated and adapted to the Latin American setting. The course consisted of ten one-week units. A total of 152 individuals enrolled in the course, 93% of whom completed it. Most of the students were healthcare professionals and the largest proportion was from Argentina. Student satisfaction with all aspects of the course was high. The initial experience obtained in training healthcare professionals in medical informatics in Latin America in their own language demonstrated that it can be used across the region, and this could represent a model for disseminating knowledge of medical informatics across other languages and cultures.

Keywords:

medical informatics/education, distance learning/ methodology, teaching

Introduction

There is a growing need to train individuals in medical Informatics (MI), the field concerned with the capture, management and use of information in health and biomedicine [1, 2].

International programs using distance learning to deliver MI education have been developed in the United States, New Zealand and Europe. In Latin America, an international program has been developed in Brazil but is delivered by means of in-person training sessions and is not on-line. Latin America is a wide and diverse region, making the delivery of in-person training programs a difficult task. Distance learning programs provided by Internet tools, may be a possible strategy to deliver MI education.

In 2005, the American Medical Informatics Association (AMIA) and the Department of Medical Informatics & Clinical Epidemiology of Oregon Health & Science University (OHSU) launched the 10x10 Program [3].

In order to develop a training program in MI that was more locally focused and delivered in the Spanish language, the MI task force of the Hospital Italiano at Buenos Aires (HIBA) entered into an agreement with OHSU to translate and adapt the OHSU 10x10 course to the Latin American region. This paper reports the experience of adapting, translating, implementing, and evaluating our effort.

Materials and methods

The goal of the course was similar to the English version in giving participants the tools for the development of solutions to specific healthcare problems using informatics principles. Moreover, at the end of the course, the participants would develop the necessary skills to implement healthcare information projects in their own workplace.

The course adhered to roughly the same outline as the English version from OHSU, covering the following main topic areas: Overview of the discipline; Biomedical Informatics; Electronic Health Records; Decision Support and Health Care Quality; MI Standards: Privacy, Confidentiality and Security; Information Retrieval and Digital Libraries; Multimedia and Telemedicine; Organization and management issues in biomedical informatics; Biomedical Informatics Subspecialties; and Information Systems in Public Health.

The teaching modalities used for the course included lectures, threaded discussion boards, recommended readings, and self-assessment.

Two surveys were administered to determine the students` opinions regarding aspects of the course: one related to the format – voice-over-Power Point vs. reading material – and the other assessed their perceptions of other aspects of the course.

Results

The course was launched in March 2006 with 152 registered students. A total of 142 (93%) of them completed the course. The overwhelming majority of students were physicians (104/152).

Most students were from Argentina (128/152), although others came from a number of different Latin American countries and Spain.

The "lecture" portions of the classes were available in two different formats. The first provided reading material on the screen and for printing, while the second consisted of voice-over-Power Point presentations.

The students needed an Internet connection to enter the virtual campus to access the course. The content was designed so that even dial-up connection could be used. The material was published in HTML or PDF, with the audio-visual material was delivered via Flash format.. Students were asked about the quality of the content using a Likert scale (1 worst to 10 best). The reading material obtained an average score of 8.5, whereas the voice-over-Power Point format obtained an average of 7.6. The combination of both formats obtained an average of 8.6

At the end of the course, students were asked about the course characteristics, the interaction with the teachers, the modality of e-learning and the main features of the course using a Likert scale (1 worst to 5 best). The whole course was scored with 4.2, the score regarding the e-learning part of the course was 4,3 and when the student were asked if they would recommend this course to their colleagues the score was 4.3.

Students were also asked how they planned to use the knowledge obtained from the course. About 42% answered that the course was preliminary training for an electronic health record implementation, 17,5% said the course taught them how to use the electronic health record, and 7% answered that the course trained them on how to assume a new role such as Chief of Medical Informatics in their institution

Discussion

MI training has been developed mainly in the USA [4] and Europe [5]. Most of these programs are taught in-person only, and the number of Spanish language courses available is limited. Most of the material related to MI training – text books, bibliography, etc. – is published in English, which provides a barrier to Spanish-speaking students. Furthermore, most of these courses do not take into account specific regional needs (e.g., American courses devote time to topics of less detailed interest in Latin America, such as the Health Insurance Portability and Accountability Act, HIPAA).

We therefore not only had to translate the course, but also add information and examples describing healthcare that was applicable to the region. We also had to create a handbook in Spanish language to explain the course materials that contained 750 pages and was rated highly by students.

When selecting the topics for the Spanish version of the course, we decided to exclude certain units, as "Evidence-based Medicine" or "MI Professional Development in the USA". We added some other topics that were relevant to our educational needs, such as "Use of Controlled Vocabulary and Terminology Services", "Digital Signature", and "Law on Privacy, Confidentiality.". We also added additional material on "Picture Archive and Communication Systems" (PACS) in radiology and "Biological Signal Processing in MI." We also broadened coverage of the impact of MI on public health, focusing on epidemiological surveillance, immunization records, and geographic information systems.

We have demonstrated that MI education can be provided in Latin America via distance learning. This kind of training was received positively by students. Future efforts will focus on improving the course and offering to a wider audience, particularly as MI applications become more prevalent in the region.

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Translation, implementation and evaluation of a medical informatics distance learning course for Latin America

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Abstract

- Growing need and interest worldwide for healthcare professionals trained in medical informatics. Distance learning technologies are increasingly used to deliver such education, but mainly limited to the English language.
- We describe the implementation of a medical informatics course delivered in Spanish for a Latin American audience.
- The course was based on the 10x10 program of the American Medical Informatics Association and Oregon Health & Science University and translated and adapted to the Latin American setting. The course consisted of ten one-week units. A total of 152 individuals enrolled in the course, 93% of whom completed it. Most of the students were healthcare professionals and the largest proportion were from Argentina. Student satisfaction with all aspects of the course was high.
- The initial experience obtained in training healthcare professionals in medical informatics in Latin America in their own language demonstrated that it can be used across the region, and this could represent a model for disseminating knowledge of medical informatics across other languages and cultures.

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Introduction

- Growing need to train individuals in medical Informatics (MI)

- International programs using distance learning to deliver MI education have been developed in the United States, New Zealand and Europe.
  - →No experience in Latin America
  - →Internet tools, may be a possible strategy to deliver MI education

Introduction

- In 2005, the American Medical Informatics Association (AMIA) and the Department of Medical Informatics & Clinical Epidemiology of Oregon Health & Science University (OHSU) launched the 10x10 Program.

- Develop a training program in Spanish language
  - →MI task force of the Hospital Italiano de Buenos Aires (HIBA) entered into an agreement with OHSU.
  - →Translate and adapt the OHSU 10x10 course to the Latin American region.

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Materials and Methods

The course adhered to roughly the same outline as the English version from OHSU, covering the following main topic áreas:

1. Overview of the discipline
2. Biomedical Informatics
3. Electronic Health Records
4. Decision Support and Health Care Quality
5. MI Standards: Privacy, Confidentiality and Security
6. Information Retrieval and Digital Libraries
7. Multimedia and Telemedicine
8. Organization and management issues in biomedical informatics
9. Biomedical Informatics Subspecialties
10. Information Systems in Public Health

Materials and Methods

- Teaching modalities
  - →Lectures
    - Reading material (pdf)
    - Voice-over-Power Point presentations.
  - →Threaded discussion boards
  - →Recommended readings
    - Shortliffe et al., *Biomedical Informatics: Computer Applications in Health Care and Biomedicine - 3rd. Edition*, Springer-Verlag, 2006
  - →Self-assessment

Materials and methods

- Learning management system
  - →Moodle
    - free, open-source package designed to help educators create effective online learning communities.

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Results

- Launched in March 2006

- 152 registered students.
  - →93% completed the course.
  - →68% physicians.
  - →84% from Argentina.

Results

- Students' evaluation of the course (Likert scale 1-5)

Question	Score
1. Did the course content meet the program's description?	4,5
2. The course gave me practical and useful information for my daily work	4,1
3. Was the course correctly balanced? Was it interesting?	3,9
4. Did the teacher have adequate knowledge regarding the topics?	4,7
5. Was the teacher organized when presenting the contents?	4,6
6. Did the teacher answer the questions promptly?	4,6
7. Was the length of the course correct?	3,8
8. Were the course materials effectively presented? Was the surfing process easy?	4,4
9. Did the course fulfill my expectations?	4,2
10. Would I recommend this course to my colleges?	4,3
11. Which is my score regarding the e-learning part of the course?	4,3
12. Which score would I give to the whole course?	4,2

Results

- Students were also asked how they planned to use the knowledge obtained from the course.
  - ⟶42% preliminary training for an electronic health record implementation
  - ⟶17,5% how to use the electronic health record
  - ⟶7% how to assume a new role such as Chief of Medical Informatics in their institution

Discussion

- MI education can be provided in Latin America via distance learning.
- Training was received positively by students.
- Future efforts will focus on improving the course and offering to a wider audience, particularly as MI applications become more prevalent in the region.
- Model for translation and dissemination of MI education to audiences in other regions of the world who speak other languages.

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Health Informatics in the Philippines

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Abstract

The progress of biomedical informatics in the Philippines has been fraught with many highs and lows. Called 'health informatics' locally, the field has been in informal and formal development for the past ten years since the first professionals commenced investing time and energy to pursue the field as a distinct discipline. Although local efforts have been hampered with infrastructure issues, there have been many activities that have provided strategic foundation for the implementation of future activities. Foremost among these is the Master of Science in Health Infromatics offered by the University of the Philippines Manila. The program offers a unique approach to learning health informatics by putting emphasis on community-based and community-managed health information systems that are appropriate for resource constrained environments. It is also unique for its heavy adoption of the principles of primary health care (as manifested by the Declaration of Alma Ata) in its curriculum design and implementation.

Keywords:

Philippines, education, informatics, health

Introduction

As a science, biomedical informatics had been loosely practiced in the Philippines as early as the nineteen eighties. Residents in tertiary care facilities who had access to IBM compatible machines were already using word processors to store patient information. In other areas, anecdotal evidence of database management systems was used for storing patient information. Epidemiologists from the Department of Health who took the Field Epidemiology Training Program (DOH-FETP) used Epi-Info[1] extensively in their practice. In fact a professional association, the Philippine Association for Medical Informatics (PAMI) led by Dr. Benjamin Marte was formed with membership mostly composed of Department of Health staff. The PAMI was able to represent the country in initial meetings of the Asia Pacific Association for Medical Informatics and was the de facto representative for the country in APAMI for the years 1994 to 1995.

It was however during the late nineties when a more structured approach to 'medical informatics' (as it was called then) appeared. This was through the establishment of the Medical Informatics Unit in the University of the Philippines Manila. Preceding the MIU however were several important events. First there was the incorporation of a non-governmental organization called the Philippine Medical Informatics Society, Inc composed mostly of academicians from the University of the Philippines Manila (UPM). Then the PMIS initiated many of the scientific activities related to the field such as the First Symposium on Medical Informatics and Seminars on Telepathology (Dr. Paul Fontelo, Armed Forces Institute of Pathology), Medical Records Management (Dr. Michael Yang, OACIS), and Integrating Technology into Medical Education (Dr. Emmanuel Besa, Medical College of Pennsylvania). However, although these activities served to keep the interest and awareness in medical informatics, they were too far in between to actually to push the science forward in the country.

Academics

By 1998, faculty members from the UP College of Medicine began taking formal courses in medical informatics in different institutions around the world; in particular, at the University of Washington, the National Library of Medicine in Bethesda, Maryland, and University of Warwick in Coventry, England. These faculty members served as the core group of what will be the Medical Informatics Unit at UP Manila.

Research

Upon return, the faculty core group started working on health information systems projects and applied many of the principles they learned from their training. Most of these researches were conducted at the Medical Informatics Unit of the UP College of Medicine while others at the World Health Organization and the Department of Health. With the experience from these projects, faculty members were able to refine their techniques and protocols to address the growing informatics needs of the country. One such project was the Community Health Information Tracking System [2], a Linux, Apache, MySQL, PHP-based system released under the general public license (GPL). CHITS was named finalist at the Stockholm Challenge

1 Epi-Info. http://www.cdc.gov/epiinfo/

2006 and one of top three e-government projects in the Philippines by the Asia Pacific Economic Cooperation Digital Opportunity Center. Several other projects with the United States Agency for International Development and International Development Research of Canada provided the experience for the faculty and staff of the MIU to handle increasingly complex projects in medical informatics.

By 2003, the faculty members realized the need to generate new blood and to formulate a structured learning program for medical informatics. A proposal for a Master of Science in health informatics was crafted together with the College of Arts and Sciences (who had a program in bioinformatics). This combined program, now called Master of Science in Health Informatics (MSHI) was finally approved in 2004 and implemented in academic year 2005-2006.

Service

A key component of the MSHI was service as well as research. As designed, students of the MSHI are expected to implement the principles and concepts of health information systems development within an existing environment relevant to their practice. As seen with the first batch of students, most of these projects are for databases for their professional organizations or specialty affiliations.

Context

A unique spin in medical informatics in the Philippines is the bias of pioneering faculty on community health informatics. This is due to the fact that most of the initial efforts began at the UP College of Medicine where a community-oriented curriculum serves as the central recurring theme in all institutional activities. This community-orientation permeates the design and delivery of the MSHI, and in the program students are asked to immerse themselves and to integrate with local health facilities to understand the issues in health information management at the grassroots level. This is very different from the approach of first world counties who expose their students to complex, sophisticated, and resource-intensive health facilities, many of them at the secondary or tertiary level. In fact, the MSHI program is unique in that it revolves around patient level data within a public health system infrastructure forming the staging are for the development of public health informatics in the future.

A clear manifestation of this philosophy is the staunch advocacy of the UPM for the use and promotion of free and open source software (FOSS). In fact, the National Telehealth Center (an institutional product of the MIU) has been named as UNDP Regional Center of Excellence for Free and Open Source Software and node of the International Open Source Network[3] for ASEAN+3.

Issues

Despite the many developments in health informatics in the Philippines, the nation still suffers from several issues that impede progress. Foremost is the lack of health human resource interested in the field. Most of the initial enthusiasts were clinician specialists who were engaged in health informatics more as a novelty rather than as a profession. When the pull of economic and professional constraints are felt, priorities shift towards clinical responsibilities to the detriment of the health informatics discipline.

A second problem is the network infrastructure (which also involves IT human resource). While connectivity is an important component of a health information systems, the availability of affordable IT human resource and their retention in the age of globalization remains an issue.

Third, the benefits of information technology have not yet dawned to many decision-makers in the health sector. The huge capital outlay for a health information system remains a stumbling block to the integration of IT in health operations.

Opportunities

An exciting development in the country is the rapidly maturing wireless cellular network with value-added services. The Philippines is the texting capital of the world and is home to 300 million messages a day. It is also a large laboratory for SMS based applications that range from games to banking. Definitely, with a wide penetration nearing fifty percent[4], SMS is a protocol waiting for a health informatics application.

A joint cooperation of the Department of Health, Department of Science and Technology, the University of the Philippines Manila, and the Philippine Health Insurance Corporation to formulate standard secure health messaging across health facilities is opening up a lot of business opportunities both for health informatics practitioners and for IT vendors as well. Called the Philippine National Health Information Infrastructure (PNHII), it will form the

2 Tolentino H, Marcelo A, Marcelo P, Maramba I. Linking primary care information systems and public health information networks: lessons from the Philippines. Stud Health Technol Inform. 2005;116:955-60.

3 International Open Source Network. http://new.iosn.net

4 Lucas D. Cell phone penetration rate seen to peak at 50%. http://news.inq7.net/infotech/index.php?index=1&story_id=78818

framework for the automation of many health transactions and may eventually pave the way for the justification of IT investments in health.

The BuddyWorks Telehealth project of the National Telehealth Center, an e-government project, is nearing completion and offers the possibility of managing electronic patient records needs of the government health bureaucracy. BuddyWorks is based on open source and is flexible enough to plug into any system that will be chosen by DOH. It can also serve as the reference implementation of the Philippine National health Information Infrastructure.

Next Steps

At center stage in health informatics in the Philippines is the Master of Science in Health Informatics program. Designed to produce the leaders who will push for the needed organizational and technological changes in the health sector, the MSHI program aims to participate actively in the efforts of the PNHII and of BuddyWorks. The cellular infrastructure will play a major role in the delivery of health messages because of its wide coverage in the country.

The Philippines will continue to focus its informatics to the real needs of the Filipino people, especially those who are marginalized and underserved.

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Live Interactive Surgical Tele-Workshop on Rhinoplasty - A Tele-CME case study

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Abstract

This paper is based on a Live Interactive Tele-Surgical Workshop on Rhinoplasty conducted by the departments of ENT & Plastic Surgery in association with the Malabar branch of the Association of Otorhinolaryngologists of India. The Centre for Tele-Health & Medical Informatics co-ordinated the CME. IP based VSAT telemedicine connectivity provided by the Indian Space research Organisation (ISRO) is confined to a small telemedicine room with limited capacity. We have extended the facility with minimal cost to two more lecture halls of different capacities and Operation Theatres.

As a part of the workshop, a Rhinoplasty was done by the mentor from an operation theatre which was viewed and interacted upon by CME participants situated one at the lecture hall of our own institution (less than half a kilometre apart) and secondly and most importantly from the Tele-medicine conference hall at the Thiruvananthapuram Medical Colege. (More than 500 kilometre apart.) All three centres viz. Operation theatre, lecture hall and the remote centre could interact with the other two centres. Such a programme was conducted for the first time in the Kerala State Tele-Medicne network. Using the technology available then, only one remote centre could be catered. But attempts to multicast such programmes to many centres is nearing completion and even that would be possible ina month.

The various challenges, the problems faced by our team and our attempts to solve will also be described in this paper and it is hoped that it will give some lessons for all those who are planning to utilise the technology in Universities and teaching centres in low resource settings..

Keywords:

telemedicine, telehealth, surgical education

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Why Teach Computer Security to Medical Students?

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Abstract

The introduction of Electronic Medical Records (EMR) within the healthcare practice can be beneficial in order to integrate and centralize heterogeneous patient information. However, there are still some problems that hinder the successful use of EMR. The concern for patient privacy is one of them. The aim of this paper is to present the results of a study that assesses attitudes of 1st year medical students towards computer security and the EMR. An anonym questionnaire was given to the students at the beginning and at the end of the academic year of 2003/ 2004 for them to comment on several security related scenarios. 238 questionnaires were answered at the beginning of the year whilst 222 were answered at the end of the year. The students feel, at the end of the year, that they understand better what computer security is and how to protect patient privacy information. This shows that teaching computer security to medical students, the future users of EMR, can greatly influence the success of EMR integration and therefore improve and fasten healthcare treatment.

Keywords:

computer security; education, medical, undergraduate

Introduction

The introduction of Electronic Medical Records (EMR) within the healthcare practice allows for the integration of heterogeneous information that are usually scattered over different locations [1] [2]. However, there are some barriers that impede its successful integration in most healthcare practices [3] [4].

One specific barrier relates with the privacy and security of patient information [5]. The use of new information systems within healthcare stresses the need for young doctors to comprehend them from their conception so that they can be used in a beneficial way and support their future daily work. As such, all the feedback provided during their training into the medical profession is essential for the enhancement of those systems [6], moreover in terms of computer security.

The Biostatistics and Medical Informatics Department of Porto Faculty of Medicine teaches Ethics and Medical Informatics to 1st year medical students [7]. The later subject includes theoretical and practical lectures about Electronic Medical Records (EMR) and computer security.

This study aims to assess the opinions, attitudes and awareness of 1st year medical students towards computer security issues relating to EMR, and how these can affect the successful integration of EMR within the healthcare practice.

Methods

An anonym questionnaire was given to the students both at the beginning and again at the end of the academic year of 2003/2004. It was applied two times so that we could compare their attitudes before and after they had attended the Ethics and Medical Informatics' subjects.

The questionnaires introduced 3 scenarios for the students to comment. The first scenario described a breach of patient privacy to an EMR by one of their colleagues. There were two questions relating with this scenario:

- Q1.A – Is the described scenario a security breach?
- Q1.B – What would you do if you found out about this breach?
- The second scenario included additional information to the first scenario. It explained that the colleague in question had shared his password with a friend and that friend was the one to access patient private information, without him knowing it. The question related with this scenario was:
- Q2 – Would you change your attitude if you found out this new piece of information?
- The third scenario introduced the issue of more sensitive information (e.g. HIV, Cancer results or even VIP related) and how this information must be protected. The question presented within the questionnaire was the following:
- Q3 – Do you think this kind of information requires stronger security measures than other types of information?

The answers to these questions were inserted into SPSS® and analysed separately.

Results

A total of 460 questionnaires were filled by the students. 52% (238) were answered before the lectures started whilst 48% (222) after the lectures finished. Table 1 shows the results obtained from the applied questionnaires.

Table 1 – Results obtained from the questionnaires

		Before the lectures % (n)	**After the lectures % (n)**
Answered questionnaires		*(238)*	*(222)*
Q1.A	*Valid answers*	*98 (232)*	*98 (217)*
	Yes	100 (232)	100 (217)
Q1.B	*Valid answers*	*61 (144)*	*60 (132)*
	Reason with	54 (77)	44 (58)
	Inform	40 (58)	50 (66)
	Others	6 (9)	6 (8)
Q2	*Valid answers*	*62 (148)*	*62 (138)*
	No	74 (109)	83 (115)
	Yes	26 (39)	17 (23)
Q3	*Valid answers*	*43 (103)*	*91 (204)*
	No	44 (91)	38 (77)
	Yes	55 (112)	62 (127)

For Q3, the main reason given by the students that felt no extra security measures were needed to access more sensitive information is that all security measures must be effective for all cases, independently of the patient or healthcare performed. The majority of the students that thought extra security measures were necessary agreed that this would provide for the protection of certain social groups from discrimination.

Conclusion

According to this study's results, after Medical Informatics and Ethics' lectures, students feel more conscientious to report privacy breaches to responsible parties (Q1.B). They understand better what computer security is and how to behave in order to protect confidentiality of electronic information. They consider indirect disclosure of sensitive information, such as with another person's password, a serious fault (Q2). Further, at the end of the year, students become more aware for the need of different protection levels of security depending on how sensitive information can be (Q3).

We believe that the introduction of Medical Informatics and Ethics early in the degree of the Medical course has an influence in the awareness and attitudes of first year medical students towards computer security and EMR. This can greatly influence the success of EMR integration whilst improving and fastening healthcare treatment.

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Ethics and Health Informatics: Professional Imperative

Laurinda B. Harman[1], Virginia L. Mullen[2]

Abstract

The complexities of protecting patient privacy increase ethical challenges for medical/health informatics professionals. These issues surface as a result of the uses of information (coding, quality review, research, public health); the electronic health record (security, software development, e-health); sensitive information (genetics, adoption, behavioral health); and professional relationships with others, including as managers and when working with vendor and as entrepreneurs and advocates. The importance of ethical principles, professional values and the use of a code of ethics are essential. The American Health Information Management Code of Ethics is used as a reference, noting that many other health care codes can be used as resources. Specific cases and a decision-making matrix is presented that will facilitate ethical decisions in the context of work.

Keywords:

privacy, ethics, medical/health informatics, electronic health record

Introduction

The health information system contains many sacred stories that must be protected, even as information is shared with legitimate stakeholders across the continuum of care and services. The ethical obligation to protect this information is at the center of decisions made on behalf of patients, the healthcare team, peers, colleagues, the public, or the many other stakeholders who seek access to patient and consumer information [1]. Core health information issues include what information should be collected; how the information should be handled, who should have access to the information, and under what conditions the information should be disclosed. Health informatics professional values must guide ethical decision-making. Ethical obligations are central to the professional's responsibility, regardless of the employment site or the method of collection, storage, and dissemination. Sensitive information (genetic, adoption, drug, alcohol, sexual, and behavioral information) requires special attention to prevent misuse. Given the corporate/business relationships in the health care community, entrepreneurial roles require expertise in the protection of the information in the world of business and interactions with consumers [2].

Ethics provides a language and a framework for formally discussing ethical issues, taking into account the values and obligations of others. Ethical discussion offers an opportunity to resolve conflicts when competing values are at stake. Ethical decision making requires people to explore choices beyond the perspective of simple right or wrong (moral) options. According to Glover, ethics refers to the formal process of intentionally and critically analyzing the basis for your moral judgments for clarity and consistency [3]. When making health information decisions, informatics professionals must go beyond the personal right or wrong moral perspective and evaluate the many values and perspectives of others who are engaged in the decision to be made [4].

Ethical responsibilities of the informatics professional

In general, the HIM professional's primary responsibilities include those related to designing and implementing a system to ensure the completeness, accuracy, and timeliness of health information. In support of these responsibilities, the HIM professional is accountable for complying with laws, rules, regulations, standards, and policies from many sources, including the government, accreditation and licensure organizations, and the healthcare facility. Some of the health informatics professional's core ethical responsibilities include the following [5]:

Protecting patient privacy and confidential information [6] ; making appropriate decisions regarding the selection and use of clinical diagnostic and procedural codes [7] ; developing policies and procedures that ensure coding accuracy that supports clinical care and research and meets the requirements for reimbursement, while avoiding fraud and abuse violation [8]; reporting quality review outcomes honestly and accurately, even when the results might create conflict for an individual or an institution [9] ; ensuring that research and decision support systems are reliable[10]; releasing accurate information for public health purposes for patients with communicable diseases, such as AIDS or venereal disease, and assisting with the complexities of information management in the context of bioterrorism and the threat or reality of global diseases, such as smallpox or avian flu [11] ; supporting managed care systems by providing accurate, reliable information about patients/consumers, clinicians, healthcare organiza-

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tions, and patterns of care, with special care devoted to issues related to access to information [12]; facilitating the exchange of information for patients, families, and providers of care, especially for those affected by chronic and terminal illness, that ensure patient autonomy and beneficence [13] [14]; ensuring that the EHR meets the standards of privacy and security according to HIPAA and other federal and state laws [15] the standards of information security [16] and software development [17] ; ensuring that clinical data repositories, data marts, data warehouses, and EHRs meet the standards of the best practices of health information and database management [18]; participating in the development of integrated delivery systems so that patients can move across the continuum of care and the right information can be provided to the right people at the right time [19] ; working in the context of e-health technologies that allow consumers, patients, and caregivers to search for health information and advice, create and maintain personal health records, and conduct virtual consultations with their care providers [20] ; ensuring that health information technology systems, including EHRs, electronic prescribing, bedside bar coding, computerized physician order entry CPOE), and clinical decision support systems reduce errors and improve quality [21] ; managing the protection of sensitive information, including genetic information [22]; drug, alcohol, sexual, and behavioral information [23]; and adoption information [24]; developing moral awareness and nurturing an ethical environment in the context of managing a health information system [25]; serving as advocate for patients, the healthcare team, and others who have interests in the health information system [26] [27] ; working with vendors in the development of business relationships that ensure ethical processes when selecting and communicating with vendors, managing vendor relationships, and dealing with the contract negotiation process [28] .

Discussion

It is important to clarify the differences between values, morality and ethics. A value is a principle, standard or quality considered worthwhile or desirable. Morality is based on values and represents your personal moral choice, i.e., this is "right" and that is "wrong." Ethics is a formal process of intentionally and critically analyzing a problem, taking into account all the facts, professional obligations and ethical principles and values of those involved in the decision, such as, patients, HIM professionals, employees, health care providers, administrators or society-at-large. The goal is to resolve conflicts among competing stakeholders.

Professional responsibilities often require an individual to move beyond personal values. For example, an individual might demonstrate behaviors that are based on the values of honesty, providing service to others, or demonstrating loyalty. In addition to these, professional values might require promoting confidentiality, facilitating interdisciplinary collaboration, and refusing to participate or conceal unethical practices. Professional values could require a more comprehensive set of values than what an individual needs to be an ethical agent in their personal lives. Professional values define the nature of all interactions in all settings and circumstances in which informatics professionals operate.

Health informatics values important to the patient/consumer include providing service; protecting medical, social, and financial information; promoting confidentiality; and preserving and securing health information. Values important to the healthcare team include promoting the quality and advancement of healthcare demonstrating expertise and skills; and promoting interdisciplinary cooperation and collaboration. Professional values important to the employer include protecting committee deliberations and complying with laws, regulations, and policies. Professional values important to the public include advocating change, refusing to participate or conceal unethical practices, and reporting violations of practice standards to proper authorities. Professional values important to individual and professional associations include obligations to be honest; bringing honor to self, peers and profession; committing to continuing education and lifelong learning; performing Association duties honorably; strengthening professional membership; representing the profession to the public; and promoting and participating in research [29]. These various professional values will require a complex process of balancing the many conflicts that can result from competing interests and obligations of those who seek access to health information and require an understanding of ethical decision-making. Values are not universally shared, so ethics gives us a framework for formally discussing the issues, taking into account the values and obligations of others. Ethical decision-making provides a framework for resolving conflicts when competing values are at stake.

Professional code of ethics and decision-making matrix

A code of ethics sets forth values and ethical principles, and offers ethical guidelines to which professionals aspire and by which their actions can be judged. A code is important in helping guide the decision-making process and can be referenced by individuals, agencies, organizations, and bodies (such as licensing and regulatory boards, insurance providers, courts of law, agency boards of directors, government agencies, and other professional groups) [30].

Glover [31] has proposed a seven-step process to guide ethical decision making. When faced with an ethical issue, the informatics professional should ask and answer all of

the following questions. The questions represent the steps in the decision-making process.

1.What is the ethical question?

2.What facts do you know, and what do you need to find out?

3.Who are the different stakeholders, what values are at stake, and what are the different obligations and interests of each of the stakeholders?

4.What options for action do you have?

5.What decision should you make, and what core HIM values are at stake?

6.What justifies the choice, and what are the value-based reasons to support the decision? What choice or choices cannot be justified?

7.What prevention options can be put into place so that this issue will not come up again?

Summary

Bioethical decisions involving the use of health information require action, and such actions always require courage. The healthcare team, the patients, and the others who are served need to know that the informatics professional has the expertise and the courage to make appropriate ethical decisions. Technical expertise must be combined with an understanding of ethical principles and the application of a professional code of ethics.

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Implementing IT Knowledge to a PostGraduate Health Care and Nurse Studying Program

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Abstract

Nowadays every visit to the doctor requests the cooperation between the nurse and IT technology. But are nurses really sufficiently equipped with knowledge about their working environment, as far as IT technology is concerned? Without doubt, more knowledge about the possibilities, benefits, possible mistakes and their consequences related to IT technology is needed for being used adequately in the health services. In the paper we will present the postgraduate program which aims at moving those possible obstacles and targets also at decreasing the lack of knowledge in this field of knowledge. We will present the study program in general and, additionally, will focus on specific IT areas like databases. The paper will also discuss the experiences and assessments which are acquired during the last years by the students in the database lecture. The mentioned lecture constitutes a part of the IT modules in the postgraduate health care and nursing program.

Keywords:

IT, postgraduate program, databases, information systems, education models, health informatics, nurse informatics, assessment

Introduction

Providing better health care for all is closely related to fast and secure information processing including data gathering, decision making, data mining and information generation, either in the health care centers, pharmacies, hospitals or any other health care institution. To meet all this requirements, it is demanded that appropriately trained staff is involved in activities where IT is a part of everyday work and life. To cope with this situation, nurses have to be trained in a proper way [7], [14].

Taking into consideration the needed knowledge from IT, we believed that the proper way to equip the responsible persons with sufficient knowledge is a regular undergraduate or post graduate education, which enables nurses to play an active role in the lecture phase as well as later in daily work with and for IT. To reach these goals, we developed a postgraduate nursing curriculum in the frame of the EU Phare Tempus project called NICE - Nursing Informatics and Computer Aided Education [1], [7] in which, as already the name itself reveals, informatics and IT are pointed out.

In the paper we will give a brief overview on the NICE curriculum. Furthermore, we will concentrate on some details in the Database lecture which is part of one of the modules of the study program. Additionally, we will present our experiences which we acquired during the last years since teaching the mentioned lecture. Experiences are very important for a further upgrading of the lecture and for up-to-date lectures materials available on webpages. Since the numbers of regularly enrolled students is approximately 15 per year, we are not able to work on summative assessment [12], but we need to find a less formal but, nevertheless, correct form for dealing with formative assessment or evaluation. The paper will be concluded by teaching results and final remarks, given in the Conclusion.

NICE curriculum

What is the concept behind “nursing informatics”? Simply speaking, we can define “nursing informatics” as the usage of information technology (IT) to support and make easier activities carried out by nurses. Some other definitions [2], [3] view nursing informatics as a discipline applying computer science to nursing processes or a combination of nursing science, informatics (information science) and computer science to manage and process nursing data, information and knowledge to support the delivery of health care.

Taking into account these definitions, we have decided that the nursing informatics curriculum needs to provide the students of the program with the following knowledge: basics of computer technology, medical informatics, nursing informatics, computer-aided patient care, computer networks and information retrieval as well as computer-assisted learning tools.

At the end of the nineties of the last decade, the NICE project was established with the aim to develop and introduce new short cycle degree courses from nursing

informatics at the university colleges. The project partners came from Austria, France, Greece, Italy and Slovenia [1]. The team who developed the curriculum consisted of members of various professions like nurses, engineers, computer scientists, medical doctors and administrators, who have very different views, opinions and beliefs on nursing informatics in general and in particular on the content of the nursing informatics curriculum [4]. The postgraduate program in Slovenia was the first one of his kind which integrated IT lectures to the curriculum for educating people of the health care and nursing domain. One of the top priority goals by establishing the program was, besides integrating informatics and computer science knowledge to the program, the integration of experts from the mentioned fields for giving lectures for nurses and health care domain staff.

After discussing various approaches that had been used in education [5], [6] as well as talking about other system approaches [6], we agreed on the common definition about teaching nursing informatics and IT as follows[1]: Teaching nursing informatics is a process in which students obtain knowledge from basics of informatics and computer science, informatics in health care (medical informatics), informatics in care and nursery (nursing informatics) computer communications and security (internet), medical instrumentation and simulation supported by computers with the aim to support nursing care processes as well as making nursing work more visible and enjoyable and, last but not least, to provide and enable better health care for all. On this foundation, taking into account also the before mentioned knowledge, the postgraduate nursing and health care informatics curriculum was developed and approved to by Slovenian authorities. Until our satisfaction with the curriculum was met, hard work was necessary and common decisions were done for each module and each single lecture.

The program is, like all other study programs for postgraduate students at our university, offered as a part time study. Most of the students are part time students (regular matriculation is also possible, but only exceptional required from students), mostly working as nurses or keeping other similar positions, having already a background knowledge from the nursing area duties or closely related to it. Some of the students have a technical background in computer science and informatics and are working in health care institutions, pharmacies, hospitals and similar institutions. Having started the program in 2001 which was attended then by one student, the number of students in the meantime has reached 10-12 students starting every year. The postgraduate program can be finished within 1,5 year (3 semesters). While two of the semesters are dedicated to attending classes and lectures, the students will spent the last semester on preparing their thesis and research. Within two semesters, the students have to pass 18 exams. Additionally to the lectures and to the gathering of practical experience, the students individually need to organize themselves when it comes to arranging time which is required for exercises, seminar work and the preparation for exams.

The offered lectures of the program are divided into three modules: Nursing informatics, informatics in health care and search for information in computer networks. In the following we will focus on the first module and give insight to the single lectures: “Information systems”, “Telematics in health care”, “Databases”, “Intelligent Systems”, “Ethics” and “Security of computerized data.” Already the titles of the lectures reveal the multidisciplinary content of the curriculum. Knowledge from the nursing program is combined with knowledge from the informatics and computer science program and is added by electrical engineering cognition. The teachers of the individual lectures have high competence in their subject as they have achieved their expertise in this specific field of knowledge. Lectures like “Information Systems”, “Databases”, “Intelligent systems” and “Ethics and security for computerized data” are given either only by a lecturer from informatics and computer science or by lecturers from two or three areas who will then cooperate in the same lecture.

For each single lecture also teaching materials were produced, concretely books were written [9] and PowerPoint presentations were prepared. Books were published in the NICE series, covering all lectures and providing basic knowledge which is required to finish the obligations of the program. Books have been a part of the NICE project as well. Additionally, PowerPoint presentations and other electronic materials and tools [13] are as response to the achieved feedback from lectures of the last years available for students via webpages [7], [14] and [15].

Database lecture: the content

This lecture covers five sections that include methodologies and techniques for database development. The lecture details are as follows:

- *Introduction:* This part briefly introduces the importance of the database and gives basic definitions and information on the architecture
- *Database design:* Database design is the most important part when developing a database. The work is divided into three parts: conceptual, logical and physical database design. The focus is on the conceptual model as a basic work for further design and development. The Entity-Relationship model is presented as a basic technique for conceptual database design.
- *Relational database:* This part discusses the logical level of the database design with properties and trans-

formation rules from the E-R model to the relational database.

- *Databases in the future:* Special areas such as medicine, health, pharmacies and some others develop special models for special needs, quite often upgraded also with the knowledge and knowledge based systems. Students will get the encyclopedical knowledge from the knowledge based systems as well as enterprise and domain models.
- *Summary:* Instructors guide students to have a look at database from their own field of profession. The enterprise is defined by each student for his/her seminar work and database design is done on a conceptual level. Results are presented and discussed with other students, the instructors and the lecturer. Final conclusions are done after having gained practical experience.

Experiences

After getting a brief overview on the nursing and health care postgraduate program and after having presented the "Database lecture", we would like to present some experiences acquired during the last years. Most of the experience we share is gathered in the informal discussion with the students after the exam of the "Database lecture" (formative assessment/evaluation). More formal assessment (summative assessment/evaluation) is not possible because the group of the participating students tend to be very small (between 5 and 12 students). Furthermore, as assessment is much more difficult when new teaching methods and experiments are just being introduced.

In general, the process of educational assessment can be approached as being the process of gathering, describing or quantifying information about learning performance. The person or lecture being evaluated can range from the performance of students and instructors to that of lectures materials, courses and or the whole study program. Educational assessment/evaluation can be done either during or after lectures and with different purposes. Generally speaking, assessment can be defined as the systematic process used to obtain information about student achievements [12] in order that that information can be used to:

- Give feedback to students.
- Make educational decisions about students.
- Make decisions about the lecture or the program and the effectiveness of the lecturer.

Students usually attend the Database lecture after having finished the Information system lecture, where they are equipped with basic knowledge about what is an information system, what are its processes and activities as well as being told the basic importance about data and database for each information system and/or application.

Among the books in the NICE-series a book for the Databases lecture is available and we, additionally, have a PowerPoint presentation about the most important parts as well. The main goal is that students understand what is a database, its importance, as well as how to develop it. They are also informed how to implement it and access data, but we do not provide any special training on this part because mostly the students will be not actively involved in the implementation or writing SQL queries, for example. But in cases where they will in the future come across developing and using a database, **we expect that queries will be very basic one.** For those involved exceptionally more practically to data access, another chapter in one of the NICE series book is available [10].

One of the goals of the lecture is to prepare students to be actively involved to the development of the database, while they will have probably the role of a domain (nursing, health care) expert consultant. Therefore they have to acquire knowledge and exercise how to do this. Thus every student has to select his or her own domain to develop a database conceptual model (abstract presentation of the database).

How do the students normally react when being asked to develop such a model? Up to then, they are mostly not familiar with the topic (except most of students with non nursing background or undergraduate study) and they are motivated to "reject" the lecture and/or to pass it as fast as possible, neglecting the importance of the topic.

After the first "shock" ("we are not able to do this"), the students slowly start making themselves familiar with the importance of collecting data and developing databases for nursing or health care processes. Usually, after having developed the conceptual model, they make themselves familiar with the importance of the whole system that they have selected or with at least a part of it. This incident is maybe surprising because they have already been close to the selected domain or working there partially already for a long time. Questions about its importance tend to arise, they ask themselves what is important, which data is need or if something is maybe missing. From the quality point of view (quality of the conceptual model), they have been in the past time very successful in their profession. One goal to be reached during the teaching process is raising awareness for the fact that the students own a very important knowledge which contributes to the success of a database. Our students also become aware that they can be an important member of the team working on developing databases on their own domains (nursing, health care). Students with a background from informatics and computer science acquire for their future work very important domain knowledge.

In the formative assessment the students tells us their own stories, quite close to that just described above. For our

students it is an unusual situation to be asked to be active in selecting and deciding on the content of their seminar paper (they select the domain as well as the possible application for which the database should developed). Transferring the gathered knowledge of the study program then later to their workplace in reality, they find out to be happy to play an active role.

In the summative evaluation, a secondary emphasis was put to assess students' achievement at the end of the lecture. The assessment data which has been collected can also be used to provide feedback about lecture materials, approach, **exacting of the whole lecture** and, last but not least, gives information on the adequacy of the lecture in the presented program.

Conclusion

The main idea of this paper was to clarify the importance of IT in the nursing and health care educational programs. Actually, IT is nowadays a part of every day life, when it comes to activities ranging from shopping up to working place surroundings and when consulting a doctor. Whenever things take an unpleasant, unintended direction, we are unsatisfied and complain either to the shop assistant or vendor or both or to our webmaster, IT engineer and, last but not least, put forward our complaints to the nurse or even to the doctor. Quite often we blame persons who are not responsible for the failure because actually the fault is related to the system which is either not good or not working correctly. But, without doubt, there is sometimes also a lack of knowledge by people using these IT systems and this deficit we would like to avoid and thus we have developed and implemented the just mentioned post graduate program.

We have decided to introduce the knowledge of IT to the educational program, independent from the fact that for our students this so far has been a new, mostly unknown domain. The NICE curriculum provides the postgraduate students with the opportunity to compensate the before mentioned lack of knowledge. By using lectures from the field of computer science and informatics we motivate our students to take over an active role in real projects in their daily work environment including developing new IT products for the mentioned domains. Depending on the environment, those products are still rare, and, after all, nurses hardly ever have an active role or do have a lot of influence in IT domains, but we are optimistic that this could chance. In the future, nurses with the required IT knowledge will not only be experts when in comes to acting as an consultant, but they will also be able to make their own proposals, suggestions and solutions concerning the conceptual level, while the implementation of it will remain the domain of IT and computer science experts and engineers.

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Implementing IT knowledge to a postgraduate health care and nurse studying program

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Slovenia

Introduction

- NICE curriculum
  - EU Thempus project
- Nursing informatics in NICE
  - Obtained Knowledge
  - Part time study
  - Three modules
  - Teaching materials
- IT lectures and Experiences
  - Databases
- Conclusion
- References and contact details

NICE Curriculum

- EU Thempus project
  - Develop and introduce new short cycle degree courses from nursing informatics at the university colleges.
  - Project partners from Slovenia, Austria, France, Greece and Italy.
- Nursing informatics definition for needs of NICE

Nursing informatics in NICE

- **Obtained knowledge**
  - Basics of computer technology,
  - Medical/Nursing informatics,
  - Computer-aided patient care,
  - Computer networks,
  - Information retrieval,
  - Computer-assisted learning tools,
  - E-learning.

Nursing informatics in NICE

- Part time study
  - 1,5 year or 3 semesters:
  - 2 teaching semesters (18 exams)
  - 1 semester to prepare the thesis
- Three modules
  - Nursing informatics,
  - Informatics in health care and
  - Search for information in computer networks
- Theacing materials
  - Books
  - PowerPoint presentations

IT Lectures

- Databases
  - Lecture structure
    - Lectures
    - Practice – developing databse
  - Student obtain basic knowledge about:
    - information system, processes, activities and importance of data and database
  - Student must develop a database from their domain

IT Lectures

- Database Lecture: The content
  - Introduction
  - Database Design
    - Conceptual
    - Logical
    - Physical
  - Relational database
  - Database in the future
  - Summary

IT Lectures

- **Database Lecture: The content**
  - Conceptual database design
    - Entity-Relationship model
      - Basic technique – it importance
      - Elements (Entity, Relation, Atribute)
      - Advices for development
      - Exampels
      - Literature
      - Others

Experiences

- **Assessment**
  - Systematic process about students achievements
    - Feedback to students
    - Educational decisions
    - Decisions about lecture, program, lecturer
- **Databases**
  - Formative assessment
    - Informal discussion with students
  - Summative assessment
    - Collecting data for longer period – valid data according to the number of matriculated student

Experiences

- Results
  - First: students are motivated to reject the lecture
    - “We are not abel to do this!”
  - Later: interest because of the known domain
    - “What can I do better?”
    - “What is important for nurses?”
  - Raising awareness
    - “We are/should be member of a development team”
  - Playing active role

Conclusion

- **Knowledge of IT is inportant**
  - Part of every day life all over
- **NICE curriculun is successful**
  - Since 2001 regular matriculation
  - Small groups
- **Experiences**
  - Students previous (working) experiences
  - Teachers experiences
  - Students (new) IT experiences
    - Formative assessment
    - Sumative assessment (up to four generations)

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Live Interactive Surgical Tele-Workshop on Rhinoplasty - A Tele-CME case study

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Abstract

This paper is based on a Live Interactive Tele-Surgical Workshop on Rhinoplasty conducted by the departments of ENT & Plastic Surgery in association with the Malabar branch of the Association of Otorhinolaryngologists of India. The Centre for Tele-Health & Medical Informatics co-ordinated the CME. IP based VSAT telemedicine connectivity provided by the Indian Space research Organisation (ISRO) is confined to a small telemedicine room with limited capacity. We have extended the facility with minimal cost to two more lecture halls of different capacities and Operation Theatres.

As a part of the workshop, a Rhinoplasty was done by the mentor from an operation theatre which was viewed and interacted upon by CME participants situated one at the lecture hall of our own institution (less than half a kilometre apart) and secondly and most importantly from the Tele-medicine conference hall at the Thiruvananthapuram Medical Colege. (More than 500 kilometre apart.) All three centres viz. Operation theatre, lecture hall and the remote centre could interact with the other two centres. Such a programme was conducted for the first time in the Kerala State Tele-Medicne network. Using the technology available then, only one remote centre could be catered. But attempts to multicast such programmes to many centres is nearing completion and even that would be possible in a month.

The various challenges, the problems faced by our team and our attempts to solve will also be described in this paper and it is hoped that it will give some lessons for all those who are planning to utilise the technology in Universities and teaching centres in low resource settings..

Keywords:

telemedicine, telehealth, surgical education

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Patterns of Practice of Telemedicine at a Quaternary Super-speciality Referral Hospital in a Developing Country

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Abstract

All India Institute of Medical Sciences (AIIMS) is the apex super-specialty, quaternary referral hospital of India. Telemedicine facilities have been available at AIIMS since 1999. A study was undertaken at the Institute from October 2005 to September 2006 to assess the patterns of practice of Telemedicine and identify the difficulties faced by the doctors. Results of the study conducted across 23 surgical and non-surgical disciplines are presented..

Keywords:

telemedicine, telemedicine utilization, tele-consultation, developing country, super-speciality hospital

Introduction

India has the second largest population in the world (1.1 billion) and providing medical care to all its citizens is a Herculean effort. The task isn't made any easier by the fact that this population is spread over the world's seventh largest land mass stretching 3214 km (North to South) and 2933km (East to West) over all kinds of terrain - from Himalayan mountain ranges to remote islands and from deserts to tropical forests. In the above scenario Telemedicine would appear to be the panacea for all ills that plague the Indian healthcare system.

All India Institute of Medical Sciences (AIIMS) is the apex super-specialty quaternary referral hospital of India. It was established in 1956 with the mandate to develop the highest standards in the trinity of medical education, research and patient care. A pilot Telemedicine project started by the Ministry of Communication & Information Technology in 1999 has developed into a full-fledged Telemedicine Facility.

The present descriptive study was undertaken at the Institute from November 2005 to October 2006 to assess the usage pattern of the Telemedicine and identify the difficulties faced by the doctors. The study demonstrated the need for distant consultation currently being fulfilled by the doctors by using conventional methods rather than Telemedicine. Most of the use of Telemedicine at AIIMS was found to be in the form of "second opinion" type Doctor-to-Doctor consultations – conforming to the role of the Institute as an apex super-speciality quaternary referral center. The problems in usage of Telemedicine relating to technical, connectivity and administrative issues as well as personal concerns of the doctors were also studied.

Materials and methods

A record-based retrospective study of last 3 years (1 July 2003 to 30 June 2006) was carried out at the Telemedicine Facility to determine the utilization pattern of the Telemedicine services at AIIMS. A non-randomized purposive sample of representative surgical and non-surgical disciplines was selected for further study on the basis of maximum frequency of usage of Telemedicine Facility during the last three years. The study was descriptive in nature, study design was cross-sectional and reference period concurrent.

A semi-structured self-administered survey was planned for the next phase. A pilot study was conducted (n=6) and the questionnaire was modified based on the inputs received. The questionnaire survey was conducted over three months (August to October 2006) amongst the doctors (Faculty members) from the disciplines selected from the above retrospective study with the following objectives:

1. To study the present pattern of providing distant medical advice from AIIMS to other doctors and patients.
2. To assess the usage pattern of Telemedicine at AIIMS
3. To identify the problems faced by the doctors in using the Telemedicine Facility.

In order to increase the sample size the study population was expanded to include Faculty members from all other surgical and medical disciplines which had utilized Telemedicine Facility during the last 3 years. To reduce bias, at

least 2 Faculty members were randomly selected from the department-wise list of designated Faculty.

The data was analyzed using Stata (ver 9.1) statistical software package which is a complete, integrated statistical package for data analysis, data management, and graphics. The findings were further analyzed to see if there was any difference in usage pattern depending on whether the respondent was from a surgical or non-surgical discipline. Fishers exact test was used as the test of significance.

Results

Total 61 questionnaires were distributed to the faculty at AIIMS of which 58 (95.08%) were completed and returned. Non-response rate was reduced to about 5% by repeated visits after stipulated collection date. 45 (77.6%) of the respondents were male and 13 (22.4%) were female. The respondents were aged between 31 – 60 years (Mean age = 44.37 years).

The respondents were from 23 clinical specialities (Table 1 - Specialities covered in the study1). 35 (60.3%) of the respondents were from non-surgical disciplines and 23 (39.7%) were from surgical disciplines.

Patterns of consultation

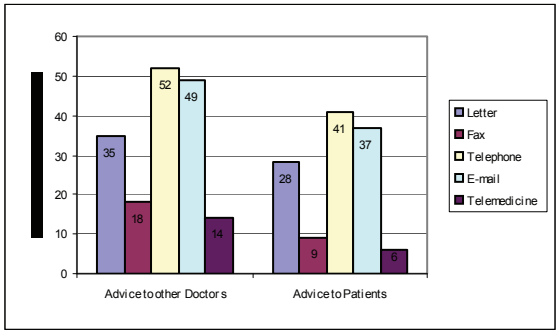

Figure 1- Methods of providing medical advice

Almost all the respondents were using conventional methods viz. letter, fax, telephone or e-mail to provide medical advice to doctors / patients in other places (Table1). Only 3 (5.17%) doctors said they did not use any of these methods, to provide advice to doctors / patients in other places.

Use of Telemedicine at AIIMS

The Telemedicine Facility had conducted a total of 481 tele-consultations in the three-year period (from 1 July 2003 to 30 June 2006). This included Telemedicine sessions with various hospitals and medical colleges within India and abroad (including UK, France, USA and Canada).

The frequency of use of Telemedicine facilities was found to be low. About one-third (32.8%) of the respondents had never used Telemedicine and 30 (51.7%) had used it less than once a month. Only 2 (3.4%) respondents had used Telemedicine every week. An overwhelming majority of the doctors i.e. 34 (87.18%) had used Telemedicine for tele-consultation and the rest 5(12.82%) had used Telemedicine only for tele-conferencing.

Table 1 - Specialities covered in the study

Non-surgical disciplines	**Surgical disciplines**
Cardiology	ENT
Dermatology	General Surgery
Endocrinology	Gastro-intestinal Surgery
Gastroenterology	Gynaecology & Obstetrics
Haematology	Neurosurgery
Medicine	Ophthalmology
Nephrology	Orthopaedics
Neurology	Paediatric Surgery
Medical Oncology	Oncosurgery
Paediatrics	Surgery
Physical Medicine & Rehabilitation	Urology
Psychiatry	
Rheumatology	

There was no significant difference in frequency of use between male / female doctors. Doctors from surgical disciplines were found to be more likely to have used Telemedicine than those from non-surgical disciplines though the difference was not statistically significant *(Table 2 –Usage of Telemedicine: Surgical vs Non-surgical 2).*

Doctors in higher age groups *(Table 3 – Relationship between usage of Telemedicine and age3)* and those with more than 10 years of experience (Table 4 - Relationship between usage of Telemedicine and experienceTable 4) were more likely to have used Telemedicine. A linear trend was noticed in the relationship between the age groups and usage of Telemedicine but the trend was not statistically significant (p=0.054). The correlation with number of years of experience was found to be statistically highly significant (p=0.019).

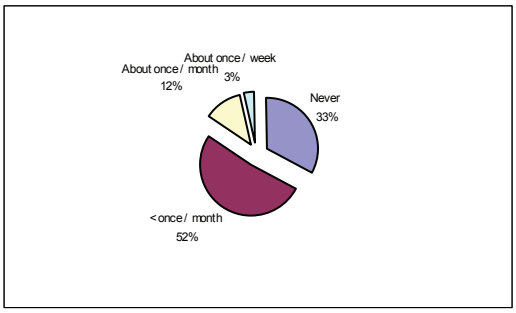

Figure 2 - Frequency of use of Telemedicine

Table 2 –Usage of Telemedicine: Surgical vs Non-surgical

Discipline	Used TM		Total
	N	Y	
Non-surgical	14	21 (60%)	35
Surgical	5	18 (78.26%)	23
Total	19	39	58

Table 3 – Relationship between usage of Telemedicine and age

Age	Used TM		Total
	No	Yes	
31-40 yrs	10	12 (54.55%)	22
41-50 yrs	7	15 (68.18%)	22
51-60 yrs	2	12 (85.71%)	14
Total	19	39	58

Table 4 - Relationship between usage of Telemedicine and experience

Experience	Used TM		Total
	No	Yes	
<= 10 yrs	8	5 (38.46%)	13
> 10 yrs	11	34 (75.56%)	45
Total	19	39	58

Patterns of telemedicine use

A cross-sectional analysis of the consultation pattern was done by asking the respondents about their last Telemedicine session. Only in 17 (43.59%) cases the patient was present during the Telemedicine session. Interaction between the specialist (at AIIMS) and the remote patient was there in only 12 (30.77%) cases. The patient was examined by proxy i.e. the remote doctor was asked to do specific physical examination, during the session in only 9 (23.08%) cases. Patient's clinical history was taken in 21 (53.85%) cases and laboratory investigations and radiological investigations were reviewed in 26 (66.67%) and 22 (56.41%) cases, respectively. Live ultrasonographic examination was done in just one case (2.56%) and special equipment like electronic stethoscope, digital ECG machine, etc. were used in only 2 (5.13%) cases.

This clearly shows that Telemedicine at AIIMS was used mainly for providing "second-opinion" type doctor-to-doctor consultations. Use of Telemedicine for direct patient evaluation was very limited.

Data transfer

Over half of the Telemedicine sessions involved online transfer of data. Only 3(7.69%) respondents had used the offline mode. 1/3rd of the respondents had used both modes – online as well as offline – and that was the preferred mode for receiving data.

Satisfaction with technical quality

Respondents had a high level of satisfaction with the technical quality with nearly 3/4th of the respondents rating it as 3 and above on a Likert scale (5=Excellent, Mean score 2.923).

Problems faced in utilization of telemedicine facilities

The various problems faced by the respondents in utilizing the Telemedicine facilities were grouped as follows (Figure 3)

1. Technical problems
2. Connectivity problems
3. Administrative problems
4. Personal concerns

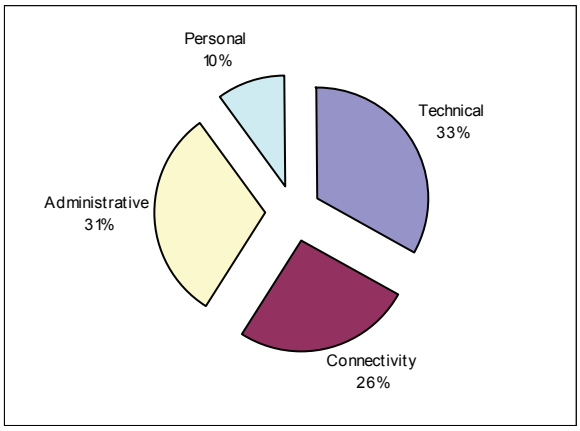

Figure 4 Problems faced in using telemedicine

More than half the respondents felt that improvements in the technological aspects (Technical and connectivity related problems) would improve their usage of Telemedi-

cine *(Figure 4 Problems faced in using telemedicine4)*. Poor quality of video was the commonest technical problem faced by more than half of the doctors. Nearly half the respondents had suffered frequent disconnections during Telemedicine sessions. More than half (61.54%) of the doctors reported difficulty in sparing time for Telemedicine because of busy work schedule. Again, more than half the doctors (56.41%) had apprehensions about limitations of Telemedicine in conducting physical examination of the remote patient and more than one-third (38.46%) were concerned about the reliability of investigations in the peripheral hospitals. The details of the various problems faced by the doctors are listed at *Table 5-Problems faced by users of Telemedicine Facility5*

Table 5-Problems faced by users of Telemedicine Facility

Technical problems	
Poor Video quality	22 (56.4%)
Audio-video mismatch	19 (48.7%)
Poor audio quality	13 (33.3%)
Poor Image quality (X-rays, photos, etc)	13 (33.3%)
Connectivity problems	
Frequent disconnection during the session	19 (48.7%)
Difficulty in getting connection	15 (38.5%)
Inadequate bandwidth	11 (28.2%)
Administrative problems	
Overcrowded work schedule	24(61.54%)
No agency to coordinate	16(41.03%)
Inconvenient timings	12(30.77%)
Distance of Telemedicine Centre from own Dept.	7 (17.95%)
Personal concerns	
Difficulty in performing physical examination of the remote patient	22(56.41%)
Medico-legal issues	16(41.03%)
Unreliable investigation reports from peripheral hospitals	15(38.46%)
Data security & confidentiality	10(25.64%)

Discussion

All India Institute of Medical Sciences (AIIMS) was established in the year 1956 as an autonomous body with the triple mandate– to develop the highest standards in medical education, research and patient care. AIIMS has lived-up to its role as the apex super-specialty, quaternary care hospital of India.

Table 6 - AIIMS : Important annual statistics (2004 - 05)

1	Teaching Departments and Centres	50
2	Faculty members	510
3	Total number of hospital beds	2012
4	Total annual OPD attendance	2,394,270
5	Total annual A & E attendance	179,574
6	Total annual admissions	212,612
7	Total annual surgeries performed	118,234

Telemedicine at AIIMS

There are two telemedicine projects in AIIMS. The first was a pilot project by the Ministry of Communications & Information Technology in 1999. This was followed by point-to-point satellite connectivity provided by Indian Space Research Organization (ISRO). These have been expanded step-by-step to now include 81 districts all over the country. The connection is through ISDN lines or through satellite communication. 6 ISDN lines have been provided each with 128 kbps bandwidth. The lines can be used singly or can be cascaded together to have an effective bandwidth of upto 768 kbps. Satellite communication is provided by ISRO through INSAT 3A satellite.

Being the apex medical institution of the country, AIIMS has a very important role to play in terms of providing super-specialist medical advice to the rest of the medical community in India. The present study shows that 95% of the doctors at AIIMS frequently provide medical advice to doctors and patients at distant places. Telephone and e-mail are the most popular methods, although some still use letters. This is proof of the immense need for means to provide super-specialist medical advice to doctors in distant places where no such facilities are available. It also establishes the fact that the doctors are comfortable with the concept of providing remote medical advice to distant places and do not have any significant concerns while using conventional methods. Thus "*the practice of medicine at a distance*", i.e. telemedicine in a broader sense, appears to be widely prevalent at AIIMS albeit using conventional forms of communication. It may safely be surmised that adoption of Telemedicine in its high-tech avatar is just a matter of getting used to the technology.

In a literature survey of teleconsultations Laatinen, et al (2002), reviewed 128 articles identified through Medline, and found that 79% of the teleconsultations were between doctors and only 8.5% were between doctors and patients[1][1]. In the present study where it was found that most of the teleconsultations were "second opinion" type doctor-to-doctor consultations and interaction between doctor and patient took place in less than 1/3rd cases.

1 Laatinen P.T., Forsstrom J.J., Loula P. Teleconsultations : who uses them and how? Journal of Telemedicine and Telecare. 2002: 8 (16) : 319-324(6).

AIIMS has had state-of the-art equipment at its Telemedicine Centre since 7 years but the present study found its use to be rather low. The usage was low in comparison with even other Indian Telemedicine projects. AIIMS had only 481 Teleconsultations in a span of 3 years whereas Christian Medical college, Vellore, in South India reported over 100 consultations in a period of 4 months[2][2] and Amrita Institute of Medical Sciences (AIMS), Kochi, again in South India, reported 874 tele-consultations in a period of 2 ½ years (Sep 2002 – Feb 2005)[3][3]. A study at the same Institute in 2004 had noted that the majority of physicians felt that better quality of patient care could be provided only in person [4] . The low usage at AIIMS could be due to lack of awareness of the potential of the technology and apprehensions about its limitations.

Most users had complaints about the technical quality and connectivity problems (Table 5-Problems faced by users of Telemedicine Facility5 & Figure 4 Problems faced in using telemedicine4). These issues will have to be addressed before more users embrace Telemedicine as a way of practice.

Significantly, it was found that doctors in higher age groups and those with more than 10 years of experience were more likely to have used Telemedicine. This difference was contrary to expectation as the younger generations are thought to be more tech-savvy and more inclined to use newer technologies. The reasons for this may be that the younger doctors are busier with routine clinical work whereas the senior doctors have more spare time and more opportunities to work outside their own department. Another reason could be that the senior doctors, because of their well-established reputation were more likely to be consulted for a "second opinion" than their younger colleagues. The good news here is that the resistance to change and adoption of new technology in any organization usually comes from the "*old block*". At AIIMS the "old block" has already been conquered and it is a matter of time before the use of Telemedicine becomes routine practice.

Some important issues in implementation of Telemedicine in the country are – availability, accessibility, acceptability and affordability and reliability[5][5]. Acceptability of Telemedicine to the clinicians can be improved by increasing their awareness about the technology and educating them about its utility.

A large number of respondents felt the need for a coordinator – a role that can be fulfilled by a Hospital Administrator.

Conclusion

This is the first study of patterns of practice of Telemedicine at this apex quaternary super-specialist referral hospital. Almost all clinicians at AIIMS were found to be using conventional methods (telephone, e-mail, letter,, fax) to provide distant medical advice. But the level of usage of Telemedicine was low even by Indian standards. Use was mostly for "second opinion" type consultations between doctors, which matches the mandate of the Institute and is also similar to international patterns of usage. Most of the problems faced by the users related to technological issues (technical and connectivity issues).

India, with its wide inequity in distribution of healthcare resources, can benefit immensely from the immense potential of this technology to take super-specialist care to the masses. But a sustainable model of Telemedicine is possible only if can we address the gaps in technology and, at the same time, improve acceptability of the technology amongst the clinicians.

Acknowledgements

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Remote Follow-up of Liver Transplant Patients: a Telemedicine Implementation Project in Latin America

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Abstract

The follow-up of patients with liver transplant is a complex task for any multidisciplinary team. Such complexity grows when patients live far away from the healthcare center area where this procedure was performed. In order to provide a greater quality of care for our patients, our primary objectives are the creation of an academic community network to improve the interaction between our transplant team and the remote care provider, and the creation of a clinical data repository using telemedicine. We developed a web based system, used by follow-up physicians to improve the quality of care and the follow-up of transplanted patients.

Keywords:

telemedicine, liver transplantation, follow-up

Introduction

The Hospital Italiano of Buenos Aires is internationally recognized among health care organizations as a care giving leader, and a referring educational and research center in Latin America.

625 liver transplants have been performed, transforming this hospital into a national and international center of reference.

It's a well known fact that the follow-up care of the patients with liver transplant by a multidisciplinary team is a daily complex task to deal with. This complexity increases considerably if the patient does not live in the city where the procedure was performed [1, 2].

This project aims to improve the quality of the care of our patients, through the interaction between our transplant team and follow-up professionals in charge, allowing referring doctors, during the monitoring, to access medical data of their patients. There is clear evidence of the effectiveness of telemedicine in improving the health of patients, giving support to their referring physicians, mainly when the geographic distances matter [3].

Materials and methods

By the end of 1999 the Hospital Italiano of Buenos Aires started the development of a Health Information System (HIS), and its most emblematic product is its Electronic Health Record "Itálica" [4, 5], which allowed the centralization of all the health care information of our patients. It's on our HIS where we set the basis to implement this liver transplanted patient follow-up system.

In addition, the Hospital has a very well trained multidisciplinary team that provides comprehensive care to each patient, from the evaluation visit through the transplant procedure and postoperative period. In this follow-up instance is where required learned skills are difficult to transmit to a third-party team.

Finally, we have a network of teams, each one conformed by physicians located outside the area of Buenos Aires, which refer us the patients. These associated providers continue monitoring the evolution when the patients return to their home places.

We have decided to develop a web based system, supported by the data modeling established in our HIS, to allow the referring physicians, in different cities, to access all the health care information of their patients, as well as to update it.

Liver transplant program processes

Including a patient into our liver transplantation follow-up system is not a complex task. The system has a representation of the stages which a liver transplanted patient must pass through. It consists of five stages: (1) Patient Enrolling, (2) Aptitude Evaluation, (3) Pre-Transplant Waiting List, (4) Transplant, (5) Post-Transplant Follow-up List.

Local data registry system

The system was designed to represent all the stages in the liver program; in addition it incorporates one more instance that allows the referring doctor's office to record what happens in the follow-up visit.

Enrollment of patients refers to the capture of certain administrative data (for example the allocation of the med-

ical team that will continue with the monitoring) and medical data (diagnosis pre-evaluation, etc.). The data is required by the Liver Program, supported by our Hospital Master Patient Index [6], based on CORBAmed [7, 8].

All data is loaded by physicians of our institution, registered in our HIS, and then, associated with other patient's medical data in the Electronic Health Record (EHR).

Remote visualization and data registry system

Once data is generated, referring doctors may visualize this information along with the rest of the patient's EHR data, from their offices via Internet. They access the system through a connection established on a VPN (Virtual Private Network) [9].

The remote data entry module is used by the referring physicians, and allows them to record any medical events during the period between Hospital Visits. They may also load results of complementary studies, either by typing or by digitalization of all the information that the patient can require.

For this last issue we had to develop an archive storage system (text documents, images, videos, etc.) that includes a viewer of JPEG images and DICOM files, which allows us to reproduce a CT scan or MRI console in practically any PC used as Workstation.

Technological requirements

We have developed our system under the security standards established by Windows XP SP2, and we considered necessary, for an optimal performance, a Pentium IV with a 512 Mb RAM. The minimum connection requirement is at least 256 Kbps of broadband connection.

Results and discussion

Today we have connected two distant monitoring medical teams of our patients, one within the province of Buenos Aires (República Argentina) and other one in Montevideo (República Oriental del Uruguay). The team at Montevideo is monitoring 78 Uruguayan patients transplanted in our Hospital. At the closure of the present work, we have 410 enrolled patients in the Transplant Program.

We have reviewed some experiences using telemedicine to follow-up and to assist patients [10], but we have not found references in the literature about the use of these applications for the remote monitoring of patients with liver transplant. We hoped that the implementation of this type of solutions can settle an improvement in the quality of the care of our patients, bringing assistance to distant doctors thanks to new TIC's.

On the other hand, we are in an experimental stage, running the program in a pilot level and still we know that we depend on the interaction and commitment of the distant medical team, nevertheless we clearly believe that this tool will contribute much to fulfill one of our main institutional objectives: the continuous search for the best quality of patient care.

There is no way to believe that the system will replace contact between the referring doctors and our local transplant team, but is a complement for the daily transdisciplinary work.

We expect to generate an academic and clinical community, which allows care givers access the patients' medical records with this remote data entry module. Today we have been using it in the follow-up of patients with liver transplant; but we think that it might be able to support any kind of patients. We state for sure that it could be the beginning of the remote consultation to the EHR of our patients.

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Remote Follow-up of Liver Transplant Patients: a Telemedicine Implementation Project in Latin America

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Introduction

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Materials and Methods

The multidisciplinary team provides comprehensive care to each patient, from the evaluation visit through the transplant procedure and postoperative period.

Network of teams conformed by physicians located outside the area of Buenos Aires which refer us the patients.

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Health Information System (HIS)

Electronic Health Record "Itálica"

allows the centralization of all the health care information of the patients

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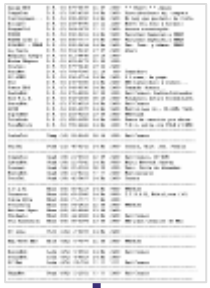
Liver Transplant Program Processes

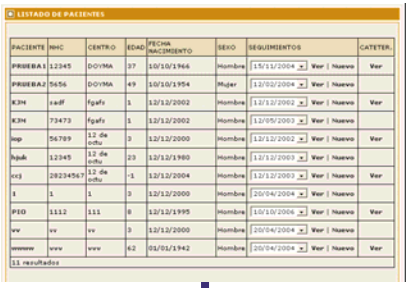


Patient Enrolling

1

Pre-Transplant Waiting List

3



Post-Transplant Follow-up List

5

2

Aptitude Evaluation

4

Transplant

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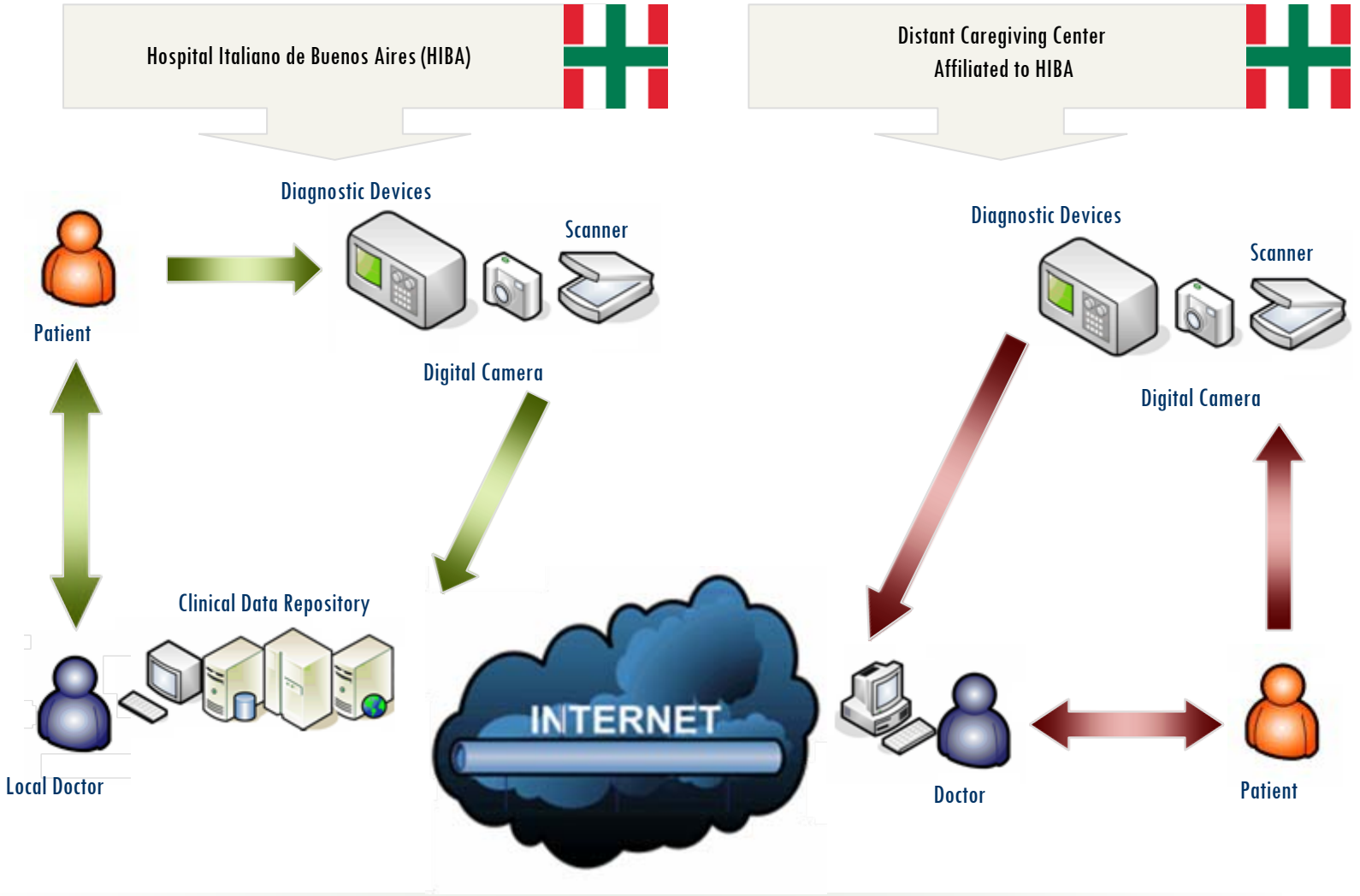
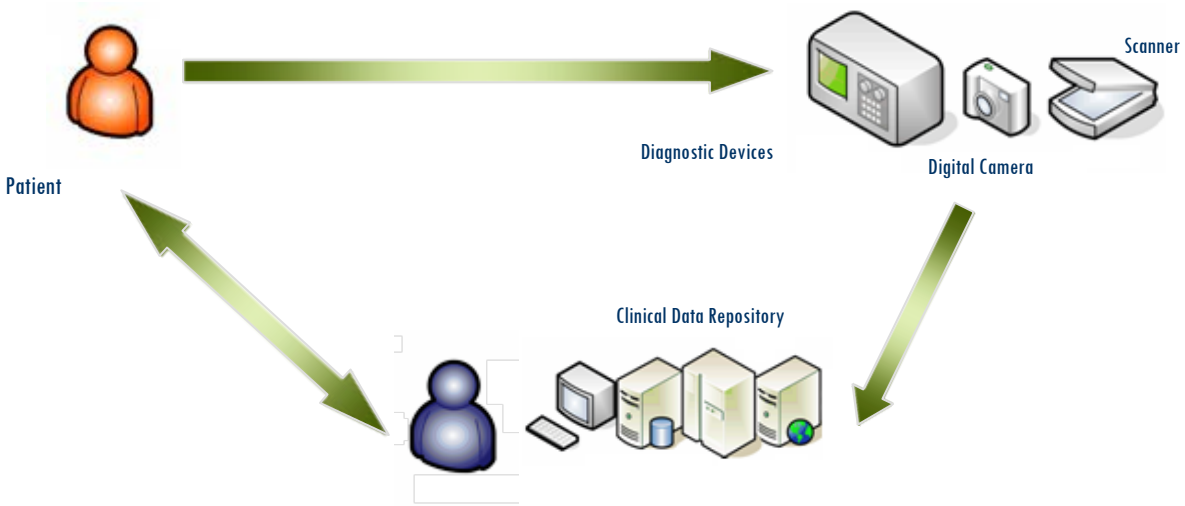
Local Data Registry System



Local Data Registry System

- Enrollment of patients refers to the capture of certain administrative data (for example the allocation of the medical team that will continue with the monitoring) and medical data (diagnosis pre-evaluation, etc.).



- All data is enter by physicians of our institution, registered in our HIS, and then, associated with other patient's medical data in the Electronic Health Record (EHR).

Remote visualization and data registry system

- Once data is generated, referring doctors may visualize this information along with the rest of the patient's EHR data, from their offices via Internet. They access the system through a connection established on a VPN (Virtual Private Network).

- The remote data entry module is used by the referring physicians, and allows them to record any medical events during the period between Hospital Visits. They may also enter results of complementary studies.
- An archive storage system (text documents, images, videos, etc.) that includes a viewer of JPEG images and DICOM files, which allows us to reproduce a CT scan or MRI console in practically any PC used as Workstation.

Technological requirements

- Software: Windows XP SP2
- Hardware: Pentium IV with 512 Mb RAM.
- Broadband connection: 256 Kbps.

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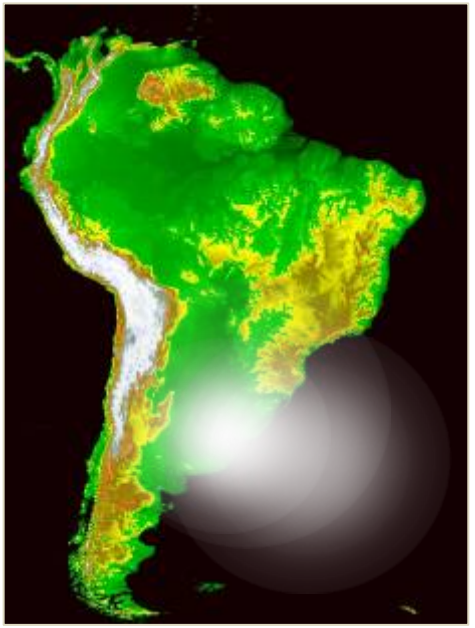
Results and Discussion

- Two distant monitoring medical teams
  - →Buenos Aires (República Argentina)
  - →Montevideo (República Oriental del Uruguay)
    - 78 patients



Results and Discussion

- There is no way to believe that the system will replace contact between the referring doctors and our local transplant team, but is a complement for the daily transdisciplinary work.

- We expect to generate an academic and clinical community, which allows care givers access the patient´s medical records with this remote data entry module.

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A Business Model of Taiwan's RFID Network Platform in Healthcare Industry

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Healthcare is life-critical. Any medical mistakes may cause irremediable regret. Patient safety is the most important issue in healthcare industry. The bottleneck of Hospital Information Systems (HIS) is the inability of tracking and identifying the patient's information like name, dispose content, operational time, and location. Radio Frequency Identification (RFID) technology can provide some supports to solve the problems to make better decision by HIS.

There are some RFID pilot projects in healthcare which have verified that it can enhance care quality, decrease medical errors, and increase both efficiency and effectiveness in healthcare resource. A "RFID Network Platform" is necessary for spontaneous and innovative applications to proliferate, and the business model is important to the platform provider for stimulating and channeling innovations to drive the network effect in healthcare industry.

This research proposes a business model for Taiwan's RFID network platform in healthcare industry. Based on the platform business model, we examined RFID applications in drug control, blood bag control, emergency medical service, and long-term care service.

Keywords:

Radio Frequency Identification (RFID), network effect, platform strategy, business model, National Healthcare Information Infrastructure (NHII)

Introduction

Healthcare is life-critical. Any medical mistakes may cause irremediable regret. Patient safety is the most important issue in healthcare industry. World Healthcare Organization (WHO) and other organizations all pay much attention about reducing medical errors and creating a medical environment for patient safety. The famous organization in healthcare, Institute of Medicine (IOM), proposed that many medical errors occur because of human carelessness. The bottleneck of Hospital Information Systems (HIS) is the inability of tracking and identifying the patient's information like name, dispose content, operational time, and location. Under such situation, it is difficult to make better decision from HIS.

Radio Frequency Identification (RFID) technology can provide objects identities, tracking and tracing. Some pilot projects have verified that it can enhance care quality, decrease medical errors, and increase both efficiency and effectiveness in healthcare resource deployment if RFID technology is applied.

In terms of economic value, there are many potential fields to implement RFID technology such as in biotechnology labs, pharmaceutical manufactories, medical appliance transportations, hospitals, and in extended healthcare service providers. Some of the applications may soon become killer applications if the government policy or some other factors trigger a mass-scale implementation.

An RFID network platform is necessary for spontaneous and innovative applications to proliferate, and the business model is important to the platform provider for stimulating and channeling innovations.

The level of information technology implementation in Taiwan's healthcare industry is high because hospitals need information systems compatible with the monopolistic from "National Insurance System" to apply medical expense. The research in the field of healthcare information management in Taiwan is also advanced because of the popularized internet infrastructure and universal users adopt rate.

Taiwan government has been paying considerable attention to RFID related industries, especially in healthcare industry. There are some government-funded pilot projects seeking to deploy RFID technology in hospitals. However, RFID implementation demands intensive and extensive data exchanges not only between levels but also across different organizations. This calls for a technologically robust and commercially sustainable platform.

This research proposes a business model for Taiwan's RFID network platform in healthcare industry. The result of research has been adopted by the Department of Health (DOH) and Ministry of Economic Affairs (MOEA) in Taiwan as guidance for future government-funded projects.

Conclusion

This research proposes a business model for Taiwan's RFID network platform in healthcare industry. We design

system architecture and the whole infrastructure for healthcare which reference from EPC Network in MIT. Based on the platform business model, we examined RFID applications in drug control, blood bag control, emergency medical service, and long-term care service.

There are some RFID pilot projects in healthcare which have verified that it can enhance care quality, decrease medical errors, and increase both efficiency and effectiveness in healthcare resource. An "RFID Network Platform" is necessary for spontaneous and innovative applications to proliferate, and the business model is important to the platform provider for stimulating and channeling innovations to drive the network effect in healthcare industry.

"RFID Network Platform" stands on a critical position in healthcare value chain. It's an important research issue for us to plan a suitable platform for healthcare to solve many existing problems in healthcare industry. And it will create many new business opportunity in the evolution about integrating RFID technology in healthcare.

The research is an exploratory study to investigate the planning and the developing strategy of "RFID Network Platform". In the future research, will reference more researches and reports from the "financial transaction platform in banking", "supply chain management (SCM) platform", and research about platform developing strategy. And finally, we will try to develop a model about the information platform developing strategy in healthcare.

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The Asthma Clinical Assessment Form and Electronic Decision Support Project (ACAFE): Collaborative Innovation and Development

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[b] *The Canterbury Hospital, NSW Australia*
[c] *Medical Systems Development and Research Group*

Abstract

Objective: The objective of this study was to describe the development of a dynamic and interoperable clinical platform prototype designed by Emergency Physicians.

Method: The investigators used collaborative innovation approach.

Results: A disease specific clinical platform that streamlined information processing and incorporated clinical pathways and quality control into workflow.

Conclusions: Collaborative innovation and problem orientated approaches are required to develop effective health informatics solutions in Emergency Medicine.

Keywords:

asthma, decision support, collaborative innovation

Introduction

Implementation of interoperable health information technology (IT) platforms and electronic decision support systems (EDSS) are important strategic goals for future health systems around the world[1,2].

Acute asthma is a common cause of presentations to Emergency departments. Current evidence suggests that asthma management in Emergency Departments (ED) is inconsistent, resulting in suboptimal compliance with evidence-based guidelines[4,5,6,7]. We report on the first interoperable and dynamic EDSS developed by Emergency Physicians for use in ED.

Methods

Conceptualisation and hypothesis generation

Key to development was identifying problems and dilemmas facing clinicians in a busy emergency department. Some of the problems identified through consensus were multiple and disparate information or data entry points, inconsistent use of clinical pathways and lack of real time quality control mechanisms.

Literature review

We performed a literature search through Medline and relevant Health Informatics publications from 1996-2006 to identify examples of EDSS for ED

Field study

A feasibility study was undertaken by Health Information Specialists to review processes of care in the current ED environment

Collaborative innovation

This concept involves the collaboration of business and consumer partners to create new products or identify new trends based on consumer needs [8]. In this project a small group of clinicians and health informatics specialists (HIS) worked together to identify clinician needs and structure workflow models (Medical Systems Development and Research Group - see www.msdrg.org).

Clinical platform development

HIS and clinicians collaborated to model clinical workflows in ED. Rapid prototype engineering was employed to continually improve on the modeling process.

Clinical platform architecture

The system aimed to comply with the National E-Health Transition Authority (NEHTA) standard guidelines for electronic decision support systems [9]. The system was also developed to adhere with HL7 principles relating to semantic and functional interoperability [10].

System evaluation

The system was evaluated in three phases: internal beta testing, simulation trials using emergency department doctor performance and clinical implementation trials.

Results

Clinical platform development

Through collaborative innovation over 12 month period, an online interface known as the Asthma Clinical Assessment Form and Electronic decision support (ACAFE) was developed.

Clinical platform features

The clinical platform incorporated multi-environment display panels focusing on ED workflows. Panels were organised using pan-out user interface design and followed the logical steps from top to bottom and left to right. ACAFE offered decision support in several dimensions. This included support for clinical diagnosis and management plan processes. The system promoted uptake of evidence based guidelines through severity grading pathways. ACAFE allowed monitoring of various clinical performance indicators such as waiting times, consultation times and discharge rates.

Basic System Architecture

Minimum server operating requirements for ACAFE system included PC with Intel Pentium III™ compatible 700MHz processor, 512MB RAM, with Windows XP Professional Service Patch 2™ operating system. The system was hosted on Internet Information Services 5.1 and accessible via hospital intranet. Further details of the system can be viewed at http://www.ostechnology.com.au/product_acafe.html

Discussion

ACAFE was the first decision support system designed to solve specific problems relating to ED information flows and adherence to clinical pathways. This problem orientated process was achieved through collaborative innovation.

The result was a dynamic interoperable clinical platform which enabled streamlining and consolidation of ED documentation and facilitated use of clinical pathways. This was coupled with real time quality control features that allowed monitoring of trends and variations in clinical practice.

Conclusion

We have demonstrated that novel solutions to information processing problems in the ED can be created using collaborative innovation and problem-orientated approach. This has important practical implications for future EDSS developments.

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Asthma Clinical Assessment Form and Electronic decision support (ACAFE) project

Dr Michael Dinh MBBS FACEM

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Royal Prince Alfred Hospital, NSW Australia

Introduction and scope

- Emergency Departments (ED)
  - High acuity
  - Rapid patient turnover
  - Information and communication critical
- Sustainable solutions to clinical pathways, multiple data entry, quality control
- EDSS and integrated clinical management systems designed for ED

Objectives

- Demonstrate collaborative innovation for development of problem orientated solutions
- Develop integrated EDSS using asthma clinical pathway as prototype
- Demonstrate performance improvements using this system

Methods

- Conceptualisation
  - Multiple data entry
  - Inconsistent uptake of clinical pathways
  - Limited quality control
- Literature review
- Collaborative innovation
  - 12 month project
  - Emergency Physicians
  - Health Information Specialists
  - Workflow modeling, data fields and clinical pathways

Methods

- System development
- System evaluation
  - Internal
  - External
- Ethics approval

ACAFE System Evaluation Outcomes	
Category	Indicator
History	Asthma precipitating factors
	Previous Intensive Care admissions
Examination	Oxygen saturations
	Ability to verbalise (words, phrases, sentences)
	Chest ausculation findings
	Peak Flows (pre and post bronchodilator PEF)
	Asthma Severity (mild, moderate, severe)
Discharge	Written asthma plan provided
	Smoking cessation advice provided
	Oral corticosteroids

ACAFE FUNCTIONALITIES

Basic Functions	Patient registration and tracking
	Triage
	Clinical assessment forms
	Management summary
	Medication chart
	Electronic order entry
	Progress notes
	Discharge summary
	Discharge documentation
Clinical Document Management	Automated discharge summary
	Automated asthma management plan
	Treatment order field and management plan linkage
Electronic Decision Support	Asthma severity grading
	Suggested treatment pathways
	Allergy alerts
	Smoking cessation and asthma management plan advice
Performance management	Waiting times, consultation times, time of clinical review
	Alerts for missing data fields
	Tracking multiple patients along clinical pathway
Quality control	Waiting times
	Admission and discharge rates
	Investigation order entry trends
Potential functions	Automated GP electronic communication

HD Michael Dinh (Staff Specialist) 10/05/2007 9:49:06 AM

ACAFE

Patient name: **Test Patient 2**
Date of birth: 14/05/1985
Triage note: SOB
History of presenting problem:

Patient ID: 18Patient 2
Sex: Male

Triage Category: 1
Triage time: 10/05/2007 9:48:59 AM
Sent to: Waiting room
Completed by: Nurse details

Target Time to disposition is 12:49AM. 3 hrs and 0 mins remaining.
Target Time to notify accepting physician is 2:49PM. 5 hrs and 0 mins remaining.
Target Time to move to inpatient ward is 3:49PM. 6 hrsand 0 mins remaining.

- Registration
- Triage
- Clinical Assessment
- Diagnosis
- Management Plan
- Progress
- Disposition
- Last Updates

Asthma Severity Grade Pending...

- File Management >
- View >
- Search >
- Decision Support >
- Admin reports >
- Logout

History

Presenting problem	
History of presenting problem	
Associated symptom	☐ Fever ☐ Chills/Sweats/Rigors ☐ Chest Pain ☐ Rash ☐ Vomiting ☐ Diarrhoea
Previous diagnosis of asthma	○ Yes ○ No
Is an asthma background history required?	◉ Yes ○ No

Asthma background history

Asthma onset	☐ Childhood ☐ Adult ☐ Unsure
Precipitating factors	☐ Respiratory Tract Infections ☐ Cold Weather ☐ Exercise ☐ Dust/Pollens ☐ Paroxysmal
Frequency of episodes	☐ Infrequent ☐ Frequent ☐ Constant
Interval symptoms	○ None ○ Nocturnal Cough ○ Wheeze
Does the patient have a management plan?	○ Yes ○ No
Is the patient usually on oral corticosteroids?	○ Yes ○ No

System Alert

Field Comments

History of Changes

HD Michael Dinh (Staff Specialist) 10/05/2007 9:49:06 AM

ACAFE

Patient name: **Test Patient 2**
Date of birth: 14/05/1985
Triage note: SOB

Patient ID: 18Patient 2
Sex: Male

Triage Category: 1
Triage time: 10/05/2007 9:48:59 AM

Sent to: Waiting room
Completed by: Nurse details

Target Time to disposition is 12:49AM. 1 hrs and 55 mins remaining.
Target Time to notify accepting physician is 2:49PM. 3 hrs and 55 mins remaining.
Target Time to move to inpatient ward is 3:49PM. 4 hrs and 55 mins remaining.

History of presenting problem:

Suggested Management Plan *Progress on Severe asthma - Stable*

TREATMENT	add	SALBUTAMOL	5MG	NEB	EVERY TWENTY MINUTES
INVESTIGATION	add	NIL FURTHER			
CONSULTATION	add	REVIEW WITH SENIOR ED STAFF			
OBSERVATION	add	CONTINUOUS CARDIORESPIRATORY MONITORING			
DISPOSITION	add	ADMIT			

Actual Management Plan *Progress on Severe asthma*

Progress number	1
Date/Time	10/05/2007 10:50:30 AM
Progress Note by	HD Michael Dinh (Staff Specialist)
Note	

System Alert

1. Severe asthma indicator
2. Manage airway, breathing circulation transfer to resuscitation room call for immediate senior ED and anaesthetic assistance

Field Comments

1. Smoking cessation advice sheet to be given
2. If yes then severity grade must be moderate or severe
3. Add investigation laboratory blood culture and chest X ray
4. Suggested Management Plan for treatment order has not been followed, SALBUTAMOL INHALED METERED DOSE INHALER 100MCG/DOSE has been selected with 12 PUFFS, SPACER and EVERY 4 HOURS

History of Changes

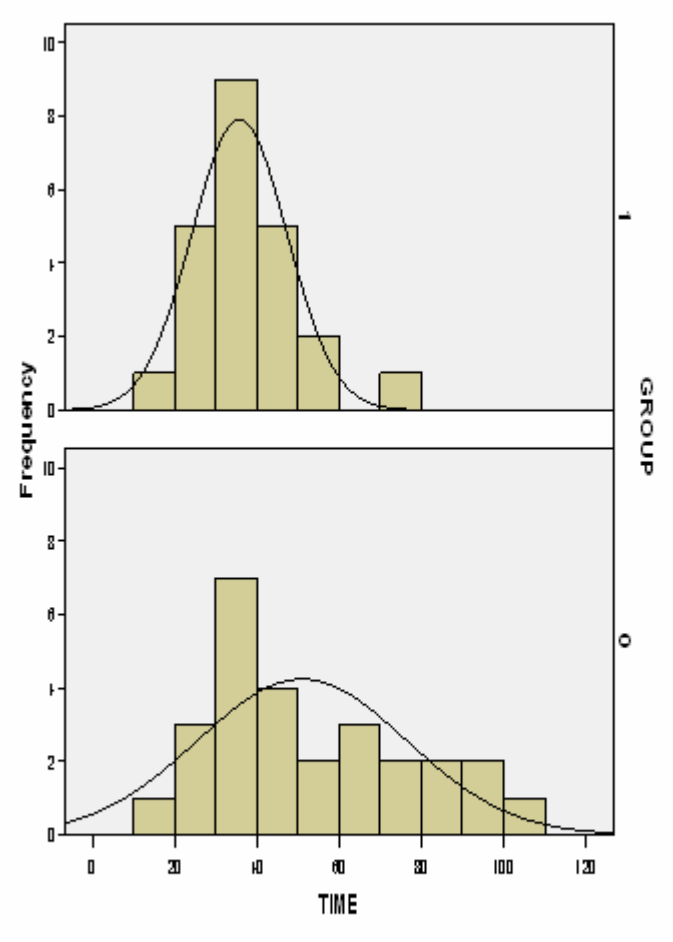
Asthma severity grading

CATEGORY	CLINICAL FIELD	METRIC	MILD	MODERATE	SEVERE
HISTORY	FREQUENCY OF EPISODES		INFREQUENT	FREQUENT/CONSTANT	CONSTANT
	INTENSIVE CARE ADMISSIONS		NO	YES	YES
EXAMINATION GENERAL INSPECTION	CYANOSIS		NO		YES
	PHYSICAL EXHAUSTION		NO		YES
	ALTERED MENTAL STATE		NO		YES
	SPEAKING IN		FULL SENTENCES	PHRASES	WORDS
VITAL SIGNS	PULSE VALUES	BEAT PER MINUTE	<100	120-140	>140 OR <40
	OXYGEN SATURATIONS	%	>95	92-95	<90
RESPIRATORY EXAMINATION	WHEEZE INTENSITY		MILD/VARIABLE/SCATTERED	MODERATE/DIFFUSE/LOUD	SEVERE/SILENT CHEST
SPIROMETRY	PEAK FLOW%	%PREDICTED	>75	50-75	<50
	PEAK FLOW	L/SEC			<100
	FEV_1%	%PREDICTED	>75	50-75	<50
	FEV	L			<1
DIAGNOSIS	CONFOUNDING FACTORS		NIL	CONFOUNDING FACTORS PRESENT	

Results

- System Evaluation
  - Internal
  - External
- Randomised control trial
- Clinical implementation trial

Results – randomised control trial



Study groups and main outcomes (* denotes significant value)

Category	Group N (%)	PI= 27	54%	EI= 23	46%	P value= 0.42	K (95%CI)
Age	Age (yrs) (SD, 95%CI)	30.1	5.72 (27.8-32.3)	32.4	6.11 (29.8 - 33.0)	0.17	
Sex	Male (%)	14	50%	10	43%	0.55	
Seniority	Intern (%)	6	22%	2	9%		
	RMO (%)	6	22%	3	13%		
	SRMO (%)	5	20%	6	26%		
	REG (%)	7	26%	10	43%		
	SS (%)	3	11%	2	9%	0.57	
Documentation	Precipitating factors	26	96.3%	23	100 %	0.35	
	Previous ICU	16	59.3%	23	100 %	0.01	
	O2 Sats	22	81.5%	21	91.3 %	0.32	0.79 (0.56.1.0)
	Chest Auscultation	26	96.3%	23	100 %	0.35	1.00
	Peak Flow	14	51.9%	19	82.6 %	0.02	0.82 (0.65-0.98)
	Speaking	16	59.3%	22	95.7 %	0.03	0.75 (0.53-0.98)
	Asthma Severity	17	63.0%	23	100 %	<0.01*	0.93 (0.81-1.0)
	Smoking Cessation advice	8	29.6%	22	95.7 %	<0.01*	0.96 (0.87-1.0)
	Asthma management plan	15	55.6%	23	100 %	<0.01*	0.82 (0.62-1.0)
	Oral corticosteroids	16	59.3%	20	87.0 %	0.03	0.84 (0.67-1.0)

Discussion

- Dynamic EDSS system prototype
  - Designed by Emergency Physicians for ED
  - 1st reported study using collaborative innovation
  - Clinical pathways, document management, real time quality control
- Problem orientated approach
  - Multiple data entry
  - Clinical guideline compliance
  - Quality control mechanisms
- Improvements in performance measures
  - Asthma documentation quality
  - Improved consultation times
  - Improved discharge information rates

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- Contact: dinh.mm@gmail.com

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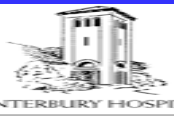
MSDRG thinking global



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Thematic Analysis of CPOE Implementation in Inpatient Settings Using Fit and Subjective Usability in the DeLone Model

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Abstract

Computerized Order Entry Systems (CPOE) are transformational technologies: their successful implementation is a process of change within complex healthcare settings. This paper presents a practical thematic analysis of a sample of the CPOE implementation literature. By using the concepts of subjective usability and fit within the Information System (IS) success model of DeLone and McLean, we show that models can be used to both organize themes and explain the concepts themselves. The DeLone model does not address change, however, therefore we suggest a broader context for the model. This study begins to address Kaplan's concerns about gaps in implementation knowledge of user acceptance and changes in work. It also provides a practical tool for organizing themes for future research. Increasing awareness about the IS implementation context will ultimately improve the safety and effectiveness of these systems.

Keywords:

attitude to computers, Computerized Physician Order Entry System, qualitative research, thematic analysis

Introduction

The healthcare system is a complex adaptive system and successful Computerized Physician Order Entry (CPOE) implementation is a process of transformation within these complex healthcare settings [2]. Success is difficult to measure. One way of assessing success is to apply established models of system implementation success as sources of themes that lead to success or, conversely, failure. Kaplan [1] feels that reviewing implementation is important because it is often ignored, it does not often concern issues of user acceptance or changes in work and finally, it does not examine processes of actual system use during daily activities. We begin to address the gap in the literature identified by Kaplan [1] with a thematic analysis of CPOE system implementation in inpatient settings.

An "efficient technology" is referred to as the one which reinforces current ways of working and performing ongoing tasks, and a "transformational technology" as the one which changes the nature of the work, as differentiated by Sviokla [3]. Physician order entry (POE) systems are transformational technologies [3]. To transform work practices requires an awareness of collaboration in healthcare [4].

The process of implementation of CPOE in an inpatient setting is successful only when the system satisfies the human end-users of the system. Satisfaction is a perception following the implementation of the system in an organizational setting. We examine a sample of the CPOE implementation literature with the concepts of fit and subjective usability within the IS success model of DeLone and McLean (Figure 1) [5]. We hypothesize that successful CPOE implementation means that the system has good fit at the organizational level and satisfaction at the user level as defined by subjective usability. There are several advantages to placing themes in a model: first, this helps to organize themes; second, and conversely, the themes may also begin clarifying the abstract concepts of fit and subjective usability; and third, there is a practical purpose in describing our approach that others might find useful.

Concepts used in this study

Fit. Kaplan describes fit as *"there are a variety of dimensions to 'fit,' including the following: workflow, level of expertise, professional norms, values, institutional setting, communication patterns, organizational culture, technology and information needs. 'Fit,' then, is useful for understanding implementation issues surrounding a particular system, why the same system may be viewed differently by different users, and also why it may be implemented more successfully in one setting than in another. 'Fit' also links evaluation and design."* [6]. We shall apply Kaplan's dimensions to the CPOE implementation literature to categorize organizational themes.

Usability. We use Hornbæk's model of usability as it provides the ISO 9241 standard usability definition as the *"[e]xtent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction [7]."* We shall be concerned with the satisfaction element of usability. Satisfaction is also difficult to measure as there are subjective usability mea-

sures of users' perception of or attitudes towards the interface, the interaction, or the outcome; and, objective measures using standardized instruments [7]. We shall use subjective usability to categorize user satisfaction themes.

DeLone and McLean's IS success model: the link for usability and fit

The IS success model of DeLone and McLean is an established construct for evaluating information system (IS) success as a process of understanding of IS and their impacts. van der Meijden et al. have established the usefulness of this model for system evaluations [7]. They used the 1992 version of the DeLone model. IS success is multidimensional and interdependent [8]. We felt this trait would be helpful for this thematic analysis of implementation of CPOE systems into inpatient settings. We have placed fit within net benefits because this both captures the higher level organizational dimensions of Kaplan and includes the organizational impact element of the 1992 model. Information, system, and service quality are not discussed here. Figure 1 shows the model adapted to show subjective usability and fit.

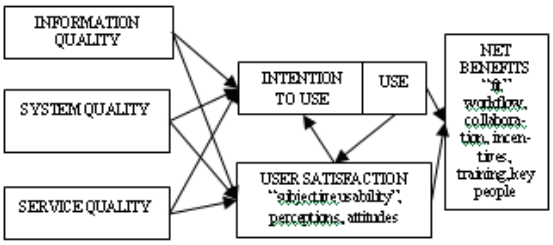

Figure 1 - Adapted from DeLone and Malone's updated D & M IS success model [5]

Methods

Literature Search

We performed a literature search using the terms "CPOE" OR "order entry" OR "e-prescribing" OR "electronic prescribing" or "electronic prescription" OR "computer prescription". This was to provide for the greatest search sensitivity. We interpreted CPOE for the purpose of this study broadly as a clinical information system [9]. The bibliographic databases PubMed. CINAHL, ISI Web of Science, and Compendex, were searched using the above search terms for the period ending November 1, 2005. Later a few articles were found incidentally. A start period was not specified. Since we found that the majority of the articles found in the other databases overlapped with those retrieved from PubMed, we used only the PubMed articles to maintain uniformity in the information and reduce redundancy of information. The bibliographies of the selected articles were not used to find additional references.

Study Criteria

The titles and abstracts of the articles were analyzed against the "inclusion" and "exclusion" criteria (Table 1) to obtain articles for the narrative review. The overall strategy was to review CPOE implementation in general within inpatient settings. A detailed reading of the included articles against the criteria allowed a further reduction in the study set to provide a final set that met the inclusion criteria.

Quality Assessment

The articles were then analyzed for their quality using assessment sheets based on the Critical Appraisal Skills Programme (CASP) appraisal tools [10] (The Quality

Assessment sheets for the selected articles can be provided on request to the authors).

Measure	Inclusion criteria	Exclusion criteria
Population	People: Physicians Inpatients Setting: Acute care	Outpatient, non-MD entry, primary care, ambulatory care, family practice, specific unit for eg. ICU, PICU, NICU
Intervention	CPOE implementation	CPOE specific manufacturers, design costing, cost/benefit, CPOE and: lab IT, radiology Information technology, health information system, decision support system, computerized information system, electronic health record, electronic medical record, guidelines, pharmacy information system, e-prescribing, specific drugs, dose calculators, barcoding
Outcomes	Human factors, usability	Changed behavior, test ordering, save time, benefit, medical error, safety, medication error, workload, nursing roles, education, training
Literature	Study type: evaluation, review, Medinfo proceedings, grey literature, expert opinion/consensus statement with evidence Language: English	Study type: editorial, opinion correspondence, commentary, interview

Table 1: Inclusion and exclusion criteria used for literature review for thematic analysis for CPOE implementation

Thematic anlysis

We undertook a simple qualitative narrative review that was concept-centric rather than an author summary [11]. This process is to identify and bring together the main, recurrent or most important issues or themes arising from a body of literature [12]. This technique was similar to the inductive approach described by Thomas [13]. This will be discussed further below. Nineteen articles met the inclusion criteria.

The quality assessment sheet had a section for themes: any comments or opinions about the CPOE implementation process were placed in this section. The sections were placed in a separate document. Re-reading of the comments and opinions permitted them to be grouped under concrete noun headings such as work, collaboration, barriers etc. Content analysis software was not used.

Results

Thematic analysis

"Fit" is a change of technology and workflow

Fit is a dynamic process [14]. Five articles describe fit as the relationship between technology and work practices or work flow [2, 4, 14, 15, 16, 17]. Fit is achieved through change or transformation of technology and work practices [14]. Some authors see only the technology as transforming work [3, 16], rather than a pure efficiency tool [3]. The organization's track record of making changes in the past influences these transformational changes as CPOE changes committee structures, member ship and accountabilities [17].

Encourage change: collaboration. This awareness can be fostered by educating all members of the healthcare team on the activities of other group members, so that each person understands what others do [16]. People work collaboratively when using clinical information systems and not recognizing this is a source of implementation failure [16]. Collaboration must also happen between administration and clinicians [18]. There must also be collaboration between problem solvers meeting regularly with users to work out procedural issues that cross boundaries [19].

Encourage change: training and support. Training and support are important tools to help staff change and accept CPOE. There must be extensive 24/7 support and a formalized training program before, during, and after implementation [18, 19, 20, 21]. Support must focus on problem solving to improve the system [19]. Problems will occur; they will be solved only if people focus upon how to make the system work better instead of being diverted by the question of whether the institution should be implementing CPOE [19]. Clinicians need to be educated about the potential long-term benefits of CPOE and remain open to the possibility of changes in their workflow [22].

Encourage change: incentives. These can include paid release-time fees to physicians to compensate them for time spent outside their clinical and administrative duties [16]. Incentive structures can also exist at the institutional level such as better access to care, better quality of care, lower cost of healthcare, lower administrative costs, improved patient management, and improved physician training incentives must be created to motivate each user

to adopt new medical technology [16]. Park et al. have attributed the high availability of CPOE systems to a combination of governmental encouragement, efforts and financial incentives and cultural characteristics in their study [23].

Encourage change: key people. Key people are identified as having universal attributes, including stability through adversity, steadfastness, initiative, and toughness [16]. These include: clinicians, top leadership, chiefs of staff, CEO, advisory groups, problem solvers [19, 21, 24, 25].

User Satisfaction is experienced as efficiency

Mekhjian et al. mention that they did not experience any significant negative results from CPOE implementation [21] though, others have experienced the opposite [22]. User satisfaction is increased when there is supportive administration and supportive heads of medical sections, direct involvement of physicians, mandatory implementation, adequate training, and sufficient hardware [25]. People who have *already changed and committed to a change* (emphasis added) focus more on issues surrounding actual implementation whereas those still contemplating the change are more concerned with the pros and cons [25].

The strongest correlates of CPOE satisfaction in the literature were efficiency characteristics such as productivity, ease of use, and speed. Van der Meijden et al. have a similar finding with a different reference set [8]: only our [4] was also discussed. The characteristics of CPOE that played a more significant role in changing the way the physicians made decisions about orders, such as reducing error and giving needed information were weaker correlates of satisfaction. In other words, although the technology itself was transformational, and patients and the hospital benefited substantively from improved quality and reduced costs, the users' satisfaction of the technology was primarily predicted by efficiency concerns [16, 21, 26]. Murff et al. suggest that the feedback of the physician's regarding satisfaction with the usage of information systems should be sought continuously and conclude that user satisfaction is a vital marker for usability of any information system [26].

Discussion

We reviewed a sample of the CPOE implementation literature that is based on inpatient settings use rather than experimental settings. The settings include the US, Holland and Korea. This points to the themes of CPOE implementation which cross boundaries. We see from the literature that fit is a key concept. Successful implementation means a good fit of technology and work practices. The literature suggests that change is necessary to achieve a good fit: some of the enablers of change are collaboration, training, support and incentives. These terms also help to define what fit is. User satisfaction also leads to fit. The users, primarily physicians in our literature, feel more efficient and are satisfied as a result.

Our thematic analysis showed that users who have changed focus on implementation and that there are enablers of change to enhance fit. The implementation process has been described as a "transformation" [2].The DeLone model does not address change. For convenience, we have placed the enablers of change within the context of organizational net benefit.

The difficulty in accommodating change into the DeLone model suggests that the DeLone model needs a broader context. Van der Meijden et al. state that the multidimensional construct of the model is appropriate for system evaluations [8]; however, change and transformation must also be captured.

Orlikowski and colleagues [27] discuss the implementation as change in a tripartite model (Figure 2): "first, the changes associated with technology implementation constitute an ongoing process rather than an event with an end point after which the organization can expect to return to a reasonably steady state; second, all the technological and organizational changes made during the ongoing process cannot, by definition, be anticipated ahead of time." They identify three types of change: *anticipated* or planned change; *emergent* or spontaneous change from local innovation; and *opportunity-based* or intentional change in response to an unexpected opportunity, event, or breakdown. The three parts of this model are interdependent.

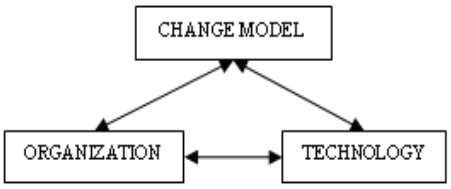

Figure 2 - Adapted from Orlikowski et al. [27; figure 3]

There is technology, or in our case, the CPOE system as described by the Delone model; the organizational context (culture, structure, roles and responsibilities); and the change model used to manage the three types of change listed above. The interaction among the three parts should be harmonious. Management can determine either a change model that is rigid with each step predefined and controlling events to fit the plan or flexible and responsive. This would require an explicit, ongoing examination and adjustment, where and when necessary, of the technology

and the organization [27]. In other words, there is constant change and feedback reacting with the system as our themes suggest.

Change and other themes could have been examined with a more rigorous method such as a general inductive approach [13]. This method uses detailed readings of raw data to derive concepts, themes, or a model through interpretations made from the raw data [13]. It is a tool used to describe the actual program effects, not just planned effects. The identification of any significant unplanned or unanticipated effects or side effects arising from program implementation can be seen as an important evaluation task [12]. The premise of evaluating effects in a structured manner would be very useful for implementation.

The outcome of an inductive analysis is the development of categories into a model or framework that summarizes the raw data and conveys key themes and processes. The category may also be linked to other categories in various relationships, such as a network, a hierarchy of categories, or a causal sequence [13]. This method is used to create models that might even show causation between satisfaction/efficiency and fit. For example, CPOE related adverse events [28] could be seen as a breakdown subjective usability and/or fit. It could also be used to examine the types of change identified by Orlikowski and colleagues [27].

Our method used an existing model, the DeLone and McLean's Information System (IS) success model to group themes, rather than creating a new model as in inductive analysis. This method is also useful to begin clarifying the concepts of subjective usability and fit themselves. This is a useful first step. Kaplan believes that because implementation is often ignored: implementation issues and barriers to system use are little different today from what has been reported over the past 50 years. This may be partly because post-implementation system evaluations often ignore issues concerning user acceptance or changes in work [1]. We find that there are limitations to the DeLone model because the change aspects identified in the literature and by Kaplan above are not easily accommodated in the model. We suggest the DeLone model addressing technology or systems be placed within a wider context of change model and organization. This would mean placing the DeLone IS success model in the "technology" construct of Orlikowski's model shown in
Figure 2.

Conclusion

We have addressed Kaplan's concern about user acceptance and changes in work by using subjective usability (user satisfaction) and fit respectively. We have used a sample of international CPOE implementation literature to find and organize some themes describing these concepts within an IS success model. Although the IS success model is useful for thematic analysis, more rigorous techniques of thematic analysis and a broader context for the IS model are needed to capture the transformational impact of implementation.

Acknowledgements

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Thematic Analysis of CPOE Implementation in Inpatient Settings Using Fit and Subjective Usability in the DeLone Model

Rekha Gaikwad & Elizabeth Keay

Medinfo 2007

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- Funding support from Canadian Institutes of Health Research (CIHR) Strategic Training Program (CHPSTP).

Introduction

- Healthcare system: a complex adaptive system.
- Successful Computerized Physician Order Entry (CPOE) implementation is a process of transformation within these complex healthcare settings.
- An “efficient technology” is the one which reinforces current ways of working and performing ongoing tasks and a “transformational technology” as the one which changes the nature of the work.

Objectives

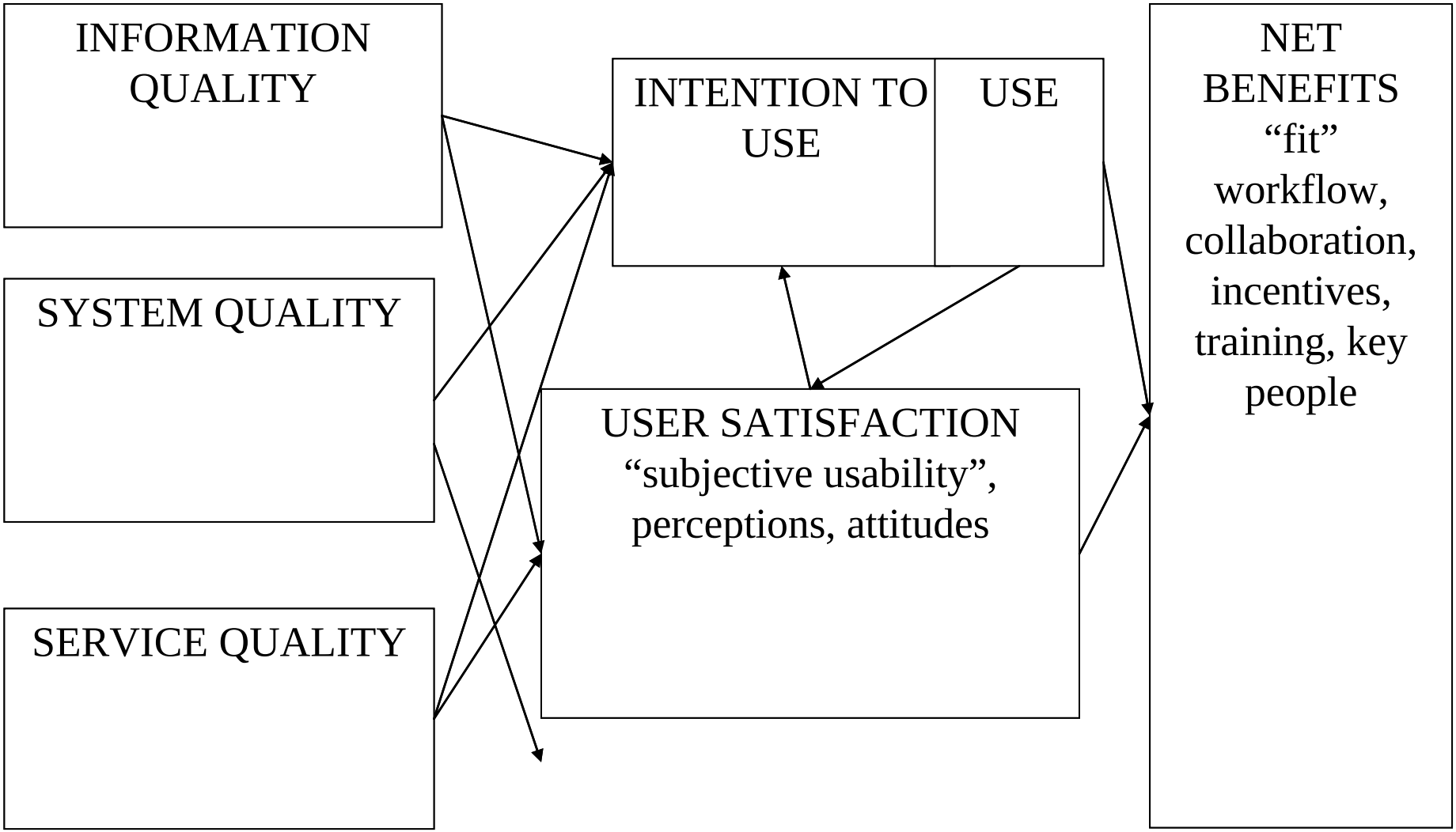
- Kaplan-reviewing implementation is important because: it is often ignored; it does not often concern issues of user acceptance or changes in work; and, it does not examine processes of actual system use during daily activities.
- We hypothesize that successful CPOE implementation means that the system has good fit at the organizational level and satisfaction at the user level as defined by subjective usability.

Concepts Used

- **Fit:** Dimensions to fit: workflow, level of expertise, professional norms, values, institutional setting, communication patterns, organizational culture, technology and information needs.
- 'Fit,' is useful for understanding implementation issues surrounding a particular system, why the same system may be viewed differently by different users, and also why it may be implemented more successfully in one setting than in another.

Concepts Used

- **Usability:** We use Hornbæk's model of usability as it provides the ISO 9241 standard usability definition as the ''[e]xtent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency, and satisfaction. We shall be concerned with the satisfaction element of usability.
- We examine a sample (19 studies) of the CPOE implementation literature with the concepts of fit and subjective usability within the IS success model of DeLone and McLean (next slide).


INFORMATION QUALITY
SYSTEM QUALITY
SERVICE QUALITY
INTENTION TO USE
USE
USER SATISFACTION
"subjective usability", perceptions, attitudes
NET BENEFITS
"fit"
workflow, collaboration, incentives, training, key people

Results: Thematic Analysis

- **“Fit” is a change of technology and workflow**
- **Fit is a dynamic process.**
- Fit is achieved through change or transformation of technology and work practices. Some authors see only the technology as transforming work, rather than a pure efficiency tool. The organization’s track record of making changes in the past influences these transformational changes as CPOE changes committee structures, membership and accountabilities.
- **Encourage change: collaboration**
- People work collaboratively when using clinical information systems and not recognizing this is a source of implementation failure.

Results: Thematic Analysis

- **Encourage change: collaboration.**
- Awareness can be fostered by educating all members of the healthcare team on the activities of other group members, so that each person understands what others do.
- Collaboration must also happen between administration and clinicians. There must also be collaboration between problem solvers meeting regularly with users to work out procedural issues that cross boundaries.
- **Encourage change: incentives.**
- These can include paid release-time fees to physicians to compensate them for time spent outside their clinical and administrative duties. Incentive structures can also exist at the institutional level such as better access to care, better quality of care etc. Incentives must be created to motivate each user to adopt new medical technology.

Results: Thematic Analysis

- **Encourage change: training and support.**
- Training and support are important tools to help staff change and accept CPOE. There must be extensive 24/7 support and a formalized training program before, during, and after implementation.
- Problems will occur; they will be solved only if people focus upon how to make the system work better instead of whether the institution should be implementing CPOE.
- **Encourage change: key people**.
- Key people have universal attributes, including stability through adversity, steadfastness, initiative, and toughness.
- These include: clinicians, top leadership, chiefs of staff, CEO, advisory groups, problem solvers.

Results: Thematic Analysis

- **User Satisfaction is experienced as efficiency**
- People who have already changed and committed to a change focus more on issues surrounding actual implementation whereas those still contemplating the change are more concerned with the pros and cons.
- The strongest correlates of CPOE satisfaction in the literature were efficiency characteristics such as productivity, ease of use, and speed.
- In other words, although the technology itself was transformational, and patients and the hospital benefited substantively from improved quality and reduced costs, the users' satisfaction of the technology was primarily predicted by efficiency concerns.

Conclusion

- We have addressed Kaplan's concern about user acceptance and changes in work by using subjective usability (user satisfaction) and fit respectively.
- We have used a sample of international CPOE implementation literature to find and organize some themes describing these concepts within an IS success model.
- Although the IS success model is useful for thematic analysis, more rigorous techniques of thematic analysis and a broader context for the IS model are needed to capture the transformational impact of implementation.

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Challenges to the Regional Comprehensive Electronic Health Record (rcEHR) - the Experiments in Koriyama

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Abstract

This paper reports on our efforts and the further challenges that we are having in our experiments in Koriyama. We have been developing electronic medical charts and health examination databases for medical and healthcare facilities, as well as eHealth cards and computer network systems on a regional basis. By integrating all of these functions, we have developed the Regional Comprehensive Electronic Health Record (rcEHR) in Koriyama. This paper explains the solutions to common problems generated in EHR development on a regional level, and upcoming challenges.

Keywords:

personal health database, eHealth card, medical record

Introduction

In Japan, the sharing of health checkup results and medication information on a regional basis began as the eHealth Card system around 1995. The Japanese government has experimented with numerous business models using the electronization of health insurance cards as its ultimate goal. However, there are just a few regions where the operations are still currently available. In regard to regional healthcare via computer networks, even though the government initially poured a sizable budget into the development of the system, an issue remains regarding its sustainability because of lack of personnel and economical reasons due to the elimination of the subsidy.

Without relying on the national budget, we have developed such systems as electronic medical charts, electronic health cards, regional medical computer networks, and a database of health checkup results. In these systems, operability, economical efficiency and interoperability have all been taken into consideration. The systems have been used for the past 20 years, and are well-established in many regions. This paper reports on the sustainable systems we have developed by integrating these operations in Koriyama in Fukushima Prefecture.

Methods

We are providing patients with their medical records and health data via electronic media used in digital cameras or cellular phones. We have named these systems My eChart and My eHealth Card respectively.

For medical and healthcare service providers, computer systems are needed to improve the efficiency of each operation at their facilities. Thus, we have developed electronic medical charts for medical facilities, an information system to record health checkup results and issue notifications for health examination clinics. Additionally, we have also developed a health checkup results database and an information system to support health guidance for the facilities. Moreover, from these systems, My eCharts and My eHealth Cards can be downloaded onto personal electronic media systems.

In regard to sharing health information between regionally-based medical and healthcare service providers, there are many restrictions in terms of time and amount of data when using patients' portable media systems. Since Internet communication is more convenient, we provide regional medical information sharing systems via highly encrypted networks.

In June 2006, we began using the electronic medical charts and My eCharts at Koriyama Medical and Nursing-care Hospital. Figure 1 shows an example of the medical imaging displayed on My eCharts. In September, we began using My eHealth Cards for workers that contain the data for physical examinations, physical fitness tests and nutritional assessments at the Health Promotion Foundation of Koriyama. We also began My eHealth Cards to provide elderly people with their general health checkup data at the Public Health Center in Koriyama. Figure 2 shows an example of the time-line graphs of the health checkup results in My eHealth cards. In April 2007, we started regional medical network to share patients' data.

Results

1. Operability

We applied the touch-screen system to our electronic medical charts. The terms, phrases and illustrations used by

each doctor are programmed into the system as a table beforehand, and this reference table will be displayed on the entry screen so that the doctor can enter data with the touch-screen. For My eCharts and My eHealth Cards, the patients will see the same screen that the doctors or health nurses do. These systems enable the patients to refer to their personal health information at home or at work without going through any special training on its operations.

2. Easiness to provide My eChart or My eHealth Card

By just clicking the data-providing button on the guidance screen for the patients, personal data will be downloaded automatically onto their My eChart or My eHealth Card. The access program, the execution environment such as DLL or OCX files, and the operation manual in the HTML format are also transferred all at once. This process takes only a few seconds and hardly affects day-to-day operations.

3. Security

The regional medical networks can be accessed only by the registered medical or healthcare specialists. An encrypted password is issued for each user as personal authentication in accessing the networks. SSL is used for communication to prevent interception. Since the data is encrypted and registered in the database in real time, it cannot be decoded through unauthenticated access (Figure 3).

4. Coexistence of applications among facilities

Coding schemes, examination methods and reference intervals, screen designs, and development environments often vary from facility to facility or from region to region. We are providing health data to the patients' media systems along with the programs and the execution environment. On the patients' media systems, we create folders for each facility, put their data, programs, tables and execution environment in them, and use each folder for one object. By using this method, even the systems developed by other manufacturers or vendors will be able to co-exist in a single patient's' media system.

Discussion and conclusion

The interoperations are considered to be the key element, and the standardization of communication protocols and coding schemes is in progress. Moreover, it is not easy to integrate information systems that have been developed and operated by each facility and organization. But, especially with the rapid increase of medical accidents and expenses, EHR is in such a high demand as measures against them that there is no time to wait for standardizations.We are aiming to create interoperations by implementing applications as objects although this is still on a regional basis. The sustainability of the systems is not proportional to the amount of money invested. Sustainable systems are the ones that have gradually been developed and have had functions added to them based on the needs and practical uses in the region. The foundation to support the sustainability of EHR systems can be seen in the prerequisite of the systems. It is believed that the interoperation of the EHR systems will lead to medical safety and the reduction of medical costs through the reduction of duplicate checkups, the prevention of dangerous drug interactions, support for doctors' treatment policies, effective healthcare guidance, and self health care. Having experienced further challenges in Koriyama, we are planning to assess these outcomes quantitatively and clarify the overall effects including extension of healthy lifetime.

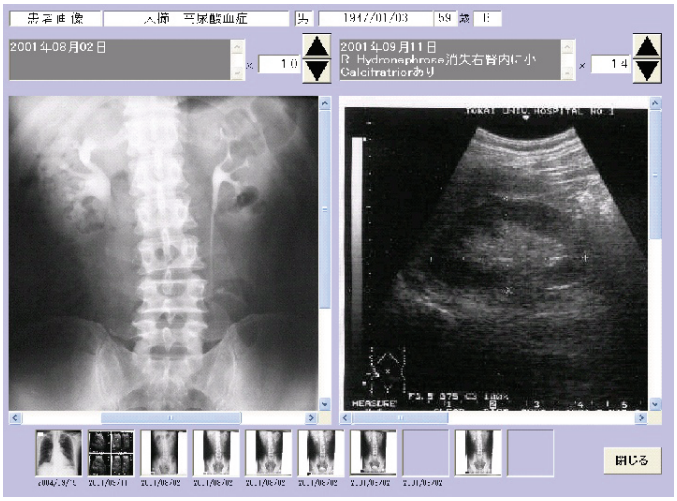

Figure 1- An example display of My eChart medical imaging

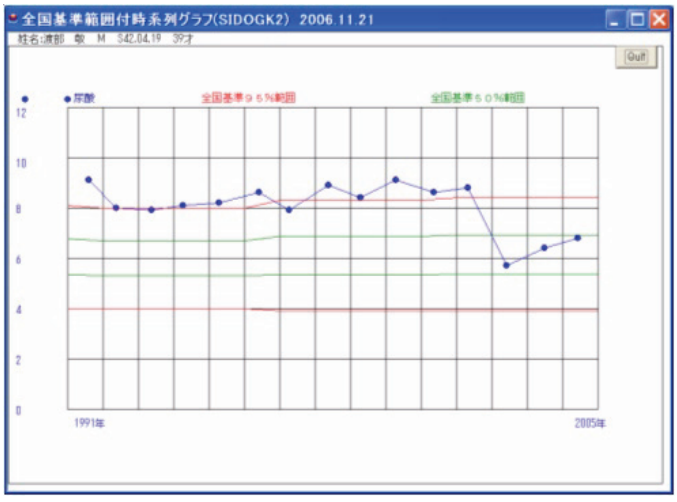

Figure 2 - An example of My eHealth Card time-line graphs

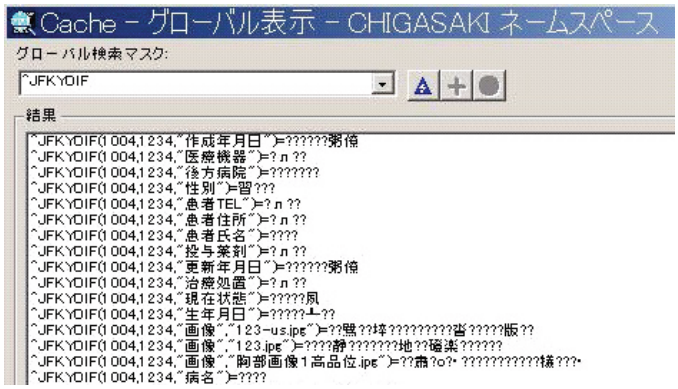

Figure 3 - The database encrypted in real time

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"To tell or not to tell?": Incorporating Disclosure and Privacy Requirements in Web Portal Design for Malaysian Cancer Patients

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Abstract

Cancer patients need to disclose their health information to their disclosure network: a group of people who patients disclose sensitive health information. The disclosure process can be done using oral as well as communication technologies like telephone and the Internet. In this paper, I propose a research agenda to ***get requirements from cancer patients and their disclosure network to build a web portal for cancer information management.*** *A web portal is conceptualized as a website set up by healthcare providers whereby patients have the ability to import necessary information (monitored and verified by healthcare providers) from their electronic medical record to disclose information to their disclosure network. Patients need to make active decision who and when to disclose as well the depth and level of information to share with others. This paper will outline the importance of the research, the methodology and expected outcomes from this research.*

Keywords:

Web Portal, disclosure, privacy, cancer information

Introduction: Health disclosure

Self-disclosure is defined as "any message about self that one communicates to another" [6]. In this paper, I will use the term self-disclosure and disclosure interchangbly. The topic has attracted scholars from diverse fields – communications, information studies, social psychology, sociology, and psychology. Northouse and Northouse (1998) presented five variables in health communication, where disclosure is one of the central variables that determine the effectiveness of communication. The authors discussed disclosure as a variable since the presence (or absence) of disclosure facilitates (or impedes) effective health communication among patients and medical teams.

Numerous studies have examined disclosure of health information. These studies looked at the content, frequency and consequences of self-disclosure in different medical situations and raised different issues of disclosure, but frequently ignored the balance between disclosure and privacy issues (Cozby, 1973; 17]. Wiener et al. (1996) explored the process of disclosure and consequences among HIV patients and their support network. It examined the caregiver-patient dyad it did not discriminate between the different roles of caregivers during the coping period, thus we are unable to conclude what specific roles are crucial for effective communication with the dyad. Another study [1] explored how family and caregivers cope with cerebral palsy, and found that support network members were dissatisfied with the information disclosure activities. That study also determined that factors such as the age of the child, the timing of diagnosis and the severity of physical disability influenced information disclosure. At the end, the study suggested "best practice" guidelines for disclosing the diagnosis of an illness to the support network. Contro et al. (2002) showed that some family members such as siblings were often not included during the information disclosure process; this in turn caused the siblings to feel "left out" of the coping process.

A few studies pointed out the lack of empirical work in understanding self-disclosure among medical teams and family in chronic illness situations [2, 5]. Families also made it clear that they wanted more information from the medical teams in order to be able to provide the appropriate support for the patient [2,9]. Other recent research on self-disclosure in healthcare examined different situations, contexts and issues as well as the nature of relationships. Topics examined include the process of disclosure (e.g. content and frequency) and its consequences [9], the dyad relationship during disclosure[14,22], practices for disclosing illness [1], disclosure of chronic illnesses [2,5] functional perspectives on health disclosure [7], privacy and disclosure [21], and the influence of illness, relationship and information-seeking on disclosure [4]. Recently, self-disclosure research in healthcare has begun to pay attention to the larger group of people involved in patient care – friends, employers, spiritual groups and self-help groups. Petronio and her colleagues (2004) explored the role of these "informal advocates" by examining the self-disclosure behavior of family and friends when they were present during a patient's visits with the physician and/or medical team.

All the empirical work mentioned above informs the question of self-disclosure in various medical situations. However, it is clear that little work has been done on the disclosure of health information using Information and Communication Technology (ICT) , specifically using web portal. Thus it is a good candidate for exploration using grounded theory, when little is known about a topic.

ICT for health disclosure

There are numerous of health websites resided in the World Wide Web today. Most of them provide health information on specific illness, treatment, drugs and rehabilitation. Websites like WEBMD (http://www.webmd.com/) and Ask Dr. Greene (http://www.drgreene.com/) are moderated by healthcare professionals and they are endorsed as one of the most reliable and trustworthy health websites. There are also many social support type websites that provide emotional support and information sharing among patients and family members. In addition, there are also new research developments for health web portal. There are many different elements that go into the web portal. For an example, a group of researcher designed and developed a diabetes web portal where patients are able to import "diabetes care plan" from their electronic medical record. Patients were able to use this information from the portal to make decisions on their own diabetes care management [8].

The focus of this research is to explore the possibility of using health web portal for health communication. The web portal has to have the ability to import medical record so that patients can use the technology to disclose information to others. The uniqueness of this research is to explore the disclosure and privacy requirements for the web portal design.

The Malaysian Government, under the Multimedia Supercorridor (MSC), has invested billions in ICT infrastructure to support Telehealth (http://www.telehealth.com.my/portals/myhealth/) projects around of the country. One of the main projects is to develop a website called Telehealth to provide credible and trustworthy health information in Malaysia context. The mission of the web portal is to enhance the quality of health among Malaysians. However, there is no cancer-specific web portal has been developed for patient communication. Thus, the outcome of this research can merge with the existing initiatives in MSC.

Methods

There are two stages for this research; the first one is to get the requirements on disclosure and privacy from patients. The technique proposed in this stage is using face to face interviews and grounded theory analysis. In the second stage, I propose to conduct software prototyping to evaluate the usability of such portal. This involves the development of desired prototype and a think aloud technique to capture user satisfaction on using the prototype.

Stage 1: Interview with patients

An interview is defined as a construction of knowledge [10] or as a "purposeful conversation, usually between two people but sometimes involving more" [13, page 93]. "Purposeful conversation" here means that interviewers have chosen a specific topic that both interviewer and interviewee can explore and discuss at length. An interview is a tool with which to elicit information from a participant, to find out his or her perceptions, meanings and construct of reality [16]; its purpose is to gather what people say about their perceptions, feelings and behaviors.; its purpose is to gather what people say about their perceptions, feelings and behaviors.

As part of my preparation, I reviewed literature pertaining to conducting interviews. From several previous research projects, I had prior experience conducting interviews with patients, family members and medical personnel in a hospital setting as well as with undergraduate students and these experiences enhanced my confidence in my ability to conduct interview-based research.

This study employed face-to-face semi-structured interviews. Interviews will be conducted wherever the subject feels comfortable. With the subject's permission, I will record the interview session using an audiotape recorder. If respondent refuse to be taped, I will take notes during the interview.

Interview protocol

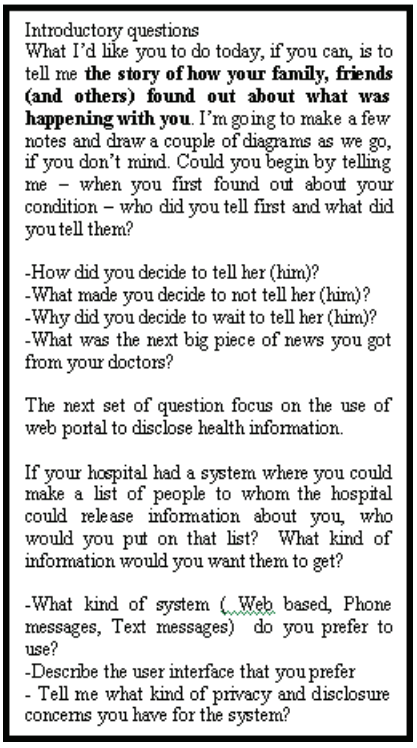
I have developed an interview protocol to start up interviews with cancer patients. I designed a protocol with a background question that asks patient's disclosure behavior when dealing with cancer. Then, I created some questions to elicit the requirements for the future web portal (Figure 1). These questions will be modified based on the feedback by the subjects.

Sampling

Research subjects comprised of medical patients in Malaysia. I will select patient with any types of cancer illness. I chose cancer illness because it is one of the leading illness in Malaysia [11]. The annual incidence of cancer was 30,000 in the year of 2000. Cancer illness has a predictable prognosis where patients have some flexibility in planning either their treatment, recovery or facing end of life situations. With this existing factual in Malaysia, it is appropriate to explore how to build a cancer specific web portal for cancer patients and their disclosure network.

Research subjects will be selected using a convenient snowball-sampling technique. The technique is convenient in the sense that respondents are recruited based on whoever who meet the criteria and was available for the interview. Using the snowball sampling technique, I will identify research volunteers based on others' recommendations [3]. Many patients who would have been reluctant to discuss their illness with a stranger were more open and willing to talk when approached by someone with whom they were comfortable. A snowball-sampling technique

takes advantage of the natural human tendency to extend trust through social relationships, since the interviewer is implicitly endorsed as trustworthy by the participant who provides the referral.



Introductory questions
What I'd like you to do today, if you can, is to tell me **the story of how your family, friends (and others) found out about what was happening with you**. I'm going to make a few notes and draw a couple of diagrams as we go, if you don't mind. Could you begin by telling me – when you first found out about your condition – who did you tell first and what did you tell them?

-How did you decide to tell her (him)?
-What made you decide to not tell her (him)?
-Why did you decide to wait to tell her (him)?
-What was the next big piece of news you got from your doctors?

The next set of question focus on the use of web portal to disclose health information.

If your hospital had a system where you could make a list of people to whom the hospital could release information about you, who would you put on that list? What kind of information would you want them to get?

-What kind of system (Web based, Phone messages, Text messages) do you prefer to use?
-Describe the user interface that you prefer
- Tell me what kind of privacy and disclosure concerns you have for the system?

Figure 1 - Interview Protocol

Data analysis

Grounded Theory is a qualitative data analysis technique that serves several purposes [20, page 24]: immersion in the real world situation to gain a deeper understanding of the research phenomena, formation of a theoretical framework that arises from the data itself, and comprehension of the process of change in real situations.

Analysis and coding will begin as soon as the first interview ends and continues until the last interview is completed and coded. Grounded theory recommends that data analysis take place in parallel with data collection [12] so that the researcher is able to make ongoing adjustments to the existing data collection process. For example, analysis of subjects' responses in the first few interviews may suggest new dimensions and directions for subsequent interviews. Ongoing data analysis in parallel with data collection also encourages the early discovery of new insights rather than waiting until the end of the entire data collection process.

Stage 2 study

In the second phase, the main research goal is to expose users to a web portal prototype and to evaluate user acceptance. The focus will be on user interface for the portal where I will explore factors that influence patient to use web portal to disclose sensitive information. Since there is no specific web portal exists yet for patient to communicate and disclose sensitive information with their disclosure network, I would like to employ a socio-engineering approach. With this approach, I will develop a software prototype and refine the design iteratively by incorporating end user needs at every stage. An adaptation of a software engineering approach called rapid software prototyping [19] will be applied to my socio-engineering nature of work.

In creating a "universal" web portal that could be used by patients all over the world, no single theory that can inform the best web portal design for disclosure activities. This is because there are many technological, human, situational and institutional factors that could influence the final product. It is a very complex design and development process to create a "one for all" system, thus a qualitative combined with rapid software prototyping approach seem to be most suitable way to proceed. In this optimization approach, researcher will try to maximize the user acceptance into system design and development. The end goal of this research is to develop an appropriate ICT innovation that could enhance social interaction among cancer patients and their disclosure network. This ICT innovation could also be incorporated in the existing telehealth system in Malaysia.

Using the rapid software prototyping approach, the main research activity is to create an artifact based on a rough approximation. The artifact will be tested and refined according to user feedback. For my research problem, I will develop the first version of the web portal using the effective web design guide. In each stage or version, I will carefully observe and document users' perception on multiple outcome variables like sense of privacy, usefulness and ease of use of the web portal. One possible way to capture users' perceptions is by using a "think aloud" technique. We can also use a technique called "aggregation" to quantify the system outcome. After each data collection, I will incorporate the users' suggestions and make necessary changes in next version of the program. I will then repeat the data collection process with end users until I find their suggestions reach saturation. I will need to observe all the outcome variables over time. The proposed duration of this prototyping process is between six to nine months. The key of this methodology is the iterative refinement process based on users' needs when they want to disclose sensitive health information over the web portal.

Expected outcomes

This research will be conducted over the duration of 24 months beginning of January 2007. It is fully funded by the Malaysia Cancer Council (MAKNA) as part of its annual cancer research award. The expected outcomes are the following:

1. a list of requirements addressing the disclosure and privacy concerns on cancer-specific web portal.
2. a web portal prototyping processes with user feedback.
3. a well developed web portal prototype.

Acknowledgement

This research work is funded by Malaysia Cancer Council (MAKNA) to facilitate the understanding of health communication through the use web portal among cancer patients and their network in Malaysia. I would also like to acknowledge Dr. Jeffrey Stanton from School of Information Studies, Syracuse University for his guidance in Information Privacy issues in health care setting.

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Darwin Revisited: Lessons Learned fromA Decade-long Evolution of a State-wide RHIO

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Abstract

Regional Health Information Organizations (RHIOs) in rural areas promise improved health care for many underserved populations. However, implementation in rural areas faces many challenges. One of the most rural states in the United States is in the process of creating a second comprehensive health information network and offers an opportunity to look at success factors for implementation of rural RHIOs. Methods: Documentation was reviewed and summarized and a core group of Vermont Information Technology Leaders (VITL, Inc.) were interviewed to ascertained lessons learned in the development of Vermont's RHIO. Results: Lessons were grouped into five major categories: early planning, organization, education and marketing, technology, and financial sustainability. Conclusion: There are a number of commonalities about all RHIOs but also a number of differences predicated on location. RHIOs must remain dynamic and learn from others in order to survive.

Keywords:

community networks; computer communication networks; medical records systems, computerized

Introduction

The development of the RHIOs in rural areas could make a major impact on health care in these traditionally underserved areas. However, there are major obstacles to implementation. The capital investment required to create a health information exchange and income to operate it are more difficult to acquire in a rural environment. The low density of providers in rural areas precludes ready distribution of costs.[1]

Other factors hindering implementation of HIT in rural areas include lack of health care professionals with HIT or medical informatics training to assist in the selection of appropriate systems and foster confidence among end users and lack of wide-spread access to high-speed networking infrastructure. The Stark legislation targeting elimination of perceived kickbacks and current IRS laws have hindered rural adoption of HIT.

Vermont, arguably the most rural state in the United States, is in the process of creating its second RHIO and offers a unque testbed to identify facilitators and obstacles for RHIO development. These issues and the organizational strategies for responding to them have resulted in the formulation of a set of guiding principles or lessons learned that could assist others in the planning of small local or much larger area RHIOs. While all RHIOs are unique, they also share certain general problems and solutions. It is this set of problems and solutions, many of which are common to both iterations of Vermont's health care network, that could contribute to future RHIO development in rural areas.

Methods

To understand the issues we reviewed documents and presentations created during the development of VTMEDNET[2] and from VITL (Vermont Information Technology Leaders, Inc.), the core development group of the current statewide RHIO[3], in order to identify parallels between the two efforts.

In addition, we completed structured interviews with three of the key leaders of VITL and the Chief Information Officers (CIOs) of two of the state's twelve hospitals who had been active in the creation of VITL. All of those interviewed were part of VITL from its inception.

Results

There are major parallels between the creation of VTMEDNET and VITL and these alone offer some lessons that could be used in beginning the process for establishing a RHIO. However, the lessons learned from the interviews and documents pertaining to VITL take understanding the development process and the success factors to a new level.

Both network iterations began with a dedicated core group of visionaries who identified key stakeholders and tried to

garner buy-in from the groups or at least their representatives. Both sought to ascertain the one project that would meet the greatest need and have the greatest impact in terms of getting support from the participants. Both started small and grew in increments. Similarities continued, but the more mature RHIO concept presented some obstacles and offered some opportunities not present in the earlier network.

Data control is critical to today's health care environment. The need to feel that data is protected extends beyond protecting patient confidentiality. Regardless of the level of cooperation, some degree of competition exists among health care organizations when catchment areas overlap. This is magnified when those catchment areas cross state boundaries.

The solution to data control will vary among RHIOs. Some prefer a totally distributed and linked model; some prefer a centralized data repository. However, many chose a federated model that incorporates both accessing discrete data from hospital and health care institutions while ownership remains within the organization and storing other forms of data in a central repository.

Learning from others is critical to understanding issues, however, structuring the administration of the RHIO is virtually always local and problematic. This is some ways mimics the question of data control. With RHIOs, there are a large number of key stakeholders, all wanting some level of decision-making authority. Two lessons gleaned from the earliest beginnings of VITL were the need to have detailed Bylaws laying out the membership of the board and the process of making decisions and the need to have one or more attorneys on retainer.

Very early in the planning stages, a needs assessment of the key stakeholders should be undertaken. This serves two purposes. First, it identifies the initial pilot project that could have the greatest impact in demonstrating the value of the RHIO. Secondly, it can serve as a tool to educate those who will be actively involved in the process of creating and supporting the RHIO.

Education of key stakeholders is vital to sustainability. Healthcare providers need to understand the value of the RHIO and why they should be willing to alter their workflow and pay for its use. Patients need to be educated about how the RHIO will improve patient safety and the steps being taken to insure privacy. Legislators, payers, and private industry managers need to be educated about how the network has the potential to improve the quality of care and reduce costs. Education is a marketing tool for sustainability.

While most people implementing such systems state that the technology is not the problem, VITL found that this was not entirely true. Interoperability among hospital systems, all in various stages of implementation, would prove challenging so the vendor selected needed to provide a high level scalable and sustainable system architecture that would handle HIE.

The decision to begin with a pilot project and only two hospitals has enabled the technology issues to be resolved, thus avoiding costly missteps and mitigating some of the issues encountered over wider areas with fewer providers. Another lesson learned from others but proving invaluable was the need to understand and address workflow issues to insure that the providers at the point of care have the least disruption to their work, thus achieving greater system use.

Finally, the inability of a fledgling RHIO to address financial issues and sustainability has been one of the major contributors to RHIO failures. VITL is exploring several financial models as part of its requirement to create a Vermont Health Information Technology Plan. Most agree that the state of Vermont needs to have a major financial stake in the development and maintenance of the network and treat it as a community utility, although difficult in a rural state with limited financial resources. However, there is also a role for payers and business to play in its sustainability as they will be major beneficiaries.

Conclusion

Health information exchange fostered by the creation of RHIOs holds the promise to improve the quality of care and reduce health care costs, particularly in rural areas. However, regional health information organizations are challenging to establish. They are composed of different healthcare organizations with sometimes differing and even conflicting missions. While the goals of RHIOs are virtually all the same, the obstacles and opportunities in their creation can differ depending on their localities.

Acknowledgements

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A Successful StrategyAddressing Wait Time and Matching Patient's to their Records

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Abstract

Matching patients and healthcare providers has new importance as nations embrace electronic health records (EHRs) and define strategies for enhancing healthcare delivery. Silos of data are broken down in the new electronic world, striving for increased patient safety, better customer service, and more cost-effective healthcare.

Long wait lists prove the bane of customer satisfaction, government policy, and effective use of resources. Matching patients to their records across the data silos is fundamental, while maintaining the integrity, confidentiality, and security of information.

The Province of Ontario developed a strategy to reduce wait times for select procedures, addressing a chronic problem of long waits for diagnostic or surgery modalities. Ontario developed a provincial Wait Times Information System (WTIS), capturing data critical to monitoring and determining best use of resources. Now used by 1700 hundred physicians at over 60 sites, WTIS has contributed to significantly reduce wait times for cancer surgery, sight restoration, hip and knee replacement, cardiac surgery and MRI/CT – which is all now publicly reported on a regular basis.

Keywords:

EMPI – Enterprise Master Person Index,
EHR – Electronic Health Record, Canada Health Infoway,
probabilistic algorithms, wait list(s),
Cancer Care Ontario, patient matching

Introduction

Canada is blazing a trail in establishing EHRs based upon blueprints developed by Canada Health Infoway, a government funded agency that oversees and disseminates healthcare funds, and addressing the customer satisfaction issue of wait lists. The Province of Ontario is breaking additional new ground through addressing wait lists for specific treatment modalities by using an electronic master person index (EMPI) as a primary tool to create the client registries necessary for EHRs and manage a complete view of patient care.

In order to ease and validate patient data entry, ensure appropriate matching of patient information across care sites; and to track when patients are on more than one list, Ontario concurrently implemented a provincial client registry. It was also understood that implementing this core piece of infostructure at the same time as a business focused consuming system was put in place would enhance adoption and prove utility of the service in its first implementation. Neither privacy nor security of personal health information is compromised in this strategy. In fact, rigorous attention at all levels of policy development and strategy deployment has been paid to this key public issue.

Learn how the strategy was created and implemented and could be applied to numerous problems that plague the healthcare delivery system, irrespective of the country or continent.

Methods

In case study format, the presenters will explore the wait list problem, the solution set defined to address the problem, and the implementation that enabled the Province of Ontario to execute a Wait List strategy and the provincial Client Registry. Additionally, the presenters will address the Infoway blueprint for client registry and how this as served as a model for interoperability and effective use of healthcare resources.

The Province, through its Client Registry deployment, is currently managing 45M records across 100 disparate source systems and has integrated the enterprise master person index (EMPI) with the Wait Time Information System (WTIS). At full deployment, anticipated for June 2007, the WTIS will serve all of Ontario and encompass approximately 50M records and 130 source systems.[1]

Noteworthy throughout strategy development and execution is the emphasis on privacy and security of personal health information, as the WTIS developed and Implemented a Privacy Policy[2] structured around the ten fair information practice principles of the Canadian Standard

1 Ontario Cancer News. WTIS/EMPI -- Making better access to care possible. 2006; 4(5).

Association's Model Code for protection of Personal Information. [3] This emphasis was defined during planning and followed in design and implementation.

Results

From the time of contract signing for the client registry software, the implementation took nine months to fully implement the provincial EMPI, and to achieve 90 percent capture with the provincial WTIS. Multiple vendors and provincial staff worked in cohesive teams to address the core objectives and document results. Results achieved to date show a reduction of 27 percent for cataract surgery, 20 percent for knee replacement, 39 percent for angiography, and 18 percent for angioplasty. The final 10 percent for WTIS will be captured by the end of June 2007.[4]

All hospital and procedure specific data is regularly reported on the Government's website (ontariowaittimes.com) – where the 1.8M hits indicate public and media interest in results. Data generated served as a rationale and impetus for the Government to invest an additional amount of greater than $100M (Canadian Dollars) to bring problem procedures in line with wait time targets established by clinical experts

This phase will include active integration to the source systems through recognized standards consistent with the Canada Health Infoway blueprints.

Discussion

Attendees of this session will be able to:

- Gain an understanding of Canadian client registries and the registry's role in achieving an EHR
- Learn how a complex project plan with multiple vendors (under separate contract) and distinct objectives can be managed.
- Describe the necessary infrastructure for a successful wait list solution
- Recognize the process of how patient data can be successfully stored, retrieved, secured, and linked with an EMPI
- Develop strategies that address breaking down silos of data in order to enhance patient safety, customer satisfaction, and more cost effective healthcare
- Discuss the correlation between Canada's healthcare system, including Client Registry and Wait List, and those in Australia and other countries

Conclusion

Increased customer satisfaction and enhanced patient care are immediate benefits of Ontario's Wait Time Information Strategy (WTIS). Key to achieving these results in a very short timeline were a clinical business focus, strong project management, meticulous planning, service level agreements with the vendors, strong stakeholder relations, and a clear focus on defining and achieving success. Achieving this has allowed Ontario to make prudent additional investments for specific procedures since success metrics have been defined, and return on investment has already been met for the initial phases of the WTIS.

Attendees will have the opportunity to learn from the advanced efforts of a government-funded system and learn success strategies that can be applied to the global wait time problem. Timelines, key elements, success strategies and pitfalls to avoid will be discussed.

Acknowledgements

Scott Schumacher, PhD, Chief Scientist, Initiate Systems Inc.

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Safe and Efficient Use of Wireless Communication in a Large Hospital

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Abstract

Computer systems, often called hospital information systems (HIS), have been installed in most large Japanese hospitals. In almost all cases, HIS have a server/client type structure connected by a LAN. For voice communication among the hospital staff, a landline telephone is often used. The potential demand for the introduction of wireless communication devices for data/voice communication into hospitals is high. However, because of guidelines made to reduce problems that might be caused by electromagnetic interference (EMI) with medical electric devices, the introduction of these systems has, until recently, been shelved in almost all cases. Because it has become possible to protect against the possible occurrence of EMI, the number of hospitals introducing such wireless communication is growing. We report a case of a university hospital in which data and voice wireless communication have been safely and efficiently introduced.

Keywords:

wireless communication, cellular phone, wireless LAN, PHS, information security

Introduction

Computer systems are rapidly being installed into most large Japanese hospitals. Usually called a hospital information system (HIS), most have a server and client type structure using TCP/IP LAN. However, voice communication among hospital staff members is often still done with fixed, landline telephones. The potential demand for the introduction of wireless data/voice communication into hospitals is high because of the promise of savings these technologies bring through improvements in patient service and labor efficiency [1]. However, because of "electromagnetic interference" (EMI) with medical devices and of guidelines enacted in many countries to protect against such interference, the introduction of such systems has been shelved in almost all hospitals. In recent years, it has become possible to protect against the possible occurrence of EMI, the number of hospitals introducing wireless communications has grown. This paper describes a university hospital in which wireless communication has been safely and efficiently introduced. (hereafter termed the target hospital).

Materials and methods

Background of the target hospital

The target hospital is located in western Japan, has 616 beds, about 300 doctors, and 350 nurses. It has 12 wards, an ICU, and an NICU. Each ward has 8-10 daytime and 2-3 night nurses. The HIS of the target hospital has 44 servers and 524 client terminals.

HIS wireless data communication

Before introducing a wireless LAN, we examined the safety limits against EMI of some commonly used medical pumps [2]. The results showed that no EMI would be expected to occur unless an apparatus with extremely strong output power were used.

Seventy-two client terminals are connected with servers using an IEEE 802.11a wireless LAN at each ward. These terminals are used only by the medical staff for browsing information, reviewing the medical charts of the patients with barcode scanning, and to immediately record medications and transfusions given at bedside. Reasons for choosing IEEE802.11a were its high rate data transfer and freedom from 2.45GHz band electromagnetic noise. To keep personal information security high, the SSID value is different on each floor and connection attempts using the SSID as "Any" are refused. Also, authentication with an ID and a password has been added and all communications are logged. The AP-5100 (ICOM Inc.), which has an OCB AES (128 bits) cipher system and a Media Access Control (MAC) address filtering function, were adopted as the access points.

Mobile voice communication for staff members [3]

In the target hospital, both landline telephones and the Personal Handy-phone System (PHS) are used for voice communication between staff members. PHS is a totally digital mobile communication system that was developed in Japan. The output of a PHS terminal is a maximum of

80mW. Almost no EMI with medical devices caused by the signals emitted by PHS terminals was found [4]. In many Japanese hospitals, PHS is used instead of the traditional nurse call system terminal. PHS is well-known for increasing efficiency, improving patient service, and raising the level of medical safety among Japanese nurses.

Doctors and some nurses working in the target hospital have had access to a public PHS terminal since November 2004. A red strap is connected to the PHS terminal to serve notice that the terminal has been registered for use in the hospital. Installing a public PHS service means no in-house telephone exchanger is needed. This results a great reduction of cost. The initial cost of this system was only about 4,500 U.S. dollars for the use of 280 PHS. If an in-house exchanger were to be installed, more than 100,000 U.S. dollars would be required. To determine the effectiveness of the public PHS system, the number of calls received on a fixed-line telephone in a ward was compared 7 days before and after the introduction. Total number of calls received was reduced from 1,908 to 997 (47.7% reduced). The number of calls received at surgical rooms increased, possibly because carrying mobile phones, including PHS, into surgical rooms is forbidden. Two years later, PHS handsets were given to every chief nurse. Also, a PHS handset that can make calls with PHS freely is provided to every ward to make it easier to contact doctors. Totally, 440 PHS handsets were in use in the target hospital at the end of November, 2006.

Mobile communication as a service for patients/visitors

In Japan, the use of cellular phones in business has been widely promoted as they are now recognized as being indispensable for doing business. The free use of phones by inpatients can decrease stress and the sense of isolation caused by hospitalization, thus raising the Quality of Life (QOL) [5].

The target hospital has permitted the use of cellular phones in unrestricted zones since January, 2004, with the following rules; “Cellular phones can be used only in visitor lobbies, single bed sickrooms, and in dining areas”, “The medical staff can use cellular phones at nurse stations and in conference rooms”, “Cellular phone use is not allowed within 50cm of medical devices”, “Patients connected to medical devices are prohibited from using cellular phones”, “After a set time for turning out sickroom lights, the use of cellular phones is prohibited”, and “Staff members are not allowed to use a cellular phone during rounds, while walking, or during explanations to patients or their family”. These rules are widely displayed and are given to inpatients. The co-operation of patients and staff members has been requested, and no EMI has been observed since these rules were put into effect.

Discussion and conclusion

In Japan, other than the target hospital, there are no hospitals with more than 600 beds using wireless communications for both data and voice communication at the end of December 2006. The main reason is the fear of EMI. However, by keeping cellular phones away from medical devices and by using mobile phones or wireless LAN apparatus with weak electromagnetic wave output, it is possible to stop or minimize EMI with medical devices. Limiting the areas in which phones are allowed is important for the purpose of preventing EMI, controlling noise, and preventing medical accidents due to the inattentiveness of the caller [6].

Acknowledgement

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Safe and Efficient Use of Wireless Communication in a Large Hospital

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Wireless Communication in The Target Hospital

- Installed systems
  1. Wireless data communication
     - Wireless LAN in wards
  2. Wireless voice communication for staff
     - PHS (A kind of cellular phone)
  3. Wireless voice communication for patients/visitors
     - Partial permission for cellular phone use
- The Target University Hospital
  - A university hospital located in western Japan
    - 616 beds and 21 specialized departments
    - 1 building for inpatients
    - 12 wards of about 50 beds each
      - Each ward has 8-10 daytime/ 2-3 night nurses
    - Most accommodate from 2-6 persons
    - About 300 doctors and 350 nurses

Safety of Wireless Communication Use in Hospitals

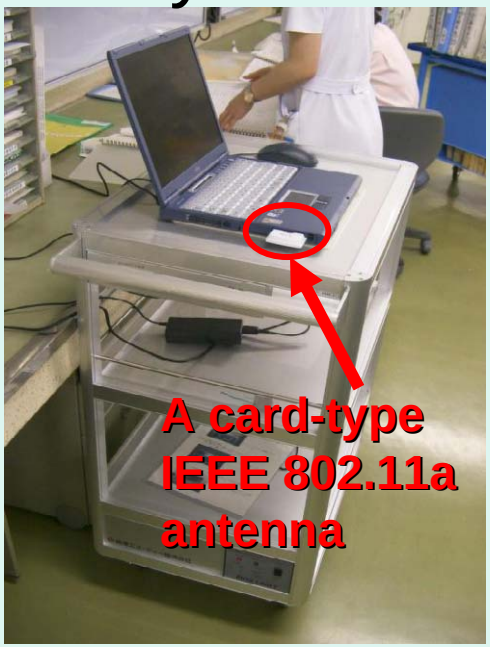
- No EMI was observed for 5.2 GHz radio waves until extremely high output power (3 W or higher) was irradiated [1]
- The power of the signal is limited by Japanese law

System	Output power (from the terminal)
2nd. Gen. Cellular phones	0.6~0.8W
3rd. Gen. Cellular phones	0.20~0.25W
IEEE 802.11b wireless LAN	10 mW / MHz (total output: 130~160 mW, approx.)

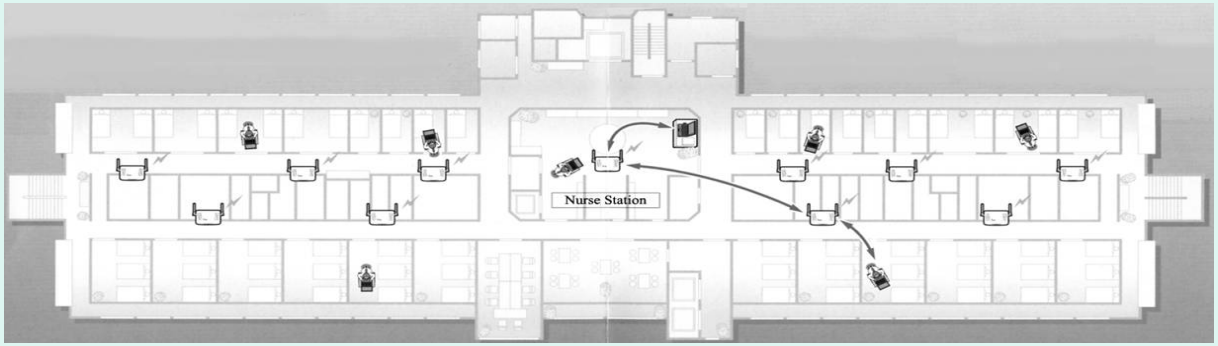
◎EMI will NOT occur when using PHS or wireless LAN in the Japanese legal setting

Wireless LAN System in the Target Hospital

- 72 HIS client terminals are connected with servers using wireless LAN
  - Terminals are limited to use in the wards by the medical staff
- IEEE802.11a standard is used
  - Apparatus that emit electromagnetic waves in the 2.45GHz band are often found in hospital wards
    - heaters, microwave ovens…
  - The data transfer rate is higher than that using IEEE802.11b/g



A notebook-type PC with an IEEE 802.11a antenna on a wagon



An image of the location of access points on one floor

Settings/Employment

- Security Settings
  - Connectable Media Access Control (MAC) addresses are registered for each access point
    - Only permitted PCs can connect to the hospital LAN
  - SSID value is different on each floor
    - An “Any” setting of the SSID is refused
  - OCB AES (128 bits) was adopted as a cipher system
    - High-speed encryption/decryption available
  - HIS user authentication with ID/passwords
  - Communication logging
- Currently used for
  - Patient ID confirmation with bar-codes
  - Entering patient information into an HIS at bedside
  - Browsing of patient data by doctors during rounds

Access Point
AP-5100 (ICOM inc.)

Improvements with wireless LAN

- Medical efficiency
  - Inputting patient information at bedside
  - Reviewing medical treatment charts
  - Sharing information
    - With an electronic patient record system, every staff member has access to registered information anytime/anywhere
- Medical safety
  - Reference to required medical information at the bedside is possible
  - Patient checks using barcode/tag scanning
  - Protection against input failures/mistakes
    - Eliminates the need to move from bedside to fixed terminals in the nurse station
- Personal information protection
  - Reduced use of paper memorandums

Wireless Voice Communication for Staff Members [2]

- Doctors have access to a public PHS terminal (WILLCOM, Inc.)
  - Cost effective service
    - US $8/month for use
    - US $4,500 to install 280 Terminals
      - Calls can be received freely
      - A limit is set at 3 numbers, designated for each handset, that can be called
- PHS (Personal Handy-phone System)
  - Uniquely developed in Japan
    - Completely digital
    - Frequency of radio waves: 1.9 GHz band
    - Handset output : 80 mW maximum
  - System structure is almost the same as for cellular phones
  - Public service available in some other Asian countries including China and Thailand

A PHS terminal for doctors in the target university hospital (WILLCOM Inc.)

Productivity Improvements with PHS

- Makes it unnecessary for nurses and pharmacists to physically search for a doctor
- Makes possible quick queries and feedback to the queries
- Number of terminals increased from 280 at start (Nov. 2004) to 440 (at the end of Nov, 2006)
  - Terminals provided to every chief nurse/every ward

Section received	Calls before introduction	Calls after introduction
Wards	1216	588
Visitor sections	458	356
Other sections	116	212
Total	1790	1126

Number of calls on weekdays (5days)

- Calls received at “other sections” increased, possibly because surgeons could not carry PHS into surgical rooms

Section Placing Call	Pharmacy	Clinical Lab.	Hosp. Affairs Section	Others
Before Installation	118	92	111	982
After Installation	23	66	38	412
Number Reduced	95	26	73	560
Rate Reduced (%)	80.5	28.3	65.8	57.0

Number of calls received in wards during working time by the section placing call

Mobile Voice Communication as a Service for Patients/Visitors

- Growing demand for the use of cellular phones
  - Over 100 million cellular phones are in use in Japan
  - Cellular phones are seen as indispensable for doing business
- Raising the Quality of Life (QOL) for inpatients
  - Free use of a phone can decrease stress and the sense of isolation
- Other factors
  - No reports of malfunction of medical devices have been made in recent years
  - Medical devices have improved protection against electromagnetic waves

Partial permission for the use of cellular phones is a welcome service for inpatients/visitors

Conditions for Cellular Phone Use in the Target University Hospital

- Cellular phone use is NOT allowed within 50cm of medical devices
- Cellular phones can be used only in visitor lobbies, single bed sickrooms, and in dining rooms
- The medical staff can use cellular phones at nurse stations and in conference rooms
- Patients connected to medical devices are prohibited from using cellular phones
- After a set time for turning out sickroom lights, the use of cellular phones is prohibited
- Staff members are not allowed to use a cellular phone during rounds, while walking, or during explanations to patients or their family

Discussion/Conclusion

- Mobile telecommunication systems in hospitals
  - Can be installed SAFELY with sufficient consideration
    - Cellular phone use should not be permitted in restricted areas
    - PHS is one of the safest and most convenient voice/data communication systems
  - Are very convenient and useful for staff/patients, but the **following problems must be addressed** [3]

1. Prevention of EMI with medical devices by signals
2. Prevention of noise caused by people talking on telephones
3. Prevention of accidents caused by lack of attentiveness of operators of communication tools
4. Prevention of private information leakage when using the camera or recording functions

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Health*Connect* NT Point to Point Electronic Messaging and Electronic Transfer of Prescriptions Service

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Abstract

The Point to Point Service provides enhanced clinical communication through standardised electronic clinical messaging between all health providers in the Northern Territory, including the public and private sectors and including specialist and general medical practitioners, allied health professionals, pharmacists, pathology and diagnostic imaging companies. The service supports integrated models of care supported through comprehensive referral management, diagnostic imaging results reporting, electronic transfer of prescriptions and transmission to the HealthConnectNT Shared Electronic Health Record.

The Point to Point Service is part of a national change management strategy to improve safety and quality in health care by establishing and maintaining a range of standardised electronic health information products and services for health care providers and consumers. Many IT projects fail in their implementation particularly in health, and the point to point service demonstrates some practical techniques which have ensured its success with clinicians.

Keywords:

Health*Connect;* E-Health; electronic mail; automatic data processing

Introduction

The Top End Division of General Practice (TEDGP) commenced the development of software to enable secure electronic messaging between health providers approximately eight years ago. The original innovative idea of the software, called Argus, was to fully integrate with the clinical desktop software packages to ensure maximization of business continuity in the clinical care environment and enhancement of clinical communication.

TEDGP commenced installing ArgusConnect software into the providers in the Top End region of the Northern Territory in September 2005 and currently there are over 115 health providers engaged in the messaging service in the private sector including the pathology providers as well as the public hospitals in the Northern Territory. The Point to Point service also links with the Northern Territory's Shared Electronic Health Record[1]

In addition, the Point to Point Service is undertaking the first electronic transfer of prescriptions trail in Australia which further enhances the comprehensiveness of the electronic messaging service. The implementation strategy has been developed in conjunction with the pharmacy, general practice and community sectors to ensure a smooth transition of the technology into the clinical environment as well as consumer acceptability.

Methods

The model chosen by the Northern Territory government was to entirely contract out the implementation of the Point to Point and Electronic Transfer of Prescriptions Service to the Top End Division of General Practice with an implementation pathway driven by the primary health care sector needs. Divisions of General Practice in Australia are uniquely placed in the primary health care sector as by the nature of their work, they have developed long standing working relationships with the multiple parties and providers across both the private and public sectors as well as engaging with the acute care hospital sector.

This choice of eHealth implementation provider is consistent with the findings outlined by Sittig[2] and findings of the Connecting For Health in the United Kingdom[3] which emphasizes the importance of clinician involvement and support by senior organizational management in e-health implementation to ensure that the e-health is driven by clinicians and not by technology.

Results

Over fifty health care sites have been connected by the point to point service with over 115 providers receiving electronic communications. General Practices are receiving and sending over 500 messages per week. The implementation of the Point to Point Service in the Northern Territory is achieving the following major outcomes:

- *Enhanced clinical Communication through standardized clinical messages*- single, comprehensive e-

messaging service with standardized templates for referral management and receipt of electronic communications;

- *Integrated model of care supported through referral management services, diagnostic results reporting and electronic transfer of prescriptions* – improved quality and safety in clinical practice with improved business performance, reductions in duplication and transcription errors and reduction of medication errors and misadventure.
- *Passing the Patient Safely Back to their Community* – the generation of electronic discharge summaries for inpatient and Emergency Department attendances.
- *Breaking Down the Distance Barriers by Improving the Co-ordination and Delivery of Health Services to Indigenous Populations* – engagement and maximisation of health providers participating in the point to point service, targeting remote indigenous communities, Aboriginal Medical Services operating in remote and major urban centres and small regional centres and towns across the Territory;
- *Establishment of the first electronic transfer of prescriptions in the aged care sector enabling streamlined prescribing, dispensing and administration of medications between a pharmacist, GP and aged care facility* - Prescriptions and aged care facility medication charts are both sent electronically and digitally signed.

Discussion

TEDGP was established in 1994 and thus has over 10 years experience building relationships with general practitioners and the broader primary health care providers. This enabled the implementation pathway of e-messaging to be driven through primary health care sector needs where the majority of e-messaging between independent clinicians and health organizations occurs on a daily basis

Critical success factors for implementation have been:

1. TEDGP implemented the point to point service under a capacity building model which developed Information Management (IM) Culture and Infrastructure within a general practices. Principles included assumption of little IM integration into general practices; Support of clinical leaders to assist other clinicians; Drawing together all IT/IM initiatives in the primary health care sector; and Linking IT/IM with patient care outcomes especially in chronic disease management.
2. Clinician participation in the development of innovative software that is functional within the complex health care environment and is acceptable to busy clinicians in both urban and rural settings;
3. Ensuring that the Point to Point Service was comprehensive and captured all e-messaging needs of the clinicians. Early work was needed to obtain agreement between the multiplicity of health care providers to proceed with implementing P2P within their environment;
4. Working closely with the Australian government on changes to the legislative and regulatory frameworks that govern health to permit electronic communication as a legally acceptable documentation pathway.

Conclusion

The Health*Connect*NT Point to Point and ETP Service implementations will continue to build on the successful development and implementation of its e-messaging service. The Northern Territory's HCNT Point to Point and Electronic Transfer of Prescriptions Service implementations are the most advanced Health*Connect*NT service implementations of their kind in Australia in terms of range of services, service coverage, provider and consumer participation. There is clear evidence that providers have embraced the concept of e-clinical messaging with sites receiving increasing number of messages and continuing requests from providers to be connected to the point to point service. There is also clear evidence of potential benefits in community medication management in reducing medication errors and misadventures for consumers and streamlining work processes and improving workplace productivity for GPs, pharmacists, other health providers such as those working in indigenous health organizations and aged care facilities. There is realization of benefits for a highly mobile Indigenous population through improved co-ordination and quality of health service delivery spanning vast distances, in some of the remotest areas in Australia. In conclusion, the Health*Connect*NT Point to Point and Electronic Transfer of Prescription Service is now demonstrating the impacts and benefits that may be realized in clinical practice across the primary health sector through innovative e-health reforms

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eReferral – Using ICT to Improve Patient Care in a Major Health Service

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Abstract

The referral of patients from one type of health care to another is a primary business of health care, and by incorporating ICT into clinical process we have improved the flow of patients around the service, reducing waiting times and increasing the level of care and quality of patient clinical outcome.

Keywords:

referral, ICT, health care

Introduction

In the industry equivalent movement of patients would be identified as a supply chain issue and authors such as Lee (1) suggest that for an organization to succeed processes that are agile, adaptable, and aligned must be developed.

As an adaptive organization, prepared to take on innovations in Information Communication Technology (ICT), during 2002 Barwon Health upgraded the patient administration system (PAS) to a best of breed database. Not only is this PAS modular providing software meeting specific clinical process requirements, it also provides the ability to create data entry tabs and data fields in house for local data needs and government reporting requirements. This software flexibility supports the redesign of a process to be incorporated into the main organisational software with minimal delay or cost, as the configuration is done in-house. In addition because this PAS is used across the region, the common healthcare problem of isolated islands of information is not encountered (2). Therefore information can be developed into reports that are delivered or made available electronically to the acute and sub-acute areas as appropriate.

Method

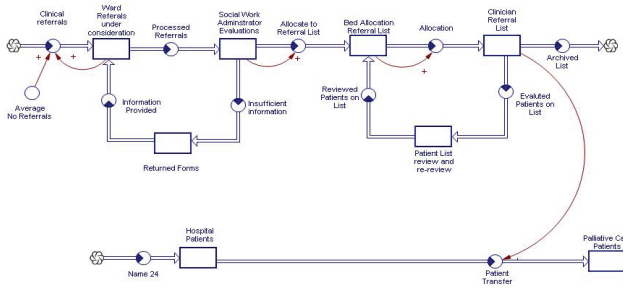

Figure 1 - Referral to sub acute care

The first and foremost issue with the paper based process is that it evolved over many years. The process was then effectively set in stone with the attitude that "this is how it has always been done" without consideration to changing needs of the organization for data, reporting, or the unnecessary complexity that had been incorporated into the evolving process.

Evolution of a process vs design

The traditional paper based process required a paper referral to be completed by the staff on the acute ward. This paper referral was transferred to the social work department via internal mail. The clinical and social information entered was often insufficient for to determine the appropriate referral to sub-acute care, so the referral was returned to the ward delaying sub acute services awareness of the potential patient. Once the referral was completed details were entered into as spreadsheet and a phone call made to the sub-acute center where a further spreadsheet was maintained. Sub-acute services then organized a senior clinician to access the patient at the acute center for the appropriateness of the referral, clinical date they will be ready to move from acute to sub-acute care and develop a treatment plan. This data flow is simply illustrated in Figure 1.

Locating the patients in the acute hospital can also be a challenge for the visiting clinicians who come to the acute site for patient assessment. Patients are often moved between wards to achieve a best patient mix on each ward. This can add time unnecessarily to the visit of the clinicians as they search for patients. The referral software has

been added to the Patients Administration System (PAS), so reports reflect patient movement as soon as the data is entered.

Information on the patients clinical needs can become quickly out of date on the referral paper. This regularly provides a challenge of information sharing between the acute and sub-acute staff. Common implications of when the information sharing breaks down include; patient condition deteriorates and they are no longer appropriate for sub-acute care, a nursing home bed becomes available and the patient is inappropriately transferred to it to clear the acute bed resulting in further disruption to the patient when they eventually get transferred to the sub-acute bed. Patients also may be transferred to the sub-acute hospital before all diagnostic tests are completed. Once again this initiates disruption to the patient and costs to the health service from unnecessary inter-hospital transfers.

The process was complex including many steps as the paper physically moved around the organisation. Analysis of the big picture and transparency of data had never been addressed. The intrinsic requirement that clinical assessment is required of each patient nominated to move from acute to sub-acute care, has not varied in the process change. This is to ensure that sub-acute care is the appropriate care for this person after their acute stay. For some patients sub-acute case is not required because they have adequate care available at home or have other medical or social complications that mean the patient requires alternative higher level of care such as nursing home.

Complex paper based process that are the result of evolution rather than design require specific staff for the process to work, with a break down of process during times of leave common. With the practice of redundant data entry by staff in different locations the ability to teach other staff to cover roles even for planned absences is difficult and time consuming as well as prone to failure due to lack of intimate familiarity with day to day tasks.

Advantages of ICT approach for clinicians

Intranet web based reports provide a single point of reference of referral information, which has met with clinician satisfaction. The clinicians buy in to the process of entering data real time and viewing reports with updated information rather than waiting for clerical staff to enter data into spreadsheets locally and then to be notified, has exceeded expectation and been sustained with minimal input in the six months since implementation.

Patient tracking as they move between wards, changes to clinical condition and inpatient procedures such as surgery are automatically provided by the ICT process assists clinical decision support (3). Removal of redundant steps with paperwork, lengthy phone calls comparing lists and faxing of referrals no longer required. These factors combine to ensure that the patient referral is received and acted upon faster than during the paper based process era. The minimum days to review has decreased by 50% from two days to one day and the average minimum days determined by day of week of referral has decreased from 3.9 to 2.6 days (Figure 2).

	Paper Based Internal Mail	ICT Approach
Minimum days to review	2	1
Average minimum days	3.9	2.6

Figure 2 - Change in time from referral to review in paper based versus ICT referral

Advantages of ICT approach for patients

Early planning of patient care with up to date patient clinical information has improved the level of care patients received because clinicians are supported in their decision-making in a timely and accurate manner. This provision of timely information supports objective decision making so that the right patient is in the correctly located bed at the right time, receiving the appropriate clinical level of care. Incorporating ICT into the process added more clinical information to the referral including previous admission details and current admission surgeries. In particular as the current admissions are updated in real time clinical readiness for transfer to sub-acute is monitored without seeing the patient saving clinicians time by reducing the number of reviews they do each Tuesday and Thursday. Saving time not seeing inappropriate patients allows for more quality time to be spent with patients who are appropriate for transfer.

Analysis "Mythbusters"

Sub Acute referral information following the computer referral implementation is freely available to other areas of the organisation in the form of web-based reports where in the past it was not transparent hidden in local spreadsheets. This facilitates strategic planning for beds as trends can be seen in the number of sub acute beds required, and analysis of peak times of demand for beds can be made objective. Both clinicians and administrators have appreciated dialog based on the same objective data. At a glance the clinicians can see the trends of patients waiting for transfer for the types of sub acute care.

The rate of rejected referrals to sub acute care has long been considered a problem for the organisation due to the sub acute clinician time. However the magnitude of the problem has been anecdotal and unsubstantiated through lack of objective statistical information. While referrals may not be accepted for unavoidable reasons such as unanticipated clinical deterioration or indeed death of the patient, the rate of acceptance is of prime relevance. With the data available so far the results show a statistically sta-

ble percentage of between 71% and 76 % from a monthly cohort of around one hundred referrals. Future review and analysis will include a break down of accepted referrals by referring ward to evaluate if the average 73% referral rate is constant across the wards, and inappropriate referrals are prevalence on particular wards requiring education.

Conclusion

The use of ICT to change the process by which patients are referred from Acute to Sub Acute care has had positive clinical and administrative outcomes. Patient referrals reach clinicians in a timelier manner, as there is no delay waiting for paper-based mail to be transported between hospitals. Clinicians also make better use of their time on the acute site spending it with patients rather that searching wards for patients who have moved. The administrative workload is also reduced as the previous handling of referral information by two sets of administrators has been eliminated by the direct clinician-to-clinician contact and web based monitoring of patient load. The foresight of appointing a project manager who had a vested interest in seeing cultural change and assisting clinicians with the change is the prime contributing factor to the success of the project. It goes without saying that the top-level management support that proposed the project was also a contributor to success. This collaboration provides the clinicians and administrators data to monitor the same cohort of patients each from their own perspectives. This information is available in real time, without subjective interference facilitating improved clinical decision-making and administrative decisions to provide the appropriate level of care as clinically dictated for the best advantage of the patient and organisation.

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eReferral – using ICT to improve patient care in a major health service

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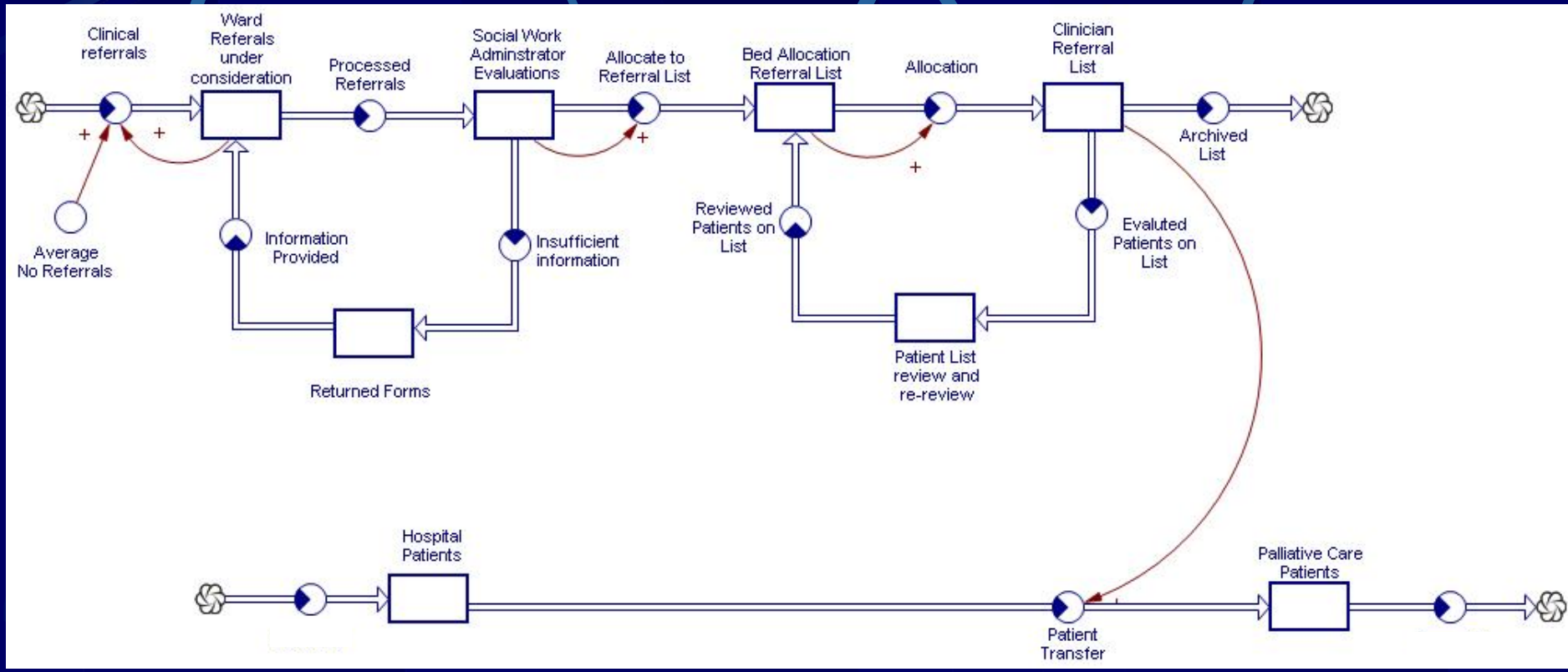
Introduction

- Patient movement an example of supply chain.
- For success processes: agile, adaptable and aligned.
- In-house flexible software supports redesign of process.
- Change management integral to combat “that’s how we’ve always done it”.

Evolution of a Process vs Design

- Evolution of a paper based process.
  - Redundant steps.
  - Out of date data.
  - Slow knowledge transfer.
- Design of an ICT process.
  - Facilitates evaluation of data flow.

Referral to Sub Acute Care



Advantages of ICT approach for Clinicians

- Reports available at any computer.
- Data up to date.
  - Changing clinical condition .
  - Ward and bed location.
- Referrals available real time, not waiting for triage by social work.
- Patients seen sooner & referred for appropriate treatment.

Advantages of ICT approach for Patients

- Clinical decisions made in a timely and accurate manner.
- Provision of wider range of data facilitates a more accurate clinical decision.
- Appropriate clinician able to spend more time with appropriate patients.

Minimum Time from Referral to Clinician review

Paper Based

Day Of Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Minimum Days from referral to first review
Patient A	■			▒		▒					▒	3
Patient B		■	←	—	—	→					▒	4
Patient C			■	▒		▒					▒	3
Patient D				■		▒					▒	2
Patient E				▒	■	▒					▒	6
Patient F				▒		■					▒	5
Patient G				▒		▒	■				▒	4

KEY

▒ Days of Clinical Review	NB: minimum time for transfer based on request page not returning to ward for more info
■ Day Patient Referred	Some wards by-passed internal mail by hand delivering referrals they deemed urgent
▒ Day Patient Reviewed	

ICT

Day Of Week	Sat	Sun	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Mon	Tue	Minimum Days from referral to first review
Patient A	■			▒		▒					▒	3
Patient B		■	←	—	→	▒					▒	2
Patient C			■	▒		▒					▒	1
Patient D				■		▒					▒	2
Patient E				▒	■	▒					▒	1
Patient F				▒		■					▒	5
Patient G				▒		▒	■				▒	4

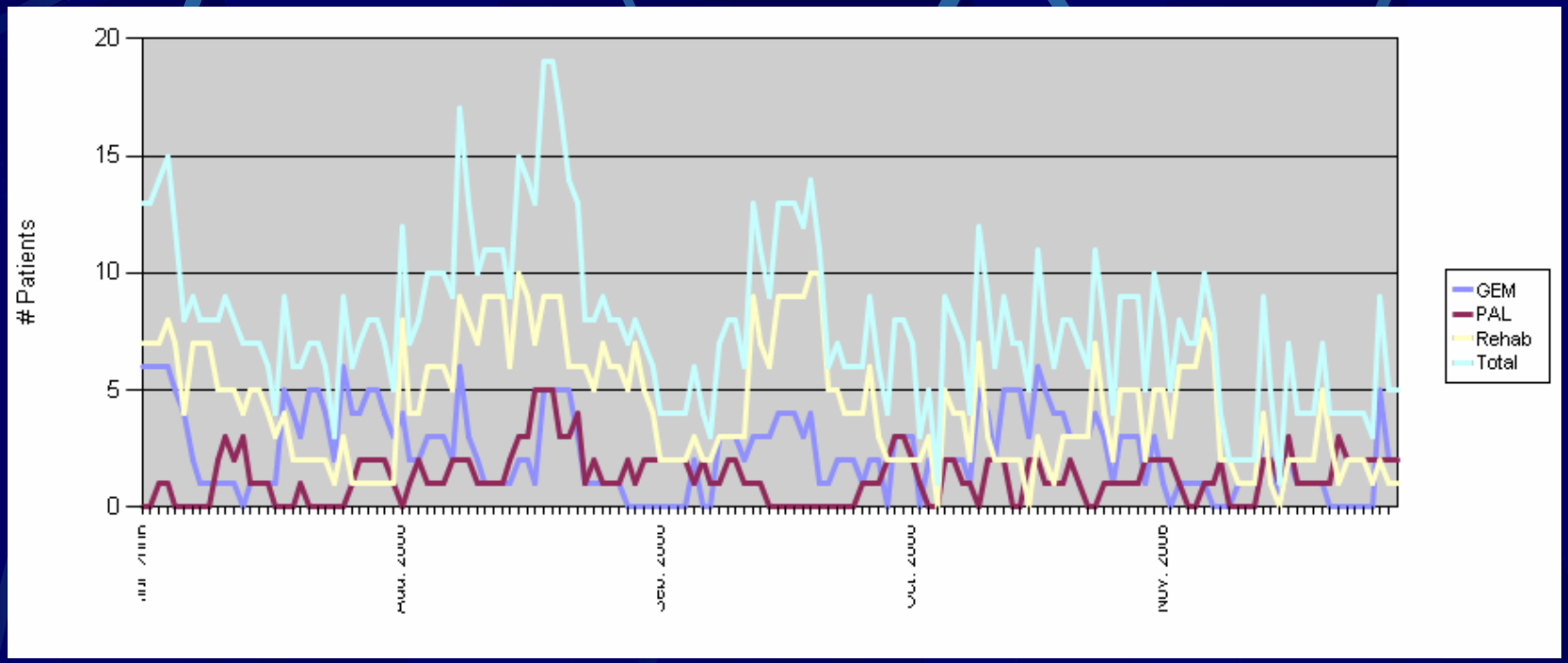
KEY

▒ Days of Clinical Review	NB: minimum days to review could potentially be zero for a patient referred first thing
■ Day Patient Referred	in the morning on Tuesday or Thursday decreasing both minimum days and average
▒ Day Patient Reviewed	

Analysis "Mythbusters"

- Number of patients waiting for transfer to Sub Acute traditionally derived at bed meeting.
- ICT removes subjectivity.
- ICT displays trends.
- ICT facilitates accurate decision making.

Referrals to Sub Acute by type of care



KPI Internal vs ICT Approach

Referral to Review	Paper Based Internal Mail	ICT Approach
Minimum Days to Review	2	1
Average Minimum Days	3.9	2.6

Conclusion

- ICT provides a clinical advantage for referrals between care types.
- Change management vital to success.
- Top level clinical and administrative support.
- Users see new process as an improvement as information instantly available.

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An Interactive Shared Decision Making System for Dental Treatment Planning

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Abstract

Patients would be more satisfied if they are involved in the decision making process for the medical treatment. In reality, however, since the decision making process is time-consuming and complex, it would be hard to make full interaction between doctors and patients in terms of shared decision making. We propose a prototype system by combining two techniques: namely, Ontological Engineering and Analytic Hierarchy Process (AHP). The ontology provides machine processible conceptualization that bases interoperation and collaboration and, the AHP gives instant evaluation of health care options in a subjective manner. Our system is designed to support an optimal treatment planning for dental restorations. The proposed shared decision making system can consider diverse values of dental restorations: time, cost, esthetic and quality values.

Keywords:

patient-centered care, AHP, permanent dental restoration, communication, ontology

Introduction

Frosch and Kaplan define the concept of shared decision making as a process in which the patient and clinician consider outcome probabilities and patient preferences to reach a mutual agreement on the appropriate health care decision[1]. The decision making process could be time-consuming and complex; doctors and old patients would be less satisfied than young patients if the process got long and complicated [1-3]. To solve these problems, the interview or interaction should be simplified in the shared decision making procedure.

To build simple and agile interactions with patients, we combined two techniques, an ontology and an Analytic Hierarchy Process (AHP)[4]. An ontology provides machine processible conceptualization that bases interoperation and cooperation among different systems. The AHP is the technique to satisfy subjective needs of decision maker, and the availability of AHP is also extensible used in shared decision making area [3, 5].

In this paper, we propose a shared decision making system prototype that interacts with patients and a doctor based on an ontology and the AHP. This system is designed to make optimal treatment planning for dental restoration. The system helps both patients and a doctor interactively consider various patient conditions such as financial status and preference of a patient as well as patient's problems.

Method

An ontology is a basement to serve proper information for both of human and system. We define classes about dental restoration method and related information. The classes have various properties to make an effective use of a decision making process, AHP.

The instance of an ontology makes knowledge that can adapt to different situations. Instances of this ontology could be crated for one hospital or one patient. Figure 1 shows an instance of AmalgamRestoration. A value of hasFinancialConstraint can be changed for different hospital that has a different price system. A locatedIn property presents a location of problem tooth that depends on each patient.

We use AHP to suggest the best treatment option for each patient. First, we import the ontology and make alternatives from instances of TxOption class and subclasses. Second, we use common properties of those instances as criterions. Third, we visualize overall expected outcomes and detail properties of each alternatives. Finally, we give a user-interface to change the relative importance of criterion.

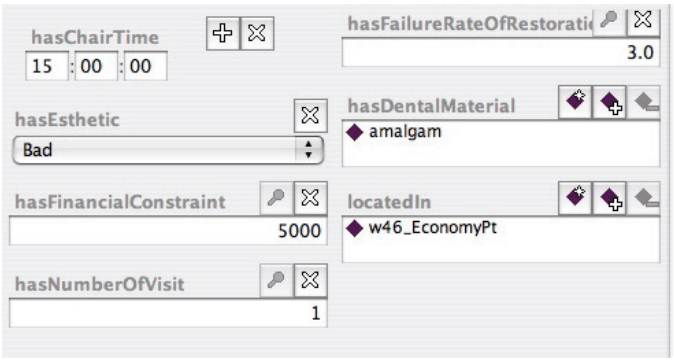

Figure 1 – An instance of amalgam restoration class

Implementation

The prototype was implemented using a described architecture to support a dental restoration treatment planning. The sub-goal of this system is providing an effective user-interface to be understood and interact with a patient.

This system is implemented as a multi-platform system based on Eclipse RCP[1]. We use a part of the JAHP[2] as a module to support the AHP. Each part of this system is described as following:

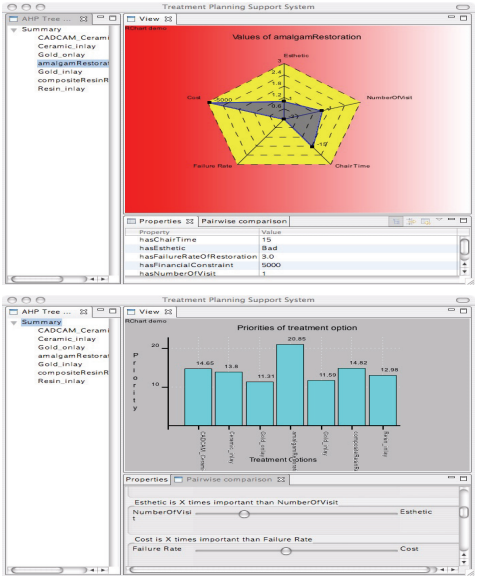

Figure 2 – Interfaces of implemented system

- Alternative Tree View
- Alternative Tree View is comprised of summery item and alternatives sub items. When the item is selected, graph and properties view will be updated to show proper graph and properties of alternative.
- Graph View
- Graph view visualizes current state by user-friendly graph. Radar graph summarizes merits and demerits of alternative at a glance. Bar graph shows expected outcome to compare treatment options.
- Pairwise comparison view
- Pairwise comparison view helps human to make pairwise comparison matrix that represents relative importance of properties. In this view, relative importance is visualized by slide bars and user can easily modify them by dragging. It affects bar graph immediately. It can be used iterative process of user to find proper solution.
- Properties View

  Properties view describes properties of treatment options based on ontology. Each property represents a characteristic of alternatives. It gives more detail information than graph view.

Conclusion and Future Works

In this paper, we built a prototype system using an ontology and an AHP technique to support an optimal treatment planning for dental restorations. This system showed: (1) A system can give instant evaluations of the treatment options for dental restorations; (2) A system can consider diverse values of dental restorations: time, cost, esthetic and quality values.

More generally, we showed the prototype architecture that an AHP integrated with an ontology: it could provide simple and agile interactions for shared decision making, and interoperations with other systems.

We have limited the scope of research to choose a best option among the provided options. Meanwhile, medical examinations could be collected from medical equipments; a reasoning functionality of an ontology could extract possible treatment options for a patient from the medical examinations. The development of these processes would help us to make a complete treatment support system for dental restorations.

Acknowledgement

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1 http://wiki.eclipse.org/index.php/Rich_Client_Platform
2 http://www2.lifl.fr/~morge/

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An Interactive Shared Decision Making System for Dental Treatment Planning

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Seoul National University, Korea

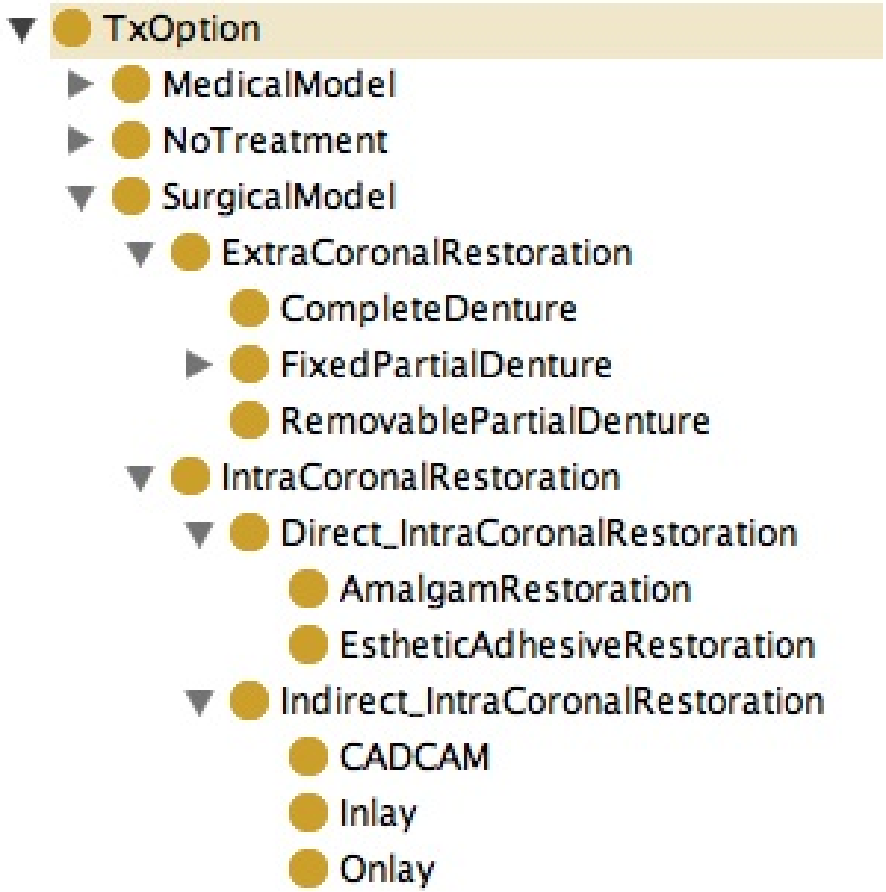
Introduction

Shared decision making

- **Shared decision making**
  - patient and clinician consider outcome probabilities and patient preferences to reach a mutual agreement on the appropriate health care decision [1]
- **Methods**
  - Counseling
    - Long and complicated process
  - Interactive Video / CD-ROM
    - Need elaborate preparing

Ontology

Class hierarchy of TxOption Class



- **List of expected treatment options**

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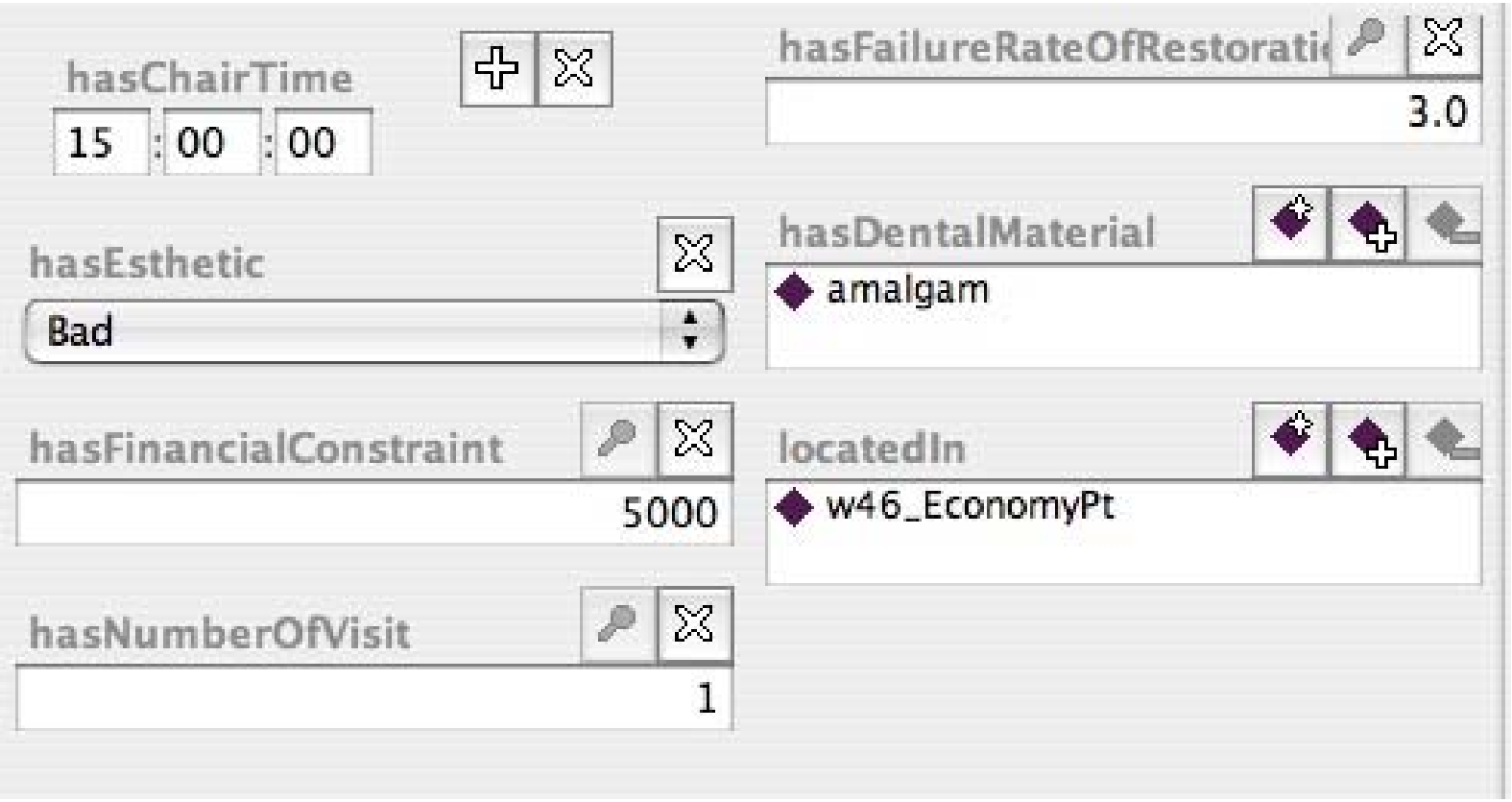
Instance of Amalgam restoration



Analytic Hierarchy Process (AHP)

Implementation (1)

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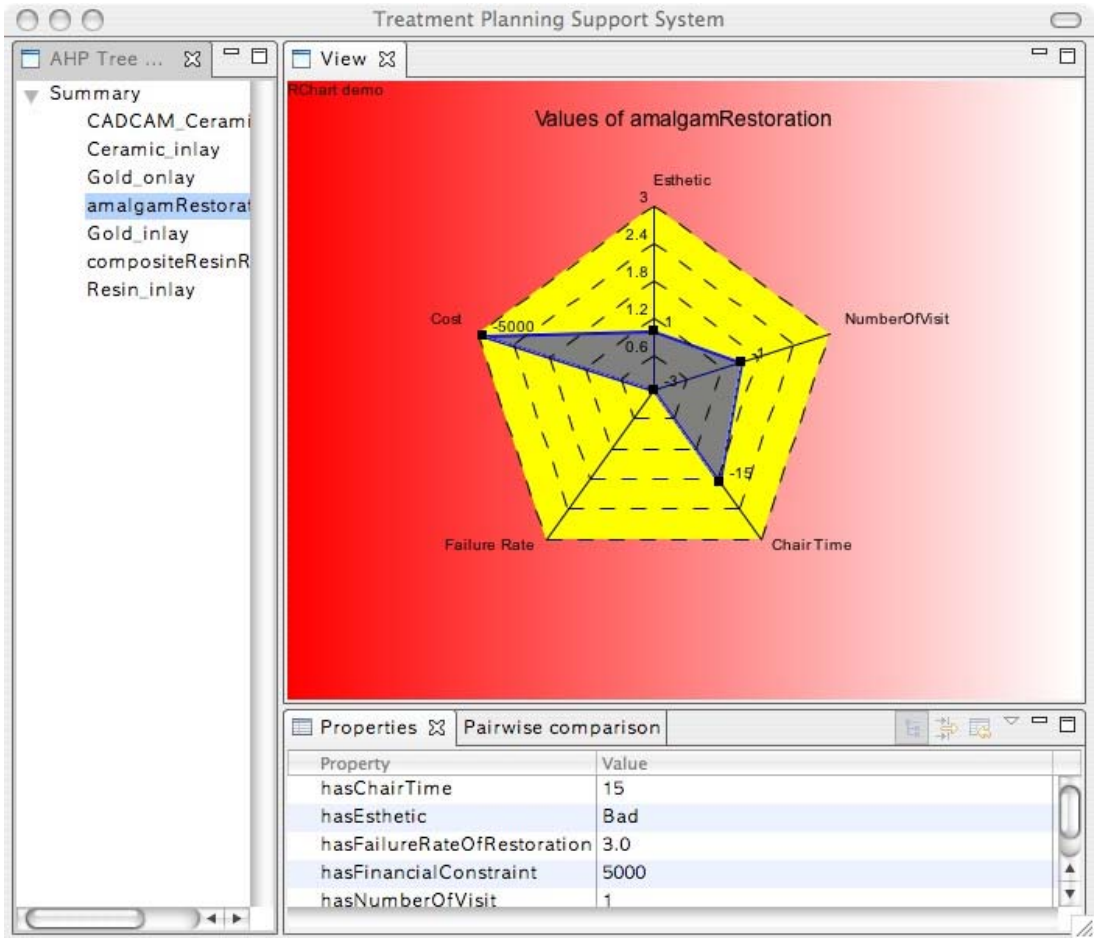

- **Properties of Amalgam restoration**

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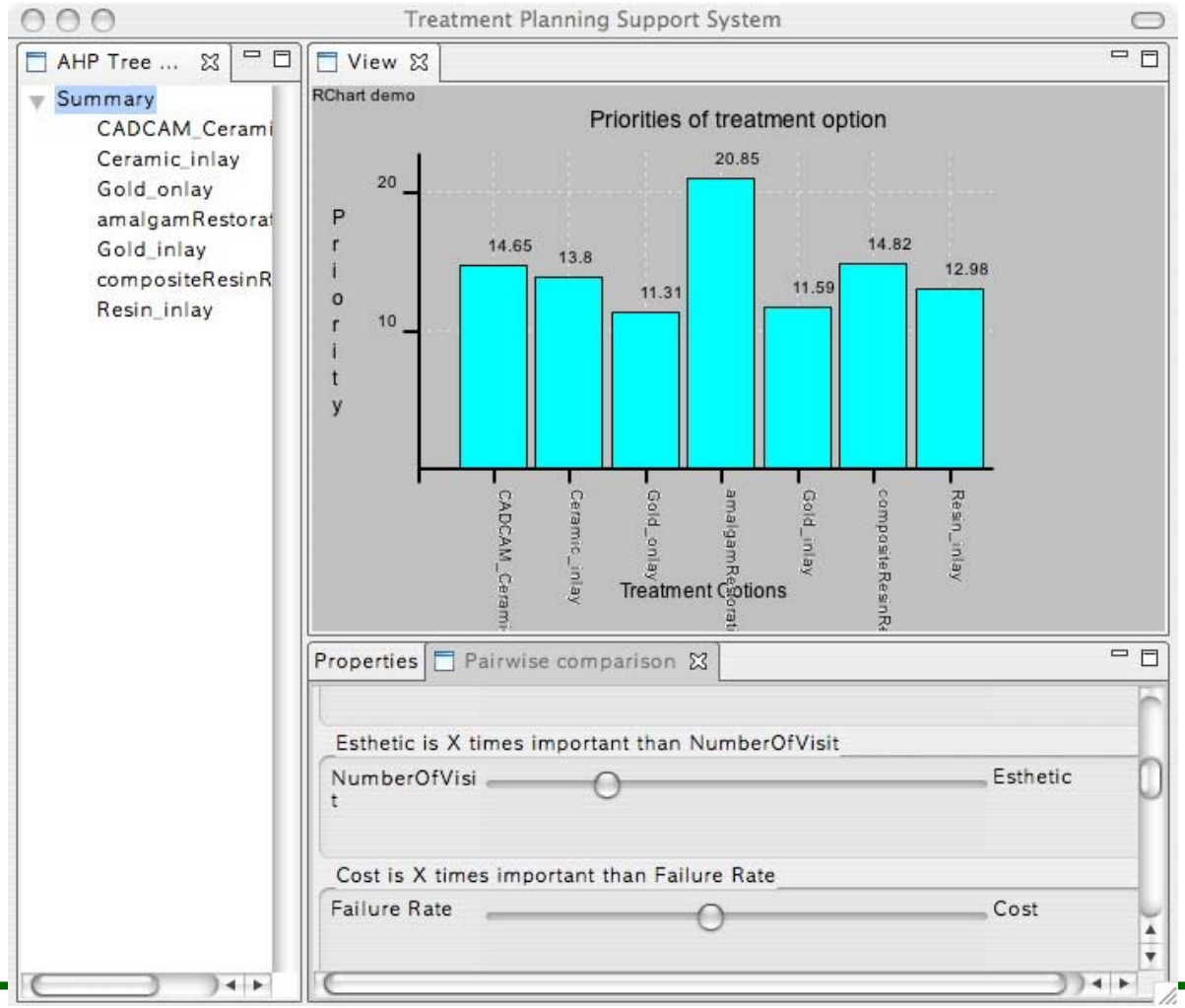
Implementation (2)



Conclusion

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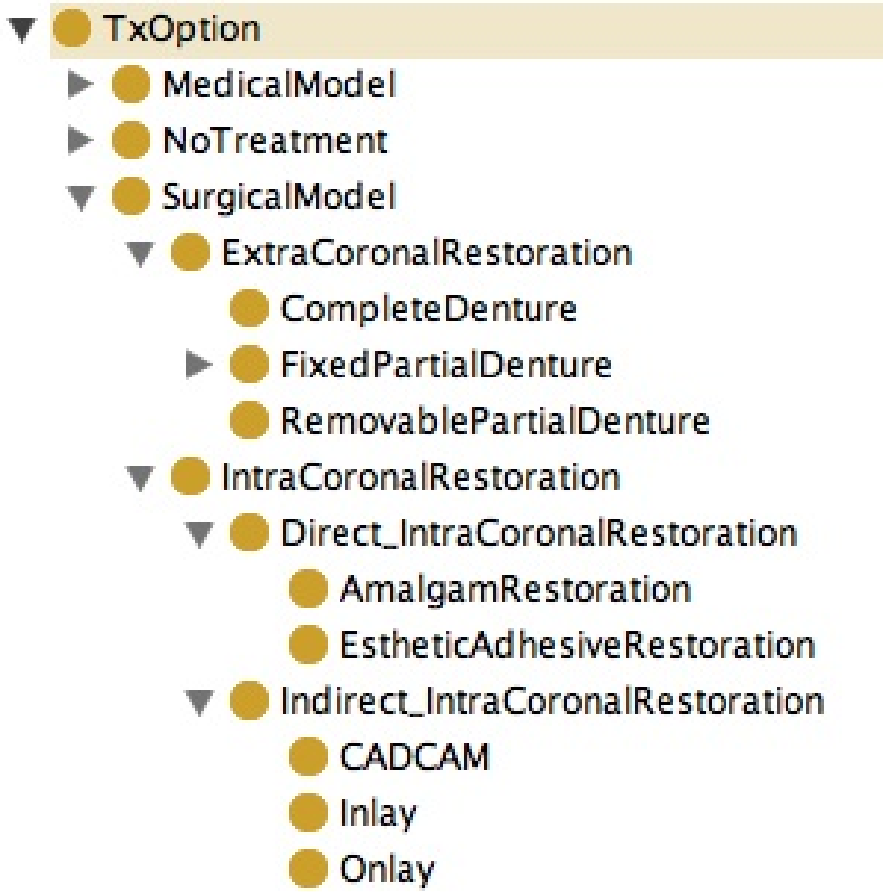

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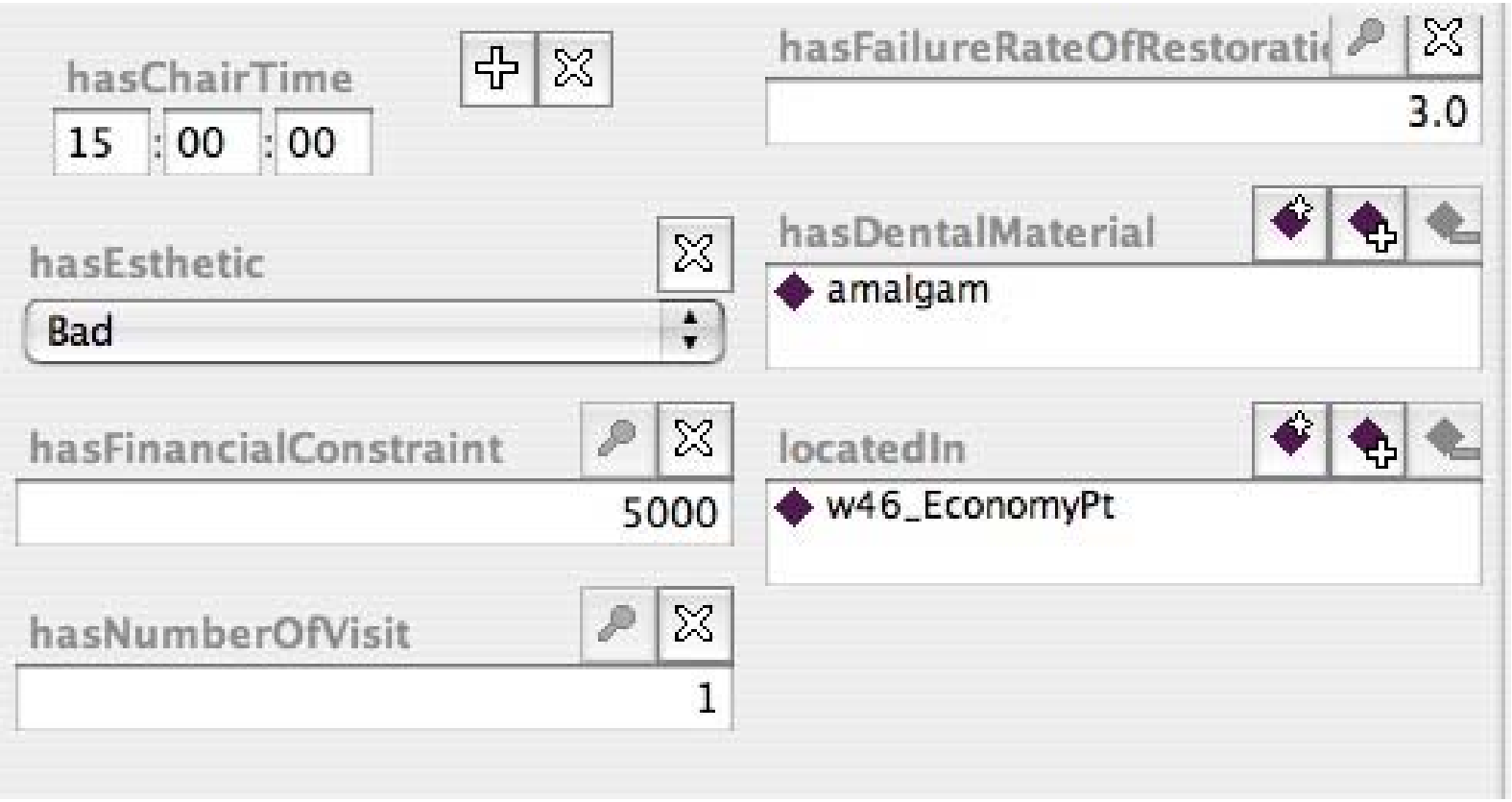

Analytic Hierarchy Process (AHP)

Implementation (1)

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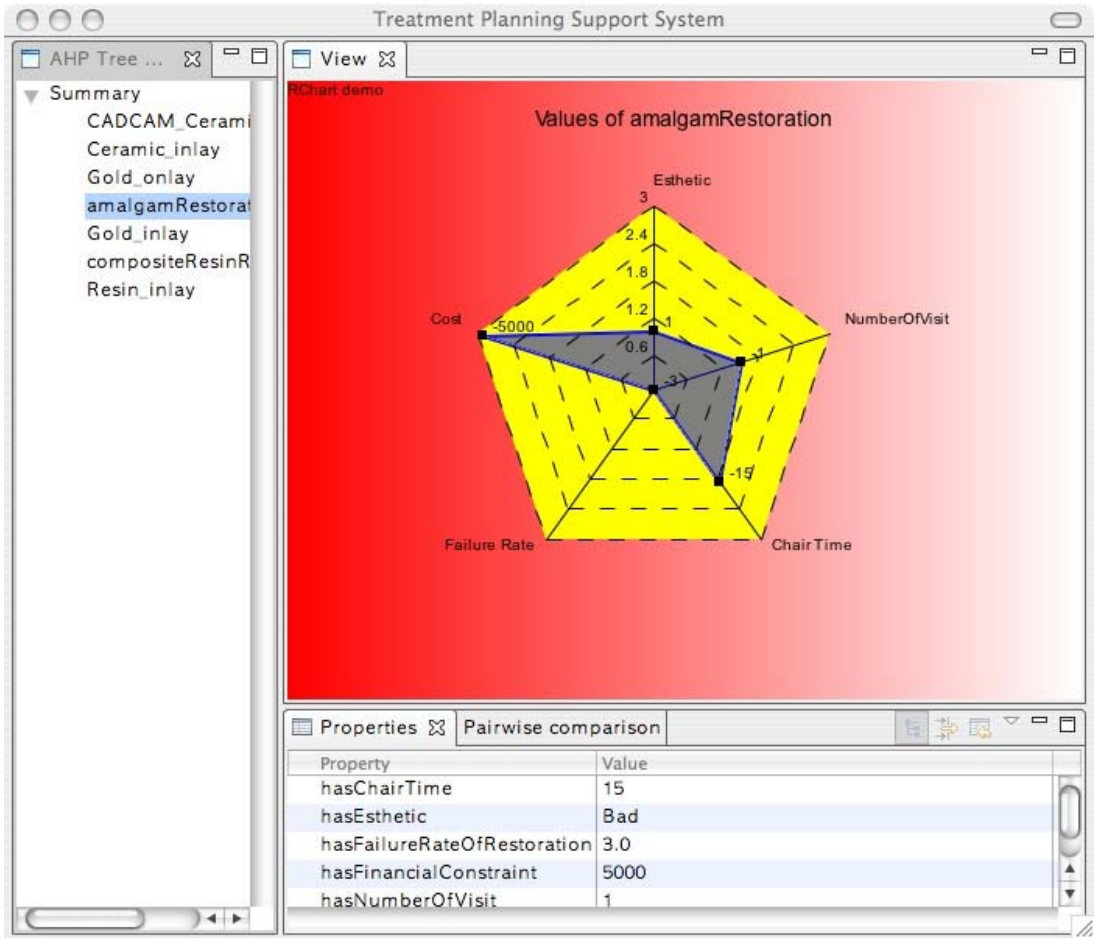

- **Properties of Amalgam restoration**

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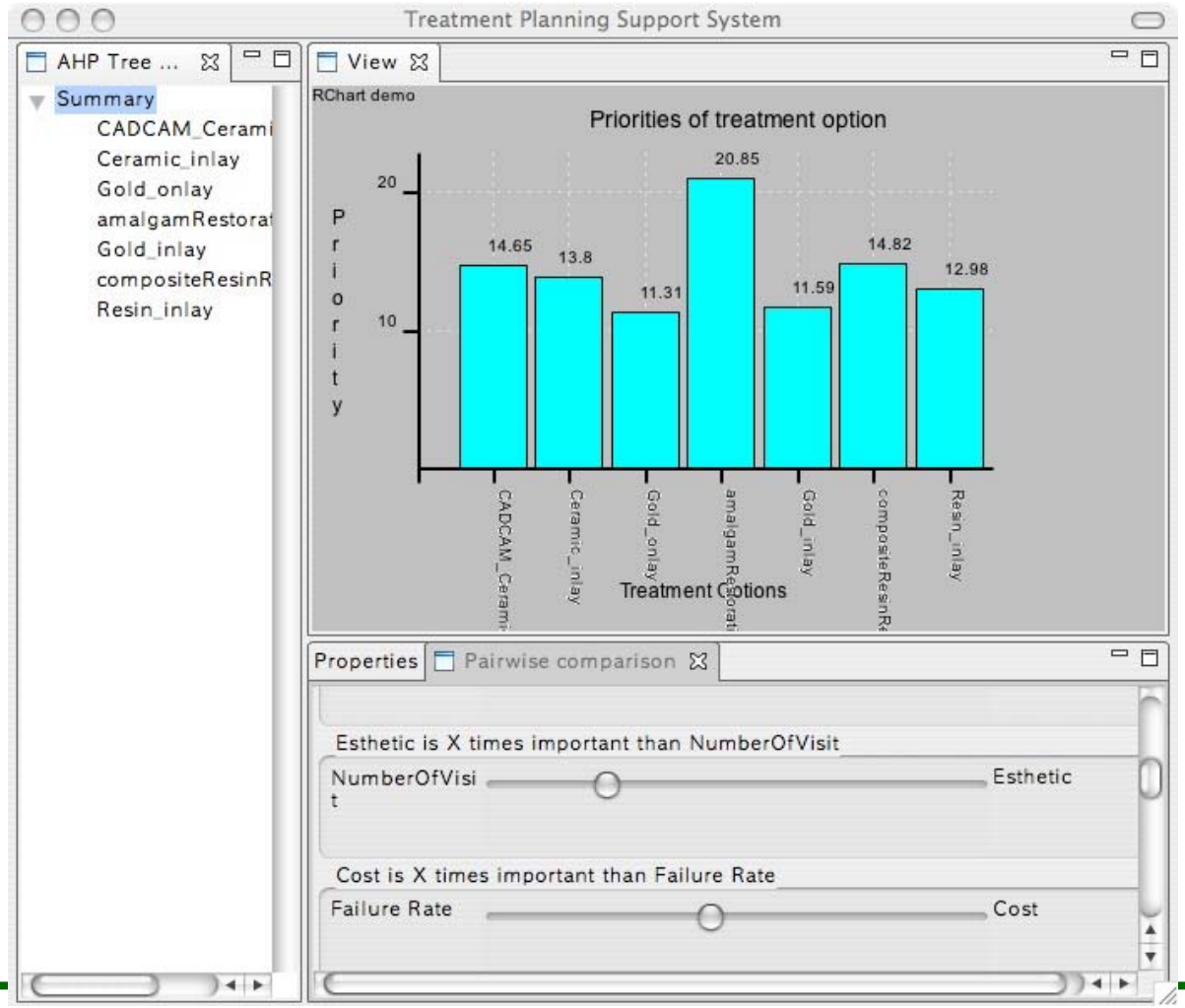
Implementation (2)



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Study of the Platform of a Medical Information System to Promote Telemedicine Services

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Abstract

Promotion of telemedicine services is an important political issue in Japan. The most important factor in determining the quality of telemedicine services is communication infra-structure. With the spread of the IP network, broadband prices have fallen and take-up has increased, but the study of the platform of medical information systems has not yet been fully developed.

This paper first proposes two requirements for the telemedicine information system: 1) to provide the best-quality transmission service with limited communication bandwidth, and 2) to widely share medical information in an integrated and secure manner. Next, it outlines the two themes of our study to achieve these requirements: 1) an on-demand medical information network system, and 2) a highly efficient Region of Interest (ROI) image coding.

The results of the study will contribute to the promotion of telemedicine services on the IP network.

Keywords:

medical information system; telemedicine; region of interest; on-demand network; IP network

Introduction

Asahikawa Medical College Hospital in Hokkaido, to which my group belongs, started a telemedicine service for ophthalmology clinics in 1994, and is now providing approximately 150 diagnostic telemedicine services per year for 22 eye clinics in Hokkaido [1][2]. Currently, this service is also provided to radiology, pathology, surgery and internal medicine departments on a daily basis.

The system of telemedicine services uses transmitters, receivers and communication lines that link between them. The most important factor that decides the quality of the service is communication lines, which are actually less established in the areas that need more remote medical services. Although this constraint is being eased thanks to the recent spread of the broadband network, the establishment of an effective communication infrastructure has not yet been achieved in mountainous areas and remote islands.

Against this backdrop, our group has been involved in various studies and developments relating to a system to improve the quality of telemedicine services. This paper outlines our study according to its main themes.

Purposes

Our study aims to develop a system that meets the two major requirements essential for an effective telemedicine information service. These requirements are: 1) to provide best-quality transmission under limited bandwidth conditions, and 2) to widely share medical information in an integrated and secure manner.

Methods

To achieve the above purposes, especially requirement of 1), the study has been conducted under the following two themes. Meanwhile, regarding of the 2), we have studied and developed the P2P medical information sharing system [3].

(1) Prioritization of medical information transmitted on the IP network

The IP network is generally based on the best-effort service, and communication bandwidth and destination are determined by the contract conditions with communication carriers on the leased line service. However, telemedicine services require a certain level of communication quality in order to operate efficiently, enabling it to prioritize medical information in an emergency. To meet these needs, we have studied and developed an on-demand medical information network system, which controls traffic by prioritizing user requests on the MPLS network.

(2) High-quality transmission of video information according to communication bandwidth

Video information plays a significantly important role in telemedicine services. However, because of its extremely large volume compared with numeric and character information and its need to be transmitted in real time, its quality can be affected by network conditions. Therefore, we have studied and developed highly efficient image coding using Region of Interest (ROI) technology so that efficient transmission can be realized according to network conditions and communication purposes.

Results

Following are the outline and results of our study on each theme.

(1) On-demand Medical Information Network System

To control the network bandwidth, it is necessary to synchronize the data transmission on users' access lines with the transmission on the core network, which links the MPLS routers. The local administrator (LA) manages users' applications and access lines, which exist between users and the core network, as a local resource. The application gateway (APGW) controls the requests from each LA, and forwards the requests to the MPLS router via the router controller (RC) to secure the resource of the core network.

In response to user requests, the LA and APGW decide the application to be prioritized and pass the result to the network control. At that time, they consider a priority policy prepared for each application and the priority level specified by users, using the analytic hierarchy process (AHP) method, to comprehensively decide the order of priority. The user specifies the priority level by stipulating the level of the emergency (urgent or normal) together with the necessity level (5 to 1), based on medical guidelines. The network is controlled so that highly prioritized applications can preferentially secure the bandwidth, and routes are arranged appropriately.

(2) Highly efficient ROI Image Coding

With limited communication bandwidth, we figured out a method of image transmission that, as much as possible, maintains the quality required from the receiver. This method, called ROI image coding, compresses the ROI specified by a rectangle on the image into high-quality data and the outside (non-ROI) into lower-quality data. As giving prominence to characteristics, the quality levels of the ROI and non-ROI are automatically decided depending on the network bandwidth.

Discussion

When the communication bandwidth is broad enough to send and receive data, the receiver has no problem in retrieving information to provide medical support for its patient. However, it is rare to have such a communication environment. In reality, telemedicine services are requested from an area that does not have sufficient communication bandwidth. For such areas, the method of highly efficient ROI image coding is useful to ensure the transmission of the minimum required medical information on the best-effort type IP network.

Telemedicine services are particularly useful in case of emergencies such as disasters and accidents, but the requested information should be preferentially transmitted on the network. This would be similar to how ordinary cars move aside to offer an open road for approaching emergency vehicles. The study of the on-demand medical information network system enables the flexible control of communication quality according to applications and user requests, and secures smooth data transmission even on a congested communication network.

Conclusion

This paper has described our study themes, the on-demand medical information network system, the highly efficient ROI image coding system as the basic study of a telemedicine information system. We believe this study will ensure the quality improvement of telemedicine services on the IP network.

Acknowledgments

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Developing a Digital Form Generation Systemfor Ubiquitous Computing Environments of EMR

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Abstract

Recently, several hospitals have changed their systems from legacy system using paper to electronic medical record (EMR) system for inpatient and outpatient. There are several obstacles to this change such as user resistance; expense of education, time spent due to entering data, and etc. So there is a significant need for easy and user-friendly data entry system using digital pen for collecting electronic medical record. Also flexible form for digital pen must be promptly created by clinical staffs. The purpose of this study is to develop the digital form generation system using digital pen to support outpatient treatment rapidly. So we implemented the digital form generation system which is consisting of digital form generator interface and digital pen data entry system. To evaluate the digital form generation system we developed prototype of EMR system and tested data processing procedure. We expect this system using digital pens can be the helpful and the easiest migration tool in successful adaptation of the EMR.

Keywords:

electronic data entry system, image, digital pen, electronic patient record, digitalized data

Introduction

The effort for computerization of the medical record has been accelerated rapidly in recent years. However, computerization of the medical record is the repetition of trial and error due to the complexity of medical record and the very nature of medical environment, which is different from computerization of other industry areas.

According to NCA (National Computerization Agency) CIO REPORT (June, 2006) of Korea National Information Society Agency, EMR system introduction rate of Korea is only 2.6%, and it is mainly conducted by giant-scale University hospitals. The main issue related to medical informatics of Korea is rigidity of hospital organization against change and expenditure [1].

Some hospitals have developed electronic data entry system and let their staffs enter data at the time of medical treatment. But the systems are used only for some limited departments. The reasons EMR systems of some hospital could not be used for the entire hospital are assessed as follows. First, it is not easy for the clinic staffs to input prescriptions and medical treatments after reviewing history and medical record. Time is the critical issue here. Second, most health care systems still use some combinations of electronic medical records and paper charts because some kinds of sheets are inefficient to become electronic data via keyboard entry system. Last, electronic medical record system does not have reliability, stability, enough scale, and fast response time to support outpatient treatment smoothly [2]. To overcome the rigidity of organization against change and to ensure the reliability, and fast response time to support outpatient treatment, EMR systems should be kept in electronic form with various input devices (i.e., Personal Digital Assistant, Digital Pen, Tablet PC, etc.). Recently, digital pen is used as one of the EMR data entry devices, and electronic medical data entry systems using digital pen are researched and developed in Europe and America [3].

According to recent researches, the digital pen is an easy, fast, and cost-effective tool, supporting rapid adaptation of EMR. At the Lineberger Comprehensive Cancer Center in USA, Elodia Cole and her fellows (2005) accomplished a comparative study to determine the speed, accuracy, ease of use, and user satisfaction of various electronic data entry platforms for use in the collection of mammography clinical trials data. Four electronic data entry platforms were tested: standalone personal digital assistant (PDA), Tablet PC, digitizer Tablet/PDA Hybrid (DTP Hybrid), and digital pen. Research shows that Tablet PC and digital pen were equally fast and easy-to-use data entry methods that were well tolerated by radiologist users. Handwriting recognition review and correction for the digital pen were significantly faster and more accurate than secondary manual keyboard and mouse data entry. Also, digital pen showed much(or significantly) lower expenditure of hardware cost and higher satisfaction than other devices [4].

Martin Schiavenato (2006) remarked on his review paper "Technology Brief: Digital Pen and Paper" about Digital pen and paper systems as an expedient and innovative way of adapting the familiar handwriting medium into the EMR. She thought the advantages of the digital pen and paper system are ease of use and small need for training. An example of Cherokee Indian Hospital case is cited. The

hospital reported savings in its insurance processing transactions using a digital pen and paper system on a per form basis from $2.00 to $0.50[5]. Martin Schiavenato recognized the digital pen and paper as a potential and promising element in the evolving pursuit of the application of technology in healthcare. And she came to the conclusion that this system can transform the familiar process of pen and forms into an expedient and effective way to document and process clinical, research, and financial/ administrative data [6]. Bethesda Emergency Associates (2006) implemented the BARTCHARTS ™, a comprehensive, paper-based template charting system using digital pen. This new system provided emergency department physicians the power of electronic documentation with the ease of paper and pen. On the other hand, Robert R. Rothstein, MD, Medical Director of BEA(Bethesda Emergency Associates in the United States of America) explained the efficiency and ease of use as following statement: “None have been as easy to use or actually have improved my efficiency like this. Within 5 minutes of sitting down with the digital pen solution for eBC I was documenting 100% of my charts." [7].

Still now, Cherokee Indian Hospital (USA), Hôpitaux Universitaires de Genève (HUG, Swiss), Royal Ottawa Healthcare Group (Canada), etc have used digital pen for the effective and easy adapting method into EMR [8-9].

In Korea, some hospitals adopted the digital pen systems from the beginning of the EMR system design, especially for reducing resistance for EMR systems, effective recoding of the physical assessment data, and for the completion of the consent [10]. The extension of adaptation area was asked by many users for several times during two years. But it takes approximately one month for collecting proposals, implementing and printing new forms. And sometimes forms for digital pen system (the following of paper - digital form) are changed for some reasons, so printed digital forms became useless. Prompt digital form generation in hospital by user and time saving for developing and printing to add new forms at existing digital pen system are requested.

So, I suggest a digital form generation system which enables clinical staffs to use digital pen and digital form at ubiquitous computing environment of EMR system. Through this system the digital form can be promptly created and printed by clinical staff.

Methods

1.Anoto functionality

Anoto functionality is technology related to digital pen and paper, which is supported by Anoto AB in Sweden. This technology allows man to continue using pen and paper to capture information and digitalize the data. This technology, entailing interpretation and transmission of handwritten texts and images, is based on a special digital pen and a paper printed with a pattern that is invisible to the eyes. The pattern consists of small dots (100 μm in diameter) arranged with a spacing of approximately 0.3 mm on a square grid. The dots are slightly displaced from the grid, each dot in one of four possible positions. It is the pattern that makes it possible for the pen to know what is written and where it is written. Each dot carries two bits of information and since the pen registers positions by reading an area of 6 x 6 dots (which can have 46 x 6 = 436 = 272 unique combinations) unique pattern is ensured on a very large area. The displacement of the dots makes it possible to uniquely identify each pattern area [11]. In this study, Anoto Functionality is used for entire system construction.

2. System Configuration

Logitech® io™2 pen was used as digital pen, and Anoto Functionality(software development toolkit, form development toolkit, pattern license) of Anoto AB is used for developing digital pen data entry system and postscript file for printing. AFPL Ghostscript 8.54 and GSview are employed to print PS (Postscript) file.

C#.NET was used for software language. Visual studio 2003 was used as a language tool. Operation environment was the Windows XP with Microsoft.NET Framework version 1.1. Microsoft.NET Framework essentially was installed first in order to install Logitech® io™2 pen. Microsoft SQL database was used for saving the vector and result value, which is recognized and converted via recognition process.

3. System development

First of all, we mapped out a scenario for hospital setting (Figure 1). We designed digital form generator to load the existing clinical documents (ex. Hangeul (Korean editor), PowerPoint, Excel, Word file). After the existing document file loaded, user can set the user-area for saving the pen-data

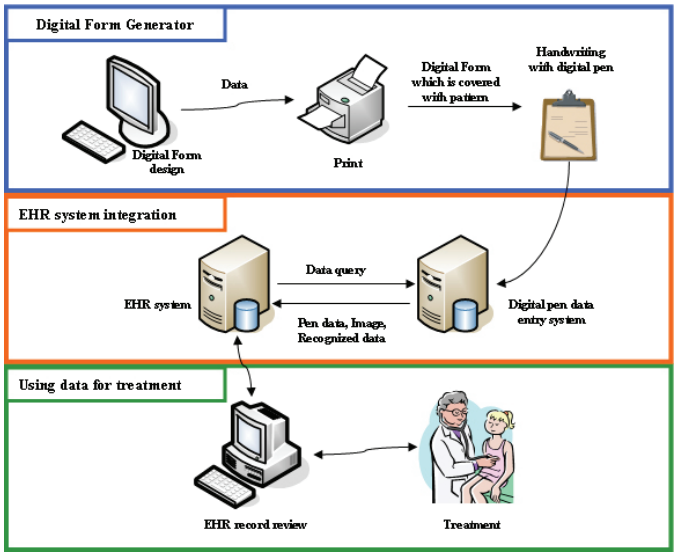

Figure 1 - System scenario

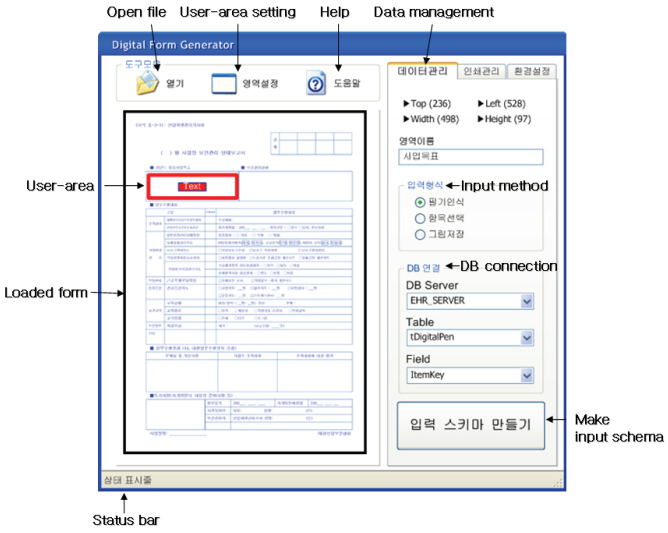

Figure 2 - User-area setting in Digital form generator

After user-area setting via digital form generator interface, digital form, which is covered with patterns would be printed out. Then the user can write treatment result or physical assessment data on the digital form freely. When the user put the digital pen into the cradle, which is connected to local PC by USB cable, the data synchronizing would be aroused and pen data would be converted into images, recognizing data and saving these in EHR system server. These data could be reviewed and used as treatment data or research data. On the base of this scenario, we planned to develop the digital form generation system, which is consisting of digital form generator interface and digital pen data entry system. To evaluate the digital form generation system, we developed prototype of EMR system and tested data processing procedure.

Results

1. Digital form generator

The user can load the existing form and easily set the user-area with dragging red box and can view the area size and position information via right side bar. The data management tab provides three ways for setting the input method (Handwriting recognized data, check box data, image) for each user-area. Database connection part shows the database server, table, field name of EMR server. As the making input schema button pressed, PAD file including user-area information and INI file for database information is generated (Figure 2).

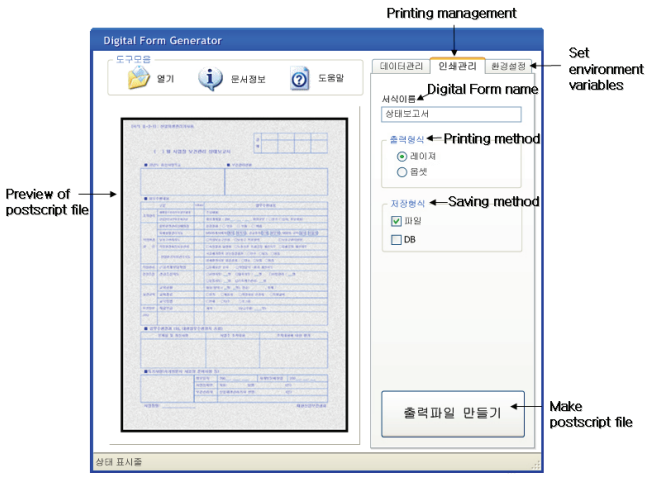

Figure 3 - Make postscript file in form generator

At the printing management tab, user can select the printing method. When user wants to print at the local or network printer, laser option could be selected. But when user wants to print a large amount of digital form at once, offset option should be selected (Figure 3).

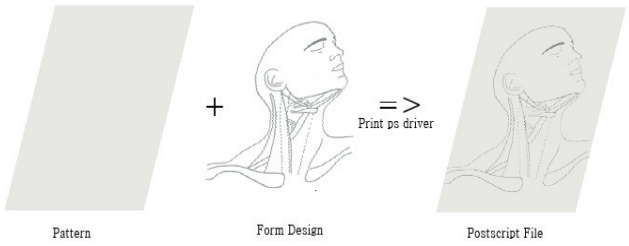

Figure 4 - Postscript output

When making postscript file button pressed, the existing form and Anoto pattern are merged and a postscript file is created for printing using postscript printer driver (Figure 4).

As the result of digital form generator, PAD file, INI file, and postscript file are generated. The digital form is printed by using postscript file.

2. Digital pen data entry system

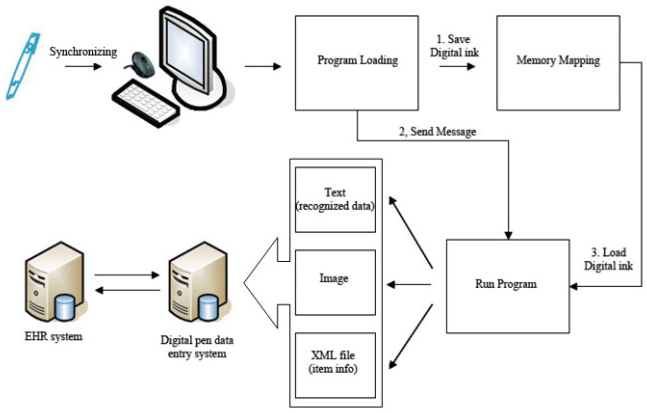

Figure 5 – Data digitalizing process

EHR system integration part of scenario can be explained as data digitalizing process perspectives. After the user handwrite on the digital form and put the pen into the cradle, the new instance of digital pen data entry system is loaded. The instance reads digital ink using address of memory map, which is transmitted to windows message. The application handles the pen data for various formats (handwritten recognized data, check box data, and image) according to input schema. After data handling is completed, the event message is transmitted to EHR system. Then EHR system reads the saved data from digital pen data entry system.

We implemented the digital form generation system, which enables user to generate digital form easily, and print whenever it is needed. This system converts handwriting data to digital data automatically, and put these into EMR database at once.

At first, we developed the digital pen generator in order to print digital form. Digital form generator interface is developed to allocate the user-area for recognition and to save data into database.

Secondly, digital pen data entry system is developed. When user uses digital form with digital pen, digital pen data entry system enables handwriting data saved as a recognized text data, image into database automatically. After handwriting and putting the digital pen in the cradle, pen data are transmitted to PC as vector format.

Conclusion

The digital form generator is an independent solution from EMR system. So when it adapted to other EMR system, less initial expenditure and more rapid adaptation are expected. Especially, in cases of questionnaire of patient symptom, consent, physical patient assessment using background image, this system would be very useful for digitalizing the patient records. The immediate use of the collected patient survey data for the patient treatment would be available. User satisfaction for EMR system would increase when this system is embedded to EMR system, because the user can create and print digital form when it is needed. Also, economic migration toward EMR system would be achieved because the repository is not necessary, and there is no need to buy another special printing system. If the printer dpi is over 1500dpi, any printer can be used. The clinic staff, even the ones, who are not familiar with a computer, would accept the collecting the electronic health record as easy and fast task. We have a plan to integrate this system with real EMR systems. We hope this system to contribute rapidly and smoothly to support medical treatment and to computerize the medical data with low cost.

Acknowledgments

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Implementation of Input Interface using General Data Transmission Methods for Digitalized BioSignal Data Management

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Abstract

The u-Healthcare is a new healthcare paradigm based on the Internet and ICT. Healthcare service using mobile devices includes sensor devices using measured biosignal data and home health network. The biosignal monitoring service is one of the monitoring services in ubiquitous healthcare. Methods of inputting, transferring, and managing biosignal data are so various that device interfaces need to be expanded. A transferred data format also needs a data transmission standard like Health Level 7. We implemented the sender/receiver interface using three devices including a PDA, a desktop computer, and a digital pen. Also the HL7-based biosignal message template and its database were designed. In the user input interface, patient/doctor's interfaces were developed separately and they enabled the user to review graphically the accumulated data. We adopted a digital pen having a powerful user-friendly input interface to develop the self-record manage application.

Keywords:

biosignal, Interface, Transmission, Database, Health Level 7, XML

Introduction

The healthcare services using mobile devices include various devices using measured biosignal data, home health network, electronic home appliances, and so on. The biosignal data management system usually monitors, analyzes and manages the biosignal data of wireless medical devices like blood pressure, pulse and ECG data, etc. In this system, some essential techniques are needed for the system functions of sending to the server wirelessly, storing, and managing the measured data. We tried to find how to input the wireless biosignal data and how to send them to the management system by an efficient data transfer method. First, to make the system construct easily and reuse the data, we referred to common data formats and transfer methods. Secondly, to full use of recent data input devices, we should expand input interfaces in ubiquitous environment. We considered several standards for EHR and applied Health Level 7(HL7) Version 3.0 to our application. We thought that HL7 was accepted medical informatics relatives as general standardized data transmission protocol. We had implemented the web-based patient monitoring system using HL7 Version 2.5 as a preliminary study in 2005. This research aimed the improvement of the previous study and it was new approach by adding user interface devices and applying the new version of standardized data transmission protocol.

Methods

The whole system are composed of 4 major parts: the client input interface of three devices, the server interface of sending/receiving data, and the user interface including a graphic view and a digital pen interface. First, we designed and implemented HL7 Message Sender/Receiver Interface. In the Message sending module, Blood pressure, pulse, respiration, temperature, SpO2 and general information of patient were input into the application program. The message receiving module was the server application of HL7 V3.0 message receiver. The server received a message from the client program and sent a HL7 V3.0 acknowledge message to the client program. The database was developed with Microsoft Windows 2003 Server, Visual C#, SQL Server 2000 and XML. It stored and managed the data in XML documents. The application program of home self-recording was implemented by a digital pen.

Results

1. **Design of HL7 V3.0 RIM-based Biosignal Database**

The Biosignal Database was designed using the RMIM (refined message information model) that was the restrained model of the HL7 RIM. The cMET schema for the measured data with texts, REPC_RM000130 (ObservationVitalSigns.xsd) was applied. It was able to easily transfer the received data into the server system. The database stored and managed them within XML format messages. We made basic messages of biosignal data with the general information of the patient, and composed the input XML template. The standard model was reflected on tables and attributes.

2. Design and implementation of message sender/ receiver interface system

When the data were input into sender devices, a desktop computer, a PDA phone, the sender interface system made HL7 3.0 XML files of them. Multiple files could be sent to the server simultaneously. The sender interface on desktop computer has the user interface of data input and sends the data into an each device and shows the converted XML files to the user. When the user enters his name and password for login on a PDA, the sender converts the written biosignal data to XML files and sends to the server database. Then the server sends an acknowledge message to the PDA application, and sends the data within XML files to the database.

If HL7 V3.0 XML files received from the sender interface are valid, the message receiver stores them to the integrated biosignal database in the server application. Each an acknowledge message (ACK) toward each valid HL7 message is sent to the sending interface. When an invalid message is received or when a communication error is occurred, the system sends the ACK message with a specific value of the error.

3. Web-based Biosignal Data Management

This application has a query function to review the accumulated biosignal data by data itself and graphics. After the program registers to the web server, users enter their name and password for login in a web site or a device interface and they can inquire or review their accumulated data by a web browser. The main function is that users can inquire their data sorted by time and data types in the table or graphic format.

The patient can review his accumulated data and view graphically by PDA phone application program. After the data inserted to the database, the patient can't edit them. After login, the doctor can monitor his patient's data anywhere.

4. Expanded input interface: digital-pen application

We designed the self-record manager program as a Windows application by C#. Self-records at home were composed with personal identification items, biosignal data input items, and a memo item that the patient could input any comment or any question to his doctor. The manager can recognize a user using the pen ID in the personal information register items, and the user doesn't need to enter its personal information each time. It makes the data store individually. The written pen data is converted to selected image types (jpg, png, pdf) and is stored. When a user selects the data, it is converted to a HL7 3.0 message XML file and is sent to the server.

We added and expanded another function to self-recorded papers in home, the program could autonomously input a date and time item, and a respiration input item. Figure 7 shows self-management record manager.

In the record format using a digital pen, about 80% character recognition was caused of presence of various handwriting patterns. So we added a correction function, and users could review and correct their written data. The push of the recognition button in the lower review window shows written data and users may correct and store them.

Discussion

We implemented input biosignal data interfaces on a desktop computer and a PDA phone. The user interface was different user screen according to the patient or the doctor. The measured biosignal data from each medical device was converted a standardized message format and sent to the data management system server wirelessly with the standardized transmission format.

The points of this study were the wireless biosignal data transmission and the application of standardized transmission protocol (HL7 V3.0). During the implementation of the applications, we faced with many problems again for using a general standardization protocol. Because items of HL7 message tags were so detailed that we were not easy to apply these items to the real message. The types of data are limited in this study. We have a plan to expand them and to expand applications of data transmission standards to other related studies. The database inquiry will also use the standardized message format. The future study of data transmission standards and technologies will be followed.

This study was one part of the Ubiquitous Biosignal Device Center Project in Korea. The project aims at developing everywhere-anytime healthcare system. By minimizing medical equipments and making the users (patients, doctors and nurses, etc) to carry them all the time. Our team is looking for the technology of standardizing and interfacing body information.

The biosignal data were continuously generated by mobile devices or wearable sensors. We started from pre-assumption that the data were already measured by sensors and the user wanted to enter them on his screen interface in this study. Finally all implementations were connected each other sub-study.

Conclusion

In ubiquitous environment, various user interfaces are needed to introduce biosignal data sending/receiving, test and expand. We implemented the user interface with a desktop computer, a PDA, and a digital pen using a standardized data transmission method. The standards are not easy to implement real situation but they will be a trend in healthcare delivery system. But they are so essential to

share the healthcare data and they can make software applications simplify. The technology-assisted application with a new device is convenient and potentially powerful complement to user-led management. The device easily to use can encourage users to self-manage their healthcare information.

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Poster 449

Implementation of Input Interface using General Data Transmission Methods for Digitalized BioSignal Data Management

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Abstract

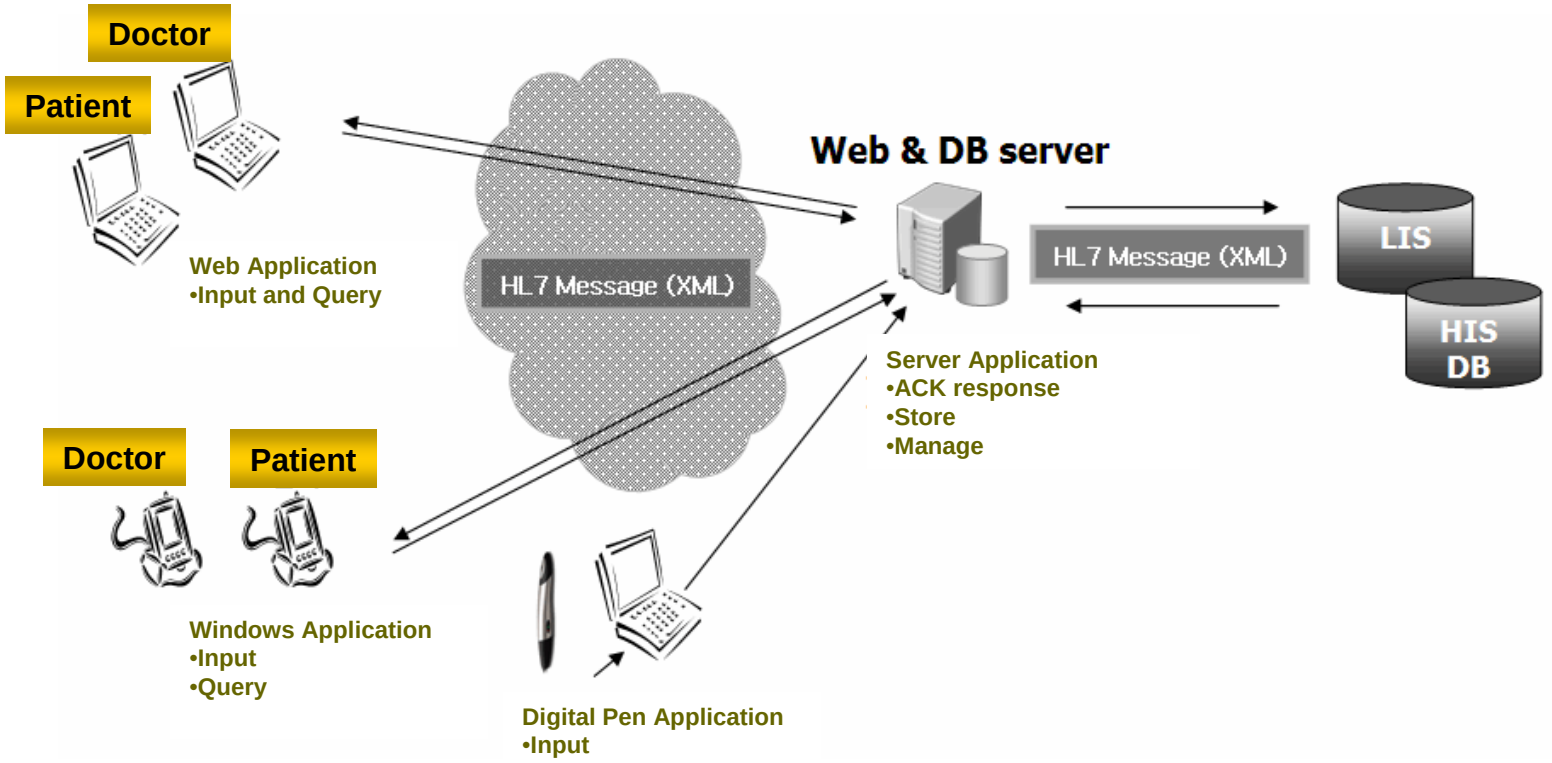
- The u-Healthcare is a new healthcare paradigm based on the Internet and ICT. Healthcare service using mobile devices includes sensor devices using measured biosignal data and home health network.
- The biosignal monitoring service is one of the monitoring services in ubiquitous healthcare. Methods of inputting, transferring, and managing biosignal data are so various that device interfaces need to be expanded. A transferred data format also needs a data transmission standard like Health Level 7.
- We implemented the sender/receiver interface using three devices including a PDA, a desktop computer, and a digital pen. Also the HL7-based biosignal message template and its database were designed. In the user input interface, patient/doctor's interfaces were developed separately and they enabled the user to review graphically the accumulated data. We adopted a digital pen having a powerful user-friendly input interface to develop the self-record manage application.

- ***Keywords:*** Biosignal, Interface, Transmission, Database, HL7, XML

Introduction

- The healthcare services using mobile devices include various devices using measured biosignal data, home health network, electronic home appliances, etc.
- The biosignal data management system usually monitors, analyzes and manages the biosignal data of wireless medical devices like blood pressure, pulse and ECG data, etc.
- We tried to find how to input the wireless biosignal data and how to send them to the management system by an efficient data transfer method.
- We referred to common data formats and transfer methods. To full use of recent data input devices, we decided to expand input interfaces in ubiquitous environment.
- We considered several standards for EHR and applied Health Level 7(HL7) Version 3.0 to our application. The preliminary study had implemented the web-based patient monitoring system using HL7 Version 2.5 in 2005.
- This research was the improvement of the previous study and it was n ew approach by adding user interface devices and applying the new v ersion of standardized data transmission protocol.

System Architecture

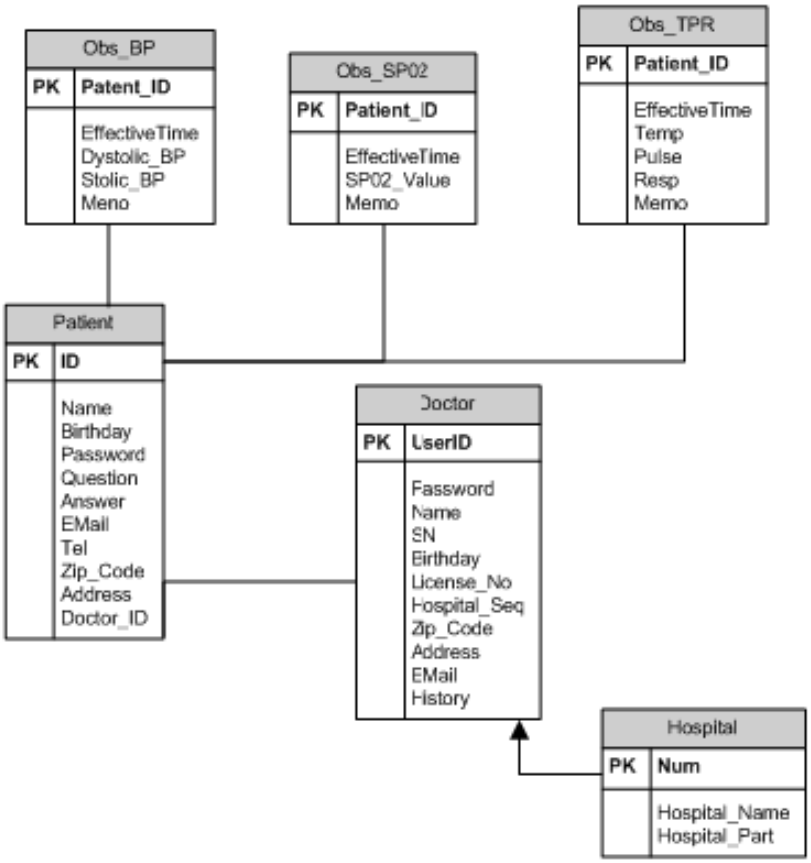


4 major parts:
the client input interface of three devices, the server interface of sending/receiving data, the user interface including a graphic view and a digital pen interface

Methods

1. Design and implementation of HL7 Message Sender/Receiver Interface for sending/receiving biosignal data and standardization
   - Message sending module of biosignal data
   - Message receiving module
   - Developed by MS Windows 2003 Server, Visual C#, SQL Server 2000 and XML
2. Web-based personal biosignal data management in a desktop computer
   - Standardized messages in user login and new user creation at the web-based interface
3. Application program for the home self-recording with digital pen
   - ioPen produced by Logitech was used

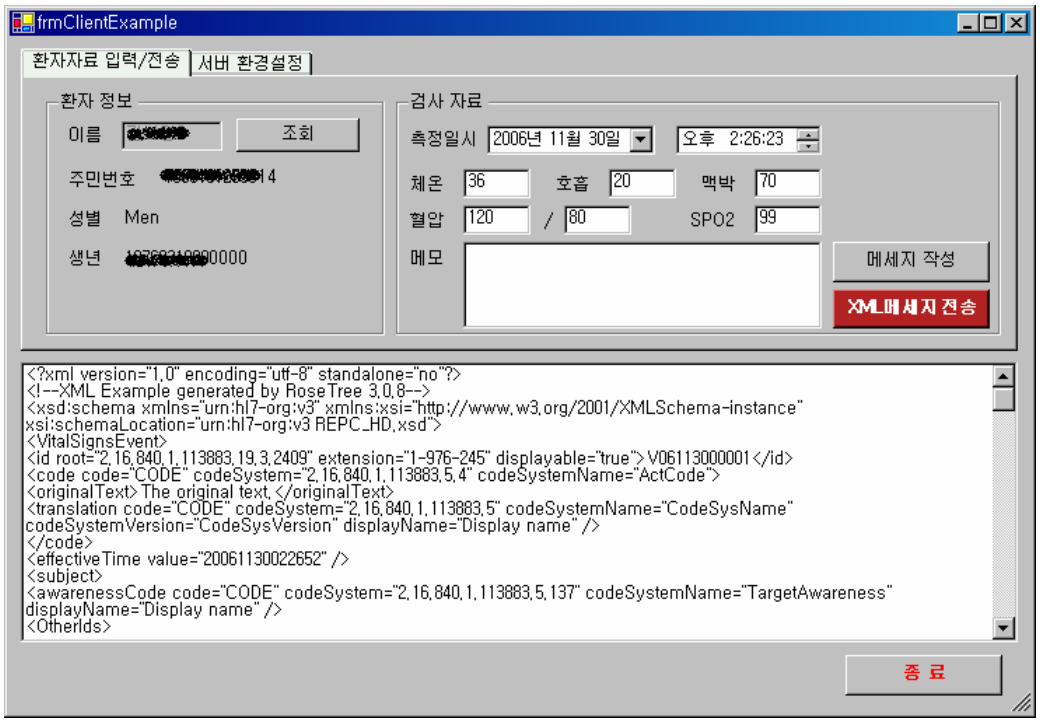
HL7 V3.0 RIM-based Biosignal Database



- The cMET schema for the measured data with texts, REPC_RM000130(ObservationVital Signs.xsd) was applied.
- The tables for other information were added.

Message sending/receiving interface

1. HL7 Message Sender Interface in the desktop computer



- The user interface of data input and sends the data into an each device and shows the converted XML files to the user.
- When the user presses the red button, the converted data can be confirmed in the lower box and are sent to server.

Message sending/receiving interface

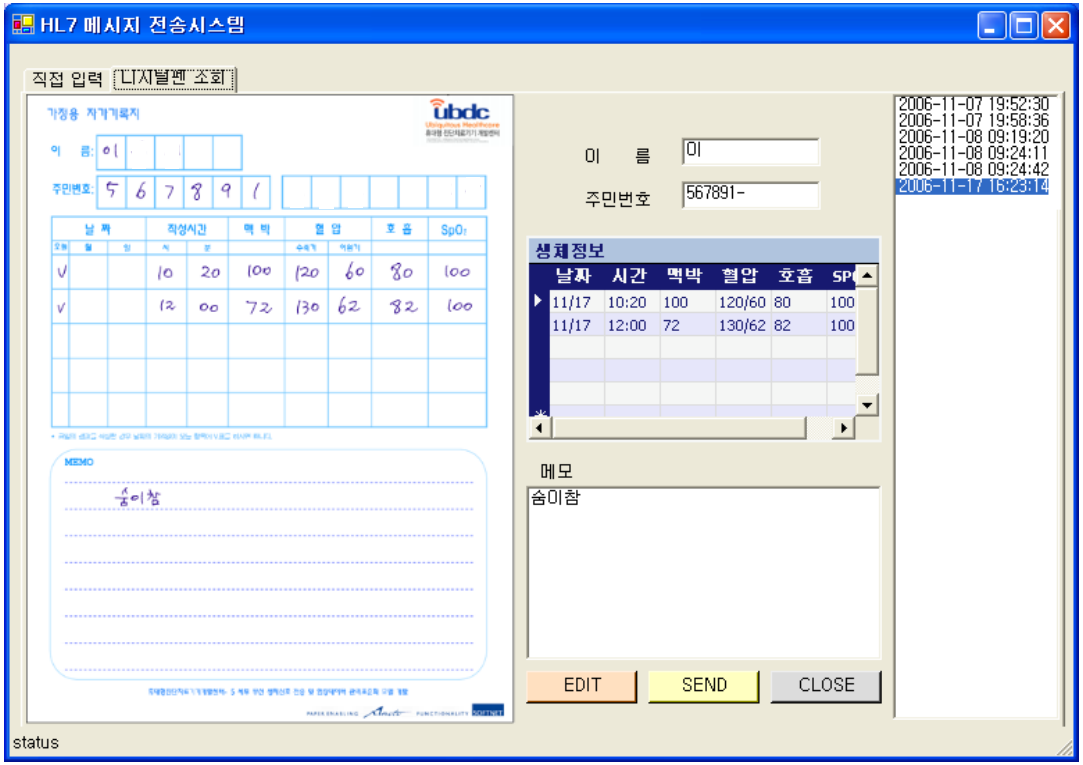
2. HL7 Message User Interfaces in the PDA phone

Inserting of Data

Inquiry of Data

- When the user enters his name and password for login on a PDA, the sender converts the written biosignal data to XML files and sends to the server database.
- The server sends an acknowledge message to the PDA application, and sends the data within XML files to the database.

Self-recording Manager by the Digital pen



- The written digital pen data is converted to selected image types (jpg, png, pdf) and is stored.
- Self-records at home were composed with personal identification items, biosignal data input items, and a memo item that the patient could input any comment or any question to his doctor.

Discussion

- The points of this study were the wireless biosignal data transmission and the application of standardized transmission protocols.
- During the implementation of the applications, items of HL7 message tags were so detailed that we weren't easy to apply these items to the real message.
- The biosignal data were continuously generated by mobile devices or wearable sensors.
- We started from pre-assumption that the data were already measured by sensors and the user wanted to enter them on his screen interface in this study. The types of data are limited in this study.
- We have a plan to expand them and to expand applications of data transmission standards to other related studies.
- The database inquiry will also use the standardized message format.

Conclusion

- By minimizing medical equipments and making the users (patients, doctors and nurses, etc) to carry them all the time. Our team is looking for the technology of standardizing and interfacing body information.
- The standards are not easy to implement real situation but they will be a trend in healthcare delivery system. But they are so essential to share the healthcare data and they can make software applications simplify.
- The technology-assisted application with a new device is convenient and potentially powerful complement to user-led management.
- The device easy to use can encourage users to self-manage their healthcare information.

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Acknowledgments

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Implementation of Input Interface using General Data Transmission Methods for Digitalized BioSignal Data Management

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Abstract

The u-Healthcare is a new healthcare paradigm based on the Internet and ICT. Healthcare service using mobile devices includes sensor devices using measured biosignal data and home health network. The biosignal monitoring service is one of the monitoring services in ubiquitous healthcare. Methods of inputting, transferring, and managing biosignal data are so various that device interfaces need to be expanded. A transferred data format also needs a data transmission standard like Health Level 7. We implemented the sender/receiver interface using three devices including a PDA, a desktop computer, and a digital pen. Also the HL7-based biosignal message template and its database were designed. In the user input interface, patient/doctor's interfaces were developed separately and they enabled the user to review graphically the accumulated data. We adopted a digital pen having a powerful user-friendly input interface to develop the self-record manage application.

Keywords:

biosignal, interface, transmission, database,
Health Level 7, XML

Introduction

The healthcare services using mobile devices include various devices using measured biosignal data, home health network, electronic home appliances, and so on. The biosignal data management system usually monitors, analyzes and manages the biosignal data of wireless medical devices like blood pressure, pulse and ECG data, etc. In this system, some essential techniques are needed for the system functions of sending to the server wirelessly, storing, and managing the measured data. We tried to find how to input the wireless biosignal data and how to send them to the management system by an efficient data transfer method. First, to make the system construct easily and reuse the data, we referred to common data formats and transfer methods. Secondly, to full use of recent data input devices, we should expand input interfaces in ubiquitous environment. We considered several standards for EHR and applied Health Level 7(HL7) Version 3.0 to our application. We thought that HL7 was accepted medical informatics relatives as general standardized data transmission protocol. We had implemented the web-based patient monitoring system using HL7 Version 2.5 as a preliminary study in 2005. This research aimed the improvement of the previous study and it was new approach by adding user interface devices and applying the new version of standardized data transmission protocol.

Methods

The whole system are composed of 4 major parts: the client input interface of three devices, the server interface of sending/receiving data, and the user interface including a graphic view and a digital pen interface. First, we designed and implemented HL7 Message Sender/Receiver Interface. In the Message sending module, Blood pressure, pulse, respiration, temperature, SpO2 and general information of patient were input into the application program. The message receiving module was the server application of HL7 V3.0 message receiver. The server received a message from the client program and sent a HL7 V3.0 acknowledge message to the client program. The database was developed with Microsoft Windows 2003 Server, Visual C#, SQL Server 2000 and XML. It stored and managed the data in XML documents. The application program of home self-recording was implemented by a digital pen.

Results

Design of HL7 V3.0 RIM-based Biosignal Database

The Biosignal Database was designed using the RMIM (refined message information model) that was the restrained model of the HL7 RIM. The cMET schema for the measured data with texts, REPC_RM000130 (ObservationVitalSigns.xsd) was applied. It was able to easily transfer the received data into the server system. The database stored and managed them within XML format messages. We made basic messages of biosignal data with the general information of the patient, and composed the input XML template. The standard model was reflected on tables and attributes.

Design and implementation of message sender/receiver interface system

When the data were input into sender devices, a desktop computer, a PDA phone, the sender interface system made HL7 3.0 XML files of them. Multiple files could be sent to the server simultaneously. The sender interface on desktop computer has the user interface of data input and sends the data into an each device and shows the converted XML files to the user. When the user enters his name and password for login on a PDA, the sender converts the written biosignal data to XML files and sends to the server database. Then the server sends an acknowledge message to the PDA application, and sends the data within XML files to the database.

If HL7 V3.0 XML files received from the sender interface are valid, the message receiver stores them to the integrated biosignal database in the server application. Each an acknowledge message (ACK) toward each valid HL7 message is sent to the sending interface. When an invalid message is received or when a communication error is occurred, the system sends the ACK message with a specific value of the error.

Web-based Biosignal Data Management

This application has a query function to review the accumulated biosignal data by data itself and graphics. After the program registers to the web server, users enter their name and password for login in a web site or a device interface and they can inquire or review their accumulated data by a web browser. The main function is that users can inquire their data sorted by time and data types in the table or graphic format.

The patient can review his accumulated data and view graphically by PDA phone application program. After the data inserted to the database, the patient can't edit them. After login, the doctor can monitor his patient's data anywhere.

Expanded Input interface: Digital-Pen Application

We designed the self-record manager program as a Windows application by C#. Self-records at home were composed with personal identification items, biosignal data input items, and a memo item that the patient could input any comment or any question to his doctor. The manager can recognize a user using the pen ID in the personal information register items, and the user doesn't need to enter its personal information each time. It makes the data store individually. The written pen data is converted to selected image types (jpg, png, pdf) and is stored. When a user selects the data, it is converted to a HL7 3.0 message XML file and is sent to the server.

We added and expanded another function to self-recorded papers in home, the program could autonomously input a date and time item, and a respiration input item. Figure 7 shows self-management record manager.

In the record format using a digital pen, about 80% character recognition was caused of presence of various handwriting patterns. So we added a correction function, and users could review and correct their written data. The push of the recognition button in the lower review window shows written data and users may correct and store them.

Discussion

We implemented input biosignal data interfaces on a desktop computer and a PDA phone. The user interface was different user screen according to the patient or the doctor. The measured biosignal data from each medical device was converted a standardized message format and sent to the data management system server wirelessly with the standardized transmission format.

The points of this study were the wireless biosignal data transmission and the application of standardized transmission protocol (HL7 V3.0). During the implementation of the applications, we faced with many problems again for using a general standardization protocol. Because items of HL7 message tags were so detailed that we were not easy to apply these items to the real message. The types of data are limited in this study. We have a plan to expand them and to expand applications of data transmission standards to other related studies. The database inquiry will also use the standardized message format. The future study of data transmission standards and technologies will be followed.

This study was one part of the Ubiquitous Biosignal Device Center Project in Korea. The project aims at developing everywhere-anytime healthcare system. By minimizing medical equipments and making the users (patients, doctors and nurses, etc) to carry them all the time. Our team is looking for the technology of standardizing and interfacing body information.

The biosignal data were continuously generated by mobile devices or wearable sensors. We started from pre-assumption that the data were already measured by sensors and the user wanted to enter them on his screen interface in this study. Finally all implementations were connected each other sub-study.

Conclusion

In ubiquitous environment, various user interfaces are needed to introduce biosignal data sending/receiving, test and expand. We implemented the user interface with a desktop computer, a PDA, and a digital pen using a standardized data transmission method. The standards are not easy to implement real situation but they will be a trend in healthcare delivery system. But they are so essential to

share the healthcare data and they can make software applications simplify. The technology-assisted application with a new device is convenient and potentially powerful complement to user-led management. The device easily to use can encourage users to self-manage their healthcare information.

Acknowledgments

This research study was funded by a grant of the Korea Health 21 R&D Project, Ministry of Health & Welfare, Republic of Korea (Grant No: A040032).

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Evaluating Benefits of a Large Domiciliary Nursing Workforce Using Mobile Computers

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Abstract

In 2003, Royal District Nursing Service (RDNS) rolled out a Mobile Computing System (MCS) to approximately 800 domiciliary nurses and allied health staff working in the greater Melbourne Metropolitan area, providing real time access to client and visit information as well as email, intranet, internet and office suite applications.

In 2005 RDNS initiated a formal evaluation of the MCS which focussed on seven key themes: client care; work practice; use; satisfaction and value; system cost and saving, system management and support model and technical performance.

The detailed findings were gathered using an online survey ,workshops with clinicians, administration and support staff at regional Centres, accompanying clinicians "on the road", interviews with Managers and Executives and review of documentation. This paper will present a number of the outcomes that informed the key summary of findings of the RDNS MCS experience to date – telling it "As It Is":

1. There has been a very successful deployment of the MCS across RDNS
2. The nursing staff are positive about having and using the MCS. There is a large "bank of goodwill" towards it and they would welcome enhancements.
3. There have been issues with MCS reliability and functionality that degrade benefits, productivity and satisfaction
4. The MCS significantly achieves RDNS objectives in relation to visit management but there is more work to do in relation to the MCS improving client care.

The evaluation of the MCS has provided insights relevant to many health care providers looking to implement mobile computing to improve health service delivery. RDNS has achieved this on a large scale and our experience can help inform the planning of other health organisations wanting to make the best possible use of information, and communication technologies in a sustainable health system.

Keywords:

mobile computing, evaluation, nursing informatics

Introduction

RDNS' Mobile Computing System (MCS) has been fully operational with more than 800 field staff users since 2003. Heading into 2006/2007, RDNS faced an imminent and significant outlay to refresh the technology, particularly the portable computing devices (tablets). In this circumstance, it was prudent and timely for RDNS to undertake a comprehensive evaluation of the MCS as it is and to review possible future directions for the system.

RDNS engaged Opticon Australia to undertake the evaluation. Opticon has provided a comprehensive "As it Is" picture of the current MCS, a detailed assessment of the value RDNS is presently enjoying from the current MCS along with the value it can expect to extract in the future, and recommended actions RDNS should take in the short and medium term to assure the sustainability of the MCS in to the future.

How was the evaluation conducted?

The evaluation process was done in four stages, Information Collection, Analysis into Findings, Evaluation of the MCS, and Recommendations.

Information collection

Opticon partnered with the RDNS project team and a broad and deep cross section of RDNS personnel to collect comprehensive information to inform the evaluation. In a first stage, this included:

- A review of a large body of documentation;
- Interviews with senior management and persons in positions of key relevance to the MCS;
- Three workshops involving clinicians and administrative staff from a cross section of Centres;
- Field visits by Opticon consultants to four centres to observe first hand work-a-day use and issues relating to the MCS; and
- A comprehensive survey completed by more than 400 staff.

Since more than 400 field staff provided survey responses, the interpretation of the results assumes that the survey response is truly representative of all field staff.

The information collection provided a repository of material on which RDNS and Opticon believed analysis, evaluation and recommendations could proceed with a high level of confidence.

Analysing the information collected into findings

The survey statistics were interwoven with the qualitative information collected in the interviews, workshops, field visits and documentation review. This combination formed a comprehensive picture of the MCS "As It Is".

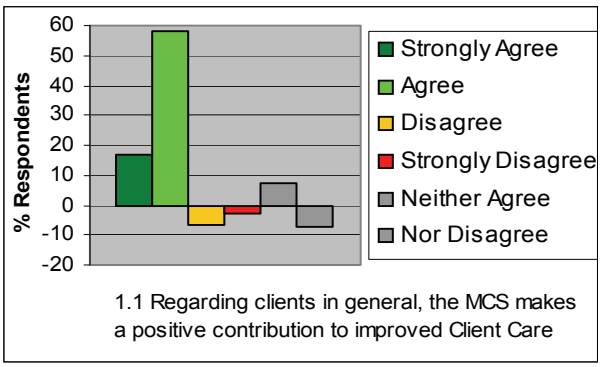
Introduction to detailed findings

The Detailed Findings are structured in line with the Themes and Key Questions specified by RDNS. These are shown in the table below.

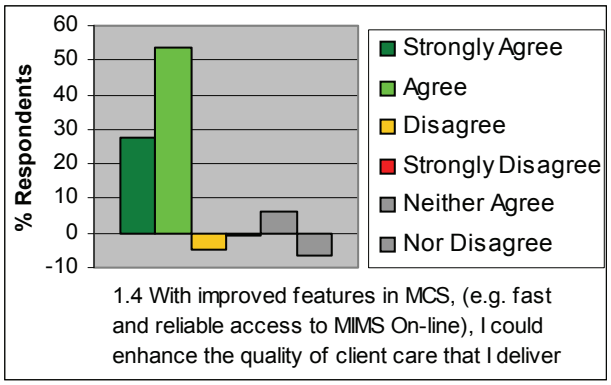
Theme	Key Question
Client Care	Is the system improving clinical care?
Work Practice	How has the system impacted work practices and stakeholders at RDNS?
Satisfaction and Value	Is the system judged to be useful and valuable to stakeholders?
System Cost and Savings	Is the system value for money?
Use	How usable is the system?
System Management and Support	How effective is the system management and support model?
Technical Performance	How well is the technology working?

Is the system improving client care?

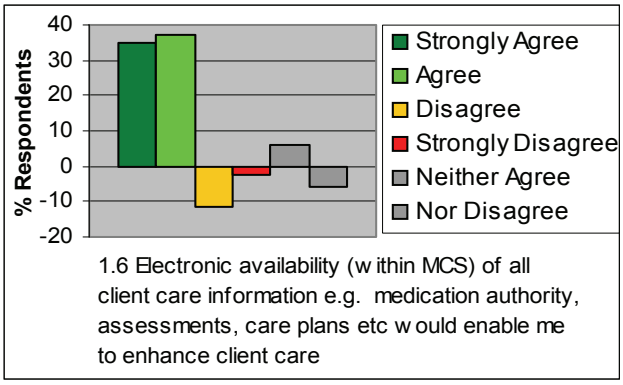
What we found is that there is a strong impression that MCS has improved client care in a general sense, as shown by chart 1.1.



1.1 Regarding clients in general, the MCS makes a positive contribution to improved Client Care



1.4 With improved features in MCS, (e.g. fast and reliable access to MIMS On-line), I could enhance the quality of client care that I deliver



1.6 Electronic availability (within MCS) of all client care information e.g. medication authority, assessments, care plans etc would enable me to enhance client care

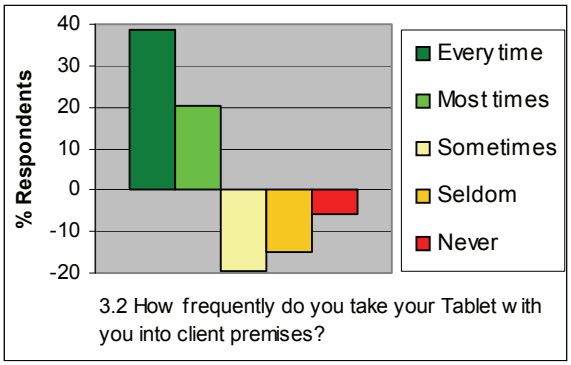
It was also found that the current system is more about static client information and visit management information but that enhanced functionality would further enable the enhancement of client care.

How has the system impacted work practices and stakeholders at RDNS

Using the tablet in the client's home

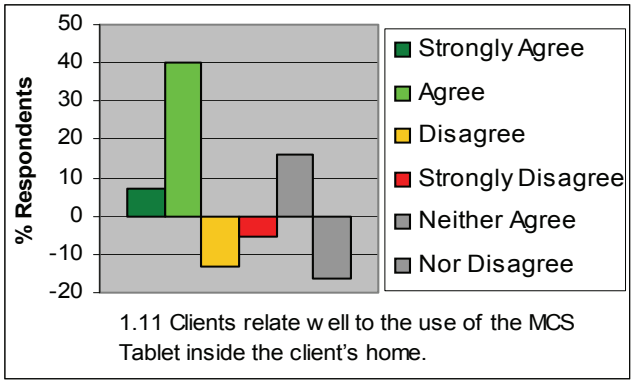
Information from workshops, field visits and the survey indicated that clinicians have mixed practices and views about using the tablet in the client's home.

Chart 3.2 shows that 60% of `clinicians take their tablet into the client's home most visits. But about 40% take the tablet in to the client's home sometimes, seldom or never.



3.2 How frequently do you take your Tablet with you into client premises?

Chart 1.11 shows clinicians have quite mixed views about how comfortable their clients feel about the clinician using the tablet ("a computer") in their home.



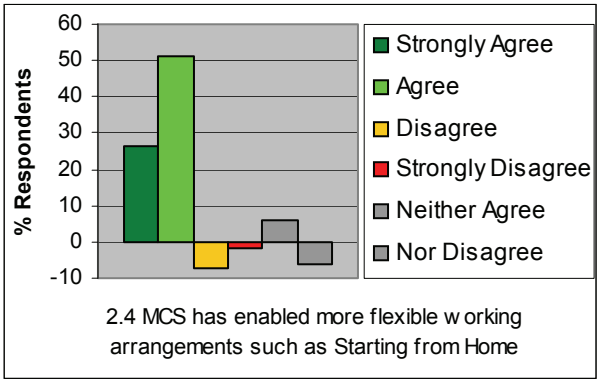
1.11 Clients relate well to the use of the MCS Tablet inside the client's home.

Feedback from the workshops and field visits provided some further insight into MCS usage during client visits. Participants reported on the one hand that MCS makes vital visit information available on site. On the other hand, they also reported that the tablet/MCS tends to become "irrelevant" in the face to face client interaction. The client interaction with the clinician is strongly identified as a trusted relationship. Clinicians voiced significant concerns relating to the potential of "with client" use of tablets creating a barrier or intrusion into that interaction.

Visit management work practices

In workshops and field visits, clinicians indicated that the MCS:

- Facilitated better visit management by making relevant information more accessible;
- Helps optimise staff resources – e.g. by facilitating client exchange 'on the road'; and
- By accurately recording travel time revealed that when not using MCS, travel time tended to be underestimated.

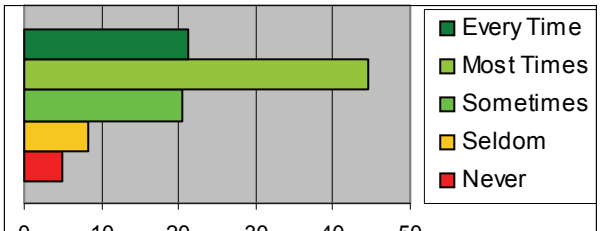


2.4 MCS has enabled more flexible working arrangements such as Starting from Home

Maintaining up to date information in MCS

An important issue for both clinicians in the field and Centre Support management in Centres and Head Office is maintenance of up to date information in MCS.

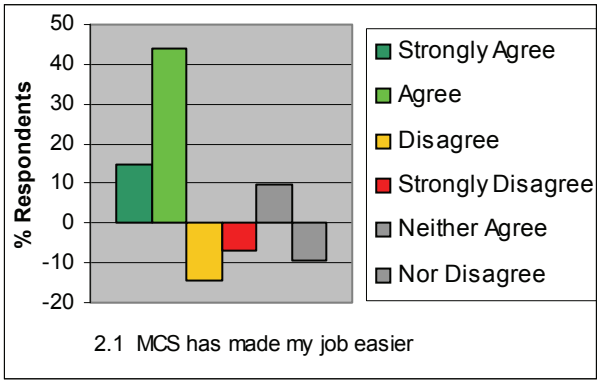
The preferred practice for field clinicians is that they update their schedule "on the road" at least once as well as at start and finish of their shift. Chart 3.6 shows that this standard is practiced by more than 80% of field staff.



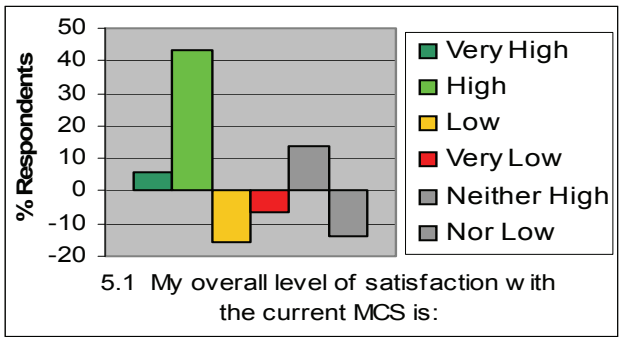
3.3 To what extent do you update client data in Gemino during or immediately after each client visit?

How satisfied are clinicians with MCS?

There was an overall positive feeling towards the MCS and staff generally felt it made their job easier.



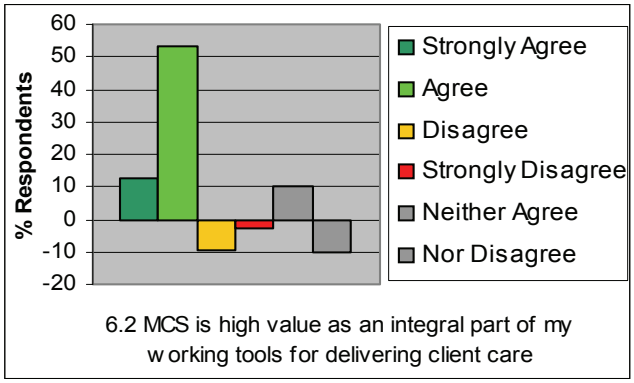
2.1 MCS has made my job easier



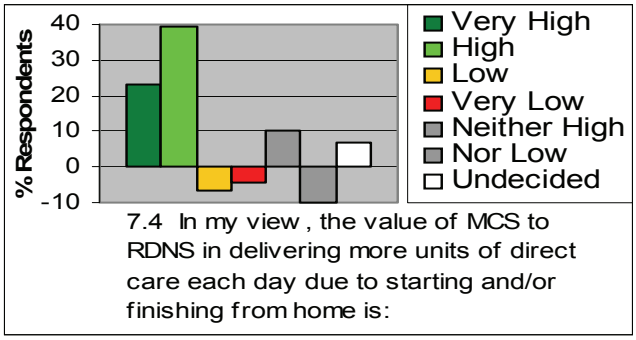
5.1 My overall level of satisfaction with the current MCS is:

Is the system value for money?

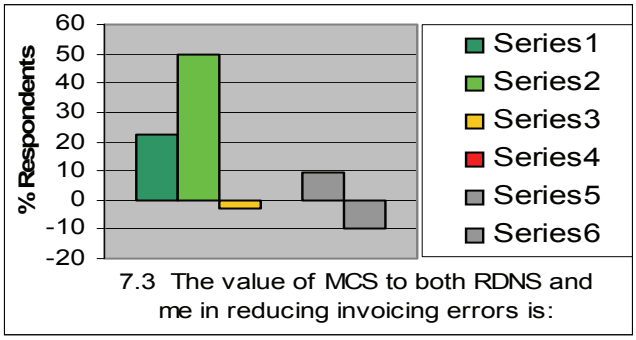
At the clinician level, chart 6.2 shows that MCS is regarded a tool with high value.



6.2 MCS is high value as an integral part of my working tools for delivering client care



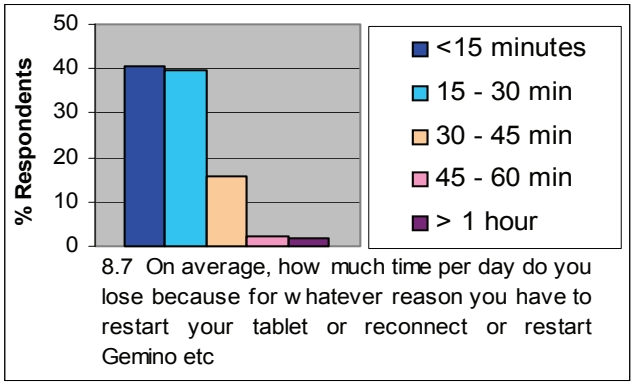
7.4 In my view, the value of MCS to RDNS in delivering more units of direct care each day due to starting and/or finishing from home is:



7.3 The value of MCS to both RDNS and me in reducing invoicing errors is:

How usable is the system?

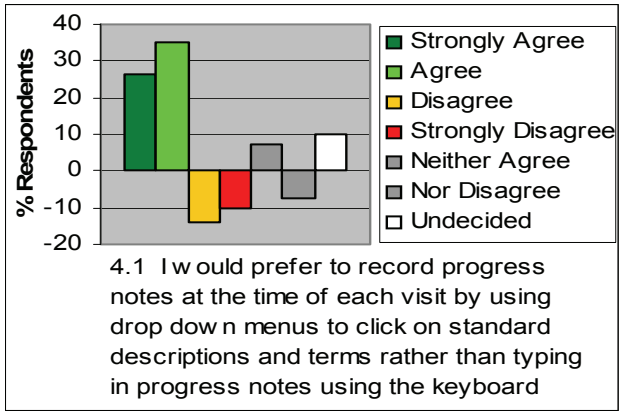
Perhaps the most telling finding in regard to usability is the amount of time clinicians expend each day dealing with various malfunctions in the MCS.



8.7 On average, how much time per day do you lose because for whatever reason you have to restart your tablet or reconnect or restart Gemino etc

What would improve usability?

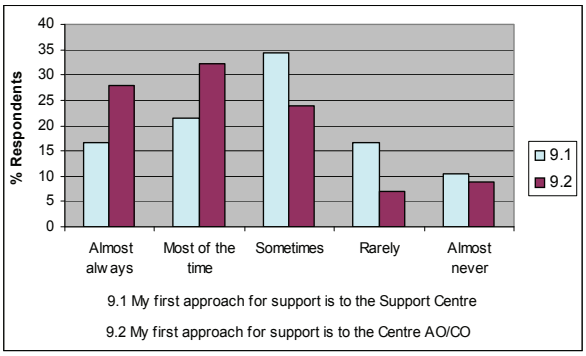
What would clinicians want to improve usability? Findings already reported have noted that the current MCS provides functionality more directed at visit management than client care. Chart 4.1 highlights clinician attitudes to some aspects of strengthening the client care toolsets in the MCS.



4.1 I would prefer to record progress notes at the time of each visit by using drop down menus to click on standard descriptions and terms rather than typing in progress notes using the keyboard

How effective is the system management and support model?

Under the RDNS model for system management and support, clinicians should go to their centre AO/CO for first level support and the IS Support Centre for second level support. In reality, practice seems to conform more to a free choice model.



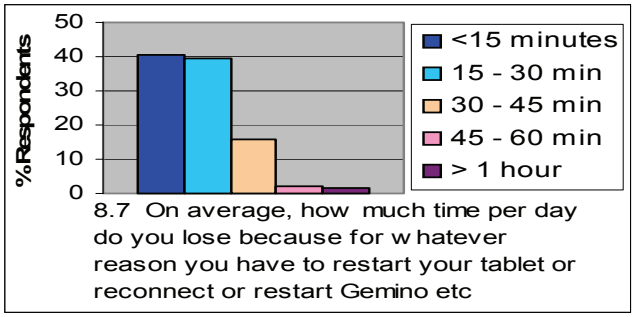
9.1 My first approach for support is to the Support Centre

9.2 My first approach for support is to the Centre AO/CO

How well is the technology working?

Reports from both the field and IS have indicated that tablets degenerate at an increasing rate as they age.

Changing batteries, re-entering data, restarting the tablet, unresponsiveness and re-attempting connections all not only add to the day's frustrations but take up clinician time. Feedback on recently replaced tablets was very positive.



Summary of findings – telling it "As It Is"

Four key big picture findings summarise the RDNS MCS experience to date:

1. In Opticon's view and experience, the successful deployment of the MCS across the 800-plus RDNS field staff is a great achievement;
2. Overwhelmingly, the field staff are positive about having and using the MCS. There is a large "bank of goodwill" towards it and they would welcome enhancements;
3. There are significant issues with MCS reliability and functionality that are frustrating to both users and support staff and seriously degrade benefits, productivity and satisfaction; and
4. The MCS significantly achieves RDNS objectives in relation to visit management but significantly under achieves RDNS objectives in relation to improved client care.

Conclusion

What RDNS has achieved in its MCS is a noteworthy success. There is widespread penetration and acceptance. The MCS has become an indispensable tool for visit management. Further, the significant bank of goodwill amongst users augurs well for introducing future enhancements.

At the same time there are performance issues and problems that detract from the positives There is also a shortfall in functionality that means the always-held ambition of using MCS to improve direct client care has not fully been realised and cannot be realised without further software development or replacement.

Acknowledgements

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Information System for Clinical Organisations: from Hospital Information System to a Sustainable National Service for Treatment and Long Term Research in Wales

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Abstract

Information System for Clinical Organisations (ISCO), originally developed as a clinical information system at the Velindre Cancer Centre in South East Wales, is now an All-Wales Electronic Health Record, primarily for cancer, serving 1000 users in 43 sites across Wales. Clinical information in ISCO is shared across organisations in Wales, improving communications between healthcare professionals and smoothing the patient pathway from referral to secondary care through to diagnosis, treatment and death. Data collected in the system is used to inform audit and research which in turn require the system to adapt. ISCO has proved to be a sustainable system in the medium term and its longer term sustainability should be assured by developments for Informing Healthcare.

Keywords:

Medical Records System, Computerised,
Hospital Information Systems,
Management Information Systems

Introduction

The Information System for Clinical Organisations (ISCO) is an Electronic Health Record (EHR) for cancer and other diseases across Wales, a principality within the United Kingdom. Designed to meet the audit needs of clinicians at Velindre Hospital in 1991, development of ISCO has always taken place with the full participation of clinicians and other users, as advocated by Protti [1]. Regular User Group meetings are held and ISCO has always had the support of the cancer centre management since its inception, ensuring financial stability.

A single casenote, multiple provider model was implemented in 1997 to meet users' and other organisations' needs, including palliative care [2]. ISCO as an EHR was born. Users may see a summary of patient care wherever it has taken place in Wales. For cancer patients the entire cancer history from screening to diagnosis, treatment and death is available. This is an individual health record event model as envisaged in the national information management and technology strategy[3].

The Cancer Information Framework has driven expansion of ISCO to include the All Wales Tumour Site Specific Cancer Datasets [3]. Cancer Services Units in hospitals across Wales collect cancer dataset information, for which purpose the system is known as Cancer Network Information System Cymru (CaNISC)[3]. Cancer data sets are used to monitor adherence to Cancer Standards and the statutory cancer waiting times.

ISCO now has 1000 users across 43 sites in Cancer Services, palliative care, Wales Cancer Trials Network, Wales Cancer Genetics, Wales Cancer Bank, Cervical Screening Wales for Colposcopy and Welsh Movement Disorder e-Network in South East Wales. There are over 338,000 individual patient records in the database.

Methods

System development and delivery

The prototyping approach is used for development where a working model of a new system module is given to users to evaluate, allowing early identification of any problems. The model is then improved incrementally according to the users' needs, as advocated by Heeks [4].

Requests for system developments, systems analysis, training, information and support needs are all met by the Clinical Information Unit (CIU) at Velindre Hospital where the critical nature of the application is well understood.

As "interoperability is the key... issue" [5], national and international standards are used where possible. There are plans to move to SNOMED CT coding in the near future.

As many organisational numbers as necessary can be stored for each patient as well as the NHS number. A unique internal system identifier and a rigorous registration process, using links to other patient databases, keep duplicate patients at a very low level.

The data structure is patient based, with logical separation of each care provider's information allowing a security model where system users can access the information they need but only edit information added by their own organisation.

Users outside of the hospital access ISCO via a web browser client. Access to the system is controlled by an authorised signatory system. Users receive training appropriate to their role before being issued a password to access the system.

Information use

The database structure allows reporting at the individual clinician level through to multi-disciplinary team, organisational and national level. Participation in United Kingdom national audits is possible by extracting the appropriate data. A set of data analysis tools allow users to validate data, perform their own analyses using a pivot table and run reports without understanding the underlying data structure. Ad hoc requirements are provided by CIU.

New innovations

Several innovative strands of work are underway in ISCO that should ensure the system's longer-term sustainability:

- a Multi-Disciplinary Team (MDT) module, supported by Informing Healthcare, enables attendance at meetings, patients listed for discussion, relevant patient information and the outcome of the discussions to be viewed and recorded
- pathology Integration and Electronic Sign Off of Results are automatically downloaded into ISCO using HL7, which is a healthcare messaging standard
- ISCO Today Sidebar, an alerter system, tailored to users, enabling them to be pro-active rather than reactive with patient pathway management and care
- an anonymised link between ISCO and The Wales Cancer Bank [6] database will allow future researchers to use clinical information matched to tissue samples from patients contributing to the development of more effective, targeted treatment for cancer.

Discussion and conclusions

The major challenges of a multi-purpose (clinical, administration and audit), local and national system are:

- organisational: robust administration processes need to be in place before new modules are implemented
- reconciling local versus national requirements
- data accuracy and consistency across all teams and organisations
- difficulties getting agreement for sharing data electronically between organisations.

Overcoming these problems has however encouraged closer working between all organisations involved.

ISCO has proved to be a sustainable system in a rapidly changing environment by:

- continually evolving to meet users' needs, with regular user group meetings
- being developed within a team that also provides users' information needs, training and support
- enjoying the support of local and national management
- providing good quality information
- investigating organisational issues before the release of new modules.

The linkage of present clinical information at a national level with future research as with the Wales Cancer Bank provides an important lesson for future sustainability. ISCO/CaNISC is to be mandated for collection of the cancer datasets and cancer waiting times within Wales and taken together with the support of IHC and the view that it is 'an EHR for Cancer' [3] should ensure its long term sustainability.

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More Evidence of the Challenges of Determining ROI on Health Information Technology (HIT): A European Telecare Case Study in Four Countries

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Abstract

Return On Investment (ROI) from novel uses of Health Information Technologies (HIT) is proving a methodological challenge. This was illustrated by an example Telecare service, linking remote patient monitoring to clinical advice and support. The service was introduced in distinct sites around Europe (London, Estonia and 2 in portugal) supporting commoner chronic conditions (diabetes, hypertension, asthma, advanced heart and lung conditions). Evaluations from patient, clinician and manager perspectives reviewed various sources (monitoring records, patient and staff progress forms, clinician activity diaries). Withdrawal rates were high. Persistent patients tended to be older and sicker. some patients were too sick to use the service, while many felt too well to warrant it. The service was never routine at any site. Adjustments were better at locations with local IT support. Work patterns did not change appreciably, though some administrative staff became more involved. Nevertheless, staff and patients were positive about the future for telecare. It still appears that investment in infrastructures of technology, trained staff and patients may be necessary before full benefits are identified and realised.

Keywords:

Telecare, telehealth, chronic disease, long term conditions

Introduction

For years the international debate has raged—is it possible to see a return on the investments on sophisticated clinical information systems? The question is an important one. The cost of these systems is enormous, easily ranging into the millions of dollars, and information technology is coming into its own at a time when the healthcare system around the world are in general financially burdened and concerned with sustainability.

As has been reported by many, the conundrum of measuring the HIT function is that:

- efficiency (“doing things right”) is easier to measure than effectiveness (“doing the right things”)
- since effectiveness ("doing the right things") and innovation ("doing new things") can not be readily quantified in terms of traditional outputs, improvements are not usually reflected in economic efficiency statistics
- new systems are often intended to change difficult to measure actions
- strategic systems elude measurement
- infrastructure investments cannot be cost justified on a ROI basis

As with any infrastructure, HIT infrastructure does not provide direct business performance. Rather it enables other systems that do yield business benefits. HIT infrastructure is strikingly similar to other public infrastructures such as roads, hospitals, sewers, schools, etc. They are all long term and require large investments. They enable business activity by users that would otherwise not be economically feasible. They are difficult to cost-justify in advance as well as to show benefits in hindsight. They require a delicate investment balance - too little investment leads to duplication, incompatibility, and suboptimal use; while too much discourages user investment and involvement and may result in unused capacity.

As Friesse points outs, some research has shown that hospitals can indeed experience powerful returns on investments, but those returns might not take the direct financial form that CEOs demand [1]. There is some anecdotal evidence of direct financial return from some electronic medical records systems in some hospitals. But what has been found more consistently over time is that most returns on investment are frustratingly intangible—though they may feed into the bottom line indirectly. This "soft ROI" includes increased workflow efficiencies, decreased medical mishaps, automated clinical decision support and the like. These improvements are clearly of tremendous value to patients and clinicians alike -- but exactly how valuable, in terms of raw dollars? The clues are enticing, but it is virtually impossible to determine objectively.

This paper will report on another HIT example of the challenge to find the evidence. The REALITY Consortium developed a representative remote monitoring service for patients with long-term conditions. The service was imple-

mented in four contrasting sites around Europe for periods of up to a year during 2004 - 2005.

Objectives

The REALITY Consortium of academics, clinicians and a technical partner developed a representative remote monitoring service for example long-term conditions. Supporting home medical and quality-of-life (QoL) monitoring and feedback to patients, the service was implemented at four contrasting sites around Europe for periods of up to a year. Socioeconomic evaluations adopted nominal viewpoints of patients, clinicians and managers. Patients were nominally most interested in technical usability and benefits of service usage. Clinicians were concerned with patient selection, training and everyday service organisation. The manager viewpoint focused on costs and wider organisational change.

The specific objectives were:

- O.G1. Develop a generalised framework for characterising and evaluating remote clinical and QoL monitoring implementations.
- O.G2. Provide information for European organisations to develop policies and guidelines.
- O.P1. Determine technology acceptance amongst diverse patient groups.
- O.P2. Determine the benefits of involving patients in collecting their own data.
- O.P3. Establish the impact of remote clinical and QoL monitoring on patients' overall well-being.
- O.M1. Provide comparative cost analyses with conventional care.
- O.M2. Identify optimal structures for future delivery.
- O.C1. Develop patient selection & training guidelines.
- O.C2. Clarify how healthcare professionals can work together to deliver services.

Methods

Figure 1 summarises the service introduced at each site. Patients were trained at clinics with home equipment to collect medical datasets specified by clinicians and Europe's generic quality-of-life (QoL) scale. Data were usually sent overnight to a central server by patients at home using telephone connections.

Clinicians could view the data and return messages of advice to patients via the server. Regular assessment of medical status and QoL factors were intended to prompt calls for face-to-face consultations or home visits by community services.

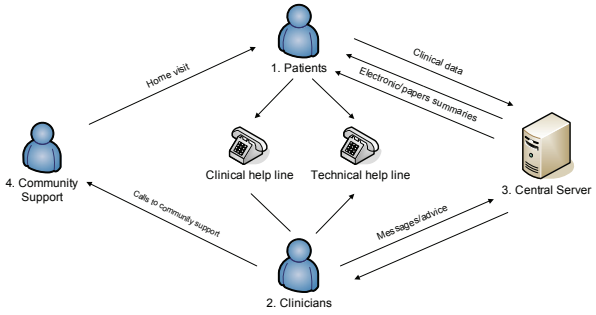

Figure 1 - Schematic summary of the REALITY service

Both patients and clinicians could communicate directly by phone and had access to technical support lines. Electronic and paper summaries of home data were provided for patients but only at Estonia.

Clinical Sites

Details on local populations and existing services were reported in [2]. Descriptions of national policies and achievements in provision for long-term conditions followed in [3].

All countries (Estonia, Portugal and England) were moving towards community care models, with varying degrees of implementation and success. Family/community doctors (GPs) were an historic feature in England. Restructuring had recently given them more powers to develop community services in combination with other health-related partners.

Results

Patients joined the project through a combination of local advertising and personal invitations. London recruited 29 asthmatics and 36 with diabetes and hypertension. 61 cases of hypertension and various heart diseases joined at Tartu. All 38 recruits at Lisbon had chronic lung conditions. Evora supported 21 asthmatics and 14 cases with advanced chronic respiratory diseases.

Most recruits had multiple medical problems. Some lived at home but most with partners/family. Conditions were often described as "reduced or inadequate".

In line with local population characteristics, several recruits at London were from ethnic minorities and many in Evora lived in rural areas. London patients appeared relatively younger and active compared to other sites. Majorities at London and Tartu were relatively well educated. The Portuguese cohorts tended to be older, sicker and rarely educated beyond primary school level.

London and Tartu had 7 doctors involved with the service. Number and roles of additional local staff at both sites were unclear. REALITY was delivered at Lisbon by a doctor-nurse team, and in Evora by a single consultant. No

staff involved from outside the main provider organisations was identified but, according to the activity diaries, Portuguese clinicians made home visits and appeared to serve in place of additional community services.

Stage of adoption

Base on interviews at site visits, two sites (London and particularly Tartu) had moved beyond constraints of novelty and early technical problems towards appreciation of consequences from new modes of service delivery. Both Portuguese sites had early technical problems, but were also thinking about wider benefits by the end of the study.

The consequences and benefits claimed were consistent across all sites (Table1). However, no example cases or documentary evidence were provided.

Table 1 - Service consequences/benefits claimed by clinicians.

For patients	Mutual	For clinicians
.	.	.
Psychological support and reassurance.	Increased communication.	More efficient use of clinic time.
.	.	.
Improved access to care.	Increased opportunities for joint decision making.	Availability of historic clinical data.
.	.	.
Increased knowledge about and understanding of their condition.	Increased quality of care (enhanced information to support clinical decision making).	Created time to address other patient concerns or health promotion.
.	.	
Increased capacity for self-management.	Increased continuity of care.	
.	.	
Increased involvement in decision-making.	Access to continuous information enabled fine tuning of treatments or dosages between scheduled appointments.	
.		
Increased motivation or reinforcement of lifestyle changes.		

Determine technology acceptance amongst diverse patient groups (O.P1)

Numbers starting with the service were lower than the recruited numbers at all sites. Numbers persisting also fell, most notably at London and Tartu. Compared to the other sites, proportions of persistent patients in Portugal collecting clinical data were relatively high and tended to complete QoL returns more regularly.

General usage results suggested that sicker patients, and those who were relatively fit but had clinically abnormal measurements for key variables, embraced the service. Delays in receiving equipment, and some early technical problems, discouraged some patients. A minority found the whole approach too complicated. Proportionately more patients from urban areas persisted, and Portuguese cases

with learning/memory problems appeared more likely to continue than those with sensory problems at London and Tartu.

Two usage features seem particularly important. Some patients were too sick to use the service while others felt too well to warrant it. Certainly, significant numbers at London and Tartu reported "lack of time".

Determine the benefits of involving patients in collecting data (O.P2)

No patients at Portugal passed beyond mid-term clinical visits without retraining in at least one category of technical service usage, and often in multiple areas. The same was true for at least half of the persistent cases at London and Tartu.

Assistance with accessing clinical messages and using the basic home unit were primary retraining needs. Help with third party devices was also prominent at Portugal because of connection problems between oximeters and the home unit.

Long gaps with no daily records were common at London, middling at Tartu, and relatively rare at Portugal. Key clinical variables were returned most frequently by persistent patients, but collection rates on lifestyle and medication compliance indicators appeared low across all sites and diagnoses.

Accuracy concerns were raised by the retraining needs identified above. When sites were asked at meetings about home data reliability, London stated that particular values or patterns may prompt independent tests and discussions at a patient's next visit. Notably at this site, medication was never changed on the basis of remote monitoring alone.

Clinicians found QoL data useful at two sites but "not readily available" or difficult to interpret at the others (London, Evora). Some patients found the questions difficult to answer, and several found them too general.

Relevance of the QoL data - as additional information to support calls on community services, or home visits by clinicians in Portugal - remains unclear. There were also no data on the nature of messages sent back to patients to illustrate how data may have influenced electronic advice.

Establish the impact of remote clinical and QoL monitoring on the patients' overall well-being (O.P3)

Independent analyses of persistent and low service users were expected by diagnostic groups at individual sites. Poor data availability - attributed to problems with electronic forms rather than clinical sites - restricted the tests to small groups.

There were no statistically significant changes according to the formal QoL instruments. There were, however, some clinical improvements at London (despite low sample sizes) and at the Portuguese sites. Changes were statistically significant but not necessarily clinically meaningful (e.g. a 1% increase in oxygen saturation at Lisbon).

Example case data examined in detail illustrated that some patients did make marked improvements while others appeared to worsen. With no data on clinical messages sent to the relevant patients or details from clinical visits, the contribution of the service as a whole is unclear.

Patient comments did suggest that basic measurement feedback educates and motivates some individuals, possibly with only minimal input from clinicians. But some patients were alarmed by seeing their abnormal measurements on a regular basis.

Point measurements at arbitrary times before, during and after an evaluation period may be misleading. There is measurement error, natural variation and, possibly above all for patients with long-term conditions, appreciable changes from day to day. These complicating factors are in addition to patients' basic skills to use the equipment.

Persistent patients (and/or carers), after at least the required four months' experience with the service, found the technology relatively easy to use. Large majorities reported improved relations with clinical staff and a greater sense of support. The psychological benefits are worth particular note, as they rarely appear in health related QoL scales.

Provide comparative cost analyses with conventional care (O.M1)

REALITY was an addition to existing services. Costs were automatically higher than conventional care and, apart from patients' sense of support and future potential for clinicians, there were few additional benefits identified over the study period.

Equipment, training and data viewing accounted for most of the additional cost/cost-related activities. Other uses of time appeared to be part of existing practice.

Numeric estimates and descriptions below might be put in context by patient numbers and progress categories involved (Table 2). Costs per patient increase if withdrawals are ignored; and retraining was a common activity at all sites.

Site expenditure on equipment and facilities and supported by the REALITY server ranged from 49,000 to 64,000 euros (Table 2). Compared to other sites, total Portuguese costs were substantially higher and costs per recruit were double. The differences were attributed to provision of oximeters with special links to the Docobo unit [4], and additional software handling firewalls at both Portuguese hospitals.

Costs include: the main Docobo units and server facilities; oximeters at Lisbon and Evora; peak flow meters at London and Evora.

Table 2 - Equipment and technical service costs (Euros) for the clinical sites

	London	Tartu	Lisbon	Evora
Total (€)	49,000	49,000	63,224	53,041
Official number of recruits	65	61	38	35
Mean cost per recruit(€)	754	803	1,664	1,515

Records via Evaluation Forms at mid-term and final clinical visits may have contained double counts. Nevertheless, visits to other clinics/hospitals were extremely high at London; and emergency hospital admissions at Lisbon were around 26-36 over the study period compared to around 2 at each of the other sites. Since these analyses, Lisbon has provided records of emergency hospital use by all their patients, to be included in ongoing work to improve evaluation methods (see S4 in particular).

There were few calls for face-to-face consultations and, notably, no recorded home visits by additional community services. In addition, regular visits to the London clinic by patients seeking feedback on data were not entered on Evaluation Forms. (Note: only Estonia patients received automated summaries, and experience at London suggests that messages to patients were not used to give such feedback).

Site activity logs (and server use by clinicians).

Logs of a "representative period" from all sites except London illustrated the 1-2 hours required to commission and initially train a patient. Tartu clinicians did not visit patients. But home visits in Portugal lasted some time and, particularly at Evora, involved considerable travel. Phone calls to patients appeared commonplace. They were short at Tartu (5mins) but almost as long as clinical visits at Lisbon (15mins compared to 20).

Clinicians appeared to access patient data in block sessions of over an hour. Records did not identify viewing practices for individual patients, but Portuguese clinicians seemed more likely to send messages back to patients (substantially more messages sent more frequently).

Summarising notes/documentation was a major activity at all sites, It was a regular three hour process at Evora though performed only once at Tartu over the logged period. In common with most of the recorded activities, time spent summarising notes specifically for the new service was unclear.

Discussion

Patient numbers fell significantly at most sites. Those who persisted felt a greater sense of support, although group data showed no improvement in health status. Clinicians had positive views about the future, but different approaches for different disease severities were not formalised and the general service was not embedded into local practice at any site.

Stronger conclusions are limited by lack of data. Obtaining costing details and independent clinical indicators for the service in operation was particularly difficult. Details on local service organisation and individual patient/carer circumstances - putting other information sources into context - were missing. Moreover, accuracy of data returned by patients was never demonstrated while specific actions by doctors to improve health or QoL status were not necessarily related to the new service and, in any case, not recorded.

Researchers believe that the technology and local service organisation required longer periods to resolve problems and adjust before formal evaluations and detailed data collection were justified. This seems true in particular for Evora where all responsibilities rested on one consultant. Perhaps clinicians at Lisbon provided the best overall summary:

"Remote monitoring can be a very important tool for patients with chronic respiratory diseases, particularly if they live alone and far from the medical services. This study showed the first steps - but there is a long way to run"

Conclusion

Patients with long term conditions tend to be older and sicker. Reporting a greater sense of support, they wished the service to continue. However, available information did not show group improvements in health status, reflect true costs, or explain the relatively high withdrawal rates at two of the four sites. Notably, some patients were too sick to use the service while others felt too well to warrant it.

Clinicians were also generally positive. In practice, though, the service was not integrated into other local operations at any site, and views appeared to reflect future possibilities rather than direct experience. Clinicians themselves concluded that "this study showed the first steps - but there is a long way to run".

There is still debate over what constitutes "evidence" and how best to obtain it in a field where technology is constantly changing and studies are relatively short. The methods raise their own difficulties. Economists, make assumptions about individual or continuous treatments

with long-term effects while poor characterisation of populations limits public health assessments. It also appears rare for organisational change to be examined with rigor.

Acknowledgments

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Development of Clinical Data Warehouse System for Clinical Quality Indicators

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Abstract

Clinical Quality indicators can be a powerful tools of improving the effectiveness of patient care. For 18 months, 20 specialists at each disciplinary developed total 34 Clinical Quality indicators and build data marts based on the EMR system, then electrically constructed clinical data warehouse system. Through the clinical data warehouse system, real time retrieval and monitoring of Clinical Quality indicators was achieved.

Keywords:

quality indicators, data warehouse system

Introduction

Clinical Quality indicators can be powerful tools of improving the effectiveness of patient care. There is no consensus about indicators for measuring quality of Hospital care in Korea. Therefore, a systemic process was initiated recently to develop and monitor indicators for the measurement of quality of hospital care through data warehouse system.

Materials and methods

The research, developing a clinical quality indicator and constructing the computing system, was processed as follows for 18 month from April 2005 to September 2006.

1. Development of a clinical quality indicator.

We organize 20 field experts of a task force team and developed a clinical quality indicator through setting a specific definition of a clinical quality indicator and inter-departmental conference. And we also made standard format to develop clinical quality indicator for each field.

2. Data mart construction

To construct a clinical quality indicator data mart we went via data refining course after through investigation of electrical clinic record. After that we construct a clinical quality indicator data mart in the data warehouse system and accumulate data by complementing of document and developing new document.

Fig.1 explains the structure of CDW. CDW DB server consists of CPU:1GHz*4, OS: UNIX-AIX5L 5.1, DB:ORACLE 9.2.0.4 and web server is made up of CPU: 1.4Ghz, OS:Window2000 Advanced SERVER, DB: MSSQL2000. MicroStrategy 7i is used as OLAP. Oracle ODBC is used as a linking method between OLAP Intelligence Server and Oracle Metadata Server, and TCP/IP is used to link OLAP/Web Server and user.

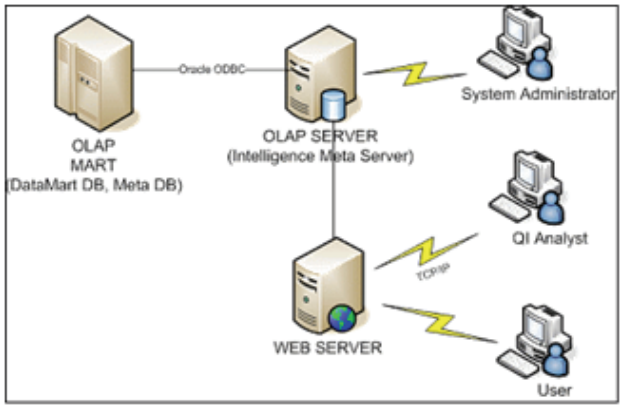

Figure 1 - Overall system configuration

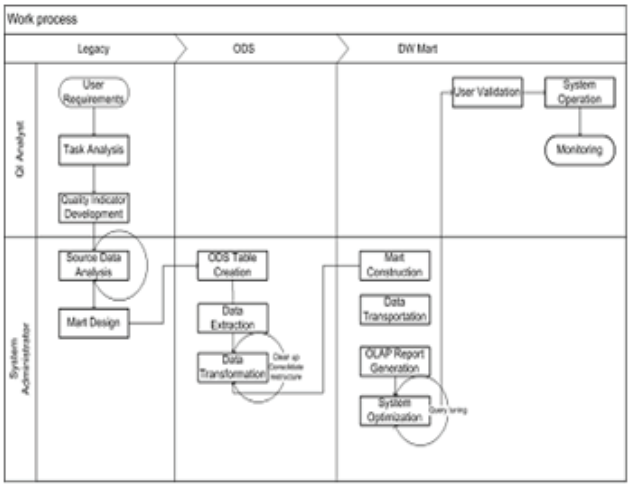

Figure 2 - Work process

3. Clinic-quality-index data warehouse system construction

A clinical quality indicator computing system is sort of data warehouse system developed by using MicroStarategy 7.2.3 Tool. Because of the task personality of a clinical quality indicator computing system, it is used for the analysis rather than a real-time process. So we used the database separately with the actual operation system.

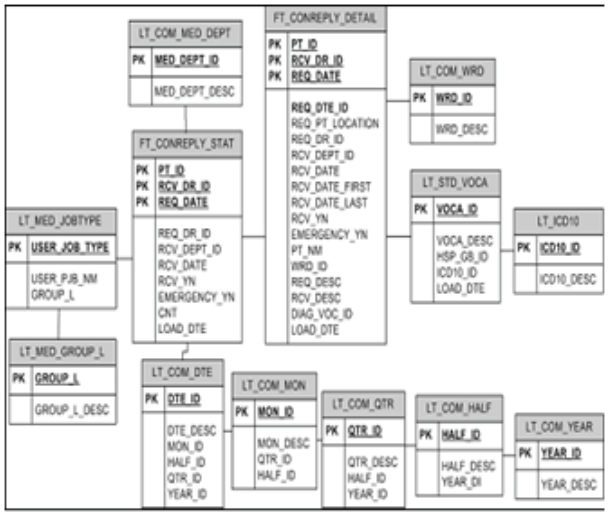

Figure 3 - Sample of ERD modeling

Results

We developed 34 clinic quality indexes and construct the data mart and did the computerizing it as a data warehouse system. The 34 clinical quality indicator item is listed on the table 1.

Table 1 - Lists of Clinical Quality Indicators (example)

domain	subdomain	clinical quality indicator
general	operation	waiting days for operation
		unexpected reoperation
	consult	response time to consult
	emerency room	readmissions to ER within 48 hours of discharge
	transfusion	return and disuse of blood
		RBC single unit
		side effect of transfusion
	CPR	survival after CPR
	mortality	mortality
		Deaths in hospital within 30 days of cystectomy surgery
		Deaths in hospital within 30 days of gastrectomy surgery
		Deaths in hospital within 30 days of prostectomy surgery
		Deaths in hospital within 30 days of nephrectomy surgery
	antibiotics	using days of antibiotics
specific	IM	(AMI patient) Aspirin at arrival
		(AMI patient) Aspirin at discharge
		AMI mortality
	AN	hypothermia after surgery
	nursing	pressure ulcer

Figure 4 - CDW system menu

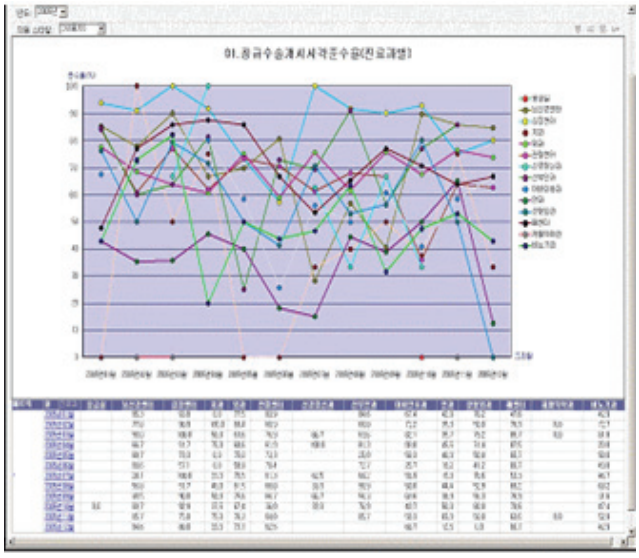

Figure 5 - graph showing the variation for a period

The screen of a clinical quality indicator of a parameter unit was implemented in data warehouse system. For its specific function such as detail data query facility in a specific total data, A annual or monthly trend query facility through the graph, optional query facility of grid and graph form, it can be possible to do real-time monitoring on specific clinical quality indicator.

Conclusion

Through the process of developing clinical quality indicator and constructing a data mart and computing system, we evaluate the possibilities of managing and applying clinical quality indicator with computing system.

The first feature of a clinical quality indicator computing system of Seoul National University Bundang Hospital is sufficient application of data that is based on electrical clinic record.

We used medical examination and treatment order, medical examination and treatment record, nursing record, inspection result as a real-time information. For its promptitude, we could investigate data easily. So many clinical quality indicator setups are expected to be possible. Also the time to be required could be reduced than the expected by using data which is coded and recorded in standardized term without further clinic-record query. Especially the possibility of practical using of formatting medical treatment and nursing records was a foundation of a clinical quality indicator computing setup.

Secondly we construct data mart and data warehouse in the system, which is separated with operating system. As a result a link information analysis that integrates data, stable refining and maintaining of latest information came to be possible. Also various analysis techniques are possible which use the graph and diverse analysis by patient, disease, and region. We prepared the basis to construct a disease-forecasting model through the data mining and expect to construct the screen of the report form afterwards.

The limit of a clinical quality indicator computing system setup is a precision verification side of the computing clinic record. In other words, wrong and missing record can be reflected as it is at a clinical quality indicator. But this problem can be solved by vocabulary system maintenance and continuous computing-clinic-record form supplementation.

Through this research, the simultaneous feedback and monitoring of many clinical quality indicator came to be possible. And also improvement inducing of each department came to be easy. From this result we can say that it is important to manage and monitor clinical quality indicator to induce a qualitative enhance of the medical treatment. We expect to develop and relate Critical pathway with Clinical Practice Guideline through the computerizing of developed clinical quality indicator.

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The Application of Integration Approaches through Biomedical Informatics in Health

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Abstract

INFOBIOMED is an European Network of Excellence (NoE) funded by the European Commission within the sixth Framework Programme. The main objective of this collaborative project is to create an stable and lasting European structure in Biomedical Informatics (BMI). This new discipline is based on the synergy between Bioinformatics (BI) and Medical informatics (MI).

Using all the relevant information, from the clinical records level down to the genomic, proteomic and molecular information levels, BMI is providing the technical and scientific infrastructure, as well as the necessary knowledge to develop new useful instruments and methods to improve healthcare advancing towards individualized medicine.

The main challenge of INFOBIOMED is to infer, based on the direct application in four pilots, the line of action and collaboration for BMI to fully export the synergies between BI and MI. In this paper, we describe the facts that support the consolidation of BMI as a relevant discipline for future European healthcare.

Keywords:

Biomedical Informatics, Genomic Medicine, INFOBIOMED

Introduction

The technology and resources, the increased knowledge extracted from large amounts of genetic and proteomic and phenotypic data are transforming the practice of medicine mostly characterized up to now by treating symptoms but also looking into the most fundamental causes and understanding the mechanisms of diseases [1]

In this context the EU funded the Network of Excellence (NoE) INFOBIOMED in order to consolidate the challenge of "Structuring European Biomedical Informatics to Support Individualised Healthcare" setting a durable structure for a collaborative approach at the European level and mobilising the critical mass of resources necessary for enabling the collaborative approach. This NoE consists of a consortium of 17 groups related with BI, MI and BMI research areas, that supports the consolidation of BMI as a relevant scientific discipline to be taken into account for future healthcare [2].

This is, BMI provides the technical and scientific infrastructure, as well as the necessary knowledge to produce new useful instruments and methods to improve healthcare in order to advance towards individualized medicine.

Further information about INFOBIOMED project is available through its web page http://www.infobiomed.org/

Materials and methods

The network has been structured by activities that cover all the significant aspects that are relevant to both MI and BI and that have the potential to provide a space for synergy between them. These aspects are envisaged for promoting integration of the research carried out in the fields of reference and they can be included in blocks of activities or workpackages (WP): NoE management (WP1); dissemination and communication (WP2); training and mobility (WP3); Data interoperability (WP4); methods, technologies and tools (WP5) and pilots applications (WP6).

Work Packages 4 and 5 have a horizontal design, the former dealing with data interoperability and the latter concerned with methods, technologies and tools. WP6 of the NoE introduces a novel vertical approach to biomedical research and healthcare.

The work in WP6 can be summarized as the application of data interoperability and management and the development of methods, technologies and tools in four pilots as 'proof of concept' of the pursued integrative vision of BMI that aim to cover the whole range of information levels from molecule to population.

Considering the different levels of heterogeneity due to BI and MI perspectives, the INFOBIOMED consortium aims in WP4 to integrate genomic, proteomic, clinical and population databases. Responding to the needs, different approaches have been made according to information linkage, data and query translation. Several of these databases containing all information levels related with the research of the diseases of interest were developed.

Due to the importance and success of ontologies in scientific research, data integration is evolving towards

ontology based methods that can solve the problems associated with syntactic and semantics gaps across data sources. This task is also relevant in INFOBIOMED and it has been developed an specific tool called Ontofusion.

INFOBIOMED efforts related with key technologies, methods and tools (WP5) were directed towards three main goals:

1. Data analysis and information retrieval: to identify, define and index the computational tools required for database integration, using and developing techniques of data and text mining, machine learning, knowledge extraction and other systems.

Diseasecard is an example of an information retrieval tool for accessing and integrating genetic and medical information for health applications (http://www.diseasecard.org) along multiple databases. Also, INFOBIOMED partners have developed the PIANA (Protein Interactions And Network Analysis) software framework that facilitates the work with protein interaction networks.

2. Image visualisation and analysis in order to enhance and develop image analysis approaches related with medical and genetic imaging techniques, like the DIA application (Dental Images Analyser) that extracts information from digitised radiographs that have been converted to the DICOM standard. Radiographic data in DICOM can be accessed by any computer system, which may be an important advantage in the studies of complex diseases, where multiple databases exist.

3. Information systems and decision support tools to extract knowledge from clinical and genomic available data sources. New models and systems to computerize clinical practice guidelines that will be a step towards genomic based enhancement of clinical decision making.

There are complementary activities for promoting integration of BMI research like dissemination and communication activities and training and mobility programmes in order to spread the knowledge generated in BMI. In this area some tools have been adapted to the needs of INFOBIOMED such as the LINK3D application (www.link3d.net). It can be used as a research tool to allow researchers to hold virtual meetings in a secure way. The INFOBIOMED website houses the European Biomedical Informatics Gateway for the BMI community and other stakeholders. It provides a central repository of reference materials and a notice board for announcing BMI events worldwide.

Results

There are four pilots in INFOBIOMED WP6 that represent the demonstration of the BMI approach to biomedical research and medical practice. The four INFOBIOMED pilots were based on several clinically relevant areas like pharmainformatics, genomics and microbiology, genomics and chronic inflammation and genomics and colon cancer.

Pharmainformatics (WP 6.1) carries out research on the impact of BMI in the drug discovery process, focussing in two case studies (Complex Regional Pain Syndrome and Nuclear Hormone Receptors) that establish an information continuum from pathology to pathway to target to ligand/ approved drug.

The approximation given by this pilot is mainly an example of translational research since its discoveries begin at "the bench" with basic research—in which scientists study those diseases at a molecular level—then progress to the individual level.

Genomics and Microbiology (WP 6.2) focuses its BMI activity on the study of comparative and functional genomic approaches combined with proteomic strategies in order to improve clinical evaluation strategies through a comprehensive pathway-related with host/pathogen interaction. The pathogens selected for this pilot are Cytomegalovirus and HIV.

In this pilot application, INFOBIOMED concentrates its efforts on the interferon pathway, combining host and virus genotype data with clinical data in order to find new markers of host immunity and viral therapy resistance. For this reason this study tries to improve clinical management obtaining information from molecular to individual level.

Genomics and chronic inflammation (WP 6.3) investigates the susceptibility to adult chronic periodontitis. A data warehouse was built combining many different causes that contribute to this complex inflammatory disease: genetics, infection, environment, intermediate phenotypes and disease phenotype. In order to gain more insight in periodontal disease, to design new treatment strategies and to devise preventive methods, this pilot focussed on the clinical management and disease prevention approach from the population to the molecular level information.

Genomics and colon cancer (WP 6.4) studies Hereditary Non Polyposis Colon Cancer. It uses the accumulated knowledge to build an infrastructure based on standards (e.g transmission of pedigrees including geno and phenotypes) that have been developed in XLM. To facilitate the use of this tool in different countries it is based on the international standard HL7. This pilot is mostly oriented towards public health, in particular towards prevention and exchane of information from the population to the molecular level.

Conclusions

The INFOBIOMED Network of Excellence is contributing to create a stable and lasting European BMI structure to

support individualised healthcare. Overcoming the obstacles and deploying the promised benefits of genomic revolution to society by combining the experience in both BI and MI developments, the methods and technologies used within the BMI integrative approach allow a direct application in the development of genomic medicine.

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Instituto de Salud Carlos III

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biotic

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Outline

- Introduction
- Technologies and resources employed
- Applications of BMI
- References

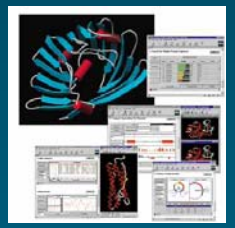
Genomic Medicine

Human Genetic Variation

Technologies | Data | Applications

Information

Genomic



Clinical

Genotyping

Haplotyping

Individual genomics (SNPs and mutations)

Diagnosis

Pharmaco-genetics

BIOMEDICAL INFORMATICS

Gene Expression DNA arrays MS, 2D ef

Functional genomics

Proteomics

Disease reclassification Pharmaco-genomics

Technologies | Data | Applications

Molecular causes of diseases

Genomic medicine

Individualised healthcare

Molecular medicine

Preventive medicine

INFOBIOMED: Structuring European Biomedical Informatics to Support Individualised Healthcare

- 17 institutions. 10 countries
- Main objective: "Set a durable structure for BMI at the European level that supports its consolidation as an integrative scientific discipline that exploits the synergies between BI and MI."
- Specific objectives:
  - “Community”: education, training, mobility, spreading knowledge, creating a self-sustainable structure.
  - “Scientific”: progress in data interoperability, interfacing of methods, technologies and tools, pilot applications.

Biomedical Informatics

Clinical

Genomic

Data

Informatics

Health Research

INFOBIOMED

- WP1 NoE management
- WP2 Dissemination and communication
- WP3 Training and mobility
- WP4 Data interoperability
- WP5 Methods, technologies and tools
- WP6 Pilot applications

Integrated vertical approach of BMI technologies used in INFOBIOMED

INFOBIOMED BIOMEDICAL INFORMATICS TO SUPPORT INDIVIDUALISED HEALTHCARE

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- Project Presentation
  - Summary
  - Objectives
  - Background
- Partners
  - Partners Description
  - Other Participants
- Project Activities
  - Dissemination and communication
  - Training and Mobility
  - Data Interoperability and management
  - Methods, technologies and tools
  - Pilot applications
- Contact Information

INFOBIOMED News

INFOBIOMED has participated with an **oral communication at the XIX International Congress of the European Federation for Medical Informatics (MIE2005),** last August 28 - September 1, 2005.

Welcome to the European Network of Excellence INFOBIOMED Website

Structuring European Biomedical Informatics to Support Individualised Healthcare funded by the Information Society Directorate-General of the European Commission within the VI Framework Programme for Research and Technological Development.

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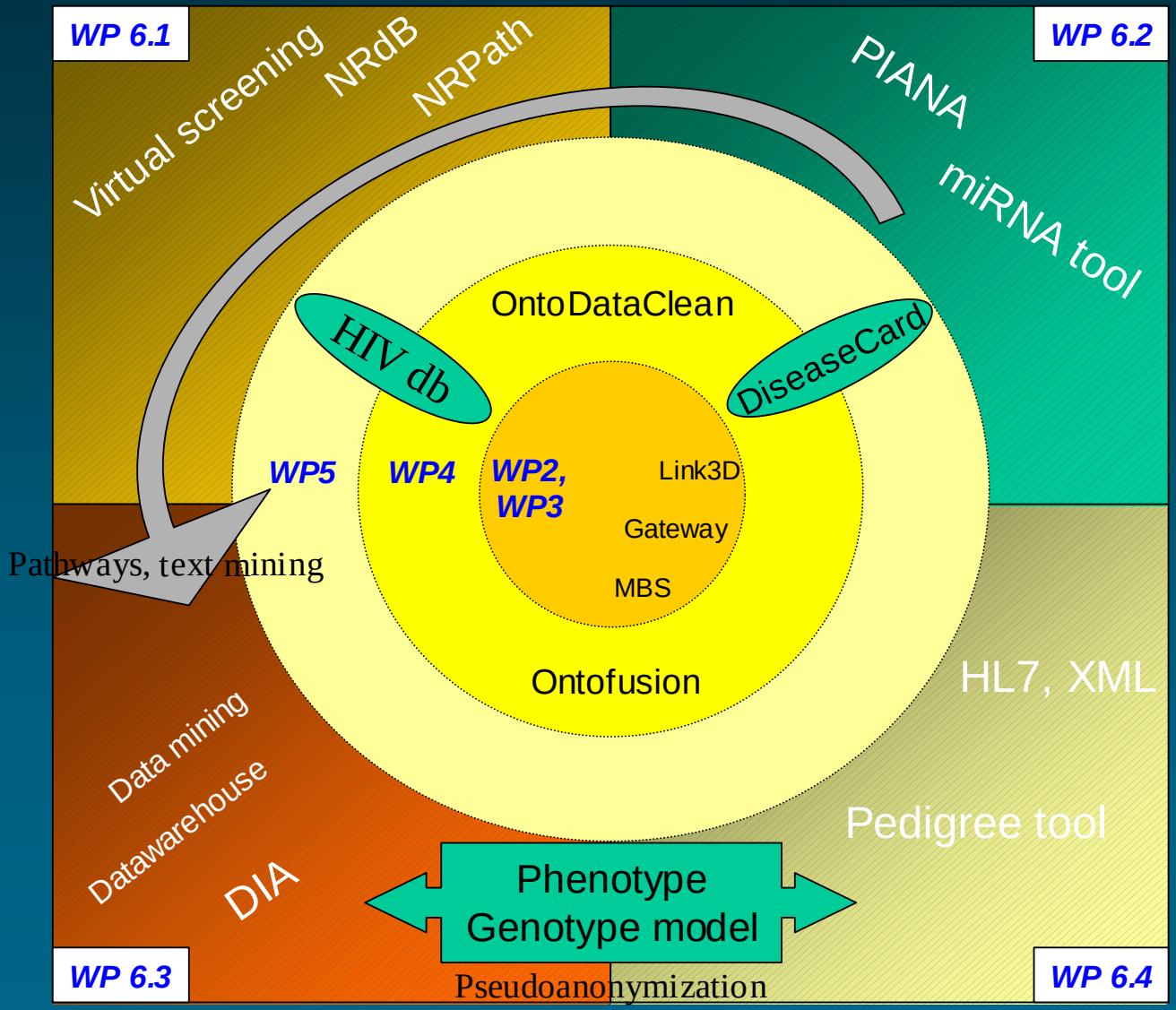
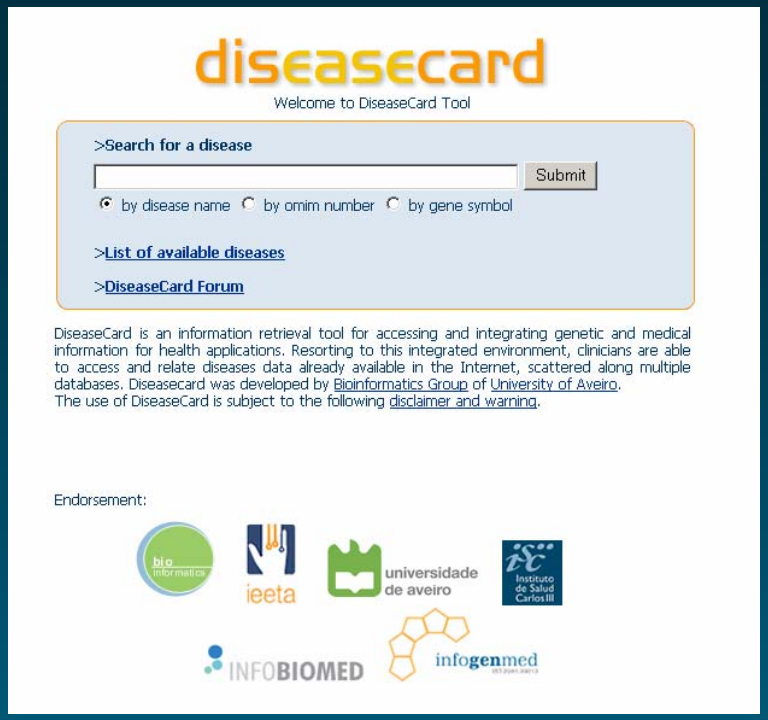
First INFOBIOMED Training Challenge

European Biomedical Informatics Gateway
Check our repository containing extensive information and the latest news on Biomedical Informatics in Europe

INFOBIOMED: technologies, tools and resources



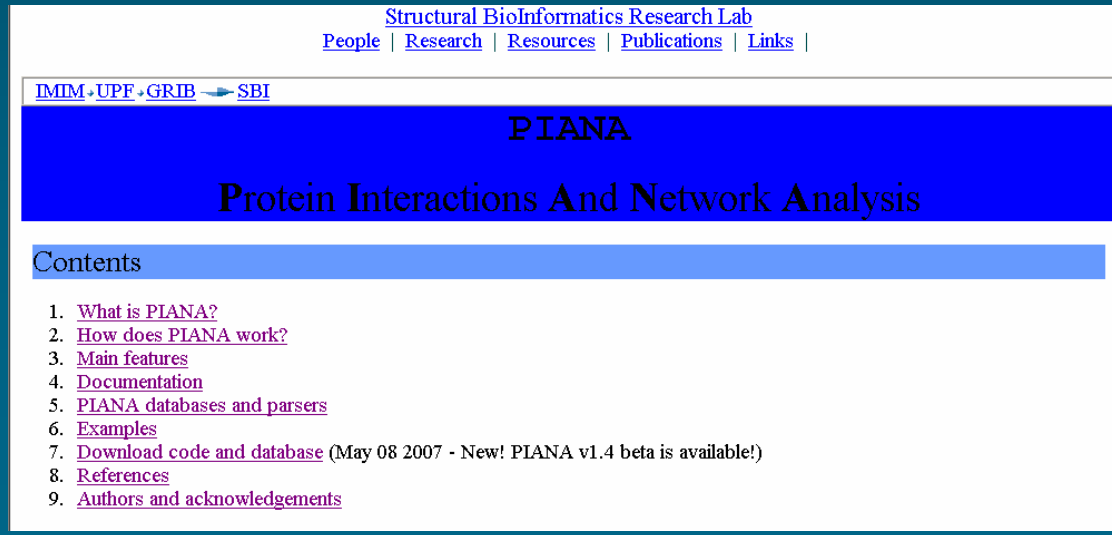


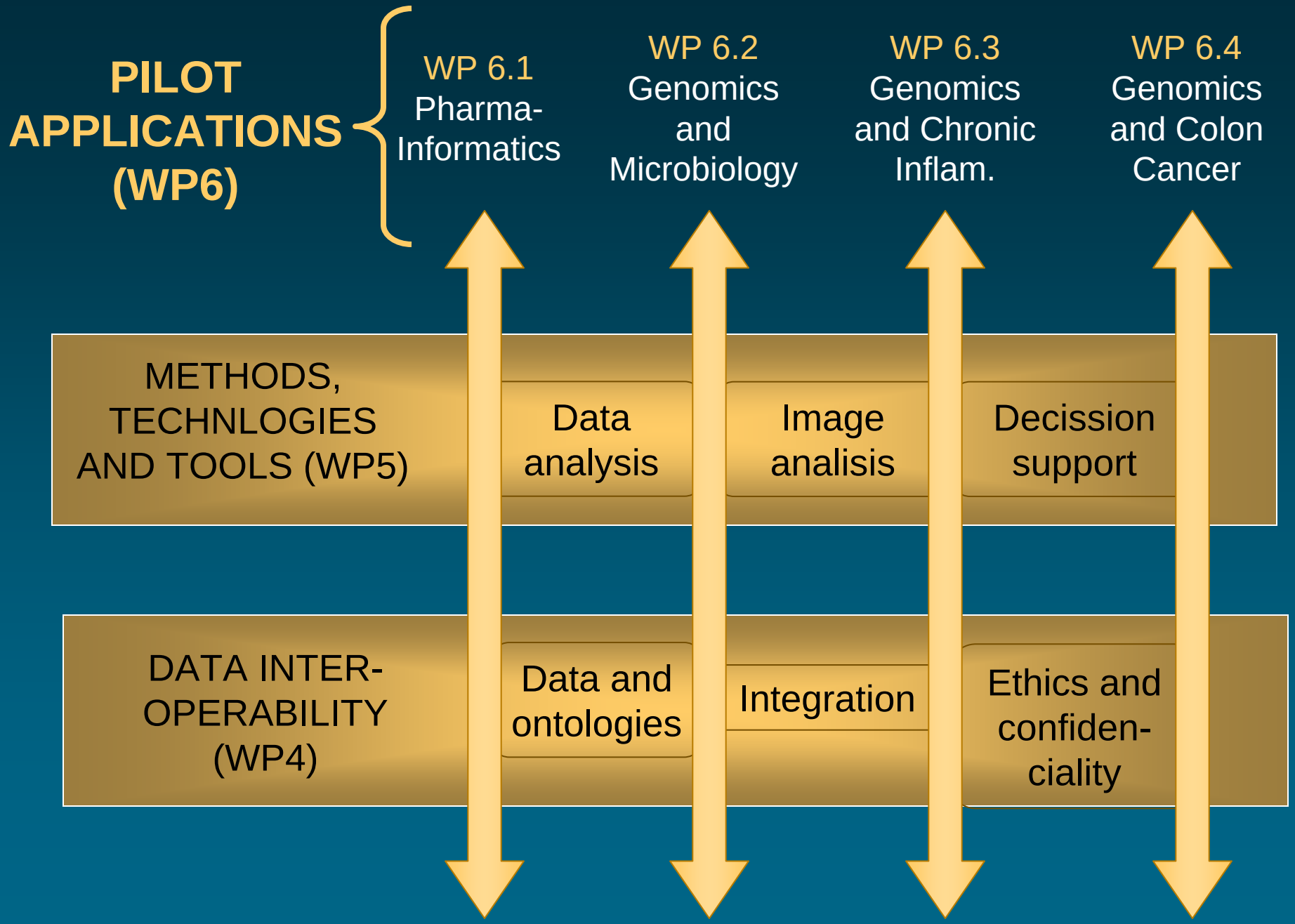
Diseasecard

http://bioserver.ieeta.pt/diseasecard/

PIANA

http://sbi.imim.es/piana/




PILOT APPLICATIONS (WP6)
WP 6.1 Pharma-Informatics
WP 6.2 Genomics and Microbiology
WP 6.3 Genomics and Chronic Inflam.
WP 6.4 Genomics and Colon Cancer
METHODS, TECHNLOGIES AND TOOLS (WP5)
Data analysis
Image analisis
Decission support
DATA INTER-OPERABILITY (WP4)
Data and ontologies
Integration
Ethics and confiden-ciality

INFOBIOMED: pilot aplications

- Pharmainformatics
  - Research in the drug discovery process
  - Establish an information continuum from pathology to pathway to target to ligand/approved drug.
- Genomics and Microbiology:
  - Improve clinical evaluation strategies through a comprehensive pathway-related with host/pathogen interaction.
- Genomics and chronic inflammation
  - Investigates the susceptibility to adult chronic periodontitis.
- Genomics and colon cancer
  - Built a infrastructure based on standards (in XLM)
  - Connecting genetic labs with hospitals and central registry

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INBIOMED, The Spanish Cooperative Research Thematic Network on Biomedical Informatics

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Abstract

Biomedical research needs to process and integrate large amounts of data, obtained from different biomedical disciplines, to research complex, multigenic diseases where the interaction of both genetic and environmental factors play an important role. It is essential to study the interactions among all the health information levels - population, disease, patient, organ, tissue molecular and genetic-. Biomedical Informatics is the discipline that provides models, methods and computer tools to integrate genetic, clinical and environmental information. In this paper we describe the successful results of INBIOMED, the Spanish Cooperative Research Thematic Network on Biomedical Informatics funded by the Spanish Ministry of Health, which is a perfect example of this line of work. INBIOMED members developed a technological platform to manage, integrate, model and analyze clinical, genetic, epidemiological and image data, for the research of any complex pathology. They also worked in the quality, security, communication and training aspects, to disseminate Biomedical Informatics in Spain. The work performed by INBIOMED was recognized as Excellent by an International Committee of Experts, who recommended its continuity and strengthening.

Keywords:

ICT in Biomedicine, Biomedical Informatics, INBIOMED

Introduction

The publication of the results obtained by the Human Genome Project has produced huge advances in biomedical research in the last years. This information has contributed to the development of new disciplines aimed at researching all factors that have an influence in diseases. Most diseases are caused by genetic and/or environmental factors, and to completely understand their causes it is essential to know patients genetic characteristics and life habits as well as the environmental agents to which they are exposed [1].

However, these data are obtained from very different biomedical disciplines, which often use them exclusively. The integration of these data is essential to be able to research complex, multigenic diseases in which environmental factors have a strong influence. It is also important to study interactions among all the information levels - population, disease, patient, organ, tissue and molecular or genetic-.

In this sense Biomedical Informatics, a recent discipline between Medical Informatics and Bioinformatics, has a relevant role in the integration of these new data and providing new approaches to old health problems, as you can see in figure 1. It does this by providing the models, methods and informatics tools to integrate information about genetics, clinics, and environmental aspects. Thus, Biomedical Informatics facilitates the development of Genomic Medicine, a new scientific discipline that aims towards the development of personalized treatments and therapies for groups of patients with common genetic characteristics[2].

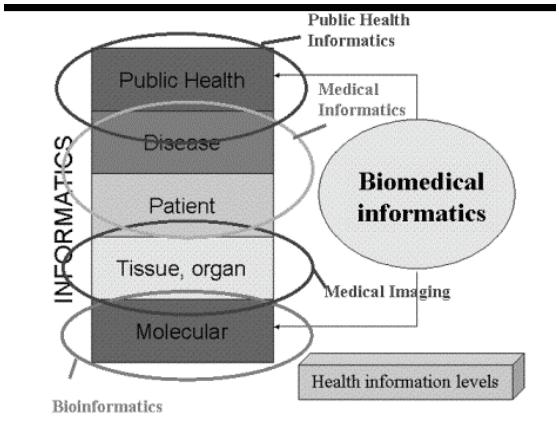

Figure 1- Integration of the health information levels

Biomedical Informatics has increased in the last years worldwide. Each year new initiatives appear in Europe mostly through the EU Framework Programmes and in the USA through the National Centres for Biomedical Computing funded by the US National Institutes of Health. All these initiatives support research in Biomedical Informatics, which is one of the most promising areas to diagnose and treat diseases in the future.

In this paper we describe the work and results obtained by INBIOMED, the Spanish Network of Cooperative

Research on Biomedical Informatics. It was one of the first technological projects in this line of work promoted by the Spanish Scientific Research, Development and Technological Research Plan from 2003 to 2006. This Plan followed the directives of the Europe Union Sixth Framework Program, which consisted of promoting cooperative research and initiatives combining elements from different disciplines. The Network developed a technological platform to store, manage, integrate, model and analyze clinical, genetic, epidemiological and image data that could be used to research any complex pathology. INBIOMED members also developed useful informatics tools, procedures and methods that have been included in the platform (SNPs and genes text mining systems, processing of biomedical images, data analysis of arrays, clinical decision support system, automated questionnaires to evaluate the diet and other environmental factors such as smoking habits). They also developed more specific tools targeted towards solving some of the problems encountered by the "bio-user" nodes. INBIOMED also made important efforts in quality, security, and communication aspects, to communicate and disseminate its results to the scientific community and other stakeholders. Moreover, due to the shortage of training offer in this area in Spain, INBIOMED members have organized Biomedical Informatics Specialization Training Plans and courses directed to researchers.

INBIOMED was formed by 13 biomedical research groups from 11 centres geographically distributed around Spain. INBIOMED coordinated relevant groups in Biomedical Informatics together with technological and pathology research groups that have a multidisciplinary character (Genomic Epidemiology, Pharmacogenetics, Molecular and Image Diagnosis), where the integration and analysis of clinical, genetic, epidemiological and imaging data is needed.

These groups were:

- Polytechnical University of Madrid. Faculty of Computer Science. Medical Informatics Group.
- Municipal Institute of Medical Research. Research Unit on Clinical and Molecular Epidemiology of Cancer.
- Municipal Institute of Medical Research. Research Unit on Biomedical Informatics.
- Sanitary Corporation "Clinic". Medical Informatics Group.
- University of "La Coruña". Faculty of Computer Science. Department of Information and Communication Technologies. Laboratory of Artificial Neural Networks and Adaptative Systems. Medical Informatics and Radiological Diagnosis.
- University of "Santiago de Compostela". Faculty of Pharmacy. Department of Pharmacology. Pharmacogenomics in Drug Research and Development Unit.
- University "Jaume I." Department of Languages and Informatics Systems. Research Group on Integration and Systems Re-engineering.
- University "Jaume I." Department of Technology. Engineering and Design. Informatics Engineering Faculty.
- University of Valencia. Faculty of Medicine. Department of Preventive Medicine. Research Unit on Molecular and Genomic Epidemiology.
- University Hospital "Virgen de las Nieves." Department of Computer Science.
- University of "Castilla-La Mancha." Department of Electric, Electronic and Automatic Engineering.
- Polytechnical University of Valencia. Biomedical Informatics Group. Faculty of Computer Science.
- Institute of Health "Carlos III". Biomedical Informatics Unit.

To achieve its objectives INBIOMED groups were organized in nine different work committees, as you can see in figure 2: Training, Quality and Ethics, Communication, Knowledge Representation, Image Analysis, Structured Data Analysis, Text Analysis, Technological Platforms and Bio-Users (Pharmacogenetics and Neuropsychiatry, Genomic and Cardiovascular Epidemiology and Cancer Epidemiology). Each Committee was composed by different research groups and was directed by a coordinating Committee, responsible for its production and quality. All the research groups were coordinated by the Department of Medical Bioinformatics of the Institute of Health Carlos III.

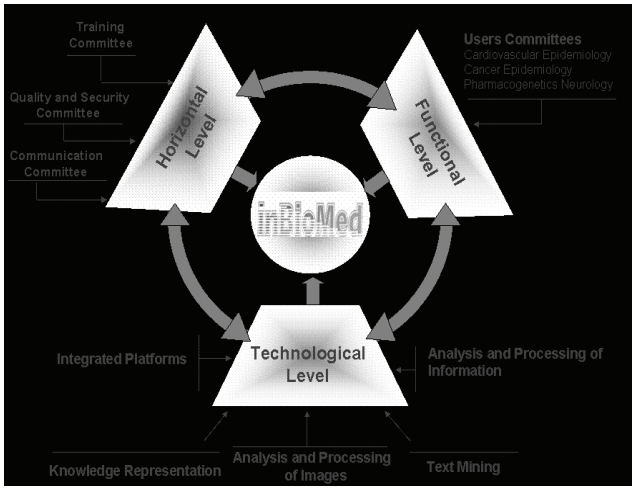

Figure 2- INBIOMED Work Committees

The structure of the cooperative work was defined in such a way that the technological platform aimed to provide solutions to the "bio-user" nodes. The platform was developed by the technological groups and updated with new solutions implemented following the proposals of the "bio-user" nodes.

Methods

The INBIOMED platform

After the creation of the INBIOMED network its members realized that the project had some drawbacks that had to be analyzed. The research groups had problems when they needed to cooperate or share information with other research groups. All the information generated in the laboratories or the gathering or collection of clinical data was very difficult to manage because of their volume. In addition, the Internet provides a huge amount of public relevant information, but in very different formats and the same problem occurred with the analysis and data processing tools.

The solution happened to use an infrastructure based on SOA (Service Oriented Architecture) that makes easy the interaction between all the research groups and the integration of their processes and data. It has a common information model to make a standard way of using the available analysis tools and getting results. To meet these needs, INBIOMED deve- loped a platform based on the development of three layers, as you can see in figure 3:

a) **Client applications** (user interface): This layer implements only the User interface with their input forms and the results presentation, delegating the responsibility to query, store and process the information as much as possible in the other two layers.

Taking into account the Web and Desktop targets, two client applications have been developed so that most of the researchers could use the platform:

1. Windows Desktop *Inbiomed Nexus Workbench* [3] to have the richest client user interface available.
2. Web based *Inbiomed Nexus Site*, it is developed under web technologies using ASP.NET 2.0 exploiting Web-Parts technology that allows the user personalize his framework.

The most interesting functionalities ready to be used are: complete management, shared relational data exploration and query, semantic query on ontology, integrated applications (but others can be developed), design and execution of Workflows, embedded IronPython, execution of IQL scripts and a lot more.

This platform has integrated the last web technologies and it is able to use ontology as data sources in both interfaces. Even those user interfaces have used an ontology to integrate diffe- rent data bases as only one. An example of this are hospital minimum basic data set (MBDS), Each hospital has his own codification language but in order to get a good and complete result many times you have to make several queries so with this integration you only have to query once to the different MBDS.

b) **Web Services Layer** (logic): This layer provides the logic of the platform, providing an easy way to query and process the information. In order to improve the cooperative spirit of INBIOMED, every research group contributes by making available his node to the others.

The main platform site implements a special web service to receive requests, to query and process data in a language oriented to batch execution called IQL [3]. It has, also, to allow the management of users, data sources, access to the other web services…

The IQL engine executes every received request in a separated thread and in a sequential way. All the data manipulation is done by using an ADO.NET data type called DataSet [4]. It manages temporal and persistent variables. For complex tasks it is possible to declare procedures containing other IQL sentences.

The platform provides support for cooperative process management and coordination through the ability to design and run workflows. INBIOMED workflow activities allow sha- ring the data repositories and executing processing tasks hel-ping human and computer based interactions in cross-groups applications to success. Also, it offers pertinent information about workflow execution progress supporting long-time transactions.

c) **Data Sources Layer** (storage): all the database servers are located in this layer. It contains the information sources accessible through the platform (public or private). Data warehouse technology plays a fundamental role guaranteeing that the information stored in the databases and finally published to the platform is well consolidated and oriented to be queried.

The main goal of the platform is to support efficient heterogeneous and distributed information sharing. The INBIOMED platform grants direct access to published relational data sources, but also solves the structural and semantic heterogeneity conflicts with the use of ontologies that define not only concepts and their relations but also mappings of concepts and entities to the published physical relational data.

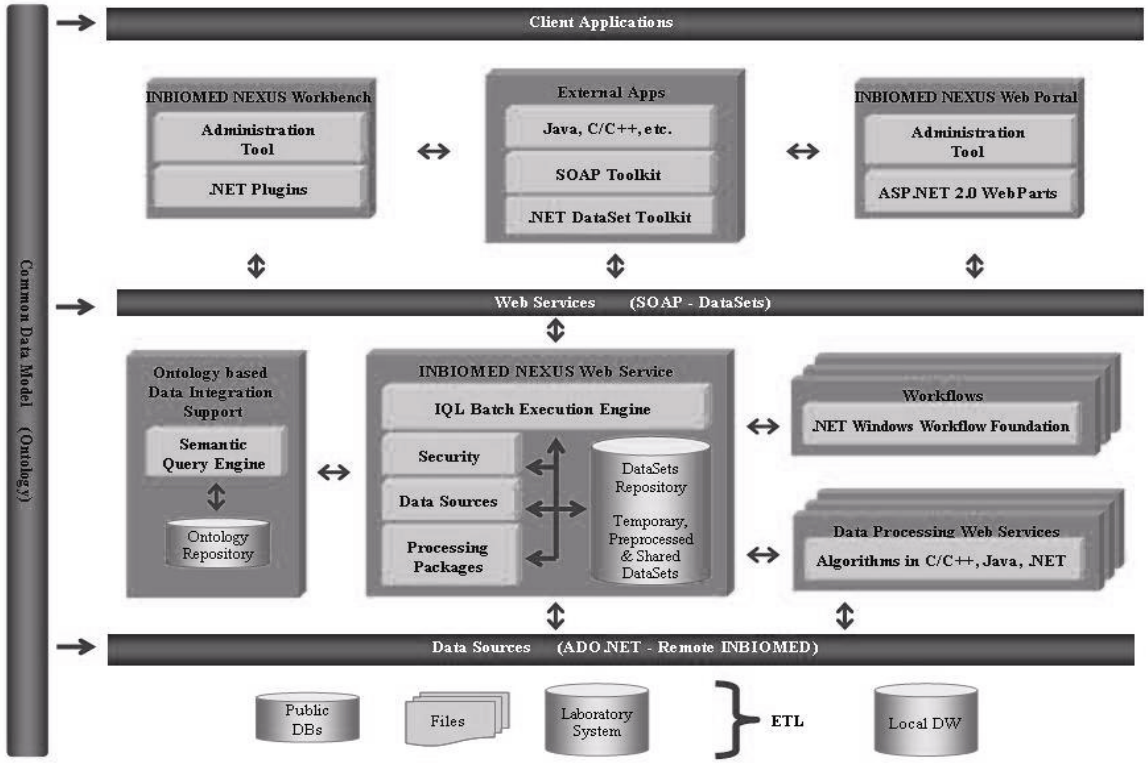

Figure 3 - INBIOMED Platform Layers

Tools

INBIOMED technological groups developed useful informa- tics tools to be used by the "bio-user" nodes and that were included in the platform. These tools include SNPs and genes text mining systems, tools to process, analyze and visualize biomedical images, clinical decision support systems, automated questionnaires, and others. The most relevant tools developed by INBIOMED are the next:PANGEA, a system to share clinical registers and obtain electronic clinical history of the patients.

- ZEHUTI, an algorithm for the calculation of the conceptual similarity between two texts by the projection of concepts into an ontology.
- Bussub, a virtual amplicon retrieval software.
- OSIRIS, a tool for the retrieval of articles from MEDLINE related to the sequence variants reported for a human gene [5].
- SeqPacker and Enzyme-Digest: tools for the analysis of nucleotides sequences.
- [2] DNASqueezer: a tool to compress DNA and RNA sequences.
- Blast2go: a tool for annotation, visualization and analysis in functional genomics research[6].
- SOC: a distributed system for the decision of clinical diagnostic
- SIREN Project: a computerized system to make inquests in Genomics Epidemiology.

Results

INBIOMED's main objective was to solve the needs of the "bio-user" groups. Each "bio-user" group had different pro-blems which required different solutions and strategies. These are detailed below by researches areas:

Cancer epidemiology

This task was leaded by Dr. Nuria Malats, head of the Research Unit on Clinical and Molecular Epidemiology of Cancer, Municipal Institute of Medical Research.

In response to the needs of the group, INBIOMED has solved in this way:

- In data analysis the researches have developed data mi-ning techniques and comparison of different data mining strategies in data analysis.

- In image visualization and analysis, it has been processed and stored biomedical images that the research in this specific area has created.
- In information retrieval, the members of this group obtain the automation and integration of heterogeneous clinical and pathologic information from hospital databases.
- In SNP searching area it has been produced an utomated search and selection of genetic polymorphisms and the use of OSIRIS to identify articles related to polymorphisms identified in genes of interest.

Pharmacogenetics in neurology

This task was leaded by Dr. Mabel Loza, chief of the Department of Pharmacology. Pharmacogenomics in Drug Research and Development Unit of the University of "Santiago de Compostela". This group had some specific needs related to schizophrenia disease that were solved as described below:

- The SNP searching was solved by automated identification of articles related to polymorphisms in genes of interest and the automation of this SNPs search was facilitated by the use of some informatics tools, like OSIRIS, SNPator and PupaSNP [7]
- A Web format database was created in order to process, store and interchange the images that were generated from several types of formats.
- The management of the Galician Computerized Biobank was improved to use its data and samples.
- The development of algorithms to set genetic expression profiles applied in microarrays assays. By this way the effectiveness predictive model of treatments with neuromedicines can be used in vitro.
- INBIOMED has developed ontology based methods that can resolve the problems associated with syntactic and semantics gaps across data sources. This ontology was created to define keywords used in schizophrenia's pharmacogenomics research and by this way to makes possible to set class relations between these keywords.
- To classify basic and clinical scientific publications according to their conceptual similarities, INBIOMED has developed the ZEHUTI algorithm.

Cardiovascular epidemiology

This task was leaded by Dr. Dolores Corella, chief of the University of Valencia. Faculty of Medicine. Department of Preventive Medicine. Research Unit on Molecular and Genomic Epidemiology. This group presented a different set of needs from the other "bio-user" groups, which are described below.

Informatics systems were developed to facilitate the efficient automatic recruitment and follow up of patients (CITAGEST), the management of biological samples (ALIGERA), the epidemiologic data collection by designing computerized questionnaires, and finally the automation and validation of information about food consumption and its conversion to nutrients by SIREN and VALFRECO.

This area of interest also shared similar needs with the other "bio-users" groups like SNPs search, information retrieval and visualization and analysis of images.

Conclusion

In this paper we have described the work done in INBIOMED, the Spanish Cooperative Research Thematic Network on Biomedical Informatics. This project was a successful example of cooperative research between different disciplines to study complex diseases. Along the three years lifetime of this project an important number of collaborations among the different nodes have taken place. The existence of Biomedical Informatics groups has allowed the setting up of a common ground and a common language between technological and biomedical research groups. The work performed by INBIOMED was recognized as Excellent by an International Committee of Experts, who recommended its continuity and strengthening.

Acknowledgments

The present work has been funded by INBIOMED Research Network.

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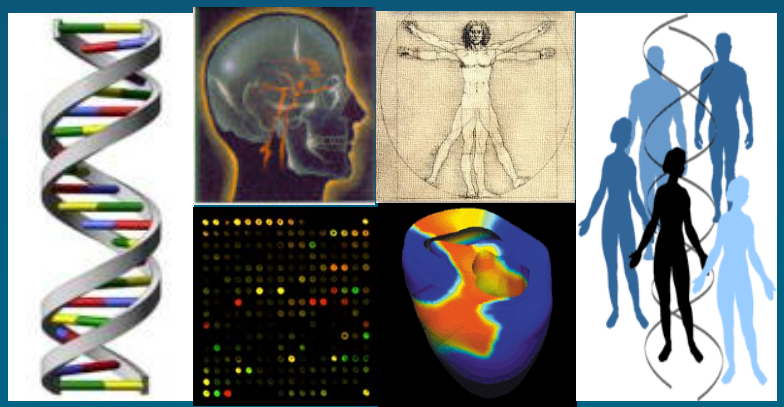
MINISTERIO DE SANIDAD Y CONSUMO

INBIOMED
The Spanish Cooperative Research Thematic Network on Biomedical Informatics



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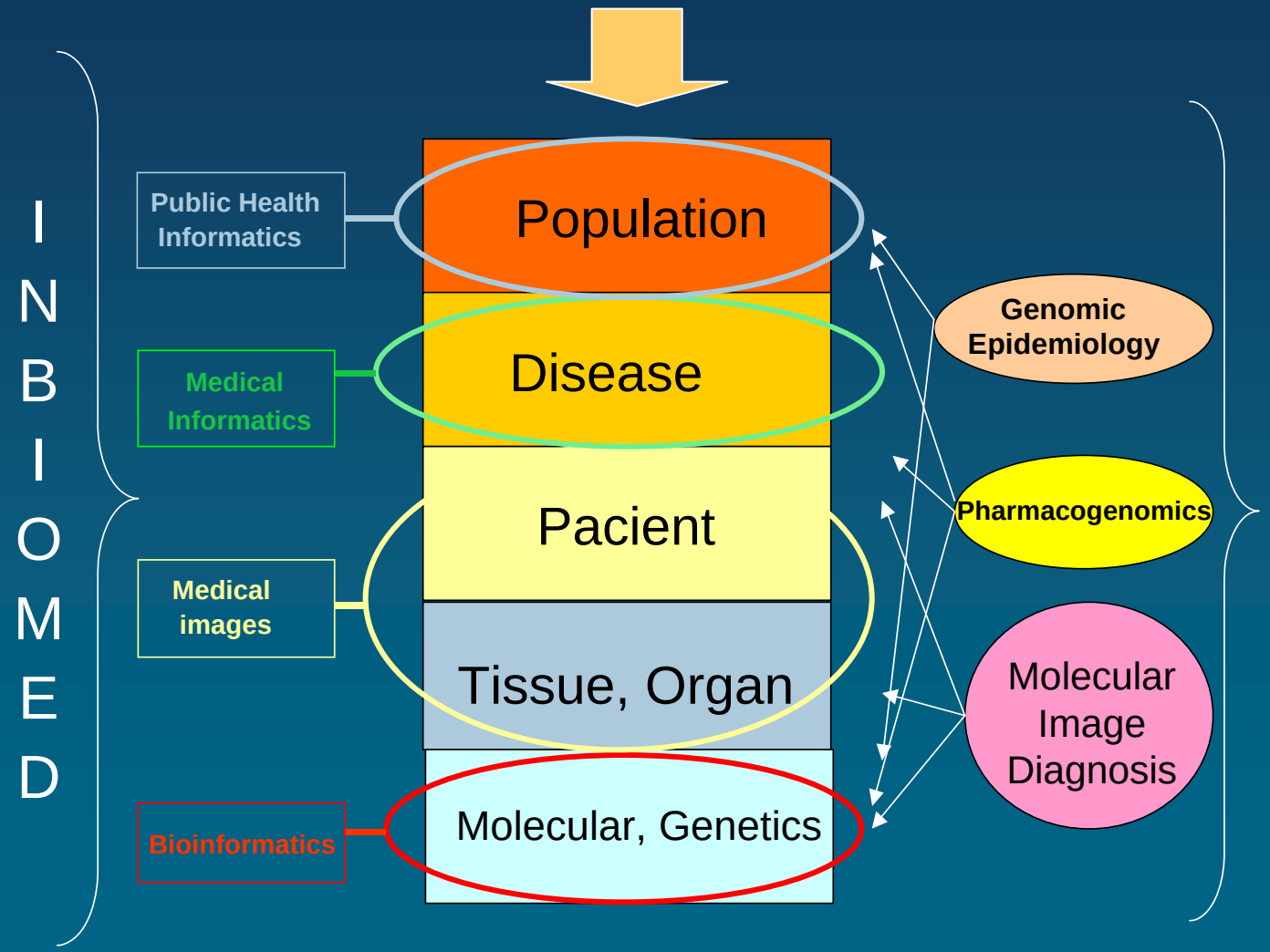
Integration of Health Information Levels



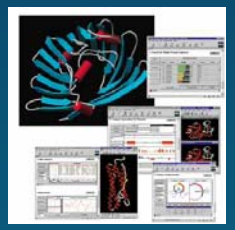
Genomic Medicine

Human Genetic Variation

Technologies | Data | Applications

Information

Clinical



Genomics

Genotypes

Haplotypes

Individual Genomics (SNPs and mutations)

Diagnosis

Pharmaco-genetics

BIOMEDICAL INFORMATICS

Genic Expression DNA arrays MS, 2D ef

Functional Genomics Proteomics

Pharmaco-Genomics Disease Reclassification

Molecular Causes of Diseases

Genomic Medicine

Individualized Medicine

Molecular Medicine

Preventive Medicine

ICT in Biomedical Research

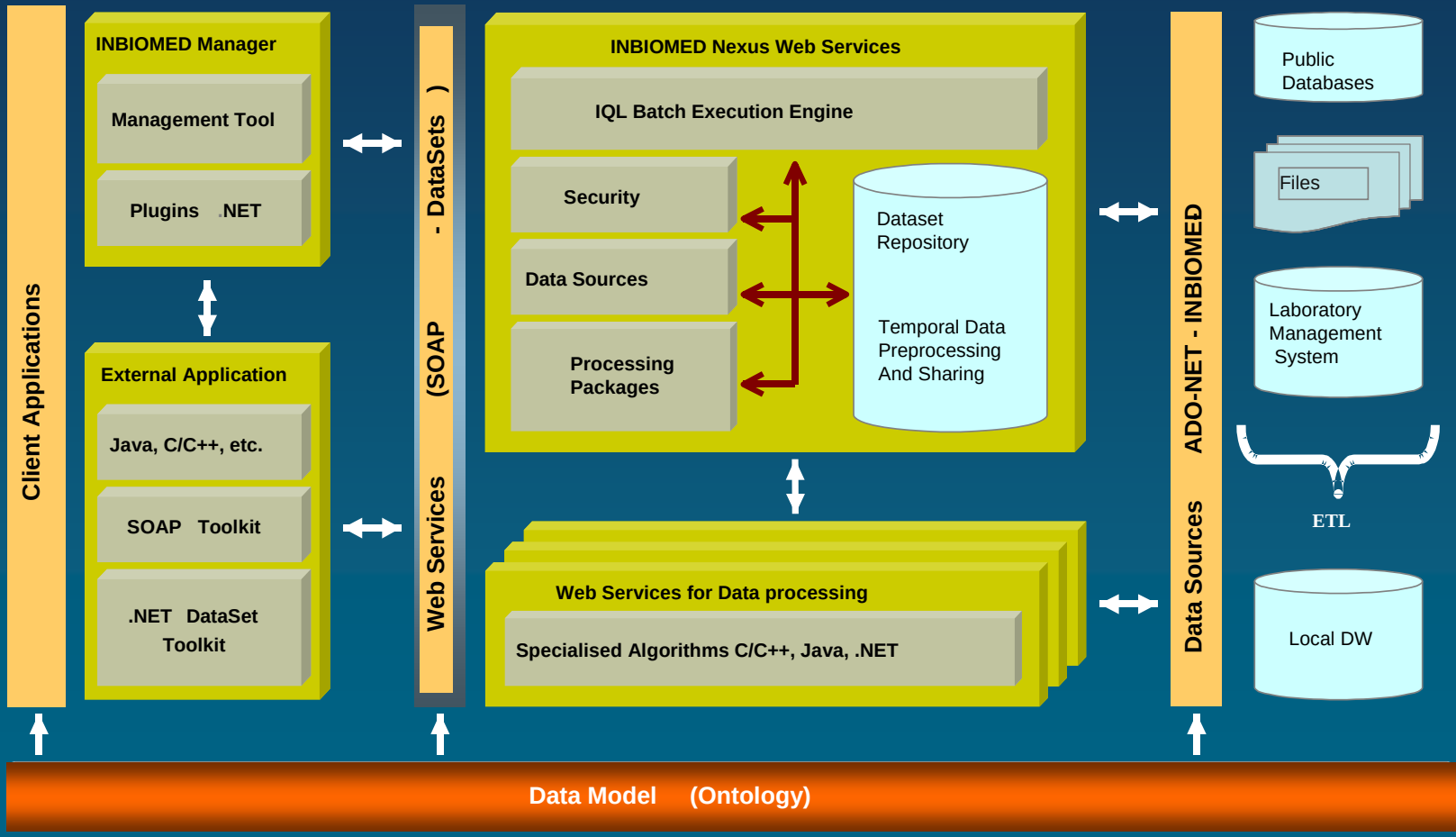
- ICT in Biomedical Research
  - tackles the acquisition, storage, integration and analysis of the biomedical data,
  - tries to provide models, methods and informatics tools
  - enables the integration of genetic, clinical and environmental factors
  - contributes to improve prevention, diagnosis and treatment of diseases in the future

INBIOMED: The Spanish Cooperative Research Thematic Network on Biomedical Informatics

http://www.inbiomed.retics.net

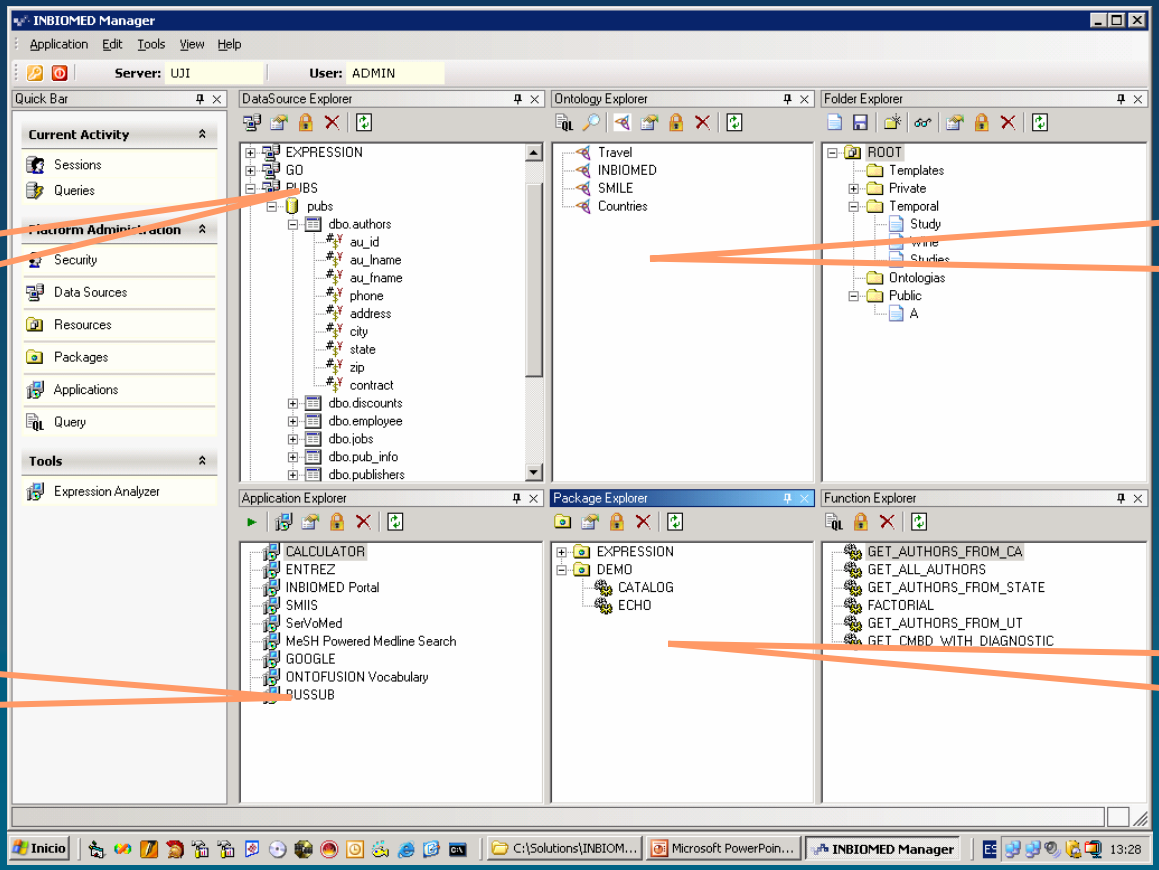
- 6 Autonomous Comunities
- 11 Centres
- 13 research groups
- +100 researchers
- Hospitals, Universities and Research Centres

Architecture of the INBIOMED Platform



INBIOMED Manager

Client Application that facilitates the management of the system, where several different relevant public databases have been integrated



Data Sources

Semantic Layer (Ontology)

Applications

Web Services

Tools

- OSIRIS: a tool for retrieving of articles from MEDLINE related to the sequence variants reported for a human gene.
- Blast2Go: a tool for annotating, visualizing and analysing data in functional genomics research.
- SOC: a distributed system for clinical decision making support.
- Tools for processing and filtering of images (DNA bands in gels, cell counting.)
- SIREN: a computerized system to make inquests in Genomic Epidemiology
- Seqpacker: tools for the analysis of nucleotide sequences.
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Results

Cancer Epidemiology

INBIOMED Contribution:

- Data analysis: development of data mining techniques and comparison of different data mining strategies in data analysis.
- Image visualization and analysis: processing and storage of biomedical images.
- Information retrieval: automation and integration of heterogeneous clinical and pathologic information from hospital databases.
- SNP searching: automated search and selection of genetic polymorphisms and the use of OSIRIS to identify articles related to polymorphisms identified in genes of interest

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- ZEHUTI algorithm: to classify basic and clinical scientific publications according to their conceptual similarities.
- Development of ontology based methods that could solve the problems associated with syntactic and semantics gaps across data sources.
- Development of algorithms to set genetic expression profiles applied on microarrays assays.
- Management of the Galician Computerized Biobank was improved to use its data and samples.

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Cardiovascular Epidemiology

INBIOMED Contribution:

- CITAGEST: an Informatics system to facilitate the efficient automatic recruitment and follow up of patients
- ALIGERA: a Tool for the management of biological samples
- Design of computerized questionnaires for the collection of epidemiologic data
- SIREN and VALFRECO: an informatics system for the automation and validation of information about food consumption and its conversion to nutrients.

- This area of interest also shared similar needs with the other “bio-users” groups like SNPs search, information retrieval and visualization and analysis of images.

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Factors Affecting Electronic Health Care Records Adoption (EHR) and Success in Three Developing Middle Eastern Countries; Lebanon, Syria, and Jordan

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Project Manager USAID/AMIDEAST, Beirut
President of Lebanese Medical Informatics Association

Abstract

"The lack of access to basic healthcare continues to stifle social and economic advancement in many parts of the developing world." [1] Moreover, IT improved many industries according late research (2004- 2006) in developing countries but not in the health care industry. This even applies to developed countries.[2] Thus, this research seeks to further our knowledge of Healthcare Information and Communication Technology Systems (EHCR) adoptions in Fertile Crescent countries of the Middle East (Lebanon, Syria, Jordan, & Iraq). Researching EHCR factors leading to successful adoption in The Fertile Crescent countries will create a panoramic and practical picture and vision for healthcare executives, healthcare IT professionals, healthcare researchers and officials in the governments responsible for finance and health policy in these countries as well as agencies and other international organizations to take action towards bridging gaps for achieving optimal and affordable health information and communication technologies as EHCR. As a conclusion, this research will promote collaborative efforts for creating a reliable, timely, high quality and affordable health care in the region.

Keywords:
electronic health record

Introduction

It is argued that there is an identifiable cluster of factors that "predispose" hospitals to adopt EHCR in general [3, 4]. In particular, this investigation focuses on assessing and estimating the relationships between Environmental factors (economic, political, etc..) and "extent and success of EHCR adoptions" and the relationships between organizational factors and "extent and success EHCR adoptions" in the hospitals of which is nearly most inclusive and representative sample of the region's hospitals that treat approximately three quarters of the population. Moreover, it focuses on the relative importance of environmental and organizational factors with respect to "extent and success of EHCR adoptions".

Methods

Descriptive multivariate hypotheses are proposed, hence multivariate regression analysis are employed in order to evaluate factors' correlation magnitude with EHCR adoption and success in the Fertile Crescent region. The two main dependent variables are the "extent of EHCR adoption" and "EHCR adoption success". The former refers the measure of adoption as sum of percentages of adoption levels and components of EHCR-supported functions performed in a hospital because it reflects the level of commitment to EHCR adoption and the factors associated with it. The latter is a summary percentage measure of the extent to which EHCR functions is perceived to be hospitals' needs[5].

Data collection includes the use of on-site structured and open ended interviews of hospital departments' managers of "A" five stars accredited 200> beds' hospitals within counties of the region. Thus the sample includes hospitals whose clients account for more than 75% of the population of these countries.

Results

2006. So real conclusions will data analysis, results, discussion and conclusions will be updated at the end of June2006

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Factors Affecting Electronic Health Care Records Adoption (EHR) in Developing Fertile Crescent's Middle Eastern Countries; Lebanon, Syria and Jordan.

PhD in Health Informatics
By Hala Badredine

The University of Bath- UK
MEDINFO, August 2007

Outline

- Definition of EHR in the context of this research
- Abstract
- Subdivisions and Classes of EHR
- Background
- Data collection & Analysis
- Methods
- SEM Model
- Syntax
- Results & Discussion
- References

Abstract

This research furthers **knowledge about factors** affecting individual managers actual individual usage of Electronic Health Care Records; (AIU-EHR), in hospitals i.e. in three developing countries of middle east. EHR is a **generic** term which incorporates several classes of systems. This research defines EHR as a scientific discipline concerned with cognitive information processing, as well as concerned with the communication tasks of health care, health care research, and education, respectively.

This investigation **focuses** on how the **independent variables** affect the dependent variable (AIU-EHR) [2,4,5,6]*:

- **Individual personality characteristics**
- **Attitudes and habits**
- **Characteristics of individuals according to their organizations**
- **EHR usefulness**

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Subdivisions and Classes of EHR

The classes or subdivisions of EHR were defined in 1997.[2,,4,5]*

1. Administrative and Clinical Information Systems

2. Management Information Systems

3. Health Care Organization Information Systems

4. Patient-Centred Administration Systems

5. Medical Knowledge and Decision Support Systems (interactive systems)

6.Transaction Processing Systems

7. The Internet

But in this research EHR is handled as a discipline not as classes.

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Background

Background: "The lack of access to basic healthcare continues to stifle social and economic advancement in many parts of the developing world."[5]

This applies to developed countries. [6]

Researching EHR factors leading to adoption in The Fertile Crescent developing countries will create a panoramic and practical picture and vision for healthcare executives, healthcare IT professionals, healthcare researchers and officials in the governments responsible for finance and health policy in these developing countries.

This also applies for agencies and other international organizations to take action towards bridging gaps for achieving optimal and affordable health information and communication technologies as EHR.

Data collection & Analysis

- **Data collection** includes a questionnaire. The researcher completed it. The researcher uses on-site interviewing of Healthcare organisations managers from macro to micro levels. The respondents are managers from healthcare departments in the three Middle Eastern countries mentioned.

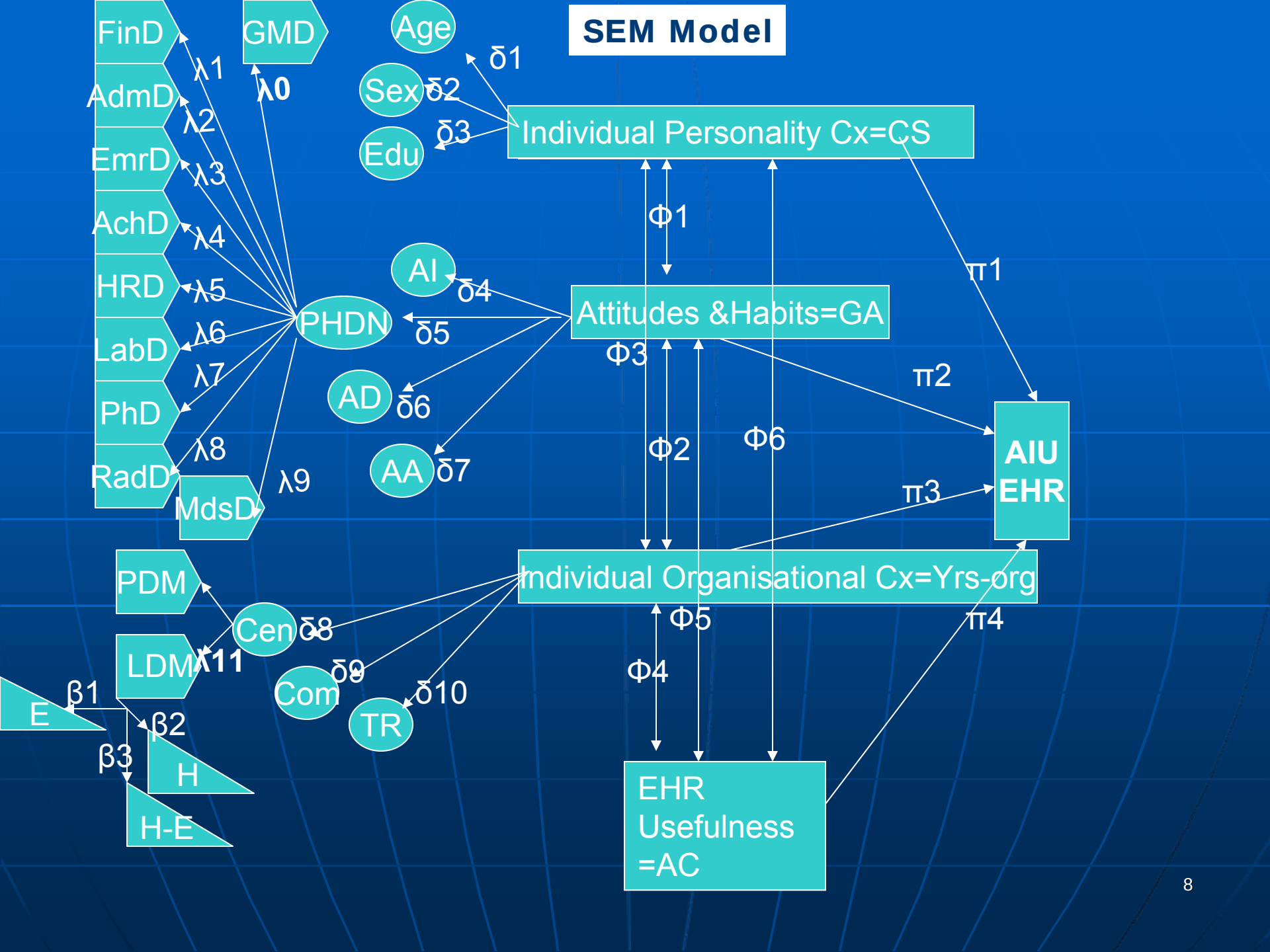
- **Structural Equation Modeling SEM [1]* & Ideamap [3]*** data analysis techniques will be conducted. The measurement model in this research uses factor analysis to assess the degree that the observed variables load on their latent exogenous and endogenous constructs respectively. SEM literature defines the independent variables as endogenous factors while the dependent variable is an exogenous factor.

- The research uses in the analysis AMOS which is an add on SPSS application. As well as, Ideamap that also tests a large number of variables horizantally and vertically, in a similar way to AMOS.

*[1- Bollen, K. A. (1989). Structural Equations with Latent Variables. New York, NY: John Wiley & Sons.
3-Moskowitz H. (2007). Ideamap. New York, NY. www.ideamap.org]

Methods

- **Methods:** Based on a socio-technical approach the research approached nearly most inclusive and representative sample of the region's hospitals in each country.
- The aim of the **sampling methodology** is to arrive at a sample that is representative of individual health care professionals in organisations (size mentioned) in the countries under study. The number of individual health care professionals of health care organisations from any one country is determined on the basis on the **country's proportionate share** of all individual health care professionals in health care organisations in the studied countries.
- Research presents the number of individual health care professionals of the number of their respective hospitals in the region by country.


SEM Model
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AIU
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Individual Organisational Cx=Yrs-org
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π4
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δ8
LDM
λ11
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δ9
TR
δ10
E
β1
β2
β3
H
H-E
EHR
Usefulness
=AC

Syntax: Paths connecting contexts or variables in the diagram

1- The paths connecting the four independent variables (exogenous); **Individual Personality Characteristics (CS)**, **Attitudes (GA), EHR-Usefulness (AC)** and **Individual Organisational Characteristics (Yrs)** with the dependent (endogenous) variable; **AIU-EHR** as the independent variable are represented by **π (Pi)** coefficients.

- 2- The shared matrix between the four independent variables; **Individual Personality Characteristics**, **Attitudes, EHR-Usefulness** and **Individual Organisational Characteristics** with each other are represented by **Φ (PHI)** coefficients**.**

- 3- The path between an observed variable and its latent independent variable is represented by **δ (Delta)** coefficients.

- 4- The path between the sub-observed variable and its observed variable is represented by **λ (Lambda)** coefficients.

- 5- The path between the late sub-observed variable and its sub-βobserved variable is represented by **β(Beta)** coefficients.

The one dependant variable:

AIU- EHR: The actual individual usage of EHR
It is defined as the average time each EHR function is used per week by the specific personnel in charge if the EHR system is used.

The main four independent variables:

I- Individual Personality Cx:
It is defined as the Cognitive structure of every manager **(CS)**

II- Attitudes:
It is defined as The General Attitudes of each manager **(GA)**

III- Individual Organisational Cx:
It is defined as the years spent by a manager in an organisation **(Yrs)** No# of years.

IV- Usefulness of EHR
It is defined as attitudes towards contribution. **(AC)**

Results & Discussion

- **Results-**
  - The four **Π** correlational analysis coeficients and AIU-EHR are significant.
  - The six **Φ** Correlational coeficients are significant.
  - Out of the ten δ Correlational coeficients, number 2,4,5,6,8,10 are significant.
  - All the **Λ** Correlational coeficients are significant.
  - Only **β1** Correlational coeficient is significant.

- **Discussion**- This study has made major contributions:
  - **described the type of institutions that use EHR**.
  - **presented EHR usage within the context of the three developing countries of the middle east health care delivery systems and the policies**
  - **paved the way for future research that can focus on the management of EHR, as an outcome.**
  - **presented a tool for measuring individual usage of EHR in hospitals, w**ith a few modifications and refinements. This instrument can be used elsewhere and as a means for comparison across hospitals and/or countries.

- **Limitations**- however, the study is not without limitations, even in what was attempted here. For example, the dependent measure AIU- EHR is an oversimplified measure which should be re-operationalized in future research. Nevertheless, it was considered provisionally adequate given the exploratory nature of this research.

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Evaluation of a Statewide Implementation of Electronic Health Records

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Abstract

The Massachusetts eHealth Collaborative is an effort to get all providers in the state to begin using electronic health records (EHRs), to implement clinical data exchange, and to get hospitals to begin using computerized provider order entry (CPOE). The Collaborative has implemented pilots in three communities in the state, and in this report we describe the evaluation of this effort, which is intended to inform strategies to spread EHRs, clinical data exchange, and CPOE across the entire state, with the aims of substantially improving the safety, quality, and efficiency of healthcare for the residents of Massachusetts. The evaluation will address how EHRs are used, the impact on the medication error rate, correlates of and barriers to adoption, whether an intervention aimed improving proficiency is beneficial, the impact of the EHR on quality, and an economic evaluation.

Keywords:

electronic health record, adoption, quality, safety, efficiency

Introduction

While electronic records are being used increasingly widely in developed nations, their impact on safety and quality has been variable [1-8]. Many features of EHRs, including electronic prescribing, interoperability and decision support, reduce opportunities for medical errors during the provision of care and have the potential to also improve quality. While implementation of an EHR system has the potential to enhance the quality and effectiveness of a physician's practice, many physicians have encountered a variety of barriers that dissuade them from electing to utilize this tool in their practices. These barriers include financial, technological and other challenges [5, 8-17].

The Massachusetts eHealth Collaborative (MAeHC) is a multistakeholder group which was formed with the aims of enhancing EHR adoption in Massachusetts, setting up clinical data exchange, and encouraging hospitals to adopt CPOE. Established with a coalition of 34 stakeholders who champion health information technology, and initial financial support from the Blue Cross Blue Shield of Massachusetts, the largest medical insurer in the state, MAeHC is working to improve the quality and safety of ambulatory care in the state through widespread EHR adoption and use.

In 2005, the MAeHC completed a proposal process for selection of three Massachusetts communities as pilots for full statewide EHR implementation. The state of Massachusetts has over 6 million residents that are cared for by approximately 20,000 physicians in about 6000 practices. The three selected communities represent over 150 ambulatory practices with over 400 clinicians. Currently, the MAeHC has implemented full EHRs in nearly half of these practices.

The eventual intent of the MAeHC is to implement EHRs and set up clinical data exchange statewide, but to do this will require significant investment and necessitate an array of policy changes. To inform this effort, we are performing an evaluation of the impact of the Collaborative in the pilot communities.

Methods

The evaluation focuses on four aims related to the implementation of EHRs. The first aim is to assess the ways that EHRs are used by physicians, ranging from those who use them proficiently to those who are just starting to use EHRs. The second is to assess how EHR use affects medication errors and overall quality of healthcare. The third is to identify physician characteristics that are correlated with the rate of EHR adoption, such as age, gender, innovational characteristics, in addition to practice characteristics such as a practice's financial health. Another aim is to facilitate EHR use through an intervention based on academic detailing [18], in addition to usual implementation strategies, and to assess whether academic detailing will accelerate EHR adoption and physician EHR proficiency. An economic evaluation is planned to calcu-

late the return on investment for EHR implementation. Finally, a preliminary evaluation of health information exchange (HIE) is planned for the final stages of the implementation effort. Evaluation across these aims will include assessment of the areas discussed below.

Effectiveness of intervention on rate and extent of adoption of EHRs

To assess the current rate of EHR adoption in Massachusetts, in 2005 we sent a one-page baseline office practice survey to the office practice managers of a random sample of 1829 ambulatory physician practices, representing approximately 30 percent of all practices in Massachusetts. A follow up survey is planned for mid 2007, after the full implementation of the EHRs in MAeHC's pilot communities. In addition, through the MAeHC, we have arranged to assess post-implementation EHR usage rates for specified features, as well as assess the planned health information exchange effort in the MAeHC communities.

Effects of EHR use on medication error rates

This aspect of the evaluation will compare errors found in handwritten prescriptions with those prescribed through the electronic health record system. Thirty physicians participated in the baseline measurement by using duplicate prescription pads for two weeks of data collection. A research pharmacist reviewed the prescriptions for medication errors, and performed subsequent chart review to clarify potential near misses and adverse drug events. A physician panel subsequently reviewed all near misses and adverse drug events.

After half of the participating practices have implemented EHRs in 2007, we will export electronic copies of prescriptions from each EHR. The other half of the physicians will serve as a control group by repeating the duplicate prescription protocol completed at baseline. The research pharmacist will review both the electronic and duplicate prescriptions for medication errors. Chart reviews and physician review panels will also be performed. Comparison analyses will be done to assess any differences in prescribing errors between paper prescriptions and e-prescribing through the EHR.

Effects of EHR use on quality of care

Quality of care has often been measured by claims-based data collection. Studies have indicated that EHRs can improve the quality of medical care, though their impact has been mixed [2,5,19]. To assess the effects of EHR implementation on quality of health care in community-based practices, the study team will obtain both pre-EHR implementation and post-EHR implementation claims-based quality data from the Massachusetts Health Quality Partners (MHQP). Comparisons between the two years are planned. These data will be linked to the physician characteristics collected in the physician survey to measure EHR usage and its relation to quality.

Studies have also suggested that EHR data exports present a unique opportunity to get faster and potentially better quality data [3]. To evaluate this potential, the study team plans to collect and assess quality data elements exported from the EHRs and compare EHR-derived quality measurements with claims-based quality measurement.

Physician use of EHRs

To assess physician characteristics and practice characteristics, we mailed an 8-page survey to 1884 randomly-selected physicians in Massachusetts, representing approximately 10 percent of physicians in the state. The questions in the survey addressed office characteristics, physician attitudes toward health information technology (HIT), barriers to EHR adoption, facilitators of EHR adoption, among others. For those who had EHRs in their practice, questions focused on EHR functionalities and degree of individual usage. A similar post EHR-implementation survey is planned for mid 2007.

Effectiveness of academic detailing on implementation

While many physicians welcome the addition of EHRs to their practices, some have greater difficulty adjusting to the EHR. In order to accelerate physician fluency with EHRs, the evaluation includes an academic detailing intervention. Academic detailing is a method of changing physician behavior that has been effective in improving prescribing behavior.[20] Using the same methodology, the intervention group (~ 15 physicians) will receive two academic intervention sessions to help them acclimate and adjust to their new EHR system. The control group will receive the usual technology support offered through the MAeHC and the EHR vendor. After the intervention, both groups will be assessed for EHR usage and satisfaction.

Economic evaluation

The planned evaluation also includes an overall economic component, which will assess the costs, savings, and return on investment related to MAeHC's implementation, interoperability, and data exchange. With respect to data exchange, we will count the number of pieces of data of various types (laboratory results, prescriptions, radiology results) moving within the communities. The eventual plan is to link the data exchanges with a statewide data exchange.

Results

The implementation effort and associated evaluation are both currently underway. Results available to date are described below.

Results from office practice survey

In our baseline survey, sent in April 2005, forty-six percent (847/1829) of office practices responded.[10] The survey was addressed to the office practice manager at each site. Weighted responses indicated that 18 percent of these practices had EHRs at the time of the survey.

Adoption rates varied slightly by type of practice, with 23 percent of primary-care-only practices, 25 percent of mixed practices (both primary care and specialty care), and 14 percent of specialty practices reporting having EHRs. The rate in specialty practices was significantly lower than the primary-care-only and the mixed practices ($P<0.01$). Practice size was also significantly correlated with EHR adoption, as smaller practices reported less EHR adoption ($P<0.001$).

EHR users were asked about functionalities that were available in their system. The most common functionalities available were visit notes, lab test results, and medication lists. However, when asked about which functionalities the majority of physicians used, laboratory and radiology result retrieval capabilities topped the list, with 87 percent of practices reporting that the majority of clinicians actively used both functionalities.

Of the practices that reported not currently having an EHR, 13 percent reported having plans to adopt an EHR within the next year, 24 percent reported plans for implementing an EHR in the next 1-2 years, and 11 percent in the next 3-5 years. Fifty-two percent of practices currently without EHRs reported having no plans to adopt an EHR in the foreseeable future.

One challenge to conducting this part of the evaluation was the unavailability of a list of statewide practice manager names. We sent the mailings to the "attention of the office practice manager" at each physician's office. Having the actual names might improve response rates.

Results from the medication error rate evaluation

Data collection for this evaluation is nearly complete. We were able to gather over 4000 prescriptions from 30 ambulatory, primary care physicians; nearly 200 chart reviews were performed to assess whether near misses (prescription errors with the potential to cause harm) were actually adverse drug events (prescription errors that did cause harm).

Our plan for this part of our implementation evaluation encountered some challenges. In comparison with our previous studies in academic settings, a larger proportion of physicians opted out due to a variety of concerns. Applying for Institutional Review Board (IRB) approval from hospital-based community IRBs was also more complex than usual, in part because less research is traditionally conducted in these settings. Also, the participating physicians came from many small independent ambulatory practices, making communication with all the various stakeholders a challenge.

Results from the quality of care evaluation

We have received HEDIS data on approximately 80 percent of the primary care physicians from our statewide physician survey sample. Analyses comparing quality of care with reports of EHR usage are underway. The methods for this part of the evaluation involve using HEDIS measures via claims-based data from the Massachusett Health Quality Partnership, which involves a long time delay (1-2 years post data collection).

An additional aim of this part of our evaluation is to examine the feasibility of gathering quality data directly from the electronic health records. This methodology for assessing quality generated concerns around physician identifiers, as well as numerous technical challenges to extract these data from multiple EHR vendors.

Results from physician survey

We also performed a statewide survey in June of 2005; a total of 1345/1884 physicians responded (71%).[9] When weighted to represent the distribution of practice size, specialty, and whether the practice was hospital-based, 23 percent of practices reported having EHRs. Practice size was strongly correlated with EHR adoption. Only 14 percent of solo practices reported having an EHR, while fifty-two percent of practices with 7 or more physicians reported having an EHR. However, due to the large number of practices with more than 7 physicians in Massachusetts, 45 percent of the physicians in the state, ranging from 10 percent in solo practices to 72 percent of large practices, reported having EHRs in their practices (see Figure 1). Practices that engaged in teaching medical students or residents and hospital-based practices both reported higher rates of EHR adoptions.

Not surprisingly, physicians reported that financial considerations present the greatest barrier to implementation. Loss of productivity was also a concern for physicians, with 81 percent of responders selecting it as a barrier. Physicians not currently using EHRs more often reported financial barriers as "major barriers" as compared with physicians who had EHRs.

Additional analyses are underway that focus on the characteristics of practices that have EHRs, as well as analyses that compare the statewide survey data with data collected in each of the intervention communities.

We believe that the high response rate was achieved because we used express mail delivery with $20 cash incentives, and multiple mailings. In addition, all envelopes were addressed to the physician specifically, and any

returned mail was researched (and re-mailed, if possible) using multiple statewide databases.

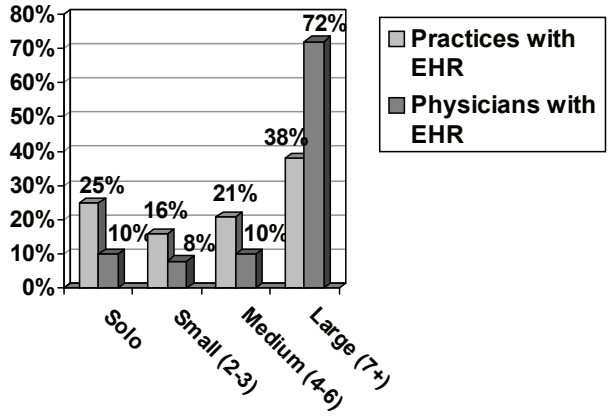

Figure 1 - Distribution of physicians and practices with EHRs by size of practice

Results from the academic detailing intervention

To date, we have been able to hire and train clinicians local to the communities participating in this intervention. This component of the evaluation is dependent upon EHR implementation, and the trained clinicians will begin the intervention in early 2007.

Discussion

The aims of this effort are to better understand more about EHR adoption in ambulatory settings, what can be done to get physicians to high levels of proficiency after adoption, how EHRs affect medication safety and quality performance in communities, and what the impact of EHR adoption and interoperability are on quality. Although we are still early on this path, we believe the preliminary results are of interest.

The results from both of our statewide surveys indicate that the rate of EHR adoption in Massachusetts in 2005 was higher than in other states in the U.S.. Practice size, as well as teaching practices and hospital-based practices, were all correlates of EHR adoption. The high response rate achieved in the physician survey suggests that our protocol, and specifically the cash incentives, can be a valuable method of obtaining high response rates from busy physicians.

EHR adopters reported various degrees of functionality within their systems. Visit notes and lab tests were the most common functionalities available. However, though many practices report having specific EHR functionalities, physicians were not necessarily using them in their practice. In our office practice survey, office practice managers reported that their physicians were using certain functionalities less than 50% of the time, or even none of the time. In 25% of practices who had clinical decision support (alerts, warnings and reminders) within that practice's EHR system, respondents reported that less than 50% of the clinicians were using that functionality. This would indicate that though physicians have functionalities within their EHR system, they don't necessarily use all of them. Some functionalities that they are not using, like clinical decision support, are important for quality improvement efforts.

Therefore, decision support standards need to be developed that will aide the availability and use of key quality-enhancing features in EHR systems. Additionally, physicians need to be trained and appropriately motivated to take advantage of the EHR.

EHR non-adopters have slightly different attitudes and weigh the challenges differently from EHR adopters. In our physician survey, non-adopters scored financial considerations as a greater barrier than did those with EHRs in place. Also, non-adopters' plans for implementation vary greatly, with the majority reporting having no plans to adopt EHRs in the near future.

Challenges in conducting this type of multi-faceted evaluation include physician concerns about privacy and security, issues related to conducting research in small communities that are not accustomed to academic research, and logistical and technical difficulties associated with independent EHR vendor systems.

Building trust in the participating practices is a key component to overcoming these challenges. For each study component, investigators and staff explained protocols and plans at the local level. Clear communication and community leadership from the coordinating organization, the MAeHC, has proven to be essential to the success of the evaluation. Their support of this research, as well as their relationships with the physicians and the vendor systems, has facilitated study operations.

An early conclusion from the work to date has been that the community-oriented approach to interoperability appears to be especially important. Our impression is that the involved practices would not have moved nearly as rapidly to setting up community data exchange without the Collaborative. In addition, we are hopeful that we will be able to identify practices that are not using the EHR to its full extent, and move them to higher levels of use than would have occurred without the Collaborative.

Conclusions

Measuring the impact of a fully-funded EHR implementation program requires a multimodal evaluation approach. This evaluation will be comparing quality, adoption rates, and correlates of EHR adoption across the state. This

Massachusetts evaluation has the opportunity to compare pilot communities that have comprehensive support to implement EHRs with EHR adoption in the rest of the state. Information collected as part of this effort will inform implementation in the rest of the state, as well as both national and international audiences. While many countries have made investments in EHRs that far exceed those made by the U.S., it is easy to have implementations that do not deliver full value. Evaluations such as this one may help justify future investments and policy choices in particular around relatively new areas such as interoperability.

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Evaluation of a Statewide Implementation of Electronic Health Records

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Introduction: EHRs and MAeHC

- Use of Electronic Health Records (EHRs) is increasingly widespread [1-8].
- Features of EHRs, such as electronic prescribing, interoperability and decision support, may enhance the safety, quality and effectiveness of healthcare.
- Barriers to EHR adoption include financial, technological and other challenges [5, 8-17].
- Massachusetts eHealth Collaborative (MAeHC):

  A coalition of 34 stakeholders, formed with aims of enhancing EHR adoption in MA. USA, setting up clinical data exchange, and encouraging hospitals to adopt computerized provider order entry (CPOE)
- In 2005, MAeHC proposed to implement EHRs in three MA communities, representing over 150 ambulatory practices with over 400 clinicians, as a pilot for statewide implementation.

Aims: Evaluating the Impact of MAeHC in Three Pilot Communities

- Assess the ways that EHRs are used by physicians, ranging from those who use them proficiently to those who are just starting to use EHRs
- Assess how EHR use affects medication errors and overall quality of healthcare
- Identify physicians characteristics that are correlated with the rate of EHR adoption, in addition to practice characteristics
- Facilitate EHR use through an intervention based on academic detailing and assess whether academic detailing will accelerate EHR adoption and physician EHR proficiency [18]
- Calculate the economic return on investment for EHR implementation
- Preliminarily evaluate health information exchange (HIE)

Evaluation Methods

- Rate and extent of EHR adoption with intervention:
  - Baseline office practice survey of EHR adoption in MA in 2005: random sample of 1829 ambulatory physician practices (30% of all practices in MA)
  - Follow-up survey is planned for mid-2007, as well as an assessment of usage rates for specified EHR features.
- Effects of EHR use on medication error rates:
  - Baseline analysis on the medication error rate in duplicate paper prescriptions collected from 30 physicians over approximately two weeks
  - After EHR implementation, analysis will be performed on 15 physicians' duplicate paper prescriptions and 15 physicians' electronic prescriptions, as compared with the baseline data.
  - Chart reviews and physician review panels aid this analysis.
- Effects of EHR use on quality of care:
  - Comparisons of pre-EHR implementation and post-EHR implementation claims-based quality data from the MA Health Quality Partners (MHQP)
  - Collection and assessment of quality data elements exported from EHRs

Evaluation Methods (cont.)

- Physician use of EHRs:
  - In 2005, an 8-page survey was mailed to 1884 randomly-selected physicians in MA (10% of physicians in the state), assessing office characteristics, physician attitudes toward health information technology (HIT), barriers to EHR adoption, facilitators of EHR adoption, etc.
  - Post-EHR implementation survey distributed in Spring 2007
- Effectiveness of academic detailing on implementation:
  - Academic detailing is a method of changing physician behavior that has been effective in improving prescribing behavior. [20]
  - An intervention group (~15 physicians) will receive 2 academic sessions to help them acclimate and adjust to their new EHR systems. A control group will receive the usual technology support offered through the MAeHC and the EHR vendor. Both groups will be assessed for EHR usage and satisfaction after the intervention.
  - At this point in time, clinicians local to the communities participating in this intervention have been hired and trained to serve as the academic detailers. Timing of the evaluation is dependent upon EHR implementation. Trained clinicians will begin the intervention in 2007.
- Economic evaluation:
  - Assessment of the costs, savings and return on investment related to MAeHC's EHR implementation and data exchange

Results: Office Practice Survey

- Out of a sample of 1829, a total of 847 completed surveys were returned, yielding a response rate of 46%.
- Overall, 18% of practices reported having an EHR.
- All results are weighted to better represent statewide trends.
- Reported having EHRs:
  - 23% of primary care practices
  - 25% of mixed practices (both primary care and specialty)
  - 14% of specialty practices
- Smaller practices reported less EHR adoption.
- Of the practices that reported not currently having an EHR:
  - 13% have plans to adopt an EHR within the next year
  - 24% in the next 1-2 years
  - 11% in the next 3-5 years
  - 52% reported having no plans to adopt an EHR in the foreseeable future

Figure 1: EHR Functionality Usage

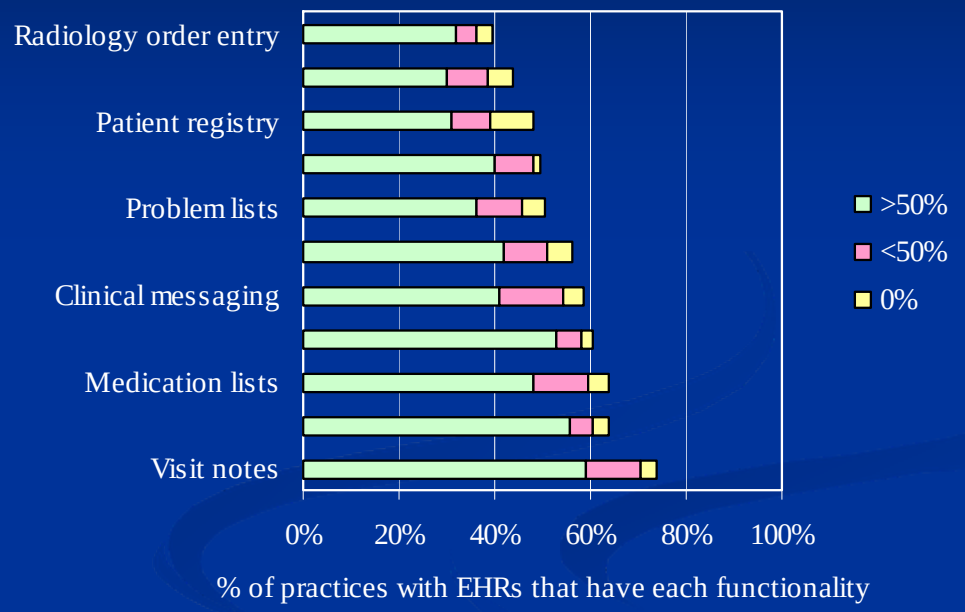


Figure 1: Availability and use of individual EHR functionalities among office practices with EHRs. The length of each bar indicates the percentage of practices that have each functionality available within their EHR system. The component segments of each bar reflect the proportion of practices in which 50% or more of the clinicians regularly use the functionality (green segment), less than 50% of the clinicians regularly use the functionality (yellow segment), and none of the clinicians use the functionality (blue segment).

Status: Medication Error Rate Evaluation

- Data collection is almost complete, with over 4000 prescriptions gathered from 30 ambulatory primary care physicians.
- Nearly 200 chart reviews were performed to assess whether near misses (prescription errors with the potential to cause harm) were actually adverse drug events (prescription errors that did cause harm).
- Challenges:
  - Many physicians opted out.
  - IRB approval processes were complex.
  - Communication with various stakeholders was difficult, since physicians came from many small independent ambulatory practices.

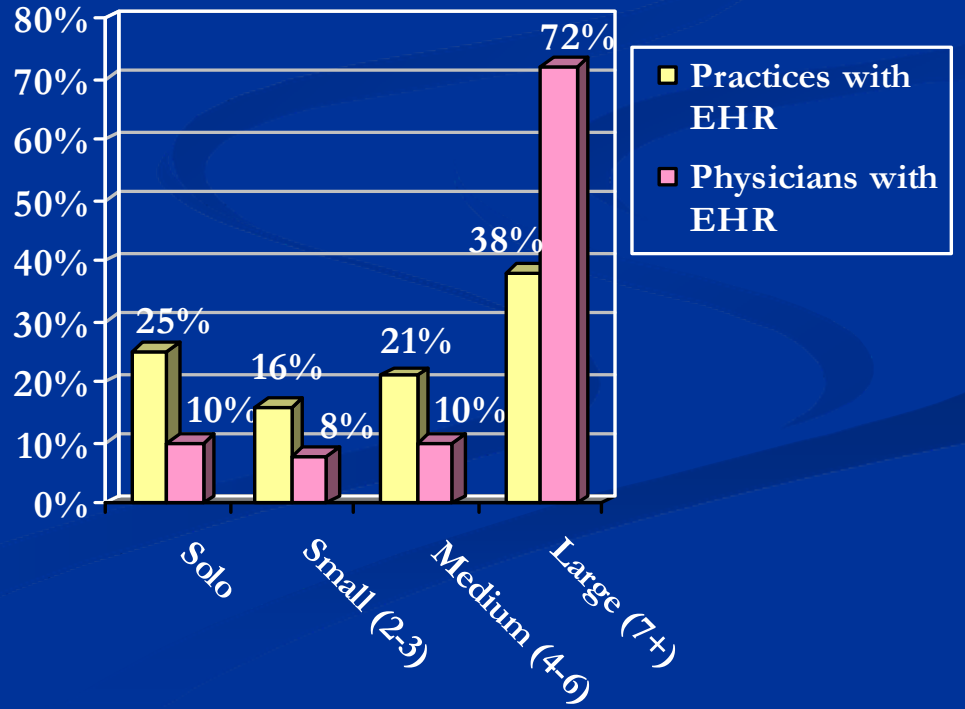
Status: Quality of Care Evaluation

- HEDIS data on ~80% of primary care physicians from our statewide physician survey sample have been received.
- Analyses comparing quality of care with reports of EHR usage have begun.
- Part of this evaluation involves using HEDIS measures via claims-based data from MHQP which requires 1-2 years after data collection to construct measures.
- We are in the process of determining methods for direct electronic data extraction from multiple EHR vendors.

Results: Physician Survey

- 1345/1884 physicians responded (71% response rate).
- Practice size was strongly correlated with EHR adoption (see Figure 2).
- Financial considerations were reported as the greatest barrier to implementation. Physicians who do not currently use EHRs more often reported this as a "major barrier" as compared with physicians who had EHRs.
- 81% of responders also reported that loss of productivity was a barrier.
- Additional analyses focusing on the characteristics of practices with EHRs and analyses comparing the statewide survey data with intervention communities are underway.

Figure 2 – Distribution of physicians and practices with EHRs by size of practice



Discussion

- Our survey results indicate that the rate of EHR adoption in MA in 2005 was higher than in other states in the U.S.
- Larger practice size, teaching, and hospital-based practices were correlated with EHR adoption.
- Visit notes and viewing lab test results were the most commonly available EHR functionalities.
- Though many physicians report *having* specific EHR functionalities, physicians were not necessarily *using* them in their practices.
- Decision support standards, additional training and appropriate motivation will aid the availability and use of quality-enhancing features in EHR systems.
- Many EHR non-adopters cite financial considerations as the main barrier to EHR adoption. Their plans for implementation vary greatly, with the majority reporting having no plans to adopt EHRs in the near future.
- Challenges in this evaluation include:
  - Physician concerns about privacy and security
  - Issues related to conducting research in small communities that are not accustomed to academic research
  - Logistical and technical difficulties associated with independent EHR vendor systems
- A community-oriented approach to interoperability and data exchange appears to be important.

Conclusions

Based on these preliminary results of ongoing research, measuring the impact of a fully-funded EHR implementation program requires a multimodal evaluation approach. The evaluation will be assessing quality, medication safety, adoption rates, and correlates of EHR adoption across the state. This Massachusetts, U.S. evaluation has the opportunity to compare pilot communities that have comprehensive support to implement EHRs with EHR adoption in the rest of the state. Information collected as part of this effort will inform implementation in the rest of the state, as well as both national and international audiences. Many countries have made great investments in EHRs, and it is important to understand the value of these systems. Evaluations such as this one may help justify future investments and policy choices, particularly pertaining to relatively new areas such as data exchange.

Acknowledgements & References

Thanks to Alexis Tumolo, Madeline McCarthy and Deborah Williams for their support and diligent work on this project. This work was supported in part by grant number 1 UC1HS015397 from the Agency for Healthcare Research and Quality, and also by the Massachusetts eHealth Collaborative. Neither organization is responsible for the contents of this paper.

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From Activity Analysis to an User Interface Navigation Structure for an Electronic Patient Record (EPR)

Jens Lauber

Department of Medical Informatics

University of Amsterdam / University of Heidelberg

Outline

- Introduction
- Objectives
- Methods
  - Activity Analysis
  - Workflow Modelling
  - Implementation of the Navigation Structure
- Results
  - Activity Analysis
  - Workflow Modelling
  - Implementation of the Navigation Structure
- Discussion & Conclusion
- References

Introduction

- At the Academic Medical Center (University Hospital in Amsterdam) a new EPR will be introduced
- Our project will give proposals for the new user interface design
- We looked into the workflow of the department of gynaecology
- Clinicians must be involved in the system development for best acceptance

Objectives

What patient data and in what context do physicians search for information and what resources are used therefore ?

Methods:
1. Activity Analysis

List all activities and its

- Roles (who is acting)
- Reason (why the action is conducted)
- Information (what is transferred)

Modelling by

- Activity
- Input
- Output
- Resource/ Method
- Control/ Constraint

Methods:
2. Workflow Modelling

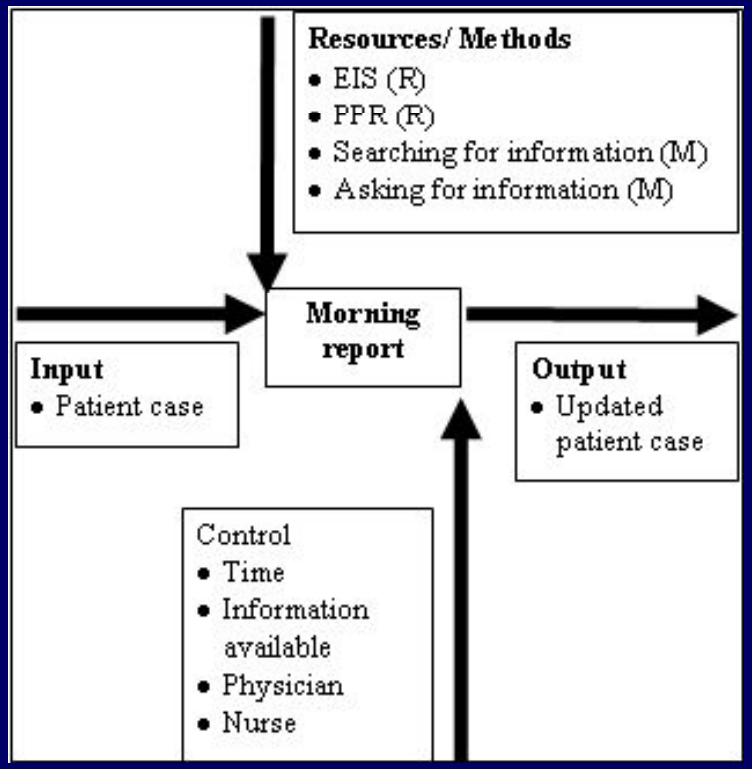
Define in chronological order the medical information reviewing process into four parts:

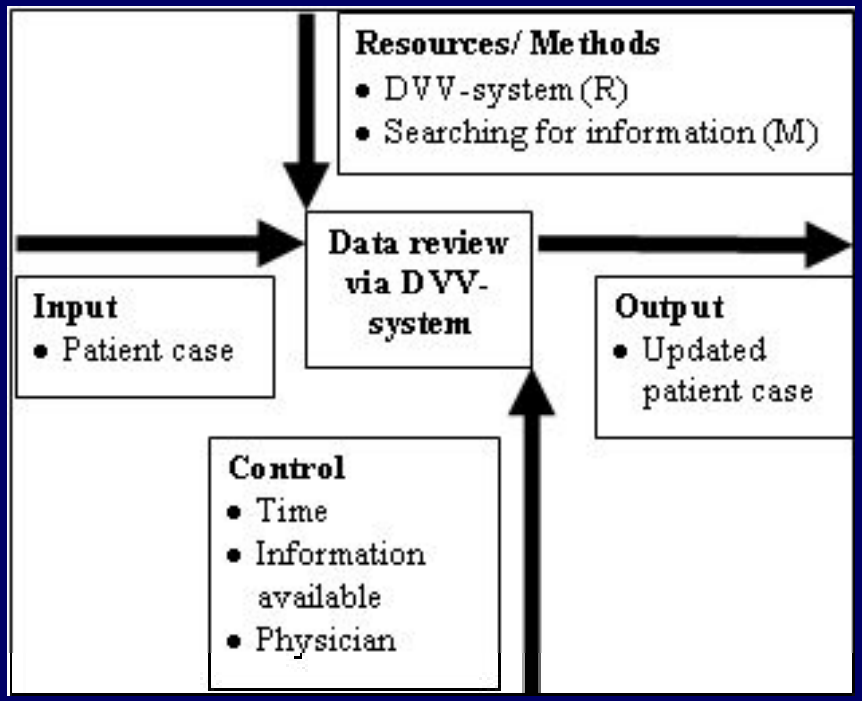
- patient summary / patient history
- actual patient status
- examinations
- daily controlled data

Methods:
3. Implementation of the Navigation Structure

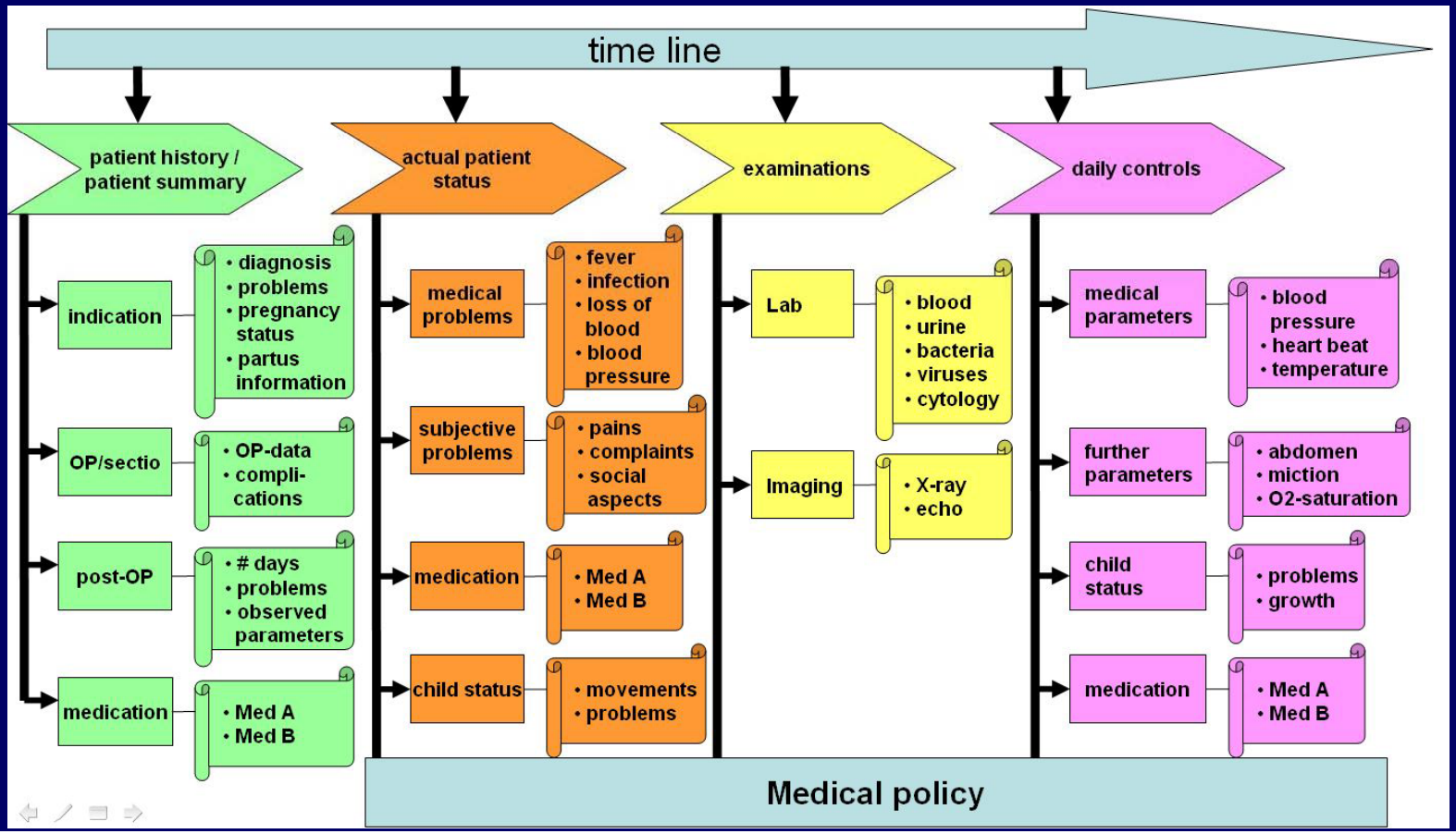
- Workflow model leads to navigation structure
- Results of Workflow modelling was mapped onto the EPR-prototype
- Navigation structure was adapted to the new workflow results obtained from the models

Results:
1. Activity Analysis





Results:
2. Workflow Modelling

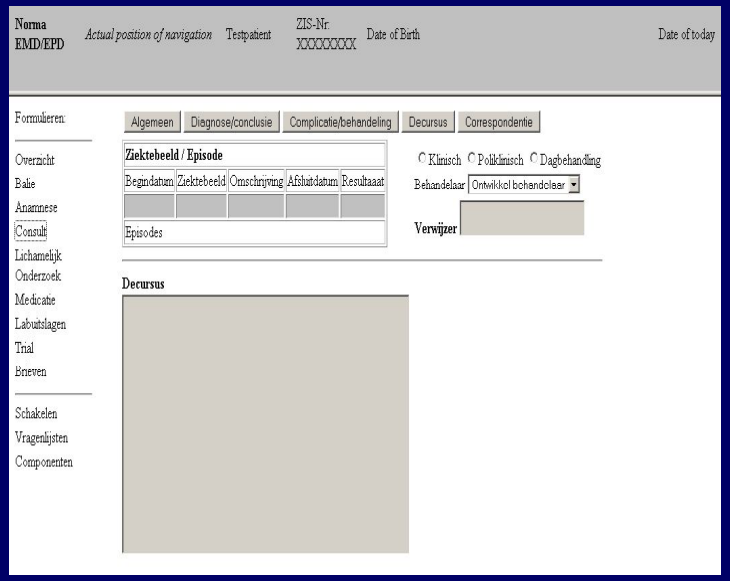


Results:
3. Implementation of the Navigation Structure

Old:

One text field

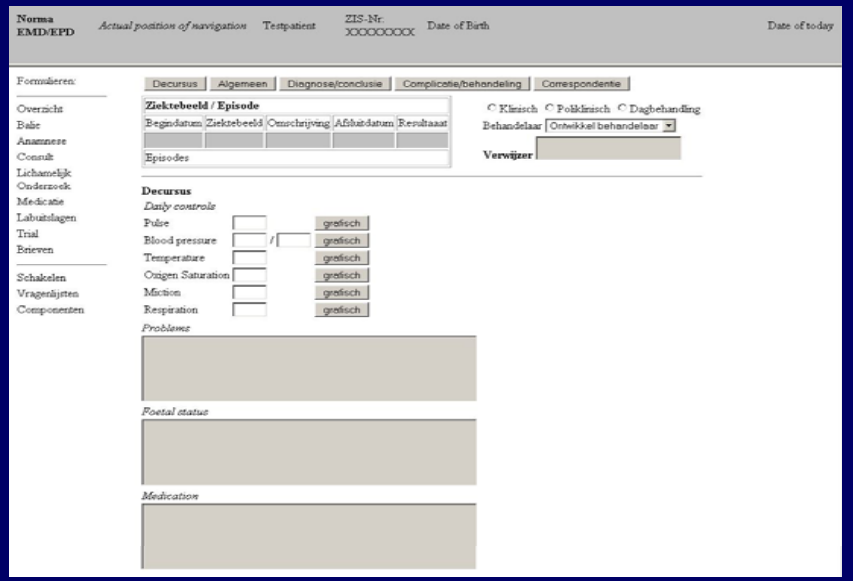
Bad overview



New:

Process driven fields

Better info searching



Discussion & Conclusion

- Some EMR-system have low acceptance
  - Tailored system by integration of the end-user
  - **Acceptance ↑**
- Perspective of data input is common in EMR
  - Focus on data retrieval / data review behaviour
  - **Better modeling** of the real scenario
- Media cracks through the use of conventional systems mixed with electronical systems
  - Investigation of the workflow streamline to find an efficient supporting navigation structure
  - **Patient safety ↑**

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Development of an Electronic Tool to Facilitate the Medication Reconciliation Process and Improve Prescribing Practices

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Abstract

Medication discrepancies occur frequently at hospital admission and discharge. Medication reconciliation is recognized as an essential process to reduce medication discrepancies and improve prescribing practices.

The University Health Network has developed an electronic tool that is integrated with the electronic patient record (EPR) and facilitates the medication reconciliation process. The tool was developed by first creating a structured, multi-disciplinary medication reconciliation strategy.

The Electronic Medication Information Transfer Tool (EMITT) is populated with patient demographics, allergies and medications from the patient chart. The tool facilitates medication reconciliation documentation as well as the coding of medication discrepancies. EMITT is integrated with the electronic discharge summary application and is able to generate an electronic prescription upon discharge. The tool also generates a medication letter, a patient medication grid and a medication wallet card.

The success of this project is attributed to the high degree of clinical leadership and involvement throughout the entire design and development of the electronic tool. It is anticipated that similar electronic models can be easily adopted at other healthcare institutions.

Keywords:

medication reconciliation, electronic prescription, preventing medication discrepancies, electronic medication reconciliation tool, medication safety

Introduction

The Canadian "Safer Healthcare Now!" initiative and the Institute for Healthcare Improvement "100K Lives" campaign have both identified medication reconciliation as an essential process to prevent medication discrepancies. The Institute for Healthcare Improvement defines medication reconciliation as "a formal process of obtaining a complete and accurate list of each patient's current home medications - including name, dosage, frequency and route - and comparing the physician's admission, transfer, and/or discharge orders to that list. Discrepancies are brought to the attention of the prescriber and, if appropriate, changes are made to the orders. Any resulting changes in orders are documented" [1].

The Canadian Council on Health Services Accreditation (CCHSA) has also recognized the importance of medication reconciliation by including it as part of the Patient Safety Goals and Required Organizational Practices (ROPs). As part of the accreditation process healthcare organization in Canada are required to:

- "Reconcile the patient's medication upon admission to the organization, and with the involvement of the patient." [2]
- "Reconcile medications with the patient at referral or transfer, and communicate the patient's medications to the next provider of service at referral or transfer to another setting, service, service provider, or level of care within or outside the organization." [2]

Canadian hospitals must meet the CCHSA requirements to be considered an accredited healthcare organization. Passing the accreditation process indicates that "the organization was assessed by its peers, met or exceeded national standards of excellence, and continues to strive for high quality health care" [3].

Many healthcare organizations are now faced with the challenge of incorporating the medication reconciliation process with current workflow practices. Some of the challenges that organizations may face include [4]:

- How to integrate reconciling meds with current workflow and prescribing practices?
- How to standardize the collection of data?
- The amount of time required to reconcile medications.

To address challenges with reconciling medications, the University Health Network has developed an electronic

tool that is integrated with the electronic patient record (EPR) to facilitate the medication reconciliation process.

Methods

Project Objectives

This project worked towards developing a web-based tool that is integrated with the hospital's electronic EPR and can facilitate the medication reconciliation process. The tool must be able to facilitate medication reconciliation throughout the entire inpatient stay and capture the Best Possible Medication History (BPMH), admission medication reconciliation, and discharge medication reconciliation. It is also essential that the tool is able to generate the best possible discharge medication list, electronic prescription, a medication letter for community clinicians and a medication grid and wallet card for the patient.

Requirements Gathering

A multi-disciplinary team comprised of pharmacists, physicians and IT professionals worked closely together to decide upon the functional requirements for the web-based application. The team was involved with a separate project that conducted a literature review, needs assessment and a baseline measurement of discharge prescription medication discrepancies to develop a structured medication reconciliation strategy [5, 6]. The results of the structured medication reconciliation strategy would provide direction of the requirements needed for an electronic medication reconciliation tool.

Technical Development and Testing

The Medication Reconciliation application known as the Electronic Medication Information Transfer Tool (EMITT) was built in-house by developers in the hospital's IT department. All required database and user interface work was also completed by the same technical team.

The application was thoroughly tested by both the technical team and pharmacists who were involved with the project. The application also underwent additional usability testing by the Human Factors team in the labs located on site at the Centre for Global eHealth Innovation.

Results

Technical Specifications

The EMITT web-based application was built using PHP, Javascript, and AJAX; it resides on an Apache server and has an Oracle database. The application is integrated with the EPR and is pre-populated with patient demographics, allergies and medications. The application is also integrated with the electronic discharge summary. Figure 1 is an example of how EMITT is integrated with the EPR and the discharge summary application.

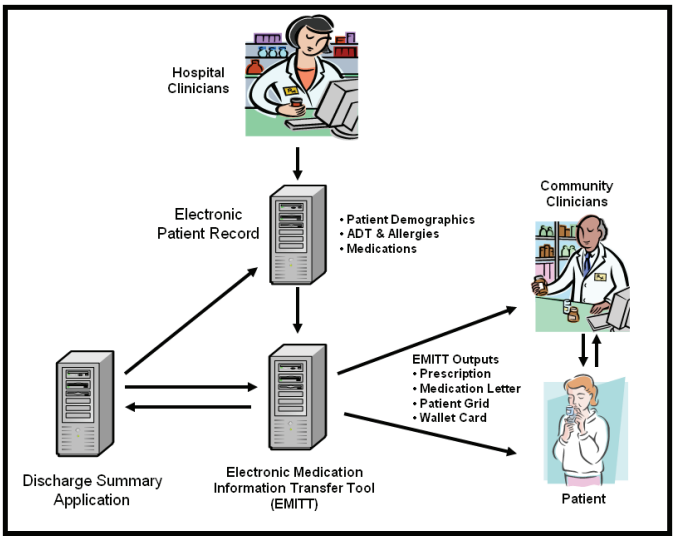

Figure 1: EMITT dataflow diagram

Application Design

The EMITT application was built to facilitate the medication reconciliation process from admission to discharge and to improve prescribing practices. The application is sub-divided into seven pages that guide a user through the Medication Reconciliation process:

Allergies and BPMH – This page allows a clinician to document and print the BPMH for both prescription and non-prescription medications. The clinician is also able to document the sources of information used to obtain the BPMH. Allergies are automatically populated from the patient's chart if available in the EPR. Figure 2 is an example of how the BPMH is documented.

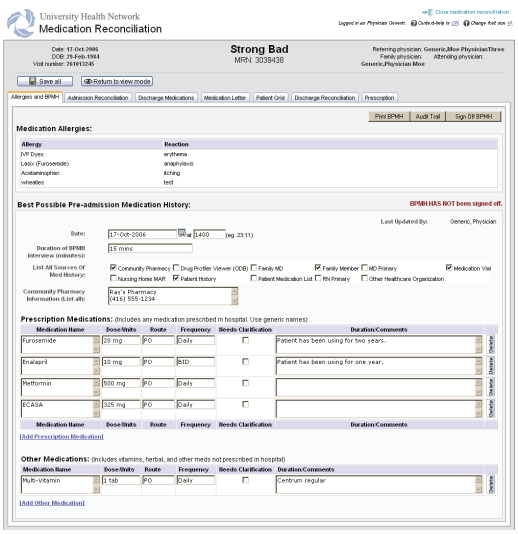

Figure 2 - Screen capture of the allergies and BPMH page

1. Admission Reconciliation – This page allows clinicians to compare the BPMH to admission orders and reconcile the medications. The BPMH medications are automatically pulled across from the previous tab and the medication admission orders are automatically populated from the EPR. On this tab the clinician is required to reconcile admissions orders and code any discrepancies according to the Safer Healthcare Now! recommendations. This tab also allows clinicians to document any issues that require follow-up. Figure 3 is an example of how clinicians would reconcile admission medications.

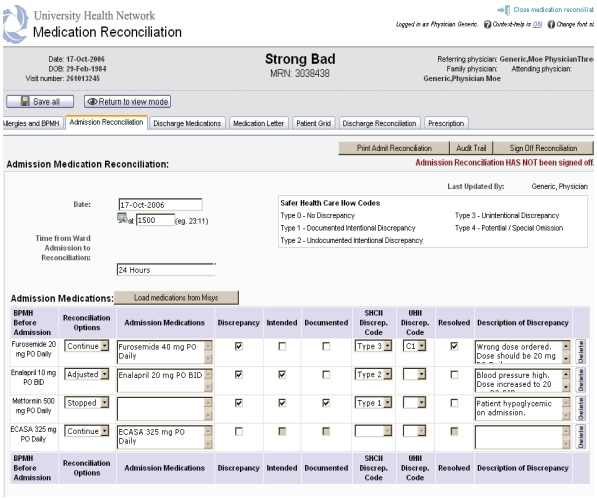

Figure 3 - Screen capture of the admission reconciliation page

2. Discharge Medications – This page allows clinicians to reconcile the BPMH with the current active in-hospital medication list. This process generates the best possible discharge list and an electronic prescription. The discharge medication list is also used to populate the medication letter and patient grid. This page is integrated with the discharge summary application and provides physicians with a recommended discharge medication list if available.
3. Medication Letter - This page is used to generate a medication letter for the patient and/or community clinicians. All of the reconciled medications on the medication letter are automatically populated from the discharge medication page. The medication letter contains a list of the patient's current medication regimen and any adjustments (with rationale) that have been made since the patient was admitted to the hospital. The medication letter also contains a description of any outstanding medication related issues to be followed up in the community.
4. Patient Grid – This page allows clinicians to generate a medication grid that outlines why a patient is taking a medication and when s/he should be taking it. All of the instructions on the patient grid are in lay terms to ensure that patients understand their medication regimen. The patient grid medications are automatically populated from the discharge medication page.

5. Prescription – The electronic prescription is generated from the reconciled medication on the Discharge medication page. This page allows the clinician to view and print out the prescription. The electronic prescription not only contains the medications that are to be dispensed, it also includes a summary of any new, adjusted, discontinued, and medications to be continued. Figure 4 is an example of how a completed ePrescription will appear.

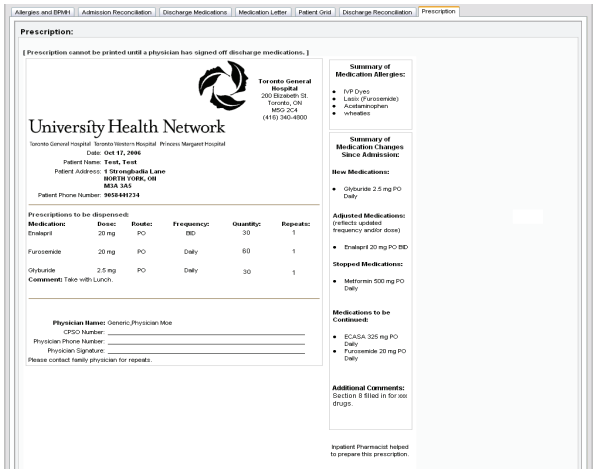

Figure 4 - Screen capture of the prescription page

6. Discharge Reconciliation – This page allows clinicians to reconcile the BPMH, the last day impatient medications and prescription medications. The BPMH and prescription medications are automatically populated from previous pages and the last day meds are populated from the EPR. This page also allows clinicians to document and code medication discrepancies.

Built into EMITT are several security features. Clinicians log into the application via the EPR which prevents an additional login and ensures that only the appropriate users have access to the application. A secondary authentication check is done on the application end to verify security. If a user does not have the appropriate security they are denied access to the application. In addition to the security checks, the application also keeps detailed audit logs of who accesses, edits and signs off on any of the pages within the application for each patient record. To improve the quality and accuracy of data within the application all fields that are currently available within the EPR are automatically populated.

Adoption and usage

The EMITT pilot has been well received and adopted by the General Internal Medicine (GIM) pharmacy team at Toronto General Hospital. Pharmacy is currently completing a study to validate and formally measure the impact of EMITT on medication reconciliation and prescribing practices. From January 2007 to March 2007, 135 patient discharge medication lists were created using EMITT in GIM at Toronto General Hospital.

The project team is currently working on a communication and education strategy to safely introduce EMITT to the other inpatient units at the University Health Network.

Conclusion

The University Health Network has developed a web-based tool that facilitates the medication reconciliation process. EMITT is integrated with the EPR and has been built to meet the medication reconciliation requirements of both the CCHSA and the Safer Healthcare Now! campaign.

EMITT is a single web-based platform that is integrated with the electronic discharge summary. The ability to populate EMITT with data from the EPR improves the accuracy and quality of data collection. EMITT is used to document the BPMH and reconcile medications at admission and upon discharge. EMITT is also used to generate an electronic prescription, medication letter, patient grid and medication wallet card.

Discussion

Healthcare organizations are constantly challenged to improve patient safety and the accuracy of medication orders. Throughout the development of EMITT the technical team worked very closely with a multi-disciplinary team of clinicians to understand the challenges with implementing a new workflow process. The ability to involve clinicians throughout the entire design, development, and implementation process allowed the technical team to develop a product that meets clinical needs and is minimally disruptive to current workflow practices.

One of the biggest strengths of this project is the amount of research and design work that went into the application before development even began. Before beginning discussions of what the application would look and how it would function, research was completed to identify what information clinicians would require to reconcile medications effectively. Additional research of UHN's current medication prescribing practices upon discharge was also completed to identify areas for improvement that could easily be incorporated into the application.

The ability to integrate EMITT with the hospital's current EPR allowed the application to leverage information that is electronically captured. This process alone minimized

the amount of duplicate documentation needed and decreased the amount of time required to reconcile medications.

The EMITT application is built on a web-based platform that could be adopted and implemented at another health-care institution. The application is fully functional even if information, such as medications, cannot be electronically leveraged from a separate data source.

EMITT provides an electronic framework for reconciling medications and guiding prescribing practices.

Acknowledgments

We would like to thank all of the clinical and technical contributors to this project. Without all of your leadership, expertise and guidance this project would never be successful.

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University Health Network

Toronto General Hospital Toronto Western Hospital Princess Margaret Hospital

Development of an Electronic Tool to Facilitate Medication Reconciliation and Improve Prescribing Practices

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b *Leslie Dan Faculty of Pharmacy, University of Toronto, Ontario, Canada*

Project Objectives

- To develop a web-based tool that integrates the hospital's electronic patient record (EPR) and facilitates medication reconciliation

- To develop a process to guide clinicians through the medication information transfer process, and help prevent discrepancies by improving prescribing practices

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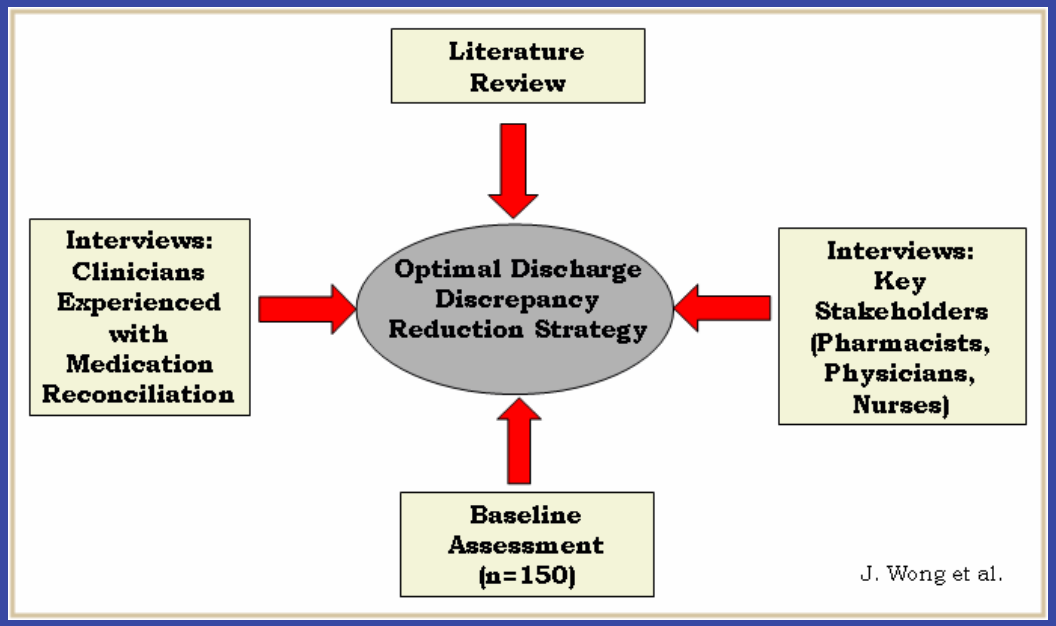
Methods

- A multidisciplinary team conducted a literature review, needs assessment and a baseline measurement of prescription discrepancies.
- The Electronic Medication Information Transfer Tool (EMITT) was built internally by developers in the hospital's information technology department.



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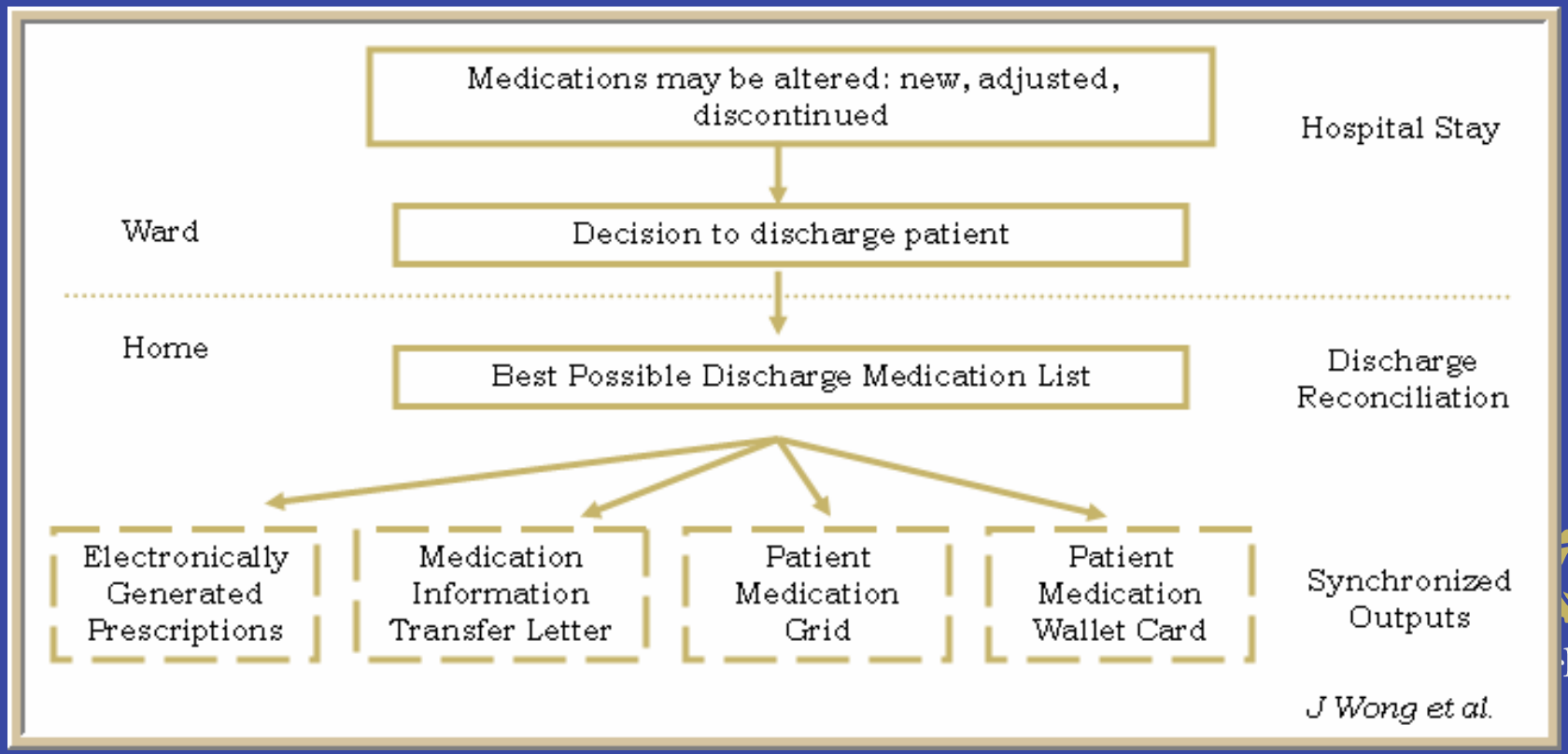
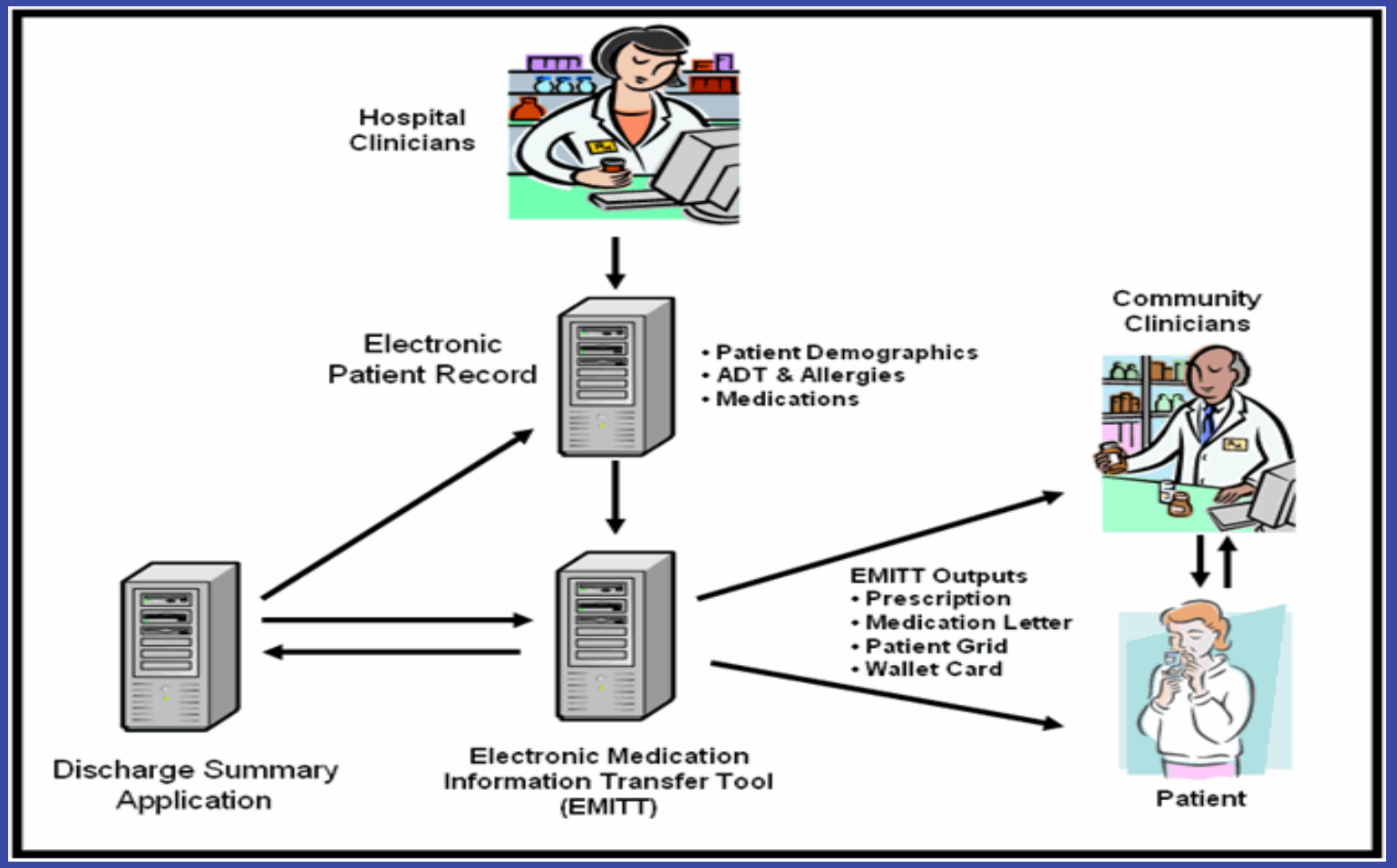
Results

- EMITT facilitates the collection and reconciliation of medication information from admission to discharge.
- It also allows for the coding and the documentation of medication discrepancies.



Results – System Design



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Innovative Features

- Medications are automatically populated by the hospital's EPR to eliminate the duplication of documentation
- Medications auto-align themselves by name for easy comparison and reconciliation
- The application follows the Institute for Safer Medication Practices guidelines and eliminates unsafe abbreviations
- EMITT is integrated with the hospital's Online Discharge Summary application
- EMITT automatically uses the best discharge medication list to generate synchronized outputs:
    - Electronically generated prescription
    - Medication Letter
    - Patient Grid
    - Medication List and Wallet Card

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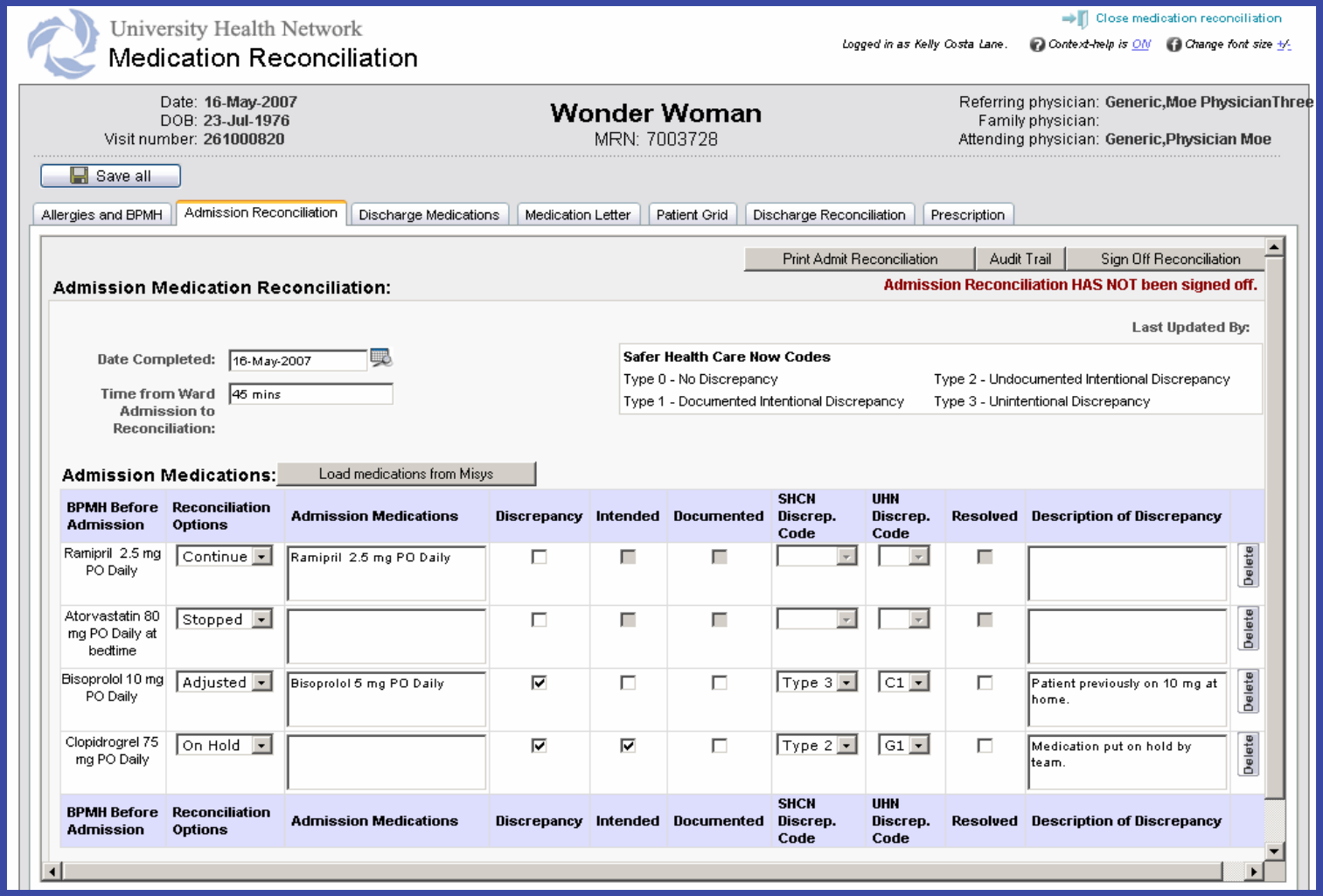
Benefits of an Electronic Tool

- Communicates patient's complete medication regimen to community clinicians post discharge
- Ability to leverage real-time data captured in the EPR
- Guides clinicians through the medication reconciliation process
- Eliminates the need for duplicate documentation
- Capability to generate reports and identify potential safety issues
- Addresses areas of potential prescription discrepancies upon discharge
    - Quantity and repeat fields are mandatory for prescription medications
    - Electronically generated prescription is clear and legible
    - Flags clinicians to write Limited Use (LU) codes on prescription

Screen Capture – Admission Reconciliation



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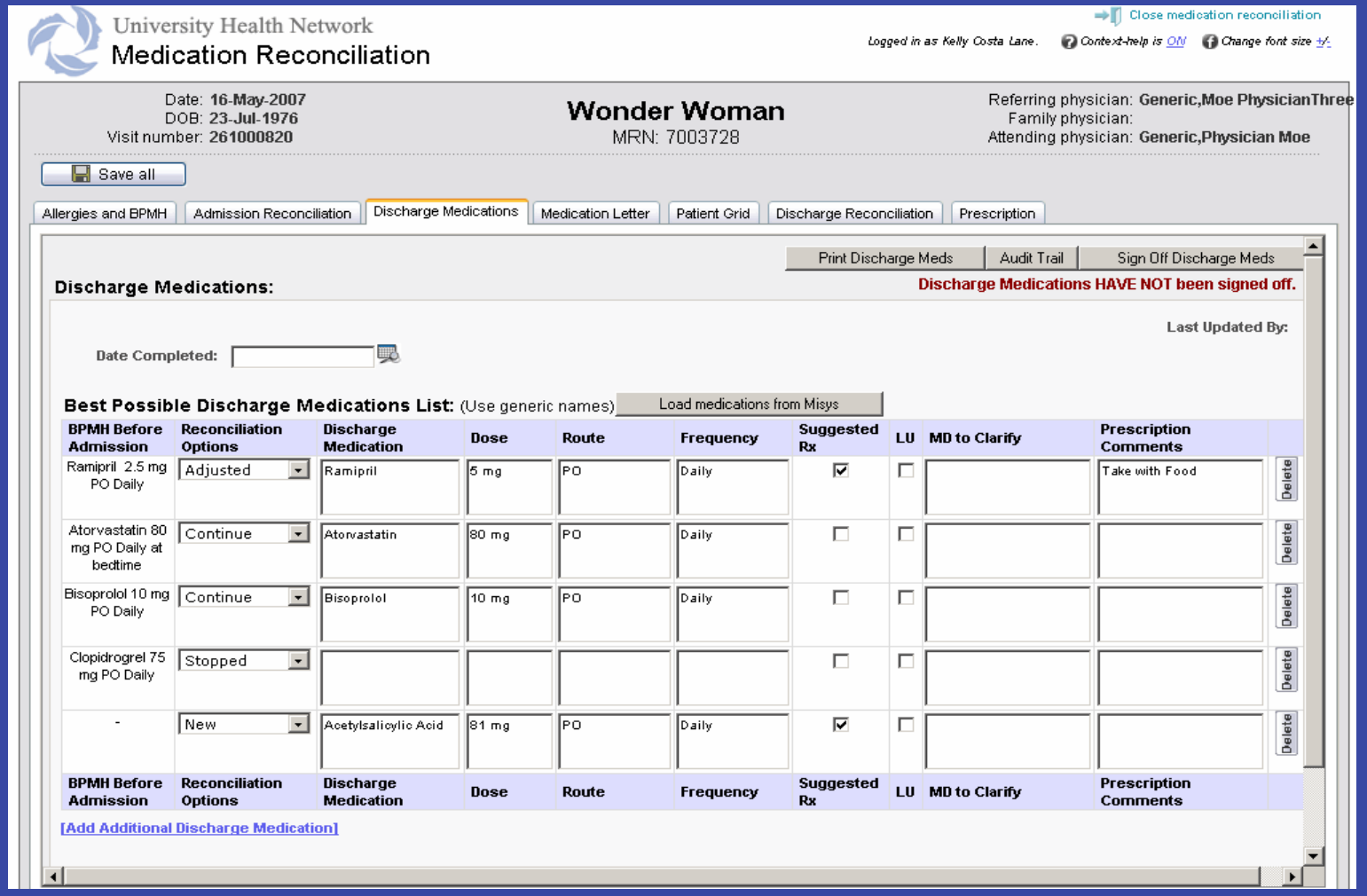
Screen Capture – Discharge Medications



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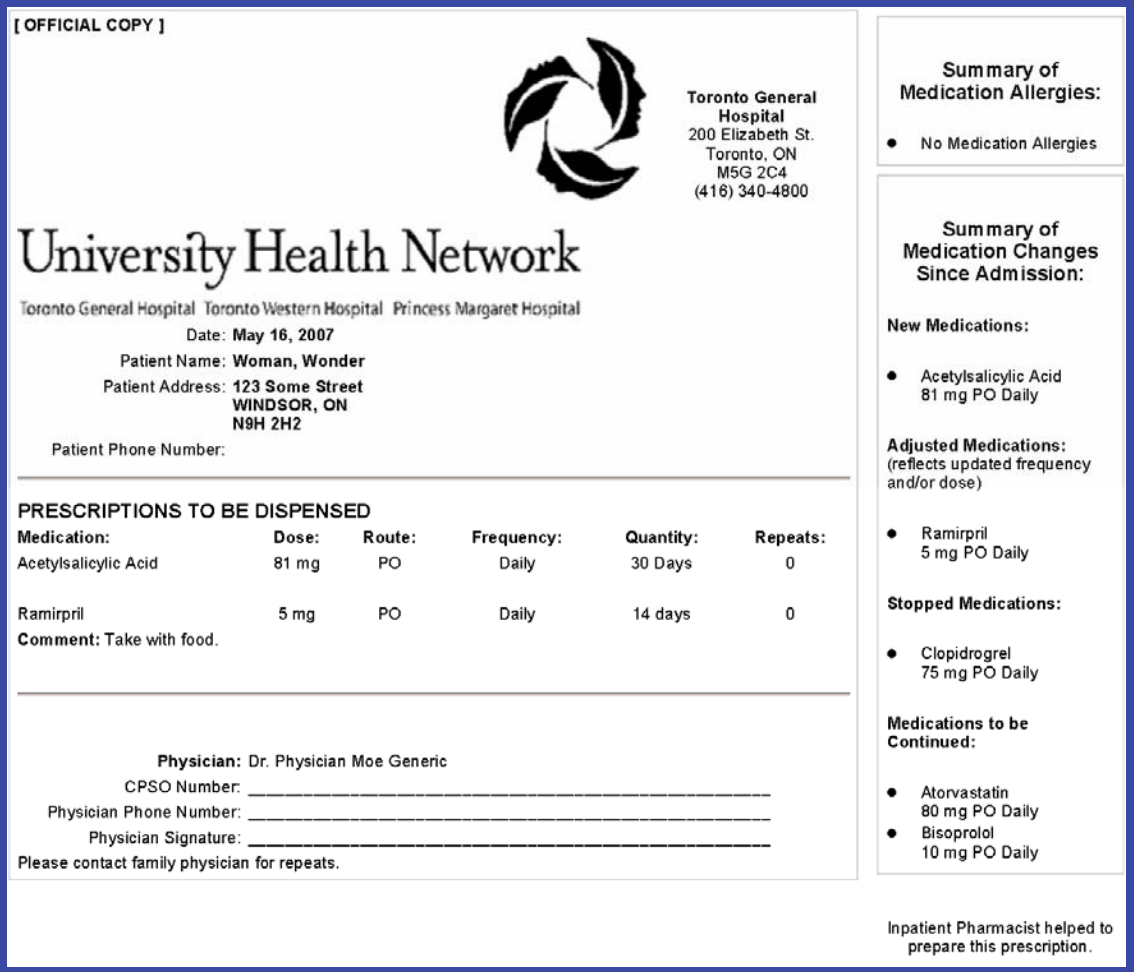
Screen Capture – Electronic Prescription



[OFFICIAL COPY]

Toronto General Hospital
200 Elizabeth St.
Toronto, ON
M5G 2C4
(416) 340-4800

University Health Network

Toronto General Hospital Toronto Western Hospital Princess Margaret Hospital

Date: **May 16, 2007**
Patient Name: **Woman, Wonder**
Patient Address: **123 Some Street**
WINDSOR, ON
N9H 2H2
Patient Phone Number:

PRESCRIPTIONS TO BE DISPENSED

Medication:	Dose:	Route:	Frequency:	Quantity:	Repeats:
Acetylsalicylic Acid	81 mg	PO	Daily	30 Days	0
Ramirpril	5 mg	PO	Daily	14 days	0

Comment: Take with food.

Physician: Dr. Physician Moe Generic
CPSO Number: _____
Physician Phone Number: _____
Physician Signature: _____
Please contact family physician for repeats.

Summary of Medication Allergies:

- No Medication Allergies

Summary of Medication Changes Since Admission:

New Medications:

- Acetylsalicylic Acid 81 mg PO Daily

Adjusted Medications: (reflects updated frequency and/or dose)

- Ramirpril 5 mg PO Daily

Stopped Medications:

- Clopidrogrel 75 mg PO Daily

Medications to be Continued:

- Atorvastatin 80 mg PO Daily
- Bisoprolol 10 mg PO Daily

Inpatient Pharmacist helped to prepare this prescription.

Conclusions and Lessons Learned

- A thorough understanding of current practices is essential for developing an effective application that addresses medication information transfer issues.
- The ability to leverage information currently stored in the EPR may improve the accuracy and quality of the data being used to reconcile medications.
- It is anticipated that this electronic framework can be easily adopted at other healthcare organizations.
- Multi-disciplinary engagement is necessary throughout the entire design and development of the application.
- The ability to leverage information for the electronic patient record is only beneficial if the information is real-time and changes as the patient's care is modified.

Contact Information and References

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Outcomes of a Three Year Videoconference Program for Family Practice Professionals

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[c] *NUTES - Telehealth Center, Federal University of Pernambuco (UFPE), Brazil*

Abstract

This article describes the challenges and results of the application of videoconference technology to support family practice professionals in the Northeast of Brazil. The NUTES – telehealth network was established in 2003, connecting four cities in the state of Pernambuco. Continuing Health Professional Education (CHE) and Teleconsultations were available to five videoconference rooms connected in this network. The Videoconference CHE Program was highly demanded but the Teleconsultation Program not. From August 2003 to December 2005 eighty five videoconferencing educational sessions were held with two thousand and three hundred participants, and until November 2006 a hundred and twenty sessions. In conclusion, besides the barriers to acquire technology in a poor region of an under development country, cultural barriers have to be undertaken by health professionals and by health managers to achieve full potential of telehealth technologies.

Keywords:

telemedicine, videoconferencing, public health, family practice

Introduction

Pernambuco is a state located in the Northeast of Brazil, it has 98,311.616 Km^2, 185 cities and around 8,5 million people living in this state, most of them on poverty condition. [1]. Providing healthcare in to so many remote locations is a difficult task. Considering access to specialist's expertise and access to high complexity exams is out of question. Several problems arise from this logistics. Hospitals in Recife (Pernambuco's capital) cannot support all demand from the state. Trying to minimize this problem a national program implementing family practice started in 1994, the Health Family Program (PSF) [2]. This program is under implementation in several cities in the country, but the goal of solving 80% of theirs income health problems has not been achieved resulting in several inappropriate patient referrals. The UFPE University Hospital, Clinics Hospital (HC) based in Recife, admits around 1,000 inpatients and provide assistance to 13,000 outpatients per month [3]. A great number of patients come from cities of Recife's metropolitan area. Beside the lack of specialized and tertiary healthcare units in the country area, another great number of patients come from remote locations. Travel is a major limiting factor even inside the metropolitan area, financial expenses, time off from work and poor public transportation system conditions are major obstacles to patients access specialized care. Based on these facts, a telehealth service was introduced to provide support to family practice professionals and reduce referrals to HC-UFPE leading to faster and better care of high complexity level medical cases.

Methods

Using videoconferencing technology, PSF professionals from Recife and other three metropolitan area cities were connected to specialists at the HC-UFPE. In 2003, a telehealth network, Rede de Núcleos de Telesaúde (NUTES) of Pernambuco, was established as a pilot project coordinated by TIS-UFPE (Health Information Technology research team), and financed by Brazil's Ministry of Health. A main telehealth center NUTES-HC-UFPE coordinates the telehealth network and four additional partner sites were connected: a PSF in Cabo de Santo Agostinho, a PSF in Camaragibe, a PSF in Igarassu, and Lessa de Andrade Policlinic in Recife. These four cities were chosen based on referral information from the epidemiology department of HC-UFPE. Two videoconferences services have been offered, a Health Continuing Education (HCE) Program and teleconsultation on demand. In each partner one videoconference room was deployed with: a videoconference dedicated system (point-to-point), a TV, a document camera, a personal computer, a printer, a webcam, a scanner and a digital camera. At NUTES-HC-UFPE the videoconference system is multipoint bridging the partner sites. The sites are connected using ISDN lines

(Integrated Services Digital Network) at 384Kb/s rate. The videoconference HCE Program is provided once a week over an annual agenda based on cities epidemiological profile and theirs local health priorities. On the other side, the speakers, most of them from HC-UFPE, were identified based on the agenda themes.

Results

From August 2003 to December 2005 eighty five videoconferencing sessions were held with two thousand and three hundred participations, most of them, physicians and nurses. A set of artifacts was introduced to follow-up the program: presence notes, videoconference agenda spreadsheet, speakers register, assessment questionnaire and spreadsheet statistics. The first videoconference session was in August 2003 about child abuse. Since then until November 2006 a hundred and twenty (120) sessions occurred: 15 in 2003, 35 in 2004, 35 in 2005, and 35 in 2006. Several specialties have presented videoconference sessions, most of them on Medical and Nursing fields. The most frequent specialties were Pediatrics (30%), Nursing (20%) and Obstetrics (16%). A survey was conducted from January 2004 to December 2005. About one thousand questionnaires (50% of attendance) were collected analyzing technical and educational aspects (such as infrastructure, devices, support team, content and speakers) and more than eighty (80%) percent of the attendance classified the sessions as “good” or “excellent”.

Discussion and conclusion

This project was originally designed to focus on teleconsultations, but results demonstrated that continuing education was far more used by health professionals. Several reasons could justify this finding. At a continuing education activity, you can ask questions to the specialist only if you want to, while teleconsultation is a direct confrontation with a specialist. Besides that, if the teleconsultation schedule is not introduced as a regular routine in the service, it is easier to order a referral using just a piece of paper with patient name, health problem and specialist required. Informing regular teleconsultation schedules could facilitate this process [4]. Most speakers were specialists and there is a significant gap between family practice and hospital practice. There are different protocols and resources to assist the patients. In 2006, the Residency of Family Physicians was created at HC-UFPE and was engaged on the videoconference sessions. The audience satisfaction has increased once the videoconference session has achieved more practical approaches than those presented by specialists. Some success factors should be considered in a telehealth program for family practice in public health. First, health department’s managers should be strongly involved and understand the requirements and benefits of a telehealth program to their communities. Telehealth must be included in health policies of the city, allowing financial support for these initiatives as a way to achieve sustainability. While in other countries, telemedicine services are financed [5], in Brazilian public health system it is still not a reality. A strategy to get a better professional engagement on telehealth services is first to introduce in their routine a videoconference program for educational purposes. A teleconsultation service should be introduced only after they get used to videoconference technologies. Technical aspects should consider not only acquiring equipments, but also maintaining and training staff in telehealth. Communication lines should achieve a good cost benefit ratio concerning the proposed service. It is also important to make consulting staff understand the possibility of reducing inappropriate referrals using a telehealth program, once it is possible to help the primary care professionals solving common clinical problems within their communities. In addition, both consultants and primary care professionals can better qualify themselves to assist their patients. Telehealth is a strong weapon to provide solutions to solve local problems and benefits all players involved.

Acknowledgments

Brazil’s Ministry of Health, FACEPE, TELEMAR.

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Outcomes of a three year videoconference program for family practice professionals

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INTRODUCTION

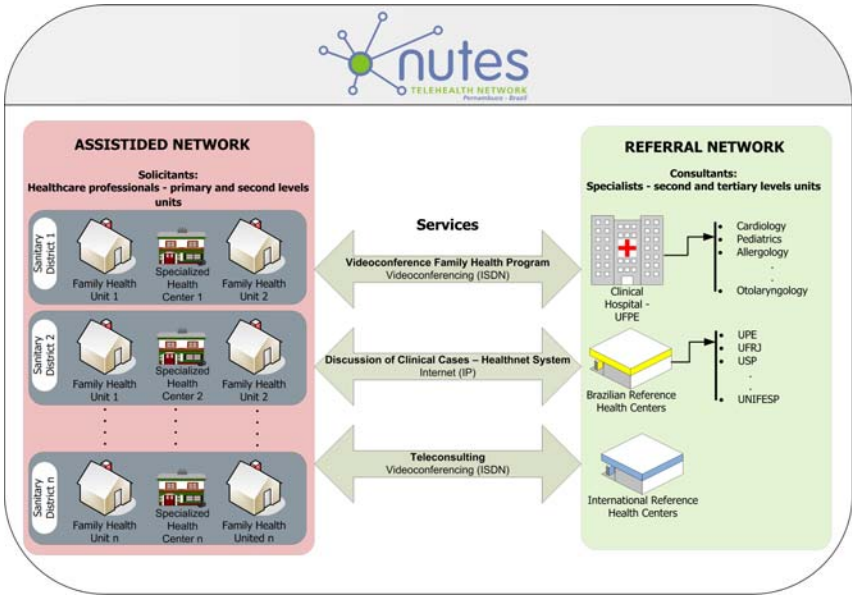
- **Pernambuco is a state of Brazil, located in the northeast region, it has 98,311.616 Km2, 185 cities and around 8.5 million people, most of them living on poverty condition.**
- **Several communities are challenged by geographic and social barriers. Family practice has only been introduced in the last decade in our state, furthermore most cities do not have specialized medical care.**
- **The only solution for health departments of these cities is to provide transportation to their patients so they can receive medical assistance at Recife, capital of Pernambuco.**
- **Several problems arise from this logistics, first, hospitals at Recife cannot support all demand from the state, besides they are supposed to assist only high complexity medical cases. Nowadays, patients suffering from common conditions have been treated at these hospitals resulting in over demand.**

INTRODUCTION

- **Therefore, a telehealth service was proposed to provide support to family practice professionals and reduce referrals to the University hospital leading to faster and better care of high complexity level medical cases.**
- **In 2003, a telehealth network, Rede de Núcleos de Telesaúde (NUTES) de Pernambuco, was established as a pilot project conducted by a research team named TIS (Health Information Technology group) and financially supported by governmental federal funds.**
- **Using videoconferencing technology, family practice professionals at Cabo de Santo Agostinho, Camaragibe, Igarassu and Recife (metropolitan area cities) were connected to specialists at the UFPE University Hospital, in Recife, Brazil. These four cities have been chosen based on referral information provided by the epidemiology department of the Clinics Hospital (HC) at UFPE.**

METHODS

- **A main telehealth center NUTES-HC coordinates the telehealth network and four additional partner sites were connected:**
  - NUTES - PSF Manoel Vigia (Cabo de Santo Agostinho)
  - NUTES - PSF Bairro dos Estados (Camaragibe)
  - NUTES - PSF Santo Antônio (Igarassu)
  - NUTES - Policlinic Lessa de Andrade (Recife)
- **A network among healthcare providers was established involving primary, secondary and tertiary level of care.**
- **Two videoconference based services have been offered to partner's cities, a health continuing education program and teleconsultation on demand.**



METHODS

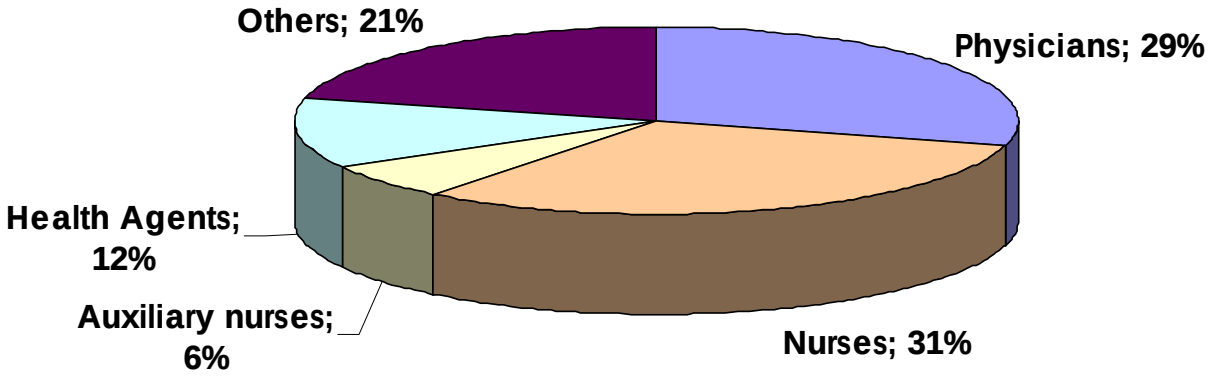
- Each partner's videoconference room is composed by a videoconference dedicated system (point-to-point), a TV, a document camera, a personal computer, a printer, a webcam, a scanner and a digital camera.
- At NUTES-HC the videoconference system is multipoint bridging the partner sites.
- The sites are connected using ISDN lines (Integrated Services Digital Network) in a 384Kb/s rate.
- Partner videoconference rooms have capability of 10-15 people, while NUTES-HC has capacity to accommodate 25 people.
- Technical assistance is available on every partner videoconference room. At NUTES-HC a team composed by information technology, healthcare students and professional, is available to set up the NUTES services.

- Videoconference health continuing education program is provided weekly. Content choice is based on local partners epidemiological data. Most speakers are faculty members. A survey was collected on every session analyzing technical and educational aspects.
- Besides continuing education, our videoconferencing equipment have been used to support clinical care, courses, administrative and clinical meetings, as well.

RESULTS

From August 2003 to December 2005 eighty five videoconferencing sessions were held with 2,300 participations.

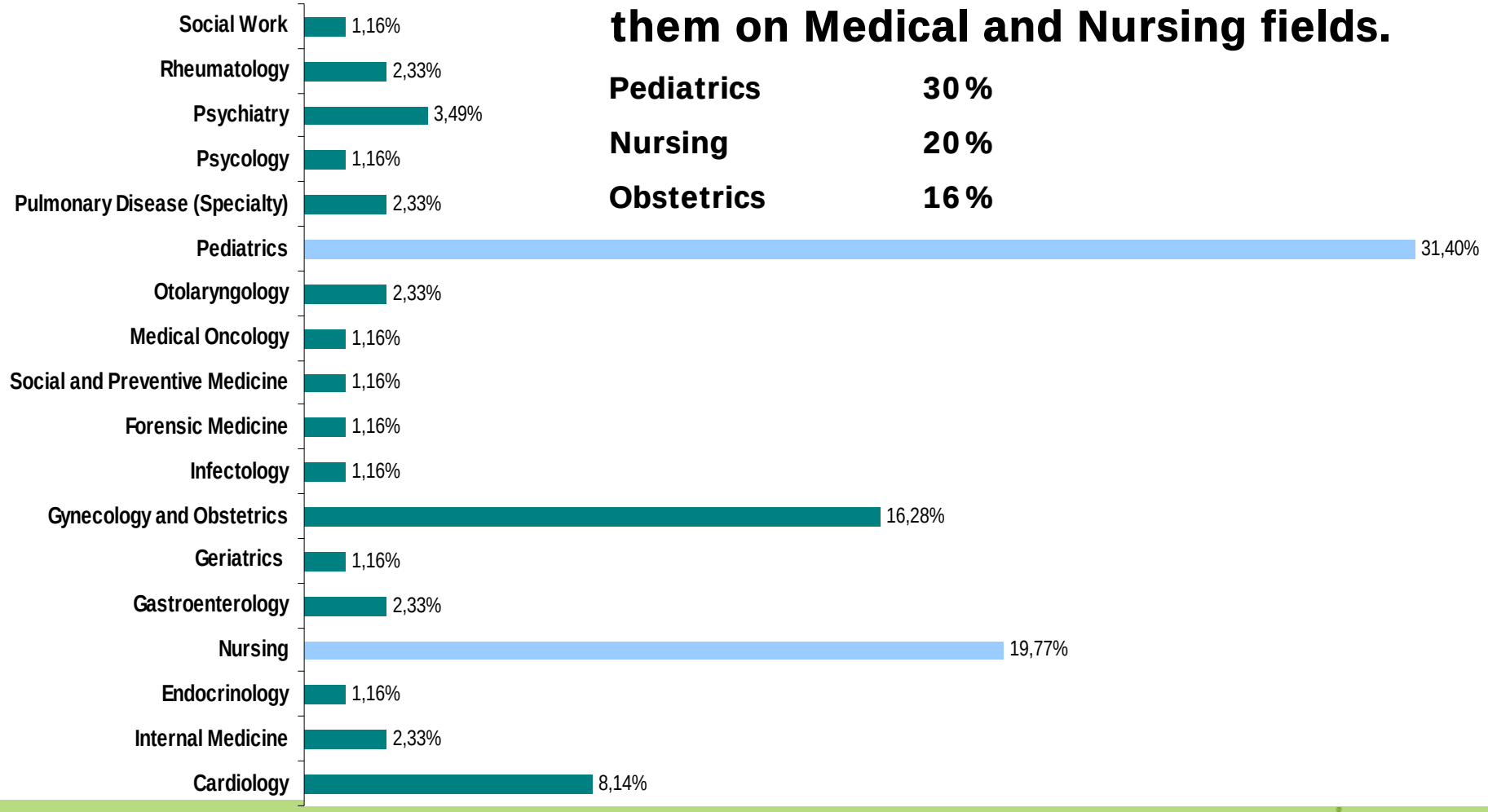
Physicians	**29%**
Nurses	**31%**
Auxiliary nurses	**06%**
Health agents	**12%**
Other health and administrative professionals	**21%**



RESULTS

Several specialties have presented videoconference sessions, most of them on Medical and Nursing fields.

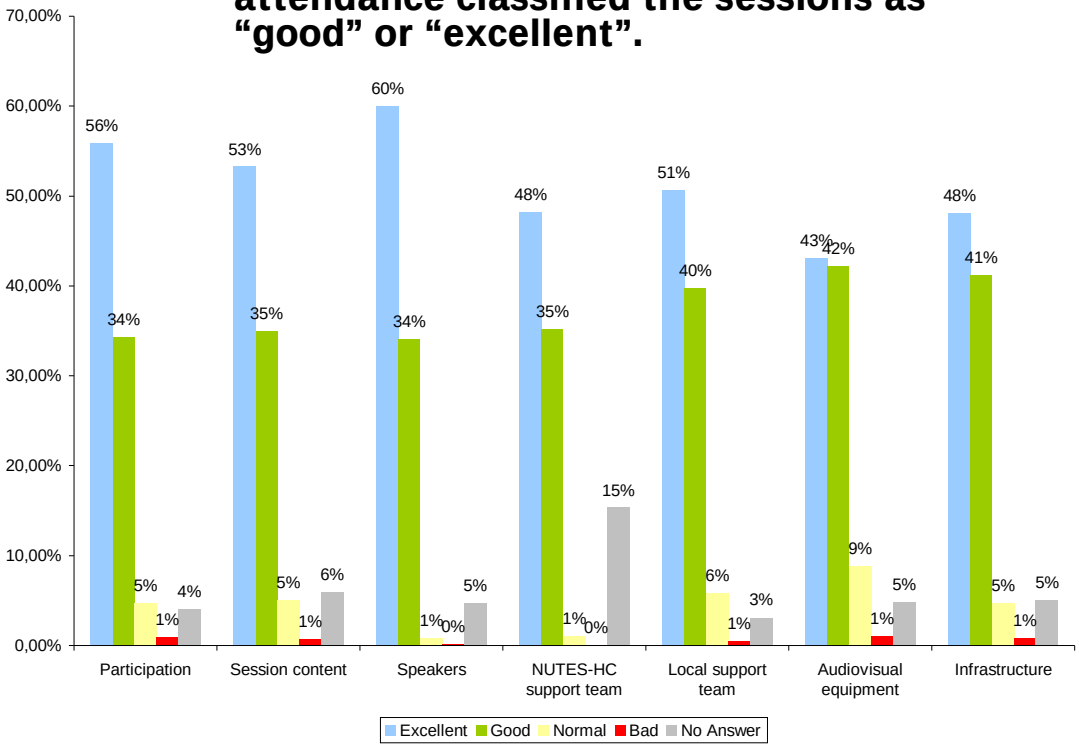
Pediatrics	**30 %**
Nursing	**20 %**
Obstetrics	**16 %**



RESULTS

- **Some examples of presented themes:**
  - Dengue, how to strike?,
  - Fever, how to treat?,
  - Bone tumors,
  - Filariasis,
  - Vaginitis/Vaginosis during Gestation,
  - Cholera,
  - Viral Hepatitis,
  - Hemogram Interpretation,
  - Parasitic Diseases,
  - How to manage Hypertension and Diabetes in FHP (HIPERDIA),
  - Asthma,
  - Schistosomiasis mansoni,
  - Tuberculosis,
  - Breast Feeding: healthy women and baby,
  - Obesity,
  - Leptospirosis,
  - Pregnancy in adolescence,
  - Malnutrition,
  - Diarrheas,
  - Violence,
  - Vaccination in first year of life, etc.

- **From January 2004 to December 2005 a survey was conducted**
- **More then 1000 questionnaires were collected analyzing technical and educational aspects (such as infrastructure, devices, support team, content and speakers)**
- **More than eighty (80%) percent of the attendance classified the sessions as "good" or "excellent".**



DISCUSSION

- **This project was originally designed to focus on teleconsultations, but results demonstrated that continuing education was far more used by health professionals.**
- **Some professional were not comfortable in exposing their lack of knowledge to the specialist.**
  - At a continuing education activity, you can ask questions to the specialist only if you want to, while teleconsultation is a direct confrontation with a specialist
  - Besides that, if the teleconsultation schedule is not introduced as a regular routine in the service, it is easier to order a referral using just a piece of paper with patient name, health problem and specialist required
  - Informing regular teleconsultation schedules could facilitate this process
- **Family practice professionals from remote locations tend to change jobs very rapidly; several teams had to be trained in telehealth every time new professionals were admitted to the unit.**
- **Most speakers were specialists and there is a significant gap between family practice and hospital practice. There are different protocols and resources to assist the patients.**

CONCLUSION

- **Some success factors should be considered in a telehealth program for family practice in public health.**
  - A strategy to get a better professional engagement on telehealth services is first to introduce in their routine a videoconference program for educational purposes. A teleconsultation service should be introduced only after they get used to videoconference technologies.
  - Health Department's managers should be strongly involved and understand the requirements and benefits of a telehealth program to their communities.
    - Telehealth must be included in health policies of the city, allowing financial support for these initiatives as a way to achieve sustainability.
  - Technical aspects should consider not only acquiring equipments, but also maintaining and training staff in telehealth. Communication lines should achieve a good cost benefit ratio concerning the proposed service.
  - Consulting staff have to understand the possibility of reducing inappropriate referrals using a telehealth program, once it is possible to help the primary care professionals solving common clinical problems within their communities.
    - With telehealth both consultants and primary care professionals can better qualify themselves to assist their patients.
  - Telehealth is a strong weapon to provide solutions to solve local problems and benefits all players involved.

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ACKNOWLEDGMENTS

- **Brazil's Ministry of Health, FACEPE, TELEMAR**

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Developing a Home-Based Palliative Care Information System by Utilizing Wired/Wireless Network and Mobile Computing System in Japan

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Abstract

Interpersonal communications within specialized community palliative care consulting teams are fundamental to patient care. However, the process of communication has not been well supported technologically. We developed a network-based information system to improve communication within team. The Network Tool is a database system developed using FileMaker Pro® (File Maker, Inc., CA, USA), which utilizes the wired/wireless network and the mobile computing system. It enables interactive communications between the office headquarters and professionals over the intranet. This database comprises information relevant to the patients including details on their family, home, medication, and actual clinical status assessed by each professional. It is designed to improve clinical information, facilitate an interdisciplinary team approach, and allow collecting structured clinical data in general practice on a daily basis. The system has been successfully implemented and used, especially to improve communication within the interdisciplinary team. This system supports practices that are consistent with improvements in the quality of care. An infrastructure that shares the database of patient's records was developed for home-based palliative care.

Keywords:

delivery of health care, palliative care,
Computerized Health Record

Introduction

In recent years, information and communication technology (ICT) support system has been recognized as a tool for improving care delivery, symptom assessment and communication between medical staff and patients/families in palliative care settings [1-3]. However, the efficient sharing of information and the process of communication within interdisciplinary teams has not been well supported technologically in the delivery of home-based palliative care. To ensure that home-based palliative care is provided reliably and sustainably, we developed a network-based information system for specialized palliative care consulting teams in the community. The objectives of this project are: (1) to improve the efficiency of visiting clinicians and nurses who are overburdened with paperwork and frustrated with bottlenecks in the information exchange process, and (2) to improve the sharing of information within interdisciplinary teams by using a network-based information system (computerized medical records).

Materials and methods

We have deployed the information system on the Okabe Clinic Regional Palliative Care Program since July 2003.

The Information System

The network tool is a database system using FileMaker Pro® (FileMaker, Inc. CA, USA), which utilizes the wired/wireless network and the mobile computing system.

This system provides the connectivity required to enable complete workforce mobility. Team staff can carry their mobile computers when working in the field. More importantly, with integrated modem, wireless LAN capabilities, and fast 10/100 Ethernet, the mobile computer allows users to stay connected at all times. This enables interactive communication between the office headquarters and each professional over the intranet.

This database comprises information relevant to the patients including details about their medical history, family, medication, administrative function and actual clinical status as assessed by each professional. It also includes narrative visit notes by each interdisciplinary expertise, physician orders, prescriptions, care plans and laboratory data. It was designed to improve clinical information, facilitate an interdisciplinary team approach, and enable the collection of structured clinical data in general practice on a daily basis.

During each visit, a professional briefly assesses the symptoms, side-effects, and other key problems of the patient

and enters this information into the system. Most importantly, visiting nurses measure vital signs including pain score [4] based on numeric rating scale (from 0 to 10). They also assess patients' symptoms including general fatigue, anorexia, nausea, dyspnea at rest, edema, dry mouth, drowsiness, insomnia, anxiety, bed sore, dysphagia, depression and delirium based on symptom intensity score (from 0 [absent] to 3 [severe]).

Subsequently, when other professionals access the patient's electronic medical record from any remote location, a window containing the patient's complete assessment information is displayed.

Physicians and managers receive updates regarding the quality of treatment being received by the patient. Each patient's identifiable data is securely and confidentially maintained on the server located at the office headquarters.

Results

The system has been successfully implemented and used, especially to improve communication within the interdisciplinary team. Using this system, field staff can electronically submit their clinical visit notes – a process that was previously done on paper, mostly in a narrative form. Since the users are required to fill out the information in a structured electronic format, we can accurately and efficiently collect a considerable amount of valuable data for future analysis and develop superior structured care plans before each patient visit. Further, the system also complements an interdisciplinary team meeting and offers 24 hours/ 7 days assistance.

After deploying this system, we have been able to improve patient care by reducing the administrative work load of our mobile workers. Clinicians and nurses can now focus on delivering high quality care, thereby significantly improving their own quality of life. In addition, field nurses may be able to make three or four additional visit each week. This system also assists in the operation of home-based palliative care during night and over the weekend; this has led to an increase in the number of patients under each team. To date, this system has been used for more than 50 advanced cancer patients and approximately 200 chronically ill patients.

Discussion

By equipping field staff with this system, we have enabled them to increase the time spent in providing care at patients' homes and less time in completing their paperwork. Now, as field staff makes their daily visit to patients' homes, the mobile computers ensure that they have all the required information with them. Hence, patient records, including medical and care history, medications, and insurance information are just a few clicks away.

The interdisciplinary team approach has been widely accepted as appropriate in the palliative care setting. The team approach, which involves shared decision making, the efficient sharing information, and the mutual understanding of the role of each member, is different from the sequential multidisciplinary care that frequently characterizes "usual" hospital care. In order to promote interdisciplinary team care, the information system we developed led to an expansion of each professional role and function, advancement of knowledge and techniques, and improvement of sharing information within team.

In this project, we did not consider the quality of symptom control and the cost of care in relation to this system. Further studies should assess symptom control as well as patient's and family's satisfaction. Cost of care also needs to be addressed in future researches.

Conclusion

An infrastructure that facilitates sharing of the database of patient's record was developed for home-based palliative care provided by the interdisciplinary team.

As a result, we now have access to all patient-related data collected by the interdisciplinary team and can leverage this data to develop new treatment plans and processes that will further enable the consistent delivery of high-quality patient care across the community.

Acknowledgments

This project was supported in part by grants from the Sasakawa Health Science Foundation, Tokyo, Japan.

References

[1] Lind L, Karlsson D. Symptom assessment in homecare using digital pens. AMIA Annu Symp Proc, 2003:914.
[2] Pearson WS, Bercovitz AR. Use of computerized medical records in home health and hospice agencies: United States, 2000. Vital Health Stat 13, 2006 Jun ;(161):1-14.
[3] Aoki N, Ohta S, Yamamoto H, et al. Triangulation analysis of tele-palliative care implementation in a rural community area in Japan. Telemed J E Health, 2006 Dec; 12(6): 655-62.
[4] Lynch M. Pain as the fifth vital sign. J Intraven Nurs, 2001 Mar-Apr; 24(2):85-94.

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Developing a Home-based Palliative Care Information System by utilizing Wired/Wireless Network and Mobile Computing System in Japan

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INTRODUCTION

・In recent years, information and communication technology (ICT) has been recognized as a tool for improving care delivery, symptom assessment and communication between medical staff and patients/families in palliative care settings.

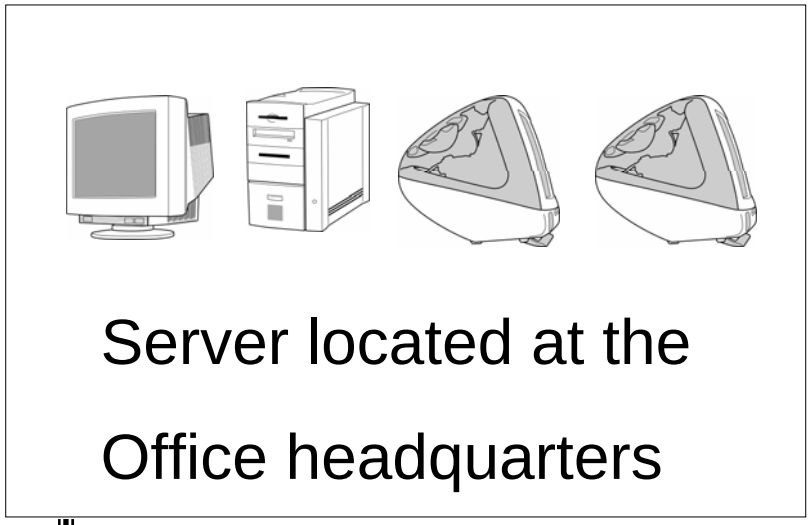
・However, the efficient sharing of information and the process of communication within interdisciplinary teams has not been well supported technologically in the delivery of home-based palliative care.

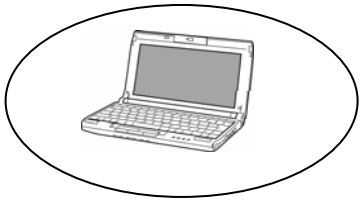
・To ensure that home-based palliative care is provided reliably and sustainably, we developed a network-based information system for specialized palliative care consulting teams in the community.

METHODS

To improve the efficiency of visiting clinicians and nurses overburdened with paperwork and frustrated with bottlenecks in the information exchange process, we deployed a database system using FileMaker Pro® (FileMaker, Inc. CA,U.S.A.), which utilizes the wire-wireless network and the mobile computing system from July,2003.

This system provides the connectivity required to enable complete workforce mobility. Our staff can carry the mobile computer while out in the field. More importantly, with its integrated modem, wireless LAN capabilities, and fast 10/100 Ethernet, the mobile computer allows users to stay connected at all times. It enables interactive communications between the office headquarters and professional over the intranet.

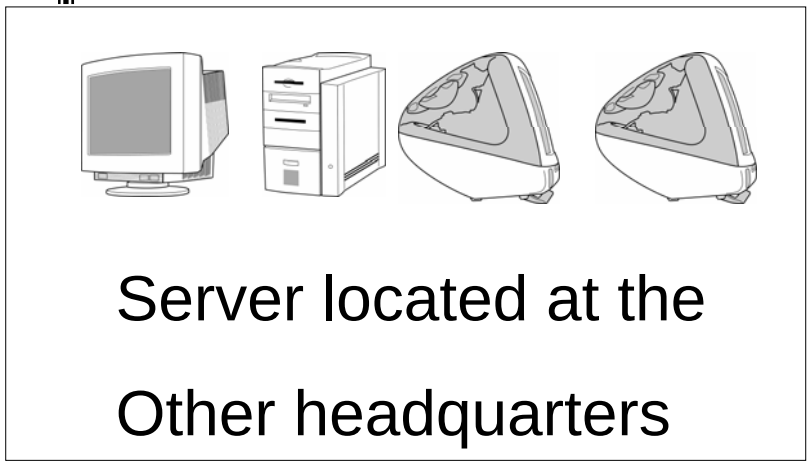




Mobile PC for each professionals

Pharmacy

Wired/Wireless secure Virtual Private Network (VPN)



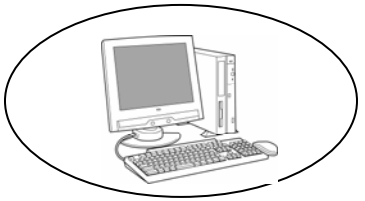


Fig.1 Wired/Wireless Network and Computer Systems

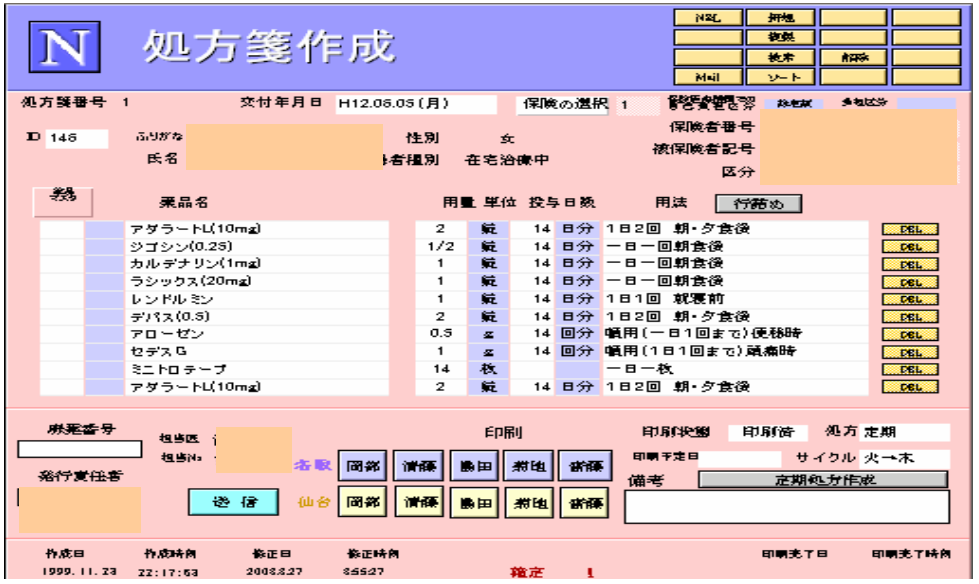
This database comprises information relevant to the patients including details on their family, home, medication, and actual clinical status assessed by each professional. It is designed to improve clinical information, facilitate an interdisciplinary team approach, and allow collecting structured clinical data in general practice on a daily basis.

During each visit, a professional briefly assesses the symptoms, side- effects, and other key problems of the patient and enters this information into the system. Subsequently, when other professionals access the patient's electronic medical record from virtually anywhere, a window appears containing the patient's complete assessment information.

Physicians and managers receive updates regarding the quality of treatment received by the patient. Each patient's identifiable data is securely and confidentially maintained in the server located at the office headquarters.


診　療　録
ID
30266
記載者
診察日
2003.6.19
患者種別
診察時刻
11:30
保険種別
所見
SpO2/99(2/1lnasal)HR101RR18
chest:右肺雑(＋)胸郭右にシフト。
半開眼。呼びかけに少し表情かえる程度。in100-200,out500
とう骨動脈触知可能。
痛み・呼吸苦訴えなし。
苦痛からは開放され穏やかな状態。このまま自然の経過にまかせる旨を説明。
visit note by physician
指導項目
新患新規指示出
同一患者同一担当者新規指示出
同一患者担当者なし新規指示出
8096
6.9.月
指示者
担当者
承認
Foley留置。ロピオン50mg5mL2A＋生食38ml=計48mLをケーデックで2ml/hrでCV三活からDIV.
承認状態
承認済
指示受状態
受け済
7955
承認日
6.9.月
受領日
6.9.月
長文の指示は看護記録で見づらくなるのでご注意
Physician's order


作業療法記録
ID
2613
在宅治療中
処置日
03.6.17(火)
記載者
保険種別
介護
開始時刻
11:30
終了時刻
12
血圧
130/80
脈拍
91
酸素
94
呼吸
体温
プログラム1
関節可動域訓練
プログラム2
W/C移乗
プログラム3
#1 痛みあり、筋緊変換困難。
ベッド上にて、苦痛様の表情あり。ROM施行中、痛み訴えないが、違和感はあるか？眉間にしわを寄せ、声をあげることはあり。
#2 移動不耐性
車椅子レンタル開始している。
本日、リクライニング車椅子乗車。2名介助。15分ほど乗車。
やや緊張した様子であるが、乗車時の苦痛なし。
60°程度の座位にて、BP106/60へ。Spo2変化なし。
85°程度でも、座位の安定性は良いが、ヤクルトをストローにて飲むと、咽せあり。
60°程度で様子みる。スナック菓子・ヤクルトを手に持たせると自力で摂取可。
#3 呼吸機能
spo2良好。著変なし。
visit note by OT/PTs


処方箋作成
処方箋番号
1
交付年月日
H12.06.05(月)
保険の選択
1
ID
145
ふりがな
氏名
性別
女
在宅治療中
保険者番号
被保険者記号
区分
薬品名
用量
単位
投与日数
用法
アダラートL(10mg)
ジゴシン(0.25)
カルデナリン(1mg)
ラシックス(20mg)
レンドルミン
デパス(0.5)
アローゼン
セデスG
ミニトロテープ
アダラートL(10mg)
麻薬番号
発行責任者
印刷
印刷状態
印刷済
処方
定期
サイクル
火一木
備考
定期処方作成
送信
作成日
作成時刻
修正日
修正時刻
確定
Prescription


ホームヘルプ記録
ID
1941
要介護区分
業務日
10:00
終了時刻
11:00
ヘルパーへの指示・連絡
体温
脈拍
呼吸
血圧
便量
便色
尿量
尿色
サービス内容
単位
時間
サービス合計
状況
感想・意見
今日は着替えは嫌だということで、顔と手だけ拭かせてもらった。ほとんど目も開けていて、側臥位にする際にも声を掛けると「できるかや」と協力してくださった。初めは「足が痛い」とおっしゃっていたが、身体を動かしているときに痛い様子も見られなかった。
アイスがお好きなそうで、ペロリと食べてしまいました。水では少しむせがありましたが、アイスはむせることもなく食べました。
作業内容
7 除雪洗浄
8 おむつ交換
28 清拭
39 体位変換
連絡事項・予定
飲食
visit note by home health aides

Assessment of Symptoms on a each nurse's visit basis

PS	全てに正常に制限なく行動できる	激しい運動は制限されるが歩行や軽い仕事はできる	軽労働不可。歩行、身の回り可。時に介助必要。50%以上起居。	身の回りのことはある程度できるが、しばしば介助必要。50%以上は臥床(または車椅子)	身の回りのことができず、全介助。終日臥床(または車椅子)
倦怠感	なし	軽度あるが支障なし	多少活動を制限	著明に活動を制限	
食欲不振	よく食べられる	まあまあ食べられる	あまり食べられない	全く食べられない	
嘔気	嘔気なし	嘔気はあるが辛くはない	しばしばあるが、何とか耐えられる	耐えられない程辛い	
嘔吐	嘔吐ない	嘔 辛			
呼吸困難	なし	軽度あ			
咳	なし	軽度あ			
痰	なし	軽度あ			
腹部膨満感	なし	軽度あ			
浮腫	なし	足首、			
皮膚乾燥					
口渇					
傾眠傾向					
意識障害					

嘔気値	嘔吐値	呼吸困難値	咳値	痰値	腹部膨満感値	浮腫値	皮膚乾燥値	口渇値	傾眠傾向値	意識障害値
0	0	2	0	0	2	1	1	3	2	2
0	0	2	0	0	2	1	1	3	2	2
0	0	2	0	0	2	1	1	3	2	2
0	0	2	0	0	2	1	1	3	2	2
0	0	2	0	0	2	0	1	3	2	2

0: absent
1: mild
2: moderate
3: severe

Intensity of symptoms experienced at the time of nurse's visit

PS(ECOG), fatigue, anorexia, nausea and vomiting, dyspnea at rest cough, sputa, abdominal distention, edema, dry mouth, drowsiness insomnia, anxiety, bed sore, pruritus, dysphagia, numbness mouth ulcer, dizziness, depression, cognitive disturbance

RESULTS

The system has been successfully implemented and used, especially to improve communication within the interdisciplinary team. With this system, our field staff can electronically submit clinical visit notes – a process that had previously been done on paper, mostly in narrative form.

By requiring users to fill out the information in a structured electronic format, we can accurately and efficiently collect a wealth of valuable data for future analysis and develop superior structured care plans before each patient visit. It also complemented an interdisciplinary team meeting and offered 24 hours/7 days assistance.

After deploying this system, we have been able to improve patient care by reducing the administrative workload of our mobile workers. Clinicians and nurses can now focus on delivering high quality care, significantly improving their own quality of life.

In addition, field nurses may be able to make three or four additional visits each week. This system also assists the operation of home-based palliative care in the night time and over the weekend; these has led to an increase in the number of patients per team.

To date, this system has been used for more than 50 advanced cancer patients and approximately 200 chronic ill patients.

DISCUSSION

By equipping our field staffs with this system, we have enabled them to spend more time providing care in patients' homes and less time filling out paperwork.

Now, as our staffs make their daily rounds to patients' homes, they have all the information they need right at their mobile computers. Patient records, including medical and care history, medications, and insurance information, are just a few clicks away.

In this project, we did not take quality of symptom control, cost of care and this system into consideration. Further studies should assess symptom control as well as patient and family satisfaction. Further research should also address cost of care.

CONCLUSIONS

An infrastructure that shares the database of patient's records is developed for home-based palliative care performed by the interdisciplinary team.

As a result, we now have access to all patient-related data collected by the interdisciplinary team and can leverage that data to develop new treatment plans and processes that will further enable the consistent delivery of high-quality patient care across the community.

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[1] Lind L, Karlsson D. Symptom assessment in homecare using digital pens. AMIA Annu Symp Proc, 2003: 914.
[2] Pearson WS, Bercovitz AR. Use of computerized medical records in home health and hospice agencies: United States, 2000. Vital Health Stat 13, 2006 Jun ; (161): 1-14.
[3] Aoki N, Ohta S, Yamamoto H, et al. Triangulation analysis of tele-palliative care implementation in a rural community area in Japan. Telemed J E Health, 2006 Dec; 12(6): 655-62.
[4] Lynch M. Pain as the fifth vital sign. J Intraven Nurs, 2001 Mar-Apr; 24(2): 85-94.

Acknowledgements

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HISA Ltd Australia

A Primary Care Physicians Web-Space

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Abstract

The Primary Care Physician Webspace (PCPW) is intended to provide a physician community with an array of support services. It provides an environment that augments and complements typical clinical management systems (CMS), links to them, and links physicians to each other, to the University of Waterloo, to regional healthcare facilities, and to local and remote information resources. CMS tend to lack Community of Practice (CoP) support, and portals tend to ignore the existence of a CMS. The PCPW addresses CoP in depth using advanced technologies built into a rapid development environment that provides software agent support for interaction with other systems, thereby addressing both challenges.

Keywords:

web-based system, communities of practice (CoP), consumer e-health, workflow, clinical information system

Introduction

Small and medium sized organizations underutilize modern information and communication technologies for communicating with their communities[1]. Relational databases, mapping, notifications, agents and advanced web-based technologies such as dynamic prototyping, are all examples of capabilities that could benefit organizations like a primary care physician's practice. The cost and complexity of deploying and maintaining such systems are major barriers to their more widespread use. The community that would benefit includes rostered patients, the general public, partner practitioners, associated staff, allied professionals, other service deliverers in the community such as pharmacies and hospitals, and, where applicable, medical residents and students.

The Centre for Family Medicine (CFFM), in Kitchener, Ontario, Canada - http://www.family-medicine.ca is a family health team[2] comprised of primary care physicians, their staff and allied professionals that, until recently, made no significant use of web-based technologies for communicating with their community. The team had chosen and deployed a CMS, but no public web site and no technology to support a broader, online community communications strategy had been acquired or designed.

In partnership with the University of Waterloo's Waterloo Institute for Health Informatics Research, the Computer Systems Group, a research group within the David R. Cheriton School of Computer Science at the University of Waterloo and the J.W. Graham Information Technology Trust, a Primary Care Physician's Webspace was created with the CFFM to help to address the Centre's online community communications needs.

Methodology

The following major steps were taken:

1. Establish an advisory panel of primary care physicians.
2. Identify the goals and objectives of primary care physicians related to Community of Practice (CoP) support as well as integration with other systems.
3. Analyze these goals and objectives and collaboratively define the needs of the physicians and the required capabilities of the system.
4. Design the system and review this with the advisory panel and a key primary care practice.
5. Using a locally-developed advanced rapid prototyping toolkit called the Web-based Informatics Development Environment (WIDE), create a demonstrable version of the system.
6. Evolve the system using the advisory panel and practice feedback through several iterations.
7. Demonstrate the system.

A key part of step two was to identify the various user communities and their corresponding information needs from the system. It is also important to note that some of the steps and sequences of steps were repeated several times. As the capabilities of the system became better understood by the advisory panel, their objectives shifted and so the requirements for the system changed.

Discussion

Communities served

Four communities are served by the system:

1. Rostered Patients and the General Public including Newcomers and Immigrants
2. CFFM Staff and Professionals

3. Prospective Medical Residents and Students
4. Other Physicians and the Medical Community

Rostered patients and the general public including newcomers and Immigrants

The cities of Kitchener, Waterloo and Cambridge and the surrounding townships that comprise Waterloo Region in Southwestern Ontario, Canada, are designated as underserviced by primary care professionals, according to the Government of Ontario[3]. Almost all doctor's offices in the region maintain a roster of patients who can make appointments to visit the office. For a family health team in Waterloo Region, such as the Centre for Family Medicine, rostered patients are their highest priority community. When the needs of that community have been met, any extra capacity within the team can be used to serve the general public. For example, the CFFM offers an extensive series of educational seminars on topics such as nutrition and diet, exercise, diabetes management and general health promotion. These seminars are first made available to rostered patients but anyone can ask to be registered if space permits.

In the PCPW the highest priority community to communicate with is the community of rostered patients. Basic information about the CFFM itself, including educational events and special clinics such as those for flu shots is of high importance to this community. As well, the PCPW provides directories of local pharmacies, medical labs and physiotherapists that are of use to this community and the general public. These directories include detailed contact information and maps that can produce driving directions. This information is especially valuable to residents of small and rural communities. Similarly, information for newcomers and immigrants is particularly valuable as Waterloo Region has the fifth highest per capita immigrant population of all urban areas in Canada, behind only Toronto, Vancouver, Hamilton and Windsor[4].

CFFM staff and professionals

Although the CFFM has an extensive e-mail system and makes very good use of it, it is a challenge to keep ten physicians and between twelve and fifteen other associated staff and professionals informed of special events, meetings and presentations. As an added complication, the CFFM physicians work from four offices in the cities of Kitchener and Waterloo and the village of Wellesley, Ontario which is approximately 27 kilometers (17 miles) from the downtown Kitchener site. The PCPW can significantly reduce the challenge of keeping the group informed of upcoming events. As well, the CFFM staff can see immediately what patients and the broader community are being told about upcoming CFFM events.

For after-hours calls from local pharmacies, physicians usually fax their on-call hours and contact information to a list of organizations. The PCPW includes a capability to provide that information to these organizations in a more secure and reliable manner.

Prospective medical residents and students

Waterloo Region has a great deal to offer prospective medical residents and students in the context of the CFFM. Residents who seek a placement in what is primarily an urban setting but also want to experience a rural community can find the CFFM to be ideal. The PCPW contains extensive links to community information about topics as diverse as regional hiking and biking trails, bus routes, arts and cultural information and social services. After attending a public lecture at the Perimeter Institute for Theoretical Physics or spending an evening with the Kitchener-Waterloo Symphony, a CFFM resident could attend a clinic in the village of Wellesley that serves a large old-order Mennonite community whose residents frequently arrive at the doctor's office in a horse and buggy.

Other physicians and the medical community

Some of the physicians at the CFFM actively teach, research and write about innovative topics in the field of Family Medicine. The PCPW currently includes several presentations and papers on the topic of the environmentally friendly doctor's office. As well, documents have been prepared to present a range of options for presenting, accessing and participating in meetings and presentations over the internet. For example, one to one meetings where no patient information is discussed can often be presented using simple internet mechanisms such as Skype[5] or Windows Live™ Messenger[6]. Presentations with a wider audience might be broadcast with a system like ePresence[7] and an event that includes secure videoconferencing requirements might be best suited to a system that is based on the OTN/North Network[8] environment.

Requirements elicitation

As previously mentioned in the Methodology section, this project involved an extensive, iterative requirements elicitation process. The cost of such a process in a traditional, commercial consulting context would have rendered the process completely infeasible. Nevertheless, it did require several weeks of meetings and discussions to educate the advisory panel about the capabilities of and issues related to current information technology and to reconcile different goals and objectives amongst the members of the panel.

A key technology that was used in the creation of the PCPW is called "Model-Driven System Generation" (MDSG). This innovative technology, which is a feature of the WIDE toolkit[9], provides an environment where the application model and operational system are always synchronized – there is no architectural gap between the model and the implementation. In traditional software

development, the phenomenon of "model drift", where the model and implementation are initially synchronized but soon separate, is very common. Without MDSG it would not have been possible to create the PCPW without a much larger budget. It was essential to this project to be able to develop a rapid prototype of a proposed feature, explore how the feature operated with the advisory panel and then either discard it as undesirable or change the model to improve it.

Content

Content in the PCPW can be classified as either original or secondary material. Original material is created mostly by CFFM professionals and staff and secondary material is sourced externally. Of the secondary material, some is presented within the CFFM with appropriate credit and some is presented as links to external web sites.

Original material includes the following:

- information about the CFFM, including vision and plans, physical sites and pictures, hours and contact information
- frequently asked questions
- medical nutrition information for patients
- information about the basics of health care in the region
- research papers and presentations
- Secondary material presented within the site includes directories of:
- pharmacies
- medical labs, and
- physiotherapists
- Secondary material presented as links to external sites includes:
- community and social services
- arts and cultural resources
- community events
- transportation around the region
- Medical-resident matching services

For all of this content, sustainability was a key concern. Specifically, it was essential that the information always be as up-to-date, comprehensive, relevant and authoritative as possible. As well, maintenance of the information should be as easy and inexpensive as possible, ideally at no cost. The following sources of information that met the sustainability criteria were levered where possible:

- Waterloo Regional Arts Council (arts and cultural information)
- Community Information Centre of Waterloo Region

When no single source of information was available that met the criteria, the WIDE toolkit provided options for amalgamating several sources of information into a single result. For example, the directory of pharmacies was created and is maintained by amalgamating and monitoring ten different data sources:

- four brand-name drug store web sites
- two employer association web sites
- four community business directories

As is inevitable with such diverse data sources, inconsistencies have been discovered and are reported back to the maintainers of the original data.

As well, regular and comprehensive checking of the site is performed automatically. Broken links to external web sites, missing images and spell checking are all performed by autonomous agents without any administrative intervention and only the results are reported to the system administrator.

Future work

The CFFM would like to explore closer connections with the hospital information systems of the two general hospitals in Kitchener-Waterloo in order to provide the primary care physicians with better access to the medical records of their patients. This integration step is currently being investigated.

As the new Downtown Kitchener Health Sciences Campus of the University of Waterloo is built, the PCPW should be extended to communicate with and enhance the online systems of the new School of Pharmacy, the School of Optometry and the new Kitchener satellite of McMaster University's Michael G. DeGroote School of Medicine.

Conclusions

The Primary Care Physician's Webspace has demonstrated a capable primary care physician support solution that allows the augmentation of commercial Clinical Management Systems with advanced web-based capabilities. It shows what can be gained by using tools, such as the WIDE toolkit, that significantly reduce barriers to partner development and understanding, and allow frequent and rapid revisions. This is particularly important when new types of requirements, such as support for CoP and little user knowledge of potential solutions exist. The PCPW allows significant systems support in the primary care setting using internet-based, browser accessible technologies.

Acknowledgements

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Integration of Evidence-Based Nursing Content: A Collaborative Study

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Abstract

In 2005, Pinnacle Health System, Zynx Health, and Siemens Medical Solutions developed a partnership to conduct a study, exploring opportunities and challenges associated with integration of evidence-based knowledge within the Electronic Health Record (EHR) with the goal of creating repeatable methodologies for nursing knowledge integration. The two-phase study involved access to referential evidence-based content and integration of customized evidence-based plans of care within EHR documentation applications.

Key results, to date, of this ongoing study include identification of data model variations between evidence-based knowledge sources and hospital information systems that expose pre/post coordination challenges; greater insight into how structured data elements should appear to end users in terms of form, order, and context; staff nurse response to availability of evidence-based content in care planning and documentation workflow; and impact of customized evidence-based plans of care on organizational processes of incorporating evidence-based practices into clinical practice. Findings included general satisfaction of the content, validation of the importance of strong nursing leadership related to implementing evidence-based practices in the organization, the need for client vendor partnering, and data documenting positive impact of integrated evidence-based content on quality of care.

Keywords:

patient care planning, outcome assessment, evidence-based medicine

Introduction

Study objectives and questions

The overall goal of this evaluation study was to test the impact of an electronic health record populated with nursing knowledge and evidence for use by nurses in assessing, planning, evaluating, and communicating patient care. During the study, both referential and integrated knowledge and evidence populated clinical applications. Referential knowledge and evidence is defined as synopses of evidence and evidence sources classified according to type of study.

The referential knowledge and evidence was available through links from specific points in the clinical workflow within Siemens applications. Integrated knowledge and evidence is defined as evidence-based assessment tools, order sets, and nursing orders/plans of care that were integrated for use in the Siemens clinical applications.

The specific objectives of the study were to:

1. Gain an understanding of the technical factors related to providing access to Zynx Health knowledge and evidence from within Siemens applications;
2. Gather data regarding various nurse users' reactions to the availability of Zynx Health knowledge and evidence in these applications;
3. Identify the specific locations within the clinical system interface from which Zynx Health knowledge and evidence knowledge provides value for nurses; and
4. Identify requirements related to the integration of nursing knowledge within the electronic health record, specifically focused on knowledge structure, content, and components most valuable to nursing practice.

Methods

The study included two phases.

Phase I: Referential performance measures and quality indicators

The first phase of the study focused on providing links from Siemens clinical systems to Zynx Health referential knowledge and evidence. Links to evidence about four nursing sensitive performance measures, patient falls, acute pain, pressure ulcers, and smoking cessation, were provided to bedside clinicians. Users had the ability to link, via a display icon, from Siemens care planning and documentation screens to the Zynx Health evidence regarding the four patient problems and return to the care planning or documentation application.

Phase II: Customized evidence-based plan of care content integrated in care planning and documentation applications

The focus of Phase II was the customization of Zynx Health evidence-based plans of care for the Pinnacle organization and integration of the content of the plans in Siemens care planning and documentation applications. The project team chose six Zynx Care plans of care that addressed key patient problems at Pinnacle: pain management, prevention of surgical site infection, prevention of ventilator-acquired pneumonia, tissue perfusion, and fall prevention. Three teams of Pinnacle nurses including clinical nurse specialists, clinical educators, staff nurses, and an Information Systems nurse liaison were formed and each team customized two plans of care. The evidence-based plans provided by Zynx include comprehensive expected outcomes and interventions assembled using a strict evidence-based methodology. The plans also include evidence links to synopses of the evidence and classified references. The plans are available in a content management tool that supports creation of plan versions specific to a particular organization.

Results

The study showed that referential access to clinical knowledge provides the most value when there are numerous devices; access from any location within the clinical area; Google-type searches for clinical topics; contextual sharing of patient specific information; and access to "nurse dashboards" that provide access to evidence about common patient problems. Integrating the plans of care within the hospital information system revealed variations in data models between evidence-based knowledge sources and hospital information systems that exposed pre/post coordination challenges, requiring modifications in the codes used within the dictionaries in the hospital information system.

Phase I results

Results of Phase I included staff reports of the value of available evidence-based content in providing them with information they had forgotten or was new; variation in the frequency of using the links to access evidence; and, preference for evidence available during care provision, rather than during documentation. Phase I results also included observation of the critical importance of initial and ongoing involvement of the Chief Nursing Office as champion of the study as well as the Nurse Educators. Initial education regarding evidence-based practice and the study was provided by the Nurse Educators.

Phase II results

The teams of Clinical Nurse Specialist, Nurse Educators, bedside nurses, and informatics nurses who developed organizational evidence-based plans of care using the vendor model plans of care, content maintenance tools, and customization tool reported several key observations.

- First, they observed that the time to complete an organizational plan decreased to less than 12 hours compared to the previous approach that took several months.
- Secondly, they reported that the quality of the plans was significantly better because the plans were based on evidence developed with a strict methodology.
- Lastly, they reported the customization process itself was very positive because it engaged the members in interesting, clinically relevant discussions and fostered collaboration between Nursing and the Information Systems Departments.

Data on the impact of integrated evidence-based assessments and plan of care content included bedside nurse reported perceptions and quantitative data related to fall rates and frequency of pain reassessment. Bedside nurses reported that the integrated assessment and plan of care content expanded their knowledge; provided accessible information so that they did not have to go to books for needed information; and that the embedded content was accessible, detailed and specific, and provided the basis for more meaningful assessments.

Overall perception of the value of the evidence-based content implemented into plans of care for Pain – Acute, Mobility – Impaired, Infection – Risk of, Surgical Site Infection, and Falls – Risk of was favorable. Plans of care for Infection – Risk of, Ventilator-Associated Pneumonia and Tissue Perfusion – Cardiopulmonary, Altered were perceived to be less helpful to the end users' planning of patient care. Figure 1 depicts the statistical mean, based on a 6-point Likert Scale, regarding the end users' perceptions of the value of each specific plan of care content.

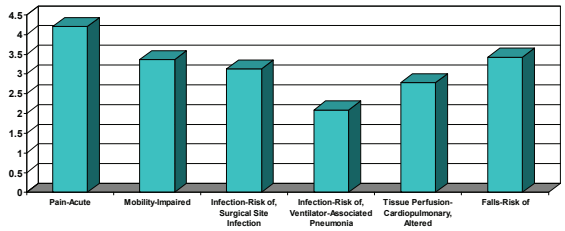

Figure 1- Value of specific content

In addition, it was observed that, following the implementation of integrated evidence-based pain assessments, fall risk assessments, and pain and fall risk plans of care, the documentation of pain reassessment improved from 76% to 94% compliance. Subsequently, there was a reduction in

the number of falls with sustained injuries noted in the organization.

Discussion and conclusion

This study demonstrated that positive value could be achieved through the integration of evidence-based knowledge within automated assessment and plan of care documentation, for use at the point of decision-making. The study fostered collaboration between clinical staff nurses and the information systems department and through this collaboration staff nurses were able to define with greater precision how structured data elements should appear to end-users in terms of form, order and context.

The study serves as a case example of a repeatable implementation model, starting with access to referential content while moving concurrently towards tighter levels of content integration within assessment and plan of care documentation functions. Success was contingent on five fundamental requirements: a strong partnership of the three organizations; strong nursing leadership, evidence-based content; tools to customize the content in accordance with institutional practices; a flexible hospital information system; and an inter-disciplinary team of experts from Pinnacle Health, Zynx Health and Siemens Medical Solutions. The implementation model can be replicated in other facilities.

Integration of Evidence-Based Nursing Content: A Collaborative Study

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A Collaborative Study

Mutual interest in better understanding methods of making evidence based content available to clinicians at the point of care.

- **Pinnacle Health**
  - **Community based healthcare system**
- **Zynx Health Inc.**
  - **Evidence-based clinical content provider**
- **Siemens Medical Solutions**
  - **Broad portfolio in healthcare IT and modality systems**

Study Objectives: 2 Phase Study

- Gain an understanding of the **technical factors** related to providing access to Zynx Health knowledge and evidence from within Siemens applications;
- Gather data regarding various **nurse users' reactions** to the availability of Zynx Health knowledge and evidence in these applications;
- Identify the **specific locations** within the clinical system interface from which Zynx Health knowledge and evidence knowledge provides value for nurses; and
- Identify **requirements related to the integration of nursing knowledge** within the electronic health.

Phase I Methods

Phase I: Referential Access

Provided Links from Siemens clinical systems to Zynx Health referential knowledge and evidence regarding four key quality indicators.

- Patient Falls
- Acute Pain
- Pressure Ulcers
- Smoking Cessation

Phase II Methods

Phase 2: Evidence Based Content Integrated in Plan of Care and Documentation

Customization of Zynx Health evidence based plans of care for the Pinnacle organization and integration of the content of the plans in Siemens care planning and documentation applications, for:

- Pain Management
- Prevention of surgical site infection
- Prevention of ventilator-acquired pneumonia
- Tissue perfusion
- Fall prevention
- Impaired Mobility

Phase I Findings

Executive Champion | Facilitating Practice Standards | Future Work

- CNO as champion support was required throughout the project – not just at the ‘kick-off’.
- Nurse Educators provided additional ‘face-to-face’ education individually with staff nurses – after the initial educational session.

Phase I Findings

Executive Champion | **Facilitating Practice Standards** | Future Work

Staff Nurse Perceptions

- Provided information they didn't know or had forgotten
- Provided evidence for the "new" information reflected in the literature
- Provided valuable information that is not sought out due to lack of time during care delivery
- Information was useful during rounds and shift report
- Information was accessed most during care provision

Phase II Findings

Executive Champion | **Facilitating Practice Standards** | Future Work

Staff Nurse Perceptions

- Embedded content expanded knowledge
- Information more accessible – do not have to go to books
- Embedded content
  - Understandable
  - More detailed, expanded
  - Provides more options

Phase II Findings

Executive Champion | **Facilitating Practice Standards** | Future Work

- Improved documentation of pain reassessment by 76% to 94% compliance
- Reduced number of falls with serious injuries

Pilot Overall Findings

Success was contingent on several fundamental requirements.

- Strong partnership of three organizations
- Strong nursing leadership
- Evidence based content
- Tools to customize the content in accordance with institutional practices
- Flexible hospital information system
- An inter-disciplinary team of staff nurses, advance practice nurses, and nursing informatics specialists

Pilot Overall Findings

- This study demonstrated that positive value could be achieved by providing access to evidence based knowledge at the point of decision making.
- Study serves as a case example of a repeatable implementation model for integrated evidence based content within the electronic health record.
- Nurses in this study shifted from task based documentation to knowledge-based decision-making.

- **Acknowledgments**

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Alberta WebSMR – The Implementation of a Synoptic Report for Cancer Surgery

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Abstract

Cancer Surgery Alberta worked with Alberta surgeons to examine the need for standardized cancer surgery guidelines within the province. Consensus was reached on the development of an electronic synoptic report to replace the traditional narrative report for cancer surgery. Minimum data sets were established by surgeons for each tumor group converted into a web-based surgical medical record (Alberta WebSMR). By working with Alberta health regions, surgeons, and Alberta Health & Wellness, synoptic reporting for cancer surgery was introduced throughout Alberta. This application has been successful in recording cancer surgeries and providing a method for access to real-time clinical outcomes data. Implementation will continue throughout the province and the number of active templates will increase. The Alberta WebSMR provides an opportunity for surgeon education, data to support decision making, and ultimately improved surgery for cancer patients.

Keywords:

cancer , surgery, synoptic, computer, operative report, outcomes

Introduction

Medical oncology services, including chemotherapy and radiation have long been centralized across Canadian provinces. Surgical oncology, on the other hand, has not met that same level of standardization. Due to the resultant lack of well-defined and readily available treatment guidelines and outcomes data in cancer surgery, the Alberta Cancer Board consulted with the Alberta Health Regions, the Alberta Medical Association, Alberta Health and Wellness, and the College of Physicians and Surgeons of Alberta to develop Cancer Surgery Alberta (CSA). Along with the Canadian Strategy for Cancer Control, CSA identified a need to establish baseline surgical information in order to better understand the current status of patient outcomes of cancer surgery and enable benchmarking of surgical outcomes. CSA obtained consensus from Alberta surgeons on the development preformatted templates and synoptic reporting that makes outcomes analysis possible. Minimum data sets were developed by the surgeons and a pilot study was conducted. Upon ascertaining that a web-based synoptic report was advantageous in providing a complete picture of cancer surgery, and thus benefiting cancer patients, a web-based medical surgical tool was developed and deployed in Alberta.

Methods

Cancer Surgery Alberta held consensus workshops to address the lack of cancer surgery guidelines. As a result of these meetings, data elements were established to create a computer-based synoptic report for rectal cancer. A pilot study was conducted to compare the feasibility of such a system to the traditional narrative report. The study looked at elements for abdominoperineal resection and anterior resection. Examining waiting times, resource utilization, staging, decision-making, guidelines, functional information, and the technical details of surgery, the findings from this initial study showed that the synoptic report captured 99% of critical information in rectal cancer versus 46% of critical information obtained from the standard narrative operative report (Edhemovic, Temple, de Gara, & Stuart, 2004 [1]). There is a paucity of information in the literature about synoptic surgical records because this is a relatively new concept. Intuitively clinicians and outcomes analysts believe that such records will offer considerable advantages. However, there is little empirical evidence reported in the literature to support this widely held opinion. The few studies reported in the literature are unanimous in identifying the advantages and superiority of synoptic reporting over traditional narrative reporting. (Dougherty, 1999 [2]; Edhemovic, Temple, de Gara, & Stuart, 2004 [1]; Hemmings, Jeffery, & Frizelle, 2003 [3]; Sleszynski, Glonek, & Kuchera, 1999 [4]) Other than the report of the pilot study of the current initiative (Edhemovic, Temple, de Gara, & Stuart, 2004 [1]), only one study was found that reported the use of synoptic reporting for surgery (DeOrio, 2002 [5]) and that study reported synoptic reporting in orthopedics. No studies were found that reported on oncology surgery. However, after consulting widely, CSA concluded that the current practice of

dictating operative reports was inadequate and needed to be replaced with mandatory reporting of certain data elements that could be most easily achieved by a standardized electronically-generated operative synopsis. CSA contracted an independent software consulting group to develop a web-based surgical medical record (WebSMR).

In order to develop a successful province-wide system, CSA had to develop a multi-disciplinary team consisting of clinical, technical, and administrative members from all health regions

and concerned organizations. This included surgeons, the Alberta Cancer Board, health records, Alberta Medical Association,

Alberta College of Physicians & Surgeons, cancer registry, information systems, and the operating room. Once a foundation was developed, a CSA steering committee was established to provide leadership in working towards all of the CSA Goals identified. In addition, tumour site working groups (TSWG) were established for the development of each template. These groups were composed primarily of surgeons that work in the tumour site area for which a template was being developed. The TSWG defined data elements and formatted their tumor specific templates, approved standards for data definitions, defined outcome queries for the database, and recommended implementation to specific surgeons and health facilities. The surgeons who generated these data elements were the cornerstone of a successful computer synoptic system. There were also several other requirements essential to the success of such a program. Physicians and executive members were involved from the beginning to ensure leadership and user uptake. Individualized training of all users at their own site, coupled with open communication and regular feedback to the end users, has also facilitated successful implementation. In creating a province wide system, it was important to establish Information Management Agreements, Privacy Impact Assessments, and security clearances with each individual health region. Each health region also created an implementation team consisting of health records, OR managers, and information systems. After a template was deployed, surgeons provided feedback and suggested changes to the data. These recommendations were catalogued and would be discussed with the TSWG at regular meetings. Approved changes would then be used to create a new version of a template, and all surgeons would be advised of the update.

The Alberta WebSMR is a technology solution that provides healthcare institutions with a simple electronic means of capturing standardized data points and generating synoptic post-operative surgical records. Its simple interactive questionnaire design makes it easy for surgeons to file consistent reports from any computer with internet access and is limited only to what the surgeon knows at the time of surgery. The heart of the Alberta WebSMR is the Survey Administration Module (SAM), managed by CSA. It is within SAM that the templates are created using the minimum data sets established by each tumor working group. SAM is a dynamic tool, allowing each template to be customized while permitting regular updates to the data sets based on surgeon requirements. It is also from SAM that CSA staff run quality assurance checks on the operative reports and distribute the reports to all interested parties in a timely manner.

To ensure successful user uptake, the Alberta WebSMR is as comprehensive as possible. The system is available from the hospital, office or any other location with an internet connection. A surgeon selects a pre-entered patient, completes a series of survey-style questions, and electronically signs the document, thus eliminating the need for transcription, cutting down review time, and providing the opportunity for surgeons to obtain real-time outcomes.

In order to maximize interoperability, the Alberta WebSMR has targeted integration to other health care systems using a standards based approach. Health Level Seven (HL7) is used as the means to define the electronic messages that Alberta WebSMR uses to send and receive data to other healthcare information systems. As the standard for interfacing clinical data in many institutions, HL7 offers simple communication with many other systems. The application currently uses HL7 2.x and therefore can be interfaced with health information systems that are in use today, with a future target of HL7 3.0. Within the HL7 messages that WebSMR sends, the Clinical Document Architecture (CDA) standard is followed when sending the WebSMR surgical report to other healthcare systems. CDA will be utilized to provide the post operative surgical report in its entirety as a document, thereby replacing the classic dictation style in updating provincial/regional EHRs. At the data element level, the use of structured clinical vocabulary is imperative to enable comparison across sectors and jurisdictions within a pan-Canadian EHR. Aligning with a more widely adopted clinical terminology standard enables more effective data aggregation and transfer across sectors and jurisdictions than the current consensus based clinical vocabulary standard of WebSMR. WebSMR data elements can accommodate to SNOMED Clinical Terms (SNOMED CT) as well as to CCI and ICD 10.

Once surgical information is collected by the WebSMR database, a data table can be exported to the preferred statistical application. As soon as a WebSMR report has been approved, the data can be analyzed through this technique. Reports can be generated based on individual, health care facility, health region, or date range.

Results

The WebSMR currently has six active tumor groups in use (colorectal, breast, liver, sarcoma, melanoma, ovarian), with over 500 reports entered by 20 surgeons in four health regions since 2005. An electronic health record interface is currently in production which will expand the number of health regions using the Alberta WebSMR from four to ten. Thus far, feedback from surgeons has been mainly positive. Regular meetings and communication with surgeons and other steering committee members has facilitated the refinement of the application, with development of new template versions, format changes, and improved work processes. Login issues and timely development of interfaces with other health systems have been the largest challenges.

There have been several aspects of the Alberta WebSMR that have received approval. Namely ease of use, reduction in chart review, and faster turnaround time for reports. Perhaps the strongest response has been towards the availability of outcomes. Waiting times can be determined based on decision date and surgery date, and reasons for delays are also monitored. Several areas directly related to the surgery are also recordable, such as preoperative testing (table 1), clinical staging, patterns of practice (table 2) and use of neoadjuvant therapies. Sample outcomes from the WebSMR can be found in Tables 1 & 2.

Table 1: Breast Cancer Method of Detection

	# patients	Patient (%)	Imaging (%)	Doctor (%)
DCIS	28	0	100	0
IBC	127	43	47	10

DCIS: ductal carcinoma in-situ; IBC: invasive breast cancer

Table 2 - Rectal cancer outcomes

	Abdomino-perineal Resection (APR)	Low Anterior Resection (LAR)
# Patients	18	48
Tumor 1-5cm	94%	6%
TME – Total	100%	63%
TME – Subtotal	0	37%
Loop ileostomy	0	44%
Margins <2cm	5%	0
APR Rate	17%	n/a

TME: total mesorectal excision

Discussion

Surgeon uptake of the Alberta WebSMR has been successful with a limited number of users in four health regions. By March 2008, the application will be deployed throughout the entire province, with an increase to ten health regions and potentially 250 users. Therefore, it is important to utilize user feedback to enhance the system at an early stage. Although login and interface issues have proved to be challenges to this point, these issues will be rectified in the near future. In contrast, the ability to review and sign-off a chart and the elimination of transcription have been met with positive review. Such features allow a surgeon to provide more time in practice and less time with administrative issues. Following successful implementation of the Alberta WebSMR throughout Alberta, CSA will examine the potential for adoption of the WebSMR by other surgical specialties in Alberta, other clinical specialties that would benefit from synoptic reporting, and other provinces across Canada.

The quality of surgery is now linked with significant short and long term outcomes, which mandates that we accurately record and measure our procedures. As such, the Alberta WebSMR offers an excellent tool to obtain real time outcomes with the ability to reflect changes in patterns of practice. It can demonstrate the capacity to analyze aggregated clinical outcomes data related to oncologic surgery with the capacity to influence the adoption of changes in practice by providing practice based evidence. Following the completion of an operative report, updated outcomes can be obtained for all aspects of surgery. For example, the method of breast detection can be determined and the results can be used to analyze the need for increased public education, improved imaging practice, etc (table 1). This analysis can prove beneficial to many facets of cancer surgery. The template that guides the surgeons as they record the data points was developed by their peers and is a subtle but potent educational means of disseminating and refreshing surgeons' awareness of cancer surgery guidelines. The Alberta WebSMR is an important educational tool for surgeons by providing them with a dataset with which to self evaluate by analyzing techniques or outcomes to identify areas where continuing education and training may be valuable. For example, a surgeon may compare personal APR rates to those of all surgeons as a whole (table 2) and draw conclusions about his/her practice measured against the norm. The delivery of timely, accurate, and aggregated surgical outcomes information also has the potential to be a powerful decision making tool for surgeons, health managers, and policy makers. For example, waiting times and reasons for surgical delays can be generated from the Alberta WebSMR. Communication of patient information is one of the barriers to reducing waiting times. Prompt reports providing information on these issues to the appropriate positions

will enhance patient care by follow-up teams and family physicians along with workload planning for the tertiary cancer care centres.

Conclusion

The WebSMR process has been highly successful in defining the elements of a cancer surgery, providing an educational tool for the participating surgeon and providing an efficient mechanism for outcomes assessment. Defining important elements will lead to standardized guidelines for cancer surgery in Alberta, and possibly Canada. In turn, the education of participating surgeons will be strengthened. Increased surgeon knowledge will ultimately benefit the patient, who will receive improved care. Likewise, decision-making outcomes will lead to better resource management within health facilities and improve availability of quality care for patients. Future integration with other areas of cancer care, such as pathology, radiation oncology, and medical oncology will provide an excellent opportunity to understand the biology of cancer.

Acknowledgments

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Intelligent Querying of Terminology Services: A Web-Based SNOMED© CT Servlet

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Abstract

Clinical terminologies are playing a major role in realising Electronic Health Records (EHR). These terminologies are becoming increasingly complex and comprehensive to enable more detailed recordings of the patient. This may increase quality of documentation but is also time-consuming and error-prone if a clinician has to navigate through a "jungle of codes" as this is often the case in current systems. The purpose of this paper is to show how the power and features of terminologies can be made accessible to the clinician. For this we developed a dynamic JavaServlet application, which provides access to intelligent SNOMED-CT search queries registered with Ocean Informatics' Terminology Server. The architecture of the Servlet and provided Webservices will enable interactivity between user and Terminology and thus reduce the time and effort required by clinicians when coding using clinical terminologies. As our JavaServlet application demonstrates, user-friendly querying of complex terminologies – even if they constantly change and are getting more complex – is possible. Our service-oriented, web-based architecture appears to be reasonably stable and sufficiently fast.

Keywords:

SNOMED-CT, terminology, Electronic Health Records, computerized medical record systems, openEHR, archetypes

Introduction

Electronic Health Record (EHR)

The characteristics of EHRs are in general as follows:

- Patient-centered
- Longitudinal, this means a long term record of care would be preferable, in the best case from the cradle to the grave
- Comprehensive, which includes records of all care events and all relevant measurements
- Prospective, this provides instructions and goals in healthcare for the patient.

To implement these EHR characteristics Information Technology (IT) is a powerful instrument. It enables efficient communication supporting a high level of Data integrity – once recorded available anywhere – Information must be of high quality, correct, complete, reliable and flexible. However, without interoperability, correct and trustful interpretation of the stored data might lead to more complex and variable processes imposing additional workload and sources of errors on clinicians [1].

A systematic collection of patient relevant data including what, where, how, when, why and who took and takes care of the patient will empower the quality of patient care. But it depends on how clinicians and carers can handle the provided IT systems, and thus on their usability. If the symbiosis between them increases, both, clinicians and IT systems will benefit from higher quality. Clinicians will make serious usage of IT features, and thus symbiosis and evolution will continue.

During the last decades there have been huge efforts in research and development of terminologies. To fulfill desired requirements of users, clinical terminologies have become more complex and comprehensive. There is a need to create applications, which can enable the usage of complex and comprehensive features. To our knowledge usability of complex and comprehensive clinical terminologies is quite difficult due to current IT solutions do not consider socio-technical aspects very well.

The aim of this paper is to

- Briefly identify common problems with clinical terminology
- Describe the development of a webbased application (JavaServlet), which enables access to intelligent queries implemented on a SNOMED-CT Terminology Server and thus overcomes some of the identified problems with clinical terminologies.
- Discuss how this use of clinical terminologies fits together with the use *open*EHR archetypes as models of clinical content.

Materials and methods

To reach our goal, we had to investigate available resources, instruments and which applications and tools are compatible for our purpose. From a technical point of view, we tried to find the most innovative solution with the best performance for the development of the application in discussions together with members of Ocean Informatics, by studying specifications and manuals and developing prototype systems to experiment with specific approaches.

*open*EHR *and Archetypes*

For future-proof development of EHRs representation, context and semantic integrity are essential. The *open*EHR and Archetypes approach can cope well with this issue. *open*EHR is originally based on the GEHR projects (Good European/Electronic Health Record). The aim is to support the communication and availability of routine data and development of EHR. It focuses on data and semantic interoperability of complete EHRs. An Archetype is a smart specification which can represent one complete clinical concept by separating clinical data collection from the record keeping concerns. E.g. a blood pressure archetype represents a description of all the information a clinician might want or has to report about a blood pressure measurement [5].

Ocean Terminology Service (OTS)

According to the product specification OTS, consists of three components, Terminology Service, Terminology set query editor and application widget for clinical application use. The terminology service restricts the set of possible terms used to populate a given data field based on the constraints expressed in archetypes - while allowing browsing of the terminology within this knowledge environment. OTS is highly scalable and supports the comfortable usage of complex terminology in clinical areas [6] in our case SNOMED-CT. In this paper we use OTS to access SNOMED CT queries via webservices.

SNOMED-CT Model

The SNOMED-CT concept model supports both pre- and post-coordinated concept expression. Post-coordinated means, that an expression which is sufficient to define a concept representation but which has not been assigned a name by being used in a definition. Pre-coordinated is a named concept representation, which is either defined, or not. The fundamental design of the SNOMED CT concept model refers to the way in which the concepts in SNOMED CT are defined and related to one another. This includes features and limitations about concepts, relationships, characteristics and roles. Within the constraints of the Fundamental Concept Model Design, the way that particular attributes are applied has a significant impact on the way that SNOMED-CT concepts are defined and the ability to compare them. This includes the use of specific sets of released attributes for findings, context model attributes providing additional defining characteristics for context dependent concepts and role hierarchies [7].

Results

In the following, we will describe the mechanisms our Servlet uses and the concepts it is based on. These mechanisms solve typical problems inherent in many clinical terminologies as the following brief literature review about typical problems in clinical terminologies reveals.

Terminology

Clinical terminology concerns the meaning, expression, and use of concepts in statements in the medical record or other clinical information systems. During the last decades there have been huge efforts solving problems of standardizing medical language and terminology but it is unknown if the development and research will ever succeed in this case [2]. In this paper, Rector also mentioned 3 assumptions about the context in which terminologies are being used:

- The purpose of clinical terminology is to support clinical software
- All terminologies will have to support conversion to existing reporting and epidemiological coding schemes
- All terminologies will need to be multilingual

The more specific the terminology, the more complex and comprehensive its vocabulary in a given area. E.g. there are two kinds of burn – thermal, chemical – and 200 body locations, using pre-coordination we would get 400 codes for burns. If we add 3 thicknesses plus unspecified we have 1.600; if we add three extents plus unspecified we have 6.400; add three levels of recency plus whether or not the burn is complicated by infection the total amount will rise to 76.800 codes only for burn. Another problem is a fundamental conflict between the needs of users and the requirements for developed software. The way humans and machines process information is very different. Machines with their digital processing capabilities are intolerant, fixed and not flexible compared to human beings with analog data processing [2].

Above we have focused on the issue of "what" the terminology can express, but what is about "how" the terminology can express its content and how the vocabulary is organized in it. Cimino [3] describes 2 approaches. One is a systematic case description by choosing the suitable term. A Fracture for example – in the first round you choose between simple or compound, in round two you decide between greenstick, avulsion, compression etc. This avoids nonsensical combinations and avoids the large numbers of terms occurring through the explosion of combinations.

Another approach will allow the user compositional extensibility by combining all the atoms of the terminology into necessary coded terms. The problem within this alternative is, that the atom cannot only consists of its letters (e.g. the word / atom *"White"*) there is a need to add a characterization. For example with the atoms *"White"* and "*Conjunctiva"* you can formulate the term "*White Conjunctiva",* but how would you formulate "Wolff-Parkinson-*White* Syndrome"? [3]

By reading medical informatics research, Terminology-systems tend to dealing with the notion of concepts. That means, that each individual term refers to an individual meaning [3].

Afterwards many vocabularies and terms are organized into strict hierarchies. For example a concept with the unique identifier/code 1000 might be the parent of the concept with the code 1200 which might be the parent of the concept 1280 and so on. With computer interfaces querying for members of a class or concept become easier (search for "all codes beginning with 1" will retrieve codes 1000, 1200, 1280). But within a polyhierarchical terminology where one concept can also belong in more than one location in the hierarchy, a single hierarchical identifier is no longer possible. Therefore is it desirable, to have the unique identifiers for the concepts which are free of hierarchical or other implicit meaning. [3]

Now search routines have to be smart enough to cope with these complex hierarchical and concept identifiers. Nevertheless, front-end terminology applications (like terminology browsers) have to be simple, easy to handle and smart enough to identify what information the user requires in what context.

Terminology browsers allow users to search and navigate through the terminology without necessarily providing editing capabilities. E.g. MicroMeSH was one of the first tools created for interacting with complex standard terminology. This program provided a search assistant with a rich set of lexical look-up facilities and a tree walker to support navigation through terminology.[4]

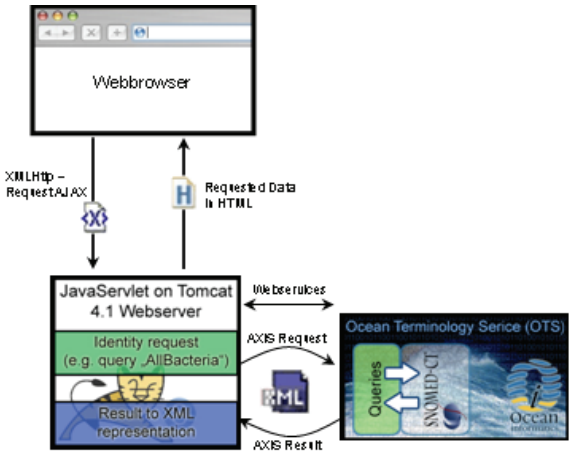

Figure 1 - Overview of the system architecture

After we made us familiar with typical problems of clinical terminologies for our development solutions and concepts have to be found, which overcome some of the problems mentioned above and can lead to innovative results. For development and research in this case, problems in interoperability have to be solved and the openEHR Archetype approach can lead to solutions. As the openEHR and archetype approach does not rely on big standardized terminologies but on "micro-vocabularies", it offers more flexibility during standardization and translation of clinical concepts and overcomes some of the shortcomings of terminology-focused approaches. Terms within an archetype can be bound to or constrained by any number of terminologies or, if highly specific to the archetyped concept, be specified within the archetype itself. To SNOMED-CT, archetypes provide the required structure for clinical concepts. Each term can be bound to a SNOMED-CT concept to specify explicitly that the archetype term and the SNOMED-CT concept have the same meaning. In addition each archetype term that is a text can be constrained by a terminology like SNOMED-CT, ICD etc., e.g. the allowed values (value set) for a diagnosis text in the archetype could be constrained by the appropriate subset of a terminology that deals with diagnoses. Archetypes in contrast to terminologies specify groups of data that as a whole are whole, discreet, highly related and clinically meaningful concepts like a blood pressure measurement consisting of the diastolic and systolic blood pressure, but also of any other information relevant for the interpretation of the readings, e.g. the position of the patient during the measurement [1].

The Servlet

In general the Servlet represents an interface between user and implemented Webservices for querying SNOMED-CT on OTS (Figure 1). The Servlet can manage two kinds of incoming data. First, information about desired commands

or queries, which will be handled within the application so desired processes can take action on OTS. In our case Webservices enable queering SNOMED-CT will be processed. After calling, OTS delivers results to our Servlet application which interpret and represents these in HTML via Webbrowser. As a consequence of this design, Bacteria for example, which are defined in Snomed CT at various locations, can be pulled together and presented coherently for a specific purpose.

It was quite difficult to access our desired information because of the abundance of different technologies and standards. In the following we present an approach to realize such an interface. The Webservices on OTS are based on .NET® and they are SOAP1 and SOAP2 compatible (SOAP: Simple Object Access Protocol) With SOAP you can exchange information between different systems. This technology is comfortable because it provides platform independency. The existing Archetype Finder (http://www.archetypes.com.au) already provides Apache AXIS1 based Webservices (Axis: Java and XML based Webservice framework, comfortable for creating interoperable applications). A couple of other specifications and tools like AXIS2, XINS (XML Interface for Network Services), JWSDP (Java Web Services Development Pack) and XFire were investigated, but AXIS1 was the easiest way to fulfill our motivation with a stable suite of webservices and we therefore used AXIS1 Technology also in our application. In addition, we chose a Tomcat 4.1 Webserver with JRE 1.4 (Java Runtime Environment).

AJAX(Asynchronous JavaScript + XML) and servlet functionality

To support high performance during querying the AJAX Technology provides the most suitable transmission architecture in our case. The big advantage of this Technology is in the *"XMLHttpRequest"* Object, which is responsible for transport of commands or actions a user wants to run on the Servlet. The Servlet connects to the Webservices on OTS and lists all available queries. The requested Data collected by the processed query will be represented as HTML by the Webbrowser (Figure 2).

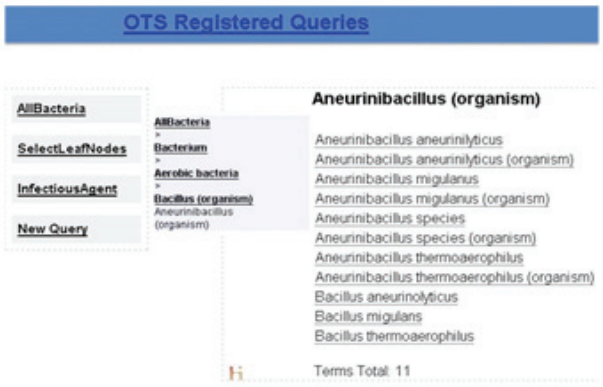

Figure 2 - The servlet in a web browser

To call a command on OTS for example to list all bacteria, we needed the definition of the Webservices on OTS. For programming the Servlet to transmit the required commands and information, the provided WSDL-file on OTS has to be converted to Java Classes by the open source tool CASTOR (so that the Servlet can take action). Now the "highway" to the Webservices is prepared, but we do not know what kind of vehicles (datasets) can drive on it to reach the Webservices. OTS defined the datasets by XML-Schemas (XML: Extensible Markup Language). The Webservices accept two different datasets: registered queries and defined terms. To implement and prepare the Servlet, CASTOR needs to be used again. After all these conversions the Servlet is able for correct interactivity and interpretation with the Webservices registered on OTS. Figure 3 shows all available queries. For example "*AllBacteria*" is a registered Query, which lists all Bacteria within the SNOMED-CT. All entries are grouped, so comfortable top-down navigation between the levels is given. First we can choose between different types of Bacteria. For example if we want to know all available entries of "Aerobic bacteria" (Figure 4) the AJAX engine will deliver a command to the Servlet to go one level deeper into "Aerobic bacteria". If you want to navigate one ore more levels higher AJAX will transmit a "go up" command to the Servlet. As you can see with AJAX is it possible to query only the requested data, this means the Servlet has not to re-query and rebuild already presented data and information.

These search routines, queries and navigation of the Servlet in cooperation with OTS Webservices will deliver fast and situation–specific results for clinicians and care professionals.

Discussion

The more detailed and specific terminologies are, the more complex and less comprehensible they get. Research of

terminologies provides huge potential for new and innovative approaches, but actually we are not able to define what will be the most suitable direction for the future [2]. However, we have to find ways and solutions to enable all features provided by terminologies, therefore considering socio-technical aspects of usability will lead to future orientated results. Without intelligent search strategies and navigation concepts, we believe that growing clinical terminologies are no longer handable leading to suboptimal quality of documentation. To prevent a lack of quality *open*EHR decided in cooperation with Ocean Informatics to construct services and applications, which can cope with the evolution of terminologies. As mentioned in results the *open*EHR archetype approach offers more flexibility and overcomes some of the shortcomings of terminology-focused approaches ([1], [5]).

Further, *open*EHR and Archetypes grant interoperability achieved by the 3 level definition. The *open*EHR reference model alone ensures syntactic (data) interoperability. Structural interoperability is achieved by the definition and use of archetypes. E.g. a blood pressure archetype will have the same meaning no matter where or in which EHR it appears. The third level describes semantic interoperability. In addition to archetypes and the reference model, archetype development must be coordinated through systematic governance. Incompatible, overlapping archetypes expressing the same concept for example have to be avoided[1].

An archetype specifying SNOMED-CT terms by including our Servlet is now available in EHR and can share its clinical knowledge and information can be safely interpreted by exchanging archetypes.

In our case all employed tools and programs to generate our Servlet served the purpose and provided correct and reliable results. The Servlet is running stable. The implementation of the AJAX Engine supports a convenient and easy to use search routine. It works quite similar to the *"GoogleSearch bar"*. If your cursor is in the search field and you are typing an "A", a list of available criteria starting with "A" will be shown nearly instantly.

Figure 3 - Registered Queries

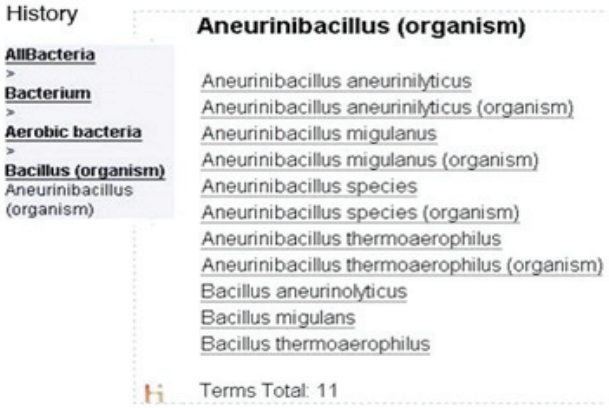

Figure 4 - JavaServlet querying "AllBacteria" on OTS; History box lists visited subcategories of "AllBacteria"; underlined terms processes to go down one more level and list terms

This proof of concept shows that the Servlet can enable available Webservices and queries on OTS and by these means improve the usability of clinical terminologies. The advantages of this approach are the following: First, the Servlet is flexible and dynamic, so there is no need to alter any parameter if queries are changing or moving. The second advantage is due to the web-based concept with a service-oriented architecture, which enables effortless integration into EHR applications. Together, this eliminates the need for directly integrating (hard-coding) clinical terminologies into software and the need for upgrading the software when the clinical terminology changes.

With regard to performance, to make our approach future proof, we need to explore the following approaches:

- Caching Results
- Cache Clustering (locate already loaded Data in cache of other users)

- Server Mirroring

The next goal will be the transport of required data into EHR applications. There is a huge range of possibilities and we will do research to find the most suitable one.

Conclusion

By means of our Servlet we were able to demonstrate that user-friendly querying of complex terminologies – even if they constantly change and are getting more complex – is possible. The technologies chosen for this purpose (Java Servlet technology, AJAX, AXIS in a service-oriented, web-based architecture) appear to be reasonably stable and sufficiently fast.

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Integration of Clinical Data to Support HIV Research

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Abstract and objective

Over the last 20 years computer science and medical informatics have evolved so that real-time data collection is now possible in the clinical practice setting, at the point-of-care. In 2004, we build a system to integrate HIV clinical data from six sites around the United States, developing an integrated clinical research cohort. The architecture and current status of the system will be described.

Keywords:

HIV, AIDS, data integration, CNICS

Introduction

The CFAR (Centers for AIDS Research) Network of Integrated Clinical Systems (CNICS) project is the first EMR-based resource network that will contribute to the contemporary HIV research agenda, and was implemented in 2004. As a clinic-based research network, CNICS directly reflects the outcomes of clinical decisions and management options made daily in the care of HIV infected individuals. Previous observational cohort studies have used structured data collection at three or six month intervals and medical record review to abstract relevant clinical data.. Unlike data collected in structured interviews or through retrospective medical record review, CNICS allows a broader range of information associated with the rapidly changing course of HIV disease management through collection of data at the point of care. The challenge for research using data from different care systems is to collect data with uniform definitions and quality. The CNICS project supports a data system that is a central repository of verified and quality-controlled data from the EMRs at six CFAR sites (the Universities of Washington, Alabama, & California/San Diego & San Francisco, Case Western Reserve, & Harvard/Fenway) EMR data are standardized and are thus available for population-based outcomes research.

Methods

Overview of the CNICS system

CNICS was built as a relational database using MySQL. The CNICS system uses a normalized relational database (SQL), Extended Markup Language (XML), and JAVA. The database server is secured with standard techniques including: strong access controls; institutional IT-support; software firewall; secure file transfer protocols; daily differential and full back-ups as well as off-site secure storage of backup media; and network-wide virus protection software. CNICS data are transmitted to the central repository using password-protected, encrypted, secure file transfer protocol. The automated parser-translator framework has been developed for demographics, clinical diagnoses, laboratory test results, and medications.

Results

The sources of data within the CNICS repository are the EMR systems at each participating CNICS site. While the EMRs at the six sites were developed independently, there is significant commonality among data elements across sites including clinical diagnoses, laboratory results, and medication data. The challenge of the CNICS project is to integrate clinical data from EMRs with uniform definitions, standards, and quality at the site level and within the CNICS repository. Therefore, a primary focus of the CNICS project has been establishing standards for terminology, format, data verification and quality assurance procedures for the CNICS group that can be used by other sites as they develop local EMRs.

CNICS contains fully integrated data on 9,311 patients, the majority of whom enrolled in the cohort after 1996 and thus, have been under care in the HAART era. Median follow up for the cohort enrolled through 2002 is four years. CNICS contains 3,210 unique observed AIDS-defining events since January 1, 1995. Among the patients in the CNICS Cohort, 3,435 (37%) had been treated with HAART (PI- or NNRTI-based regimen) prior to initiating care at a CNICS site and 2,715 (29%) received their first HAART regimen while in care at a CNICS site.

Conclusion

CNICS is a successful and unique resource for HIV clinical, translational, and basic research, poised to address the challenging and evolving issues in HIV care and research.

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How to Represent the Medical Annotations?

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Abstract

The medical practice needs an important collaboration of the health care professionals. This collaboration must be improved by efficient exchanges of information. Annotations (post-it, comments) are one of the strategies used by the practitioners to communicate in an informal way. In this paper, we want to describe precisely these annotations. This model can be used to design electronic settings (indexing or laying out annotations according to various points of view).

Keywords:

annotation, collaboration, electronic health record, knowledge engineering, patient safety, quality of care

Introduction

Health care professionals (HCP) use the paper and electronic documents of the health records to keep traces of their communications and of their acts. Most of the time, on paper, the documents are annotated. Indeed, the documents are structured and they are not sufficient for all the comments. Consequently, practitioners use annotations (post-it, comments) to communicate in an informal way. They have similar difficulties with the electronic documents but unfortunately the existing annotation tools are not sufficient. The purpose of this paper is to describe precisely these medical annotations for integrating them in the electronic settings.

Methods

In the DocPatient[1] project, we studied the existing annotation tools. We compared their functionalities with the paper practices of annotations. We chose 6 functionalities and we implemented them in the DocAnnot model [1]. We evaluated this tool with 20 practitioners. This evaluation allowed us to improve our tool and to understand how annotations are necessary for the HCP' collaboration. But we still need a better description of these annotations to represent and display them in our system.

We also collaborated with the LAMIH[2] who have similar problems when they study the semi structured information written in a textbook by the nurses during home care activities. We described in [2] a conceptual model of these communication notes. We propose four interpretation levels (contextual, perlocutory, locutory/illocutory and collaborative) to organize the concepts used when a note is produced or read.

In this paper, we apply this model to describe more in detail the annotations, which are a particular type of communication notes. Our aim is to answer to the following questions basing us on the notion of discourse structure, speech acts and collaborative activities:

- **Contextual level:** What is the context which leads the author to produce an annotation? Who is speaking or writing or drawing? when? Where? for who?
- **Perlocutory level:** In which way does the author want his annotation to be used and how the reader uses it?
- **Locutory/illocutory level:** What are the means used by the author's annotation to transmit his message? Which target? anchor? form?
- **Collaborative level:** What is the impact of the annotation on the activities?

Results

Contextual level: A medical annotation is written in a *spatio-temporal framework of creation* and is read in a *spatio-temporal framework of reading* (at a particular date, in the patient's room...). The *annotator* is a writer who belongs to the medical team (a physician, a nurse...). The annotator writes the annotation for one or more *targeted readers* (the annotator himself, several member of the medical team...) but, as the health record remains in the patient's box, all the medical workers are *potential readers*. The *real readers* are readers which can be targeted, potential or *collateral readers*. The *collateral readers* have not been envisaged by the annotator as a computer scien-

1 The DocPatient project (2002-2005 University of Amiens) is financed by the Picardy region. We worked with a pilot site (paediatric intensive care and neonatal medicine) and an industrial partner (UNI-MEDICINE).

2 http://www.univ-valenciennes.fr/LAMIH/

tist who studies the health records. An annotation deals with an *object of communication*, a topic.

Perlocutory level: The annotator produces a note according to an *intention of use*. We distinguished two objectives: (i) *the annotator writes the note for himself* but he can communicate the note according to the needs of the organization members (memos, personal notes, reports of actions, links); (ii) *the annotator writes the note according to an intention of communication for one (or several) targeted readers* (daily instructions, transmissions, requests for information, emphases of information). In addition, an annotation can correspond to several intentions of use. For example, a physician wants to *draw the attention* of the fellows by *linking* documents. Moreover, in the medical context, most of the annotations are written to collaborate. Consequently, most of them are *incidental reflections* which are not inevitably related to the documents but to the activities described in them.

Locutory/illocutory level: To annotate, the practitioners choose a *target* which can be can be a collection of documents, a document, a part of a document (a paragraph, an image…), or another annotation. He also chooses an *anchor* which links the annotation to the target (a line, a surrounded sentence…). Finally, he writes a *contents* which is a trace of one of his mental representations elaborated about the target. He adds a layout, a *shape* to this content (bold, coloured sentences...). The content of the annotation has an *illocutory force*, it can be used to achieve an act. Austin distinguishes the constative and performative utterances. The constative utterances assert or state something that can be judged as true or false and the performative utterances perform the actions mentioned rather than express a proposition about it. In the medical annotations, we rarely find constative utterances, but we find them in the documents to describe the patient's state. On the contrary, we find performative utterances in the annotations and in the documents because the practitioners use the annotations to keep traces of the actions which have been carried out or which will be carried out.

Collaborative level: To describe the annotations, we also used a collaborative point of view: the Hoc's architecture of collaboration [4] which proposes three levels: action, plan and meta-collaboration. We use the example of a physician who sticks a post-it "BG in two hours" to describe this three levels.

- **Action level:** When the physician sticks the post-it, he deliberately *creates a local interference*. The post-it facilitates his own task. The others worker are aware of his activity and will not schedule a care at the same time. The post-it also make easier the tasks of the others practitioners, who can be disturbed by this new task. A nurse reads this annotation and *detects the interference*. She had scheduled the bath of the child at the same time. She *identifies the goal of the annotator*. He wants to supervise the evolution of the blood gas. She *solves the local interference* by delaying the bath.
- **Planning level:** The nurse *updates her representation* of the child. She understands that the physician wants new blood gas because the child is ill. She also *updates her representation of the controlled process* (the evolution of the child's state) and *her representation of the controlled activity* (the cares). For that, she readjusts her *representation of the common goal* (to keep the child in a stable state), of the *common plan* (the blood gas have priority on the other cares) and of the *distribution of the tasks* (she must prepare the material for the physician).
- **Meta level:** The nurse uses the vocabulary of the field, a *common code*, to associate the abbreviation "BG" with the meaning "blood gas". In order to have a *representation* compatible with the physician's representation, she translates the post-it which is written according to the physician's level of expertise in her own level of expertise. To finish, she *updates his own representation and his representation of her partners*. She's used to work with the physician, so she can infer on the aim of this new BG. She also knows what the physician expects from her (to prepare the material).

The complexity of the collaborative activities must be underlined. A fellow analyses the same comment from another point of view and this note can induce others activities.

Discussion and conclusion

Usefully managing and laying out annotations is a challenge because their informal and unforeseeable nature makes them difficult to handle. Their description according to multiple points of views is a solution to consider their multiple facets. Our model is coherent with the implementation of our annotation tool dedicated to the electronic health record and will be easily integrated. Moreover, this representation is also satisfactory in respect of the evaluation carried out with the HCP. We of course need to collect more data to evaluate this model with various medical specialties. The following step consists in building a computational model directly usable by electronic settings, for example, to index the annotations or to lay out them according to various points of view. We evoke the possibility of building an ontology to represent this model. To conclude, a detailed modeling of these annotations allows not only their computerization but also their integration in the complex process of medical information management. The originality of our modeling comes from the way we take into account of some collaborative knowledge.

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How to represent the medical annotations ?

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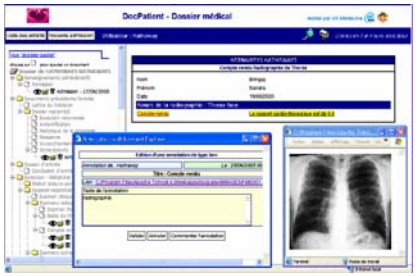
Introduction/Background: DocPatient Project

- **Initial report:**
  - Need of annotations to support the collaboration of the health care professionals in the documents of the health record

- **Methods:**
  - Study of the existing electronic annotation tools and comparison of their functionalities with the paper medical practices of annotations
  - Selection/Implementation of 6 functionalities in a model
  - Evaluation of the model with health care professionals



- **Results:** Specification of an annotation tool dedicated to the electronic health record to **support collaborative practices** [1]

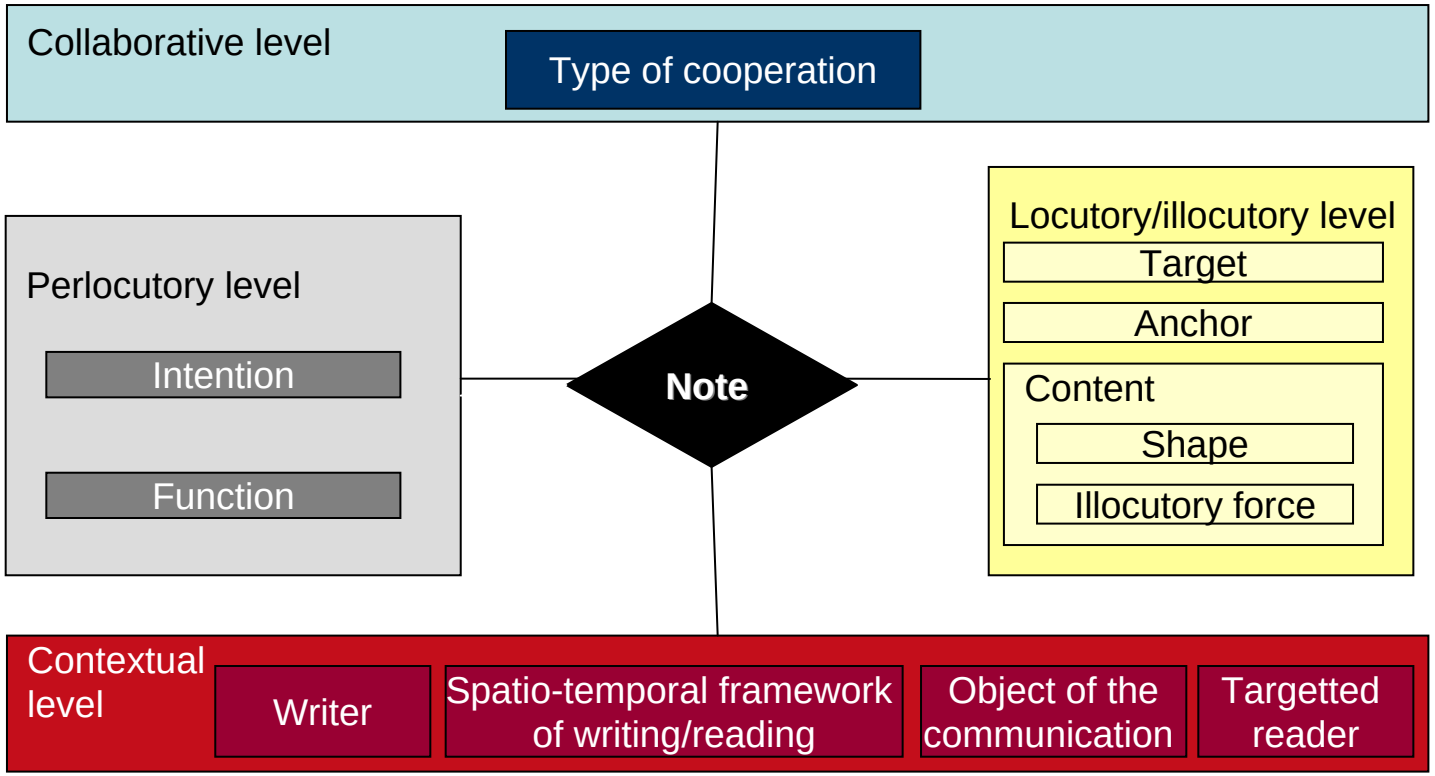
- **Need: A better description of these annotations to represent and display them in our system**

Introduction/Background: Collaboration with LAMIH

- **Initial report:**
  - Need of a description of the medical information

- **Results:**

4 levels to describe medical information [2]

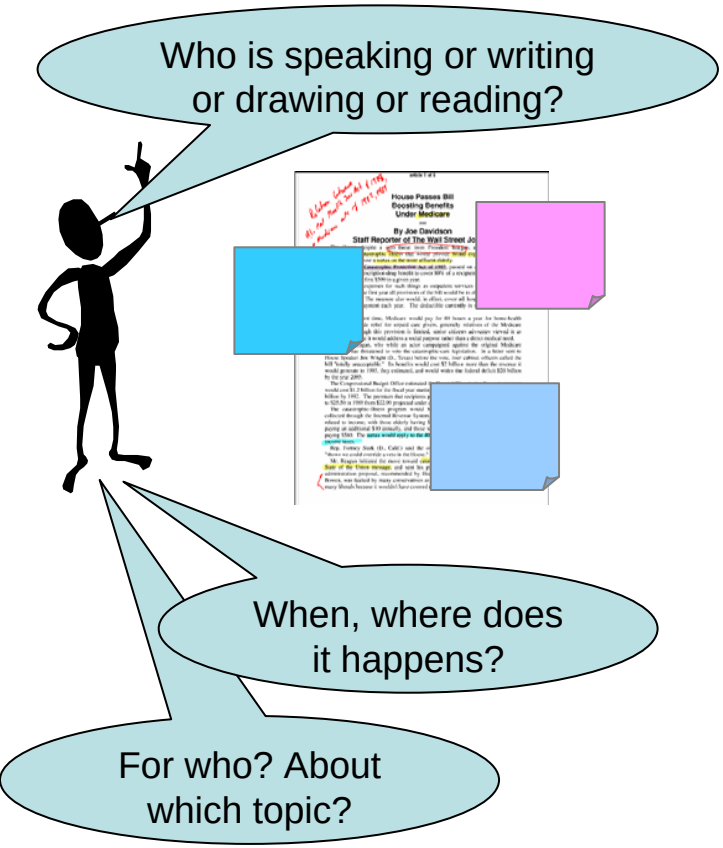


Objectives

- To improve collaborative practices
- Need of a detailed description of the annotations for a better integration in the Electronic Health Records (indexing and layout according to various points of view)
- Application of the model of the communication notes to the annotations of the health care records

Results: Contextual level

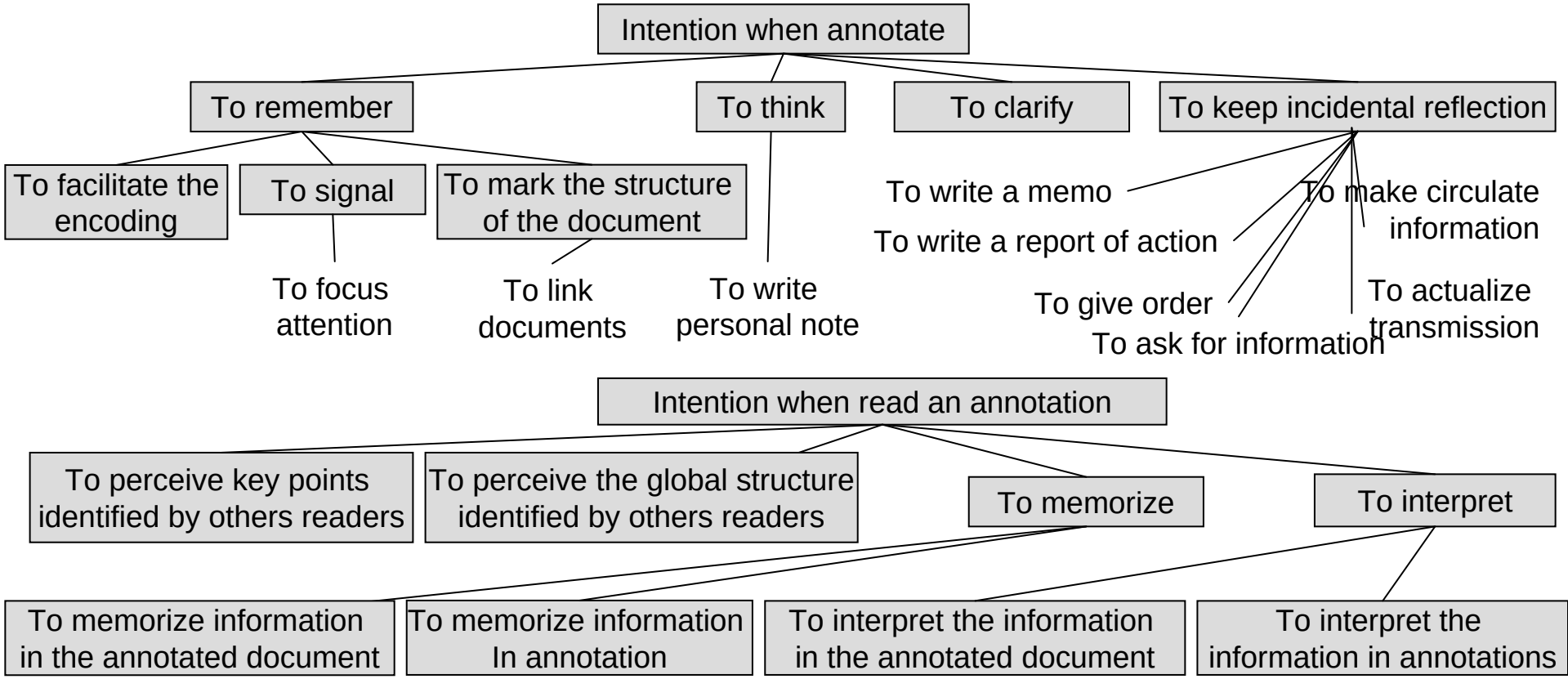
Contextual level: What is the context which leads the author to produce an annotation and what is the context which leads a reader to interpret it?



- ***Spatio-temporal framework of creation/reading:*** at a particular date, in the patient's room, in the physician's office...
- ***Annotator:*** writer who belongs to the medical team (physician, nurse, fellow...)
- ***Targeted readers:*** the annotator himself, one or several member of the medical team, the family...
- ***Potential readers:*** as the Health Record remains in the patient's box, all the medical workers
- ***Real readers:*** targeted, potential or ***collateral readers*** (readers who have not been envisaged by the annotator e.g. computer scientist who studies the Health Records)
- ***Object of communication***, a topic (patient's state, care planning)

Results: Perlocutory level

Perlocutory level: In which way does the author want his annotation to be used and how the reader finally uses it?



Results: Locutory/illocutory level

Locutory/illocutory level: What are the means used by the author's annotation to transmit his message? How does the reader interpret it? Which target? Anchor? Form? Illocutory force?

- ***Target:*** collection of documents, a document, a part of a document (a paragraph, an image…), or another annotation
- ***Anchor:*** link between the annotation and the target (a line, a surrounded sentence…)
- ***Contents:*** trace of one of the mental representations of the annotator elaborated about the target
- ***Shape:*** a layout added to the content (bold, colored sentences...)

This table gives the percentages of the practitioners who use annotations by professions and by types of annotations

	Physician	**Fellow**	**Nurse**	**Ad agent**
Post-it	80%	80%	80%	100%
Comment	100%	80%	100%	60%
Mark	100%	80%	80%	100%
Personal note	100%	100%	40%	100%

Results: Locutory/illocutory level

Locutory/illocutory level: What are the means used by the author's annotation to transmit his message? How does the reader interpret it? Which target? Anchor? Form? Illocutory force?

This table classifies the types of annotation according to the classification of speech acts mainly used to formulate the content

- ***Illocutory force [4]:*** action associated to the speech act (directive, commissive, declaration, representative)

Personal annotations which can be published	
Memo	Directives, Commissives
Personal note	Declarations
Report of action	Declarations
Link between documents	Representatives, Declarations
Emphase of information	Representatives, Declarations
Annotations writen to be published	
Order	Directives, Commissives
Transmission	Representatives, Directives
Request for information	Directives
Circulation of information	Declarations

Result: Collaborative levels

Collaborative level: This level exists only if the annotation is produced in the context of collaborations. What is the impact of the annotation on these activities? The reader integrates the annotation in his own tasks and he interprets it according to the various levels of collaboration mentioned by [5]

- **Example:** a physician sticks a post-it "Blood Gas in 2 hours"
  - **Action level :**
    - When the physician sticks the post-it, he deliberately ***creates a local interference*****.**
    - A nurse reads this annotation and ***detects the interference*****.** She had scheduled the bath at the same time.
    - She ***identifies the goal of the annotator*****.** He wants to supervise the evolution of the blood gas.
    - She ***solves the local interference*** by delaying the child's bath.

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- **Example:** a physician sticks a post-it "Blood Gas in 2 hours"
  - **Planning level :**
    - The nurse ***updates her representation*** of the child. She understands that the physician wants new blood gas because the child is ill.
    - She also ***updates her representation of the controlled process*** (the evolution of the child's state)
    - and *her* ***representation of the controlled activity*** (the cares given to the child). For that, she readjusts her ***representation of the common goal*** (to keep the child in a stable state), of the ***common plan*** (the blood gas have priority on the other cares) and of the ***distribution of the tasks*** (she must prepare the child and the material for the physician).

- **Complexity of the collaborative activities:** A fellow analyses the same comment from another point of view and consequently, this note induces others collaborative activities.

Discussion, Conclusion and Prospects

- **Usefully managing and laying out annotations** is a challenge because their informal and unforeseeable nature makes them difficult to handle.
- Their **description according to multiple points of views** is a solution to consider their multiple facets.
- When an annotation is described according to different the items of our model, an agent (man or machine) has the necessary knowledge to effectively use, exchange and lay out it.
- A detailed modeling of these annotations allows not only their computerization but also their integration in the complex process of medical information management.
- This **representation is coherent with the implementation of our annotation tool** dedicated to the Electronic Health Record and will be easily integrated.
- Moreover, this **representation is also satisfactory in respect of the evaluation** carried out with the Health Care Professionals.
- The originality of our modeling comes from the way we take into account of some **collaborative knowledge** which are not often used to build collaborative tools in medical situations.

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  - [4] J.M. Hoc, Towards a cognitive approach to human-machine cooperation in dynamic situations. IJHCS, 2001: 54: 509-540.

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Aligning HL7 CDA and CDISC ODM

An Experiment in Cardiovascular Radiology

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[C]*CDISC Board of Directors and Sanofi-aventis R&D, Bagneux, France*

INSERM : U872 – team 20

- INSERM : Institut National de la Santé Et de la Recherche Médicale
  - French National Institute for Health and Medical Research (Ministry of Health & Ministry of Research)
  - 13,000 people (6000 researchers) - 360 units
    - 85% housed within university hospital or cancer treatment centers
- U872 – team 20 : Knowledge engineering in Public Health and Medical Informatics
  - Methods and tools allowing modelling, formalizing, and acquiring medical knowledge in order to develop knowledge based systems in medicine

AP-HP Patient care

- Most important French University Hospital Organization with
  - 1,000,000 hospitalized patients
  - 38 hospitals with round 23,000 beds + 1400 day care and 850 home care capacity
  - 90,000 employees including 19,000 physicians
- Single HIS/EHR: CareByThales® (Thales©) (2009)

Clinical information
Nurse notes
Discharge summaries, DRGs
Flow sheets, Care plans
Medical order
Imaging reports
Lab results

Patient focus
(Point-of-Care)

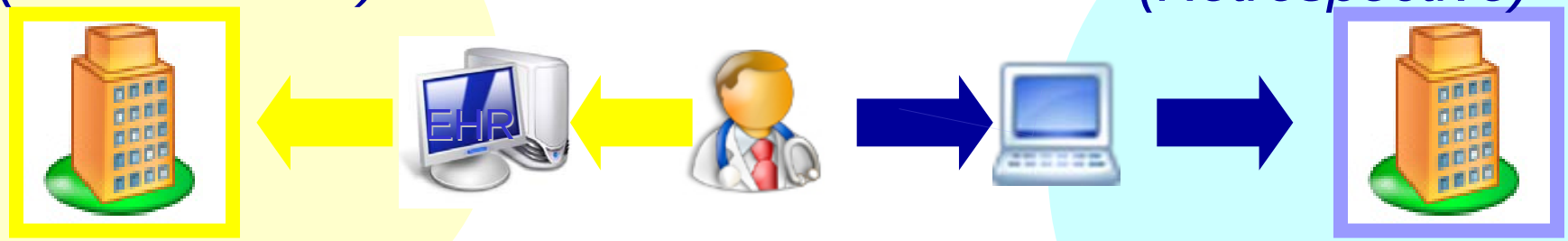
EHR

Context and problems
Redundant data entry

- Clinical data of EHR are not commonly used in clinical research

Patient focus (Point-of-Care)

Population focus (Retrospective)



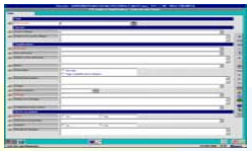
EHR : DxCare ® (MEDASYS ©)

Multiple applications
Multiple data forms
=> Redundant data entry

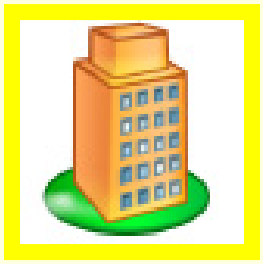
CDMS : Air On Line (AOL)® (KIKAMEDICAL©)

Objective
Single data entry for multiple uses

Patient focus
(Point-of-Care)



Population focus
(Retrospective)



EHR

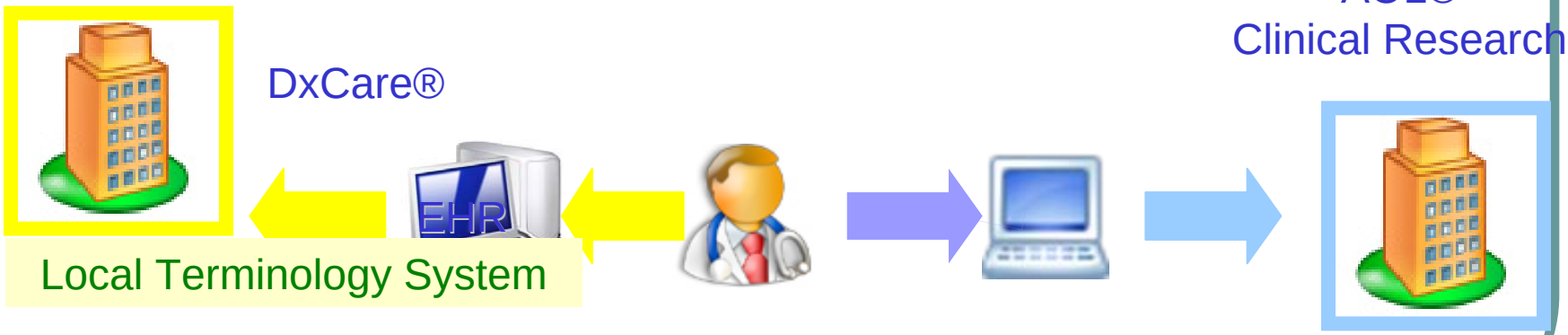
Clinical Trials

Alerts
Decision
Support system

Single application
Single multi-purposes data entry form

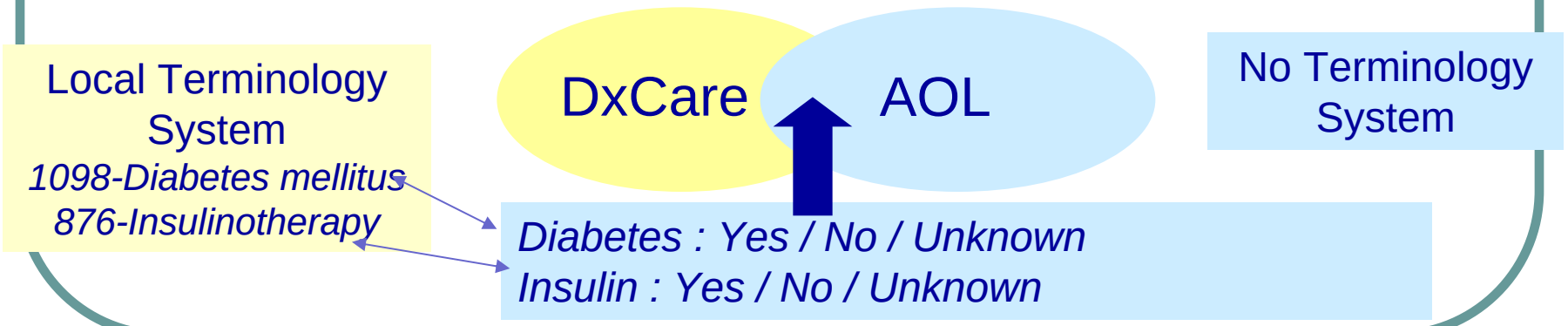
Material
HEGP : Cardiovascular radiology

- Patient care : DxCare ® (MEDASYS ©)
- Clinical research : regional & national registries
  - AIR On Line (AOL)® (KIKAMEDICAL©)
  - ViewCare®



Method (1/2) : Single “care-research” cardio-vascular form

- Restrict the problem to a syntactic alignment
  - Integrating only 2 contexts (DxCare (EHR) & AOL)
  - Single cardio-vascular radiology form
    - Including all clinical items required in both contexts
    - Semantic representation of the clinical data shared by both contexts was driven by the context of clinical research



Method Step (2/2) : Syntactic mediator

- Generate from the single form 2 different messages to feed EHR and the external system with the appropriate format
  - CDA r2 (HL7) for DxCare (EHR)
  - ODM (CDISC) for AOL (national registry)
- Solution 1 : Syntactic alignment of XML structures
- Solution 2 : XForms
  - W3C standard for web forms
  - Separate the interface from the content
  - Generate several XML structures from the same interface

Results (1/2): Syntactic mediator

DxCare

HL7 - CDA

DOM parser (Java)

198 items

SYNTACTIC MEDIATOR (1) (from HL7-CDA to CDISC ODM)

ODM

DOM Parser (Java)

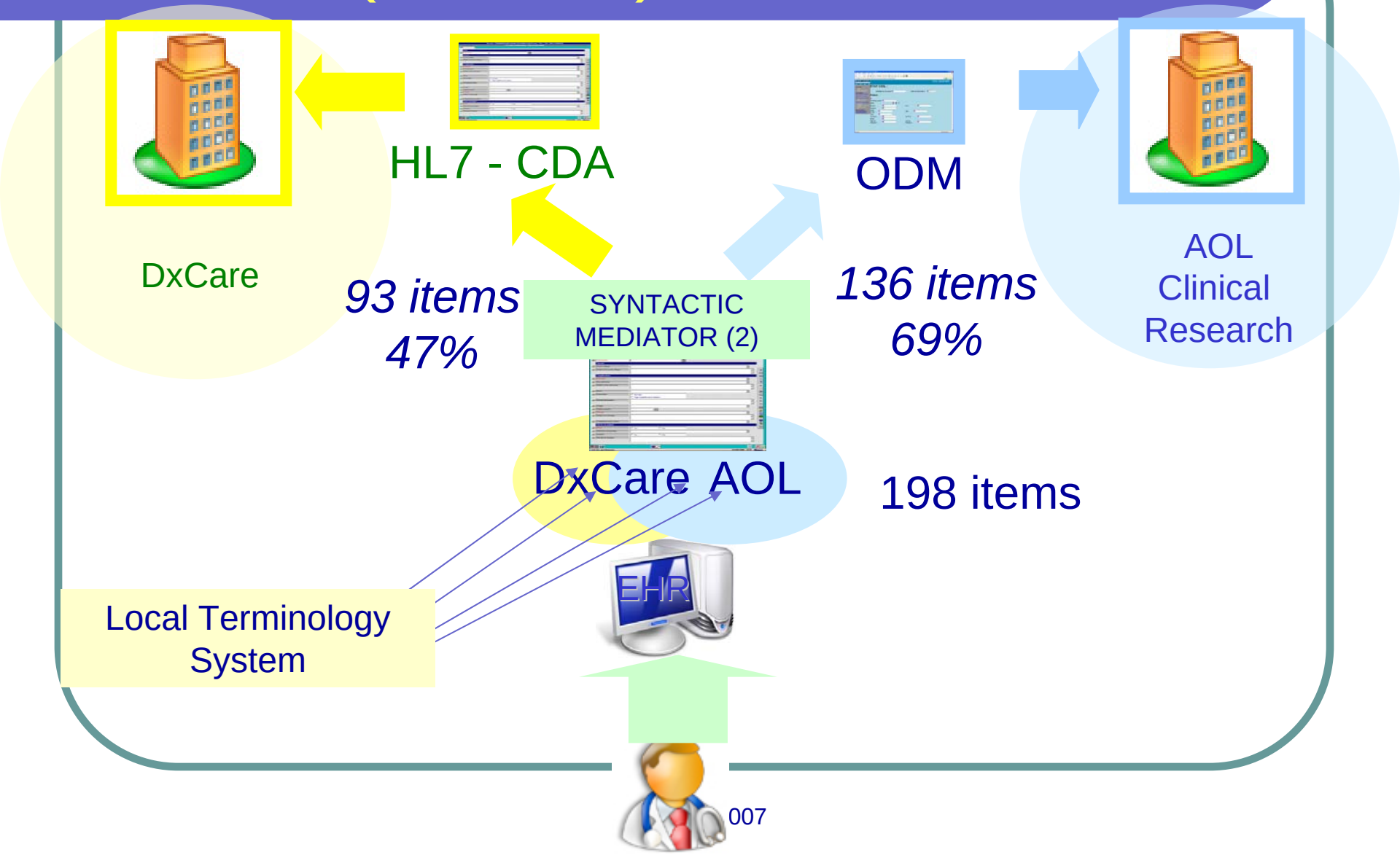
136 items

AOL Clinical Research

DxCare AOL

Local Terminology System

Results Step (2/3): : Syntactic mediator (XForms)



Discussion

- Assessment of work
  - Syntactic alignment (HL7/CDA to CDISC/ODM) avoids double data entry
    - Based on XForms : emerging technology (few implementations)
- Limits : work in progress
  - Testing integration in daily practice
  - Semantic issues
    - Documenting the semantic gap between contexts
    - Semantic mediator

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Aligning HL7 CDA Templates and CDISC ODM An Experiment in Cardiovascular Radiology

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Abstract

There are few implementations of automatic extraction of clinical data from Electronic Health Record (EHR) to clinical research data management system (CDMS). At the G.Pompidou European Hospital (HEGP), cardiovascular radiology reports are captured twice, first in the EHR and then in a national CDMS dedicated to clinical research in arteriography. The objective is to develop tools for producing both an HL7 CDA report for patient care and a CDISC ODM message for clinical research from a single multipurpose form. We adopted and compared two approaches: 1) implementing a single "care-research" form within the EHR and aligning XML structures of HL7 CDA document and CDISC ODM message to export relevant data from EHR to CDMS; 2) displaying a single "care-research" XForms form within the EHR and generating both HL7 CDA document and CDISC ODM message to fill directly both EHR and CDMS. The solution based on XForms avoids overloading EHR with irrelevant information. Beyond syntactic interoperability, a perspective is to address the issue of semantic interoperability between both domains.

Keywords:

HL7, CDA, CDISC, ODM, medical records systems, computerized, biomedical research; clinical trial

Introduction

Considerable efforts were realized for standardization and communication of medical information for both patient care (driven by HL7 (HL7 RIM, Clinical Document Architecture (CDA))) and biomedical research (driven by CDISC (Clinical Data Interchange Standards Consortium).

In 2004, CDISC initiated the Biomedical Research Integrated Domain Group (BRIDG) that addresses the issue of interoperability between systems that capture patient data, as Electronic Health Records (EHR) and clinical data management systems (CDMS) for biomedical research [1]. In addition, within the IHE (Integrating the Healthcare Enterprise) initiative, an integration profile called RFD (Retrieve Form for Data-capture) provides a method for gathering data within a user's current application to meet the requirements of an external system [2]. RFD aims at supporting the retrieval of forms from a form repository, display and completion of a form, and return of instance data from the display application to the source application.

Although there is an issue to connect patient care and biomedical research, nowadays, in practice, clinical trials or epidemiological studies often require specific manual entry of data, some of which already reside in the EHR [3,4].

Material and methods

Nowadays, in the G.Pompidou Hospital (HEGP), radiologists enter clinical data of arteriographies through a form of the EHR (DxCare®, Medasys©) and then fill another form of a national CDMS for clinical research in cardiovascular radiology (AIR On Line (AOL)®, Kika Medical©).

We used a two steps methodology to implement a solution to capture data for both patient care and research in the cardiovascular radiology domain.

Designing a multi purposes "patient care-research" form

Items required for patient care and for clinical research were analysed and compared.

A single multi purposes form was designed including all the required items for cardio-vascular radiology. Since we could only make changes in the EHR forms, to evade semantic interoperability issues, the items that were required in both contexts (patient care and research) were represented according to the research context. We took into account the data types, the modalities of answer and the data type controls of the CDMS for clinical research.

The multi purposes form was implemented on one hand in DxCare® ("Care-research" CV form(a)) and on the other hand using the standard XForms ("Care-research" CV form (b)).

Exporting data from EHR to clinical data management system (CDMS)

We analyzed the differences between the HL7 CDA [5] and CDISC ODM models on both a structural and organizational point of view (with regard to the context of data capture).

We implemented two approaches to export data from EHR to clinical data management system (CDMS):

The first approach consists in 1) generating for each instance of the "Care-research" CV form (a) implemented in DxCare® the corresponding HL7 CDA document and 2) aligning XML structures of HL7 CDA document and CDISC ODM messages to export relevant data from EHR to CDMS (figure 1).

The second approach, based on the IHE integration profile RFD, consists in displaying the "Care-research" CV form (b) implemented using XForms technology [6] within the EHR and generating both HL7 CDA document and CDISC ODM message to fill directly both EHR and CDMS (figure 2).

Results and discussion

The comparative analysis of clinical data captured in patient care and clinical research showed that, in the domain of cardio-vascular radiology, 93 clinical items are relevant for patient care and 136 for clinical research. The mixed "Care-Research" CV form contains 198 items.

The comparative analysis of both standards HL7 CDA and CDISC ODM showed that some differences are due to different contexts of data capture in patient care and clinical research. These differences intervene primarily in the representation of the patient's administrative data. With regard to the structure of the models, the HL7 CDA model allows representing clinical data according to an infinite depth of sections since CDISC ODM proposes only three levels of depth to represent clinical study data. The generic solution used to generate a CDISC ODM message from an HL7 CDA document including more than three levels of depth is to concatenate labels of items from the sections above section 3 and to group them under only one item group. « Section 1 » in the CDA document is aligned with the ODM « FormData » tag. Items of the last section in the CDA document (« section n ») are copied in the ODM « ItemData » tag. Label of « ItemGroupData » results from concatenation of items of the « section 2 » to « section n-1 ».

Tools were developed to implement two approaches to export data from EHR to clinical data management system (CDMS).

The tool developed according to the first approach uses the mixed "Care-Research" CV form implemented in DxCare (198 items) and produces a CDISC ODM message including 136 items for biomedical research (figure 1).

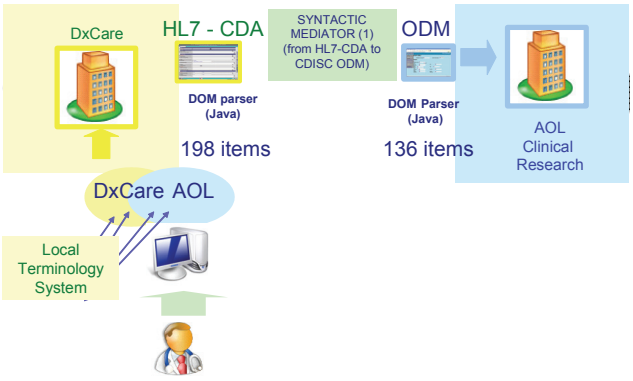

Figure 1- Production of a CDISC ODM message from a HL7 CDA document and using a mapping file

The tool developed according to the RFD profile produces an HL7 CDA document including 93 items dedicated to patient care and a CDISC ODM message including 136 items dedicated to biomedical research from the same single "Care-Research" form implemented in XForms (198 items) (figure 2).

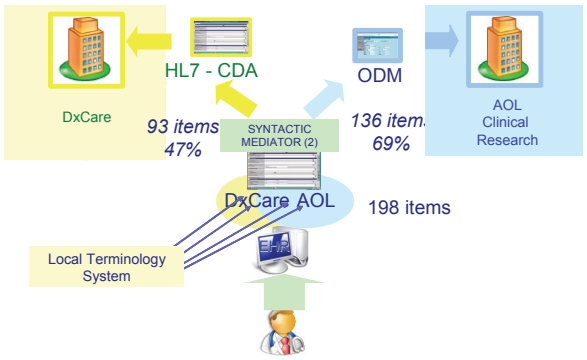

Figure 2- Production of a HL7 CDA document and a CDISC ODM message from a multi-purpose XForms form

We showed that it was possible to exploit for clinical research data captured in the EHR during patient care. The benefit for healthcare providers consists of the absence of time consuming and error prone double data entry, the automatic transfer of administrative and clinical data relevant for biomedical research towards a national CDMS and the storage of a structured data containing information necessary for patient safety in the EHR (for example adverse events).

A first limit of this work is that the tools were not tested in daily practice. We are working with Medasys© and a company developing CDMS for clinical research to implement

this workflow in HEGP. Another limit is that this experiment only addresses syntactic interoperability between standards of patient care and clinical research. There is an issue to solve semantic interoperability between applications while implementing integration profiles between patient care and research.

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[6] Xforms: http://www.w3.org/MarkUp/Forms/

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email: christel.daniel@spim.jussieu.fr

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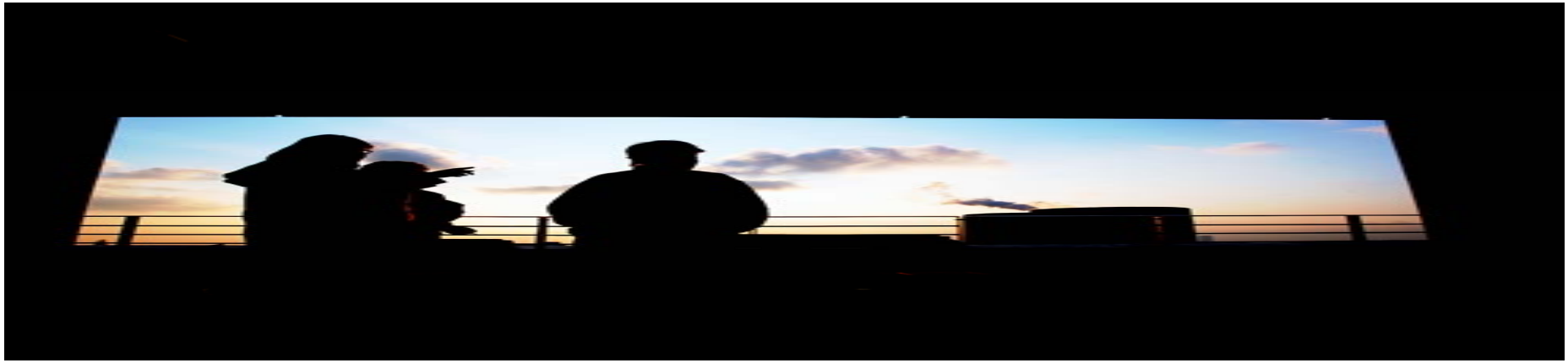
Adapting SNOMED CT® For Use In Denmark. The Tools And The Process Of Concept Based Translation

Ulrich Andersen[a], Janni Lerche[a], Palle G. Petersen[a], Knut Bernstein[b]

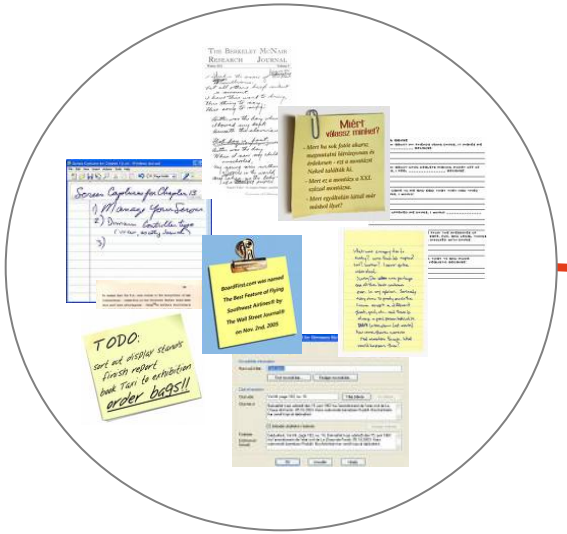
[a]*National Board of Health, Copenhagen, Denmark*
[b]*MEDIQ, Copenhagen, Denmark*

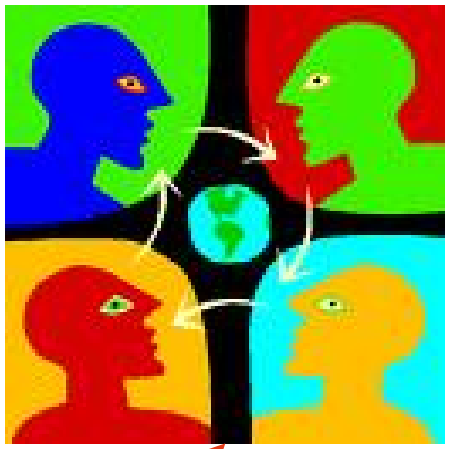


What We Need Is…

- Sharing health care information between professionals, departments and organisations – supporting improved quality, transparency and continuity throughout the whole period of care.

- Computerizing the data – making them suitable for electronic communication between different systems and in a unambiguous form, which can be read, understood and used of all professionals in the interdisciplinary team





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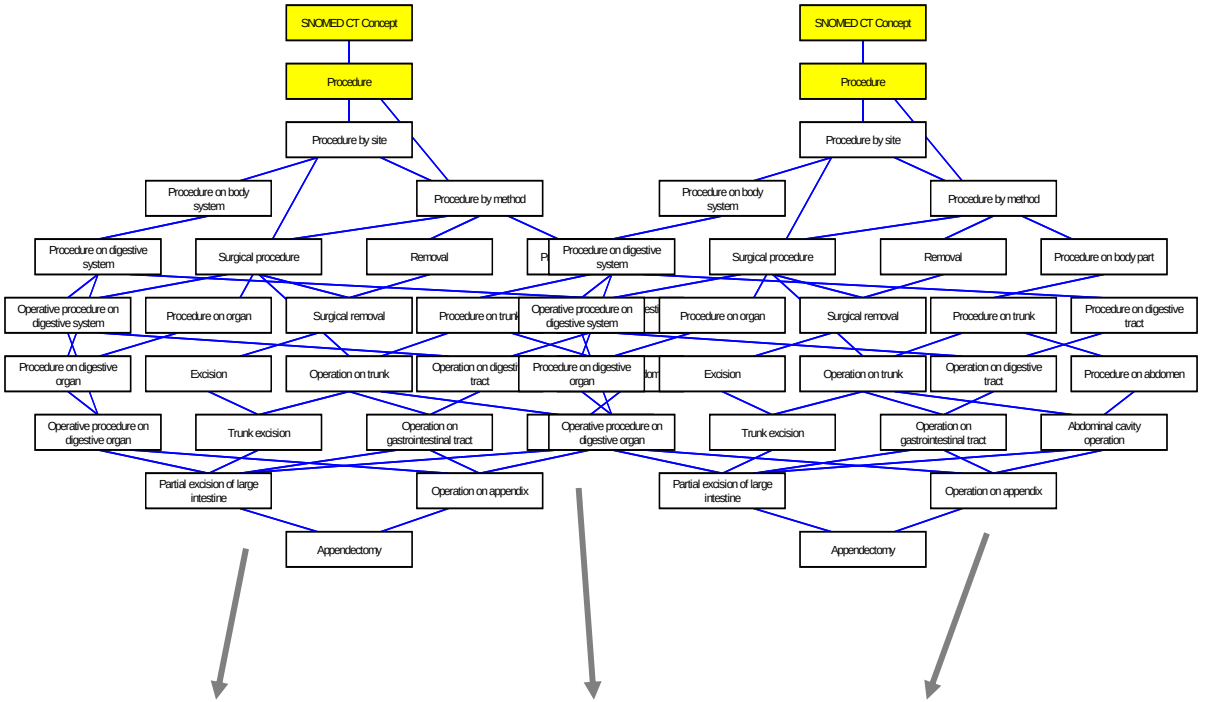
What is SNOMED CT®?

SNOMED CT® is an international, inter-disciplinary health terminology made for electronic use.

- 380,000 concepts
- 900,000 terms
- 1,400,000 relationships



Abdominal surgery

Endurance
Energy Conservation
Rest
Sleep
Activity Tolerance
Psychomotor Energy
Child Development: 2 Months
Child Development: 4 Months
Child Development: 6 Months
Child Development: 12 Months
Child Development: 2 Years
Child Development: 3 Years
Child Development: 4 Years
Child Development: Preschool
Child Development: Middle Childhood

Pain treatment

Body Mechanics Promotion
Energy Management
Exercise Promotion
Exercise Promotion: Strength Training
Exercise Promotion: Stretching
Exercise Therapy: Ambulation
Exercise Therapy: Balance
Exercise Therapy: Joint Mobility
Exercise Therapy: Muscle Control
Bowel Incontinence Care
Bowel Incontinence Care: Encopresis
Bowel Irrigation
Bowel Management
Bowel Training
Constipation/Impaction Management
Constipation/Impaction Management
Diarrhea Management

Primary care

Uoplagthed
Risiko for uoplagthed
Svækket mestring
utilstrækkelig friholdelse af luftvejene
Allergisk reaktion over for latex
risiko for allergisk reaktion over for latex
Angst
Frygt for døden
Risiko for aspiration
risiko for svækkelse af relation mellem forælder og barn/spædbarn
Autonom dysrefleks
risiko for autonom dysrefleks
forstyrret kropsopfattelse
risiko for uhensigtsmæssig ændring i legemstemperatur

Subsets of concepts can be generated for specific purposes

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Translation - Requirements

Method

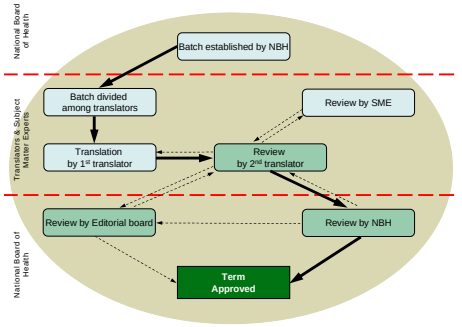
- Concept based translation
- Linguistic guidelines
- Access to Health Care literature
- Feedback loops and iterations

Competences

- Bi-lingual translators
- Subject Matter Experts
- An editorial board with terminologists and clinicians

Process

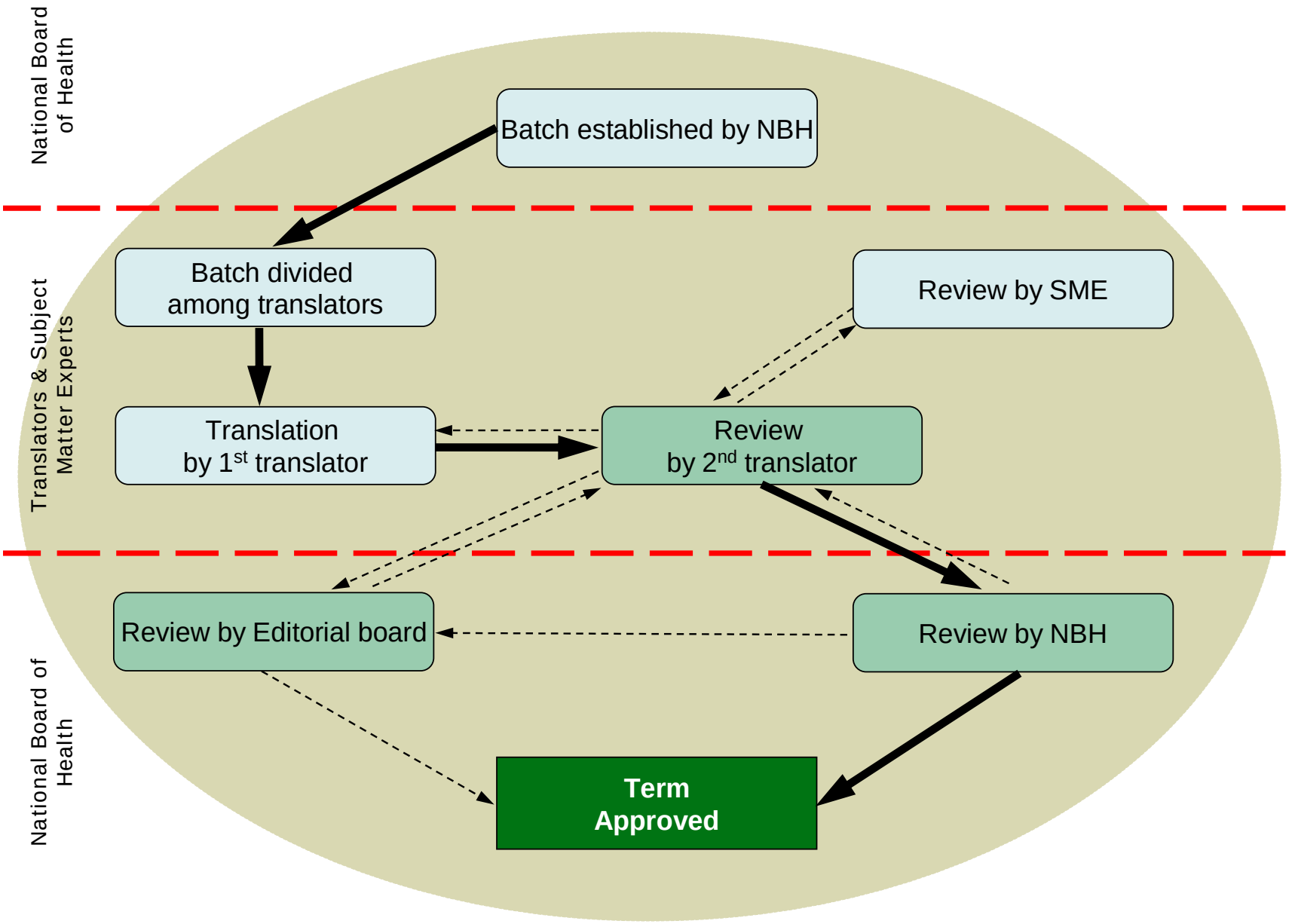
Managed workflow



Tool support

www.sundterm.dk

Translation Workflow



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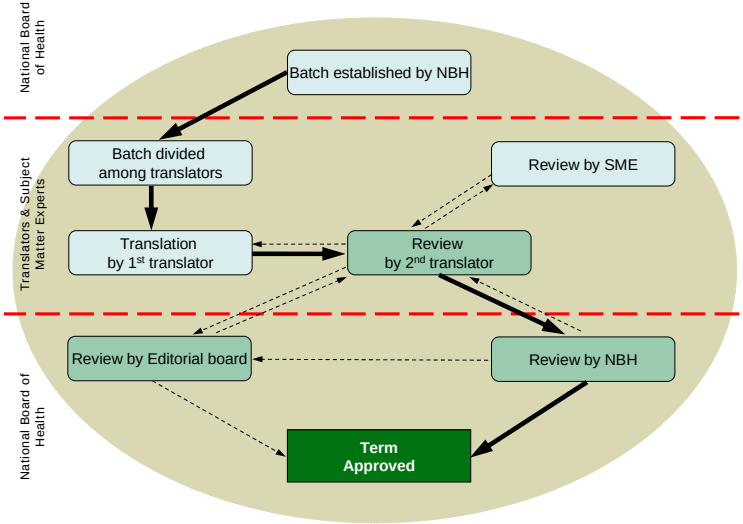
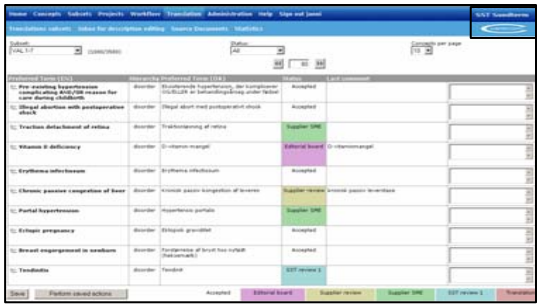
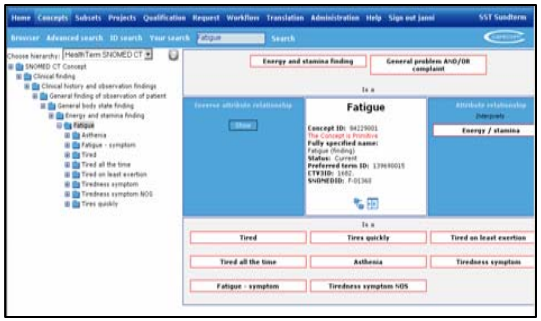
Translation Workflow

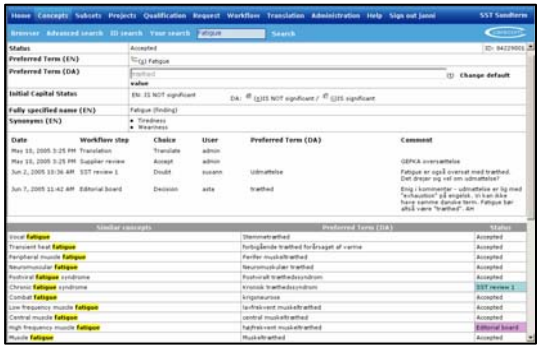




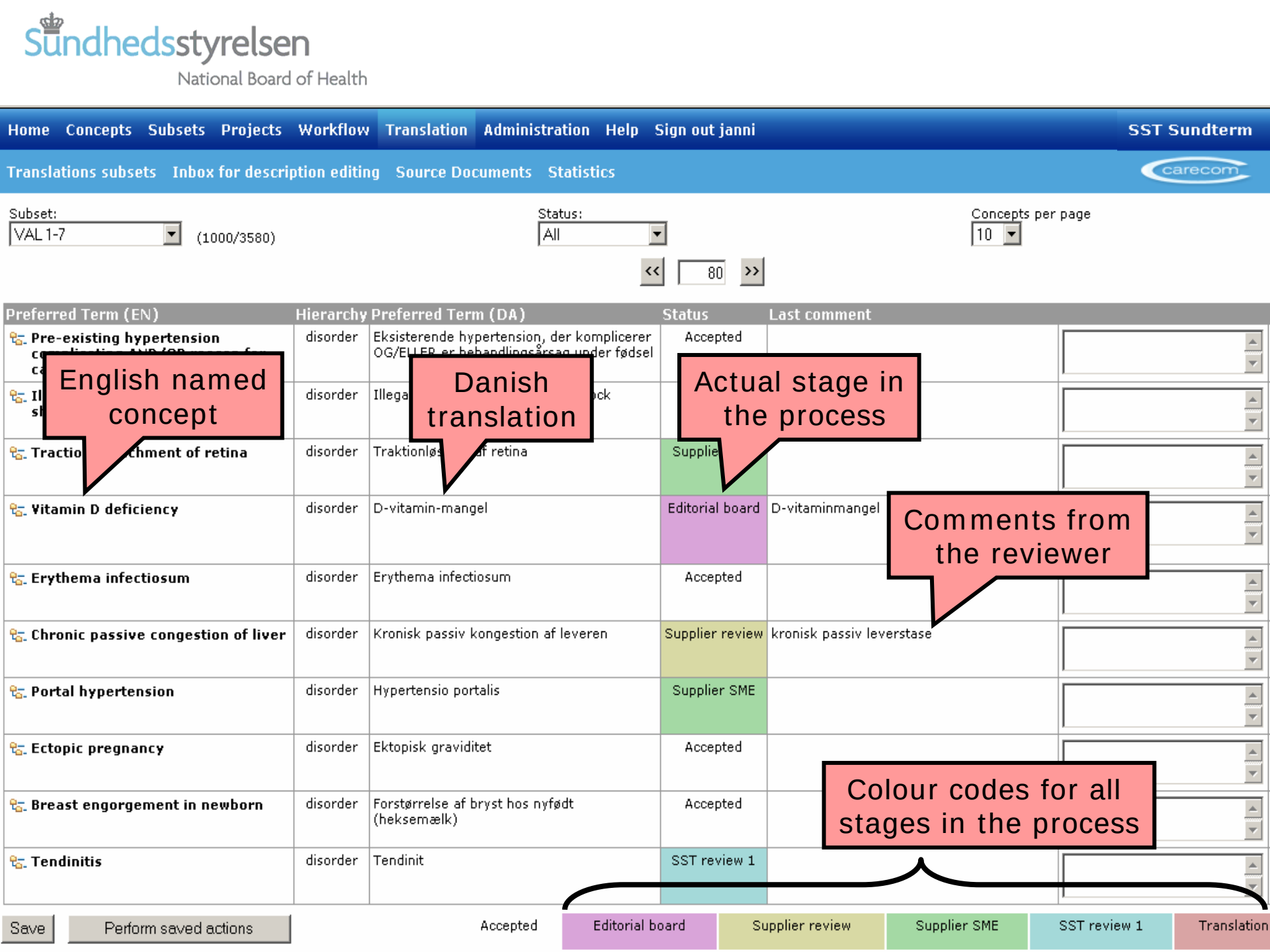
Overview, translation



Concept definition



Detail, translation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National Board of Health
Home Concepts Subsets Projects Workflow Translation Administration Help Sign out janni
SST Sundterm
Translations subsets Inbox for description editing Source Documents Statistics
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(1000/3580)
Status:
All
Concepts per page
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<< 80 >>
Preferred Term (EN)
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Preferred Term (DA)
Status
Last comment
Pre-existing hypertension
disorder
Eksisterende hypertension, der komplicerer
Accepted
disorder
Accepted
Vitamin D deficiency
disorder
D-vitamin-mangel
Editorial board
D-vitaminmangel
Erythema infectiosum
disorder
Erythema infectiosum
Accepted
Chronic passive congestion of liver
disorder
Kronisk passiv kongestion af leveren
Supplier review
kronisk passiv leverstase
Portal hypertension
disorder
Hypertensio portalis
Supplier SME
Ectopic pregnancy
disorder
Ektopisk graviditet
Accepted
Breast engorgement in newborn
disorder
Forstørrelse af bryst hos nyfødt (heksemælk)
Accepted
Tendinitis
disorder
Tendinit
SST review 1
English named concept
Danish translation
Actual stage in the process
Comments from the reviewer
Colour codes for all stages in the process
Save
Perform saved actions
Accepted
Editorial board
Supplier review
Supplier SME
SST review 1
Translation

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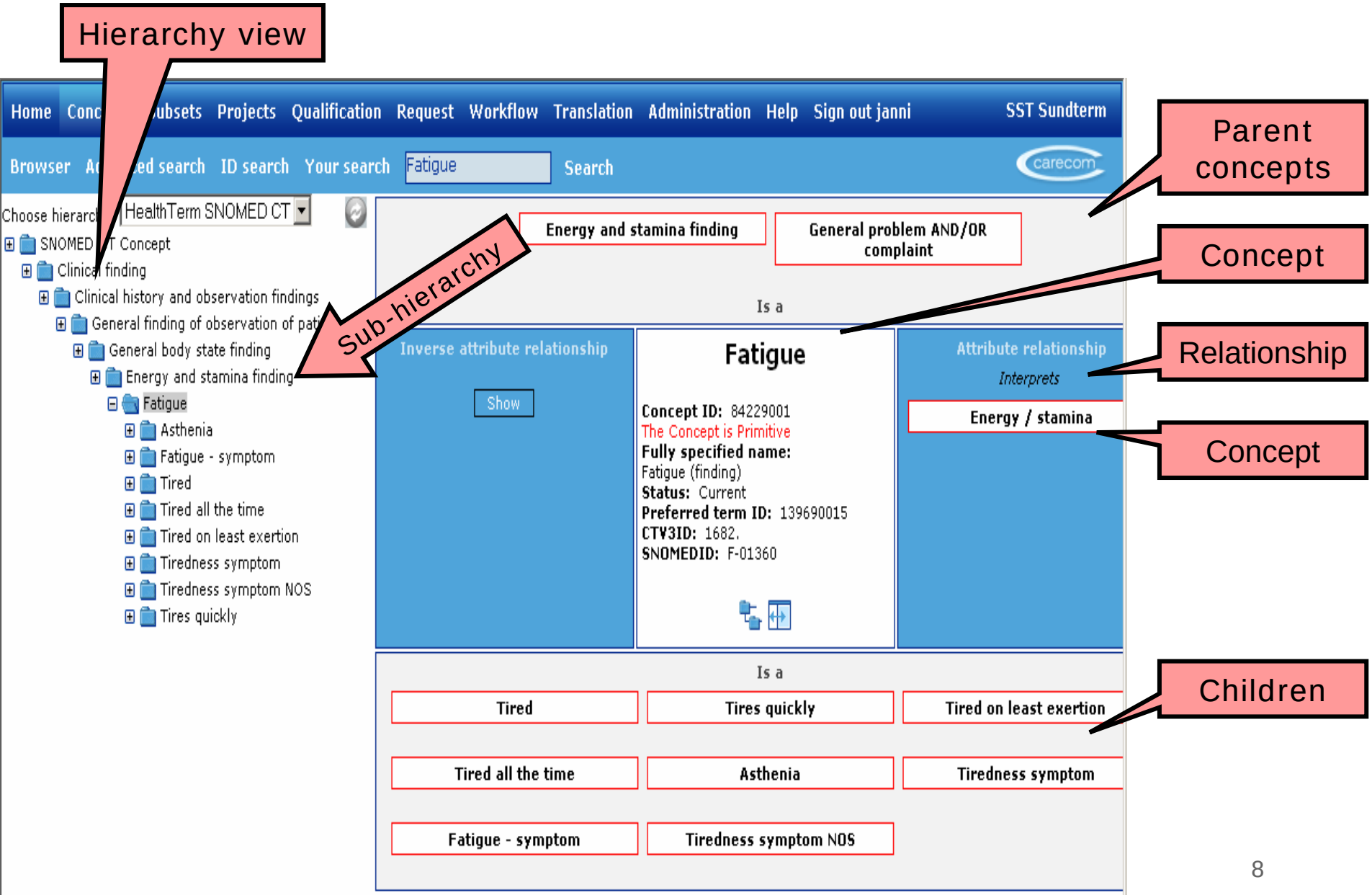

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Home | Concepts | Subsets | Projects | Qualification | Request | Workflow | Translation | Administration | Help | Sign out janni | SST Sundterm

Browser | Advanced search | ID search | Your search | Fatigue | Search | carecom

Status	Accepted	ID: 84229001
Preferred Term (EN)	(s) Fatigue	
Preferred Term (DA)	træthed (t) **Change default value**	
Initial Capital Status	EN: IS NOT significant	cant
Fully specified name (EN)	Fatigue (finding)	
Synonyms (EN)	• Tiredness • Weariness	

English named term

Danish translation

Date	Workflow step	Choice	User	Preferred Term (DA)	Comment
May 10, 2005 3:25 PM	Translation	Translate	admin		
May 10, 2005 3:25 PM	Supplier review	Accept	admi		GEPKA oversættelse
Jun 2, 2005 10:36 AM	SST review 1	Doubt	susa		Fatigue er også oversat med træthed. Det drejer sig vel om udmattelse?
Jun 7, 2005 11:42 AM	Editorial board	Decision	asta		Enig i kommentar - udmattelse er lig med "exhaustion" på engelsk. Vi kan ikke have samme danske term. Fatigue bør altså være "træthed". AH

Similar concepts with Danish translation

Similar concepts	Preferred Term (DA)	Status
Vocal **fatigue**	Stemmetræthed	Accepted
Transient heat **fatigue**	forbigående træthed forårsaget af varme	Accepted
Peripheral muscle **fatigue**	Perifer muskeltræthed	Accepted
Neuromuscular **fatigue**	Neuromuskulær træthed	Accepted
Postviral **fatigue** syndrome	Postviralt træthedssyndrom	Accepted
Chronic **fatigue** syndrome	Kronisk træthedssyndrom	SST review 1
Combat **fatigue**	krigsneurose	Accepted
Low frequency muscle **fatigue**	lavfrekvent muskeltræthed	Accepted
Central muscle **fatigue**	central muskeltræthed	Accepted
High frequency muscle **fatigue**	højfrekvent muskeltræthed	Editorial board
Muscle **fatigue**	Muskeltræthed	Accepted

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Further developments and lessons learnt

Further developments

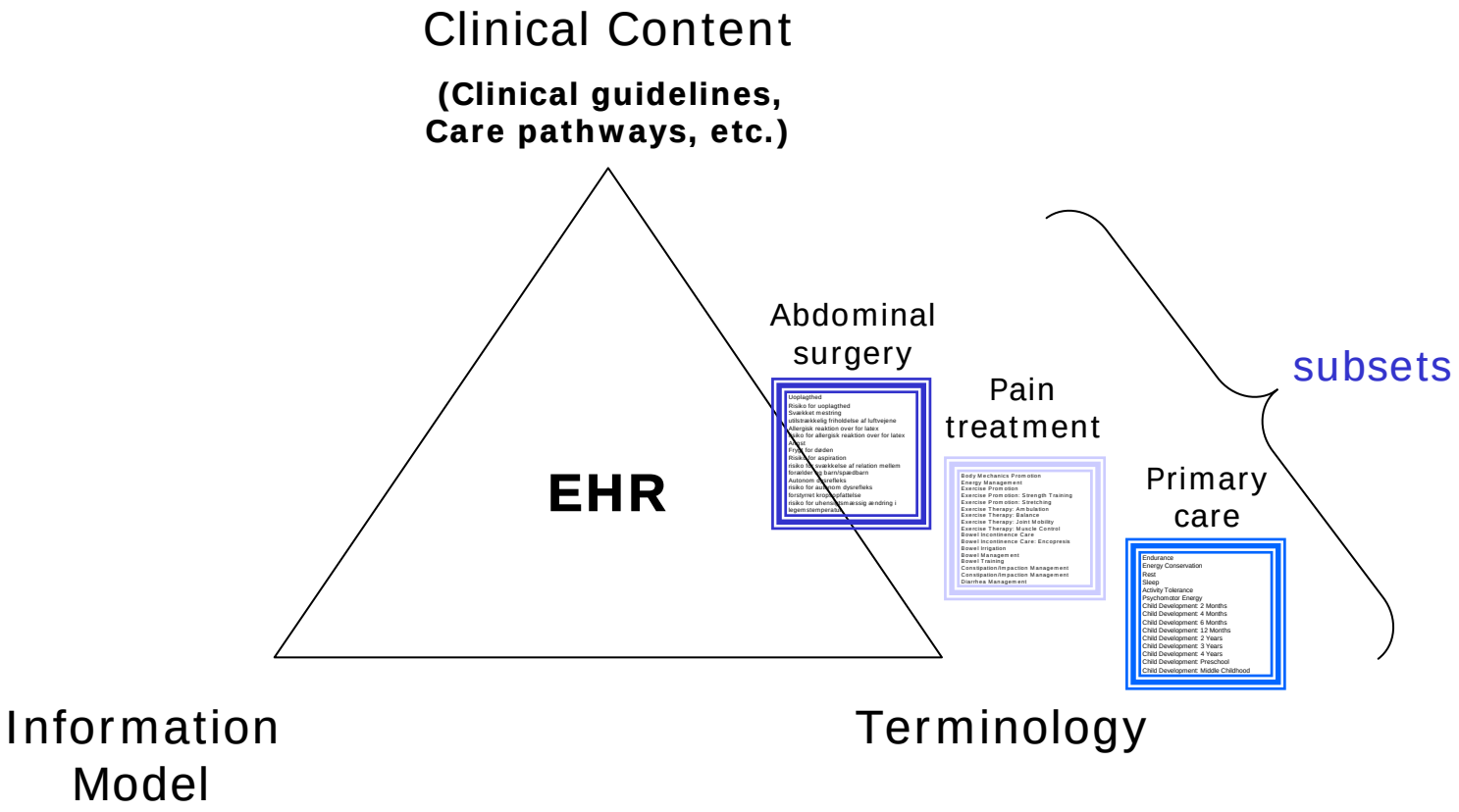
- 200.000 translated and validated concepts ultimo 2007
- 30.000 translated concepts has been clinical qualified of ultimo 2007
- Initiation of a EHR test project ultimo 2007
- 280.000 SNOMED CT concepts translated and clinical qualified 2010

Calculated costs for the whole project: 6.000.000 USD

Lessons learnt

- Using concept based translation the national context can expressed
- Iterations and feedback-loops increases quality and must be integrated in the process
- Linguistic guidelines are needed to get harmonised results
- A tool handling the workflow and supporting a distributed translation process is required
- Provision of synonyms and subsets are crucial for clinical acceptance
- Exchange of experience is needed – IHTSDO.org will support this

Requirements for a structured EHR



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- http://www.ihtsdo.org

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Adapting SNOMED CT® for use in Denmark – the Tools and the Process of Concept Based Translation

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[b]*MEDIQ, Copenhagen, Denmark*

Abstract

A common clinical terminology is a cornerstone for well structured documentation in electronic health records and a precondition for secondary use of data and semantic interoperability. The Danish authorities have selected SNOMED CT® as the main reference terminology for healthcare. The entire human medical domain of SNOMED CT® will be translated into Danish. Instead of just translating the terms, a concept based translation method is used. The terms' position in the terminological network, i.e. the relations and the attributes, are mapped to a corresponding Danish concept model. Professional translators, terminologists and domain experts are involved in the translation. A translation tool supporting all involved actors has been developed in order to manage this complex and distributed process. This paper describes the translation process and the developed translation tool.

Keywords:

SNOMED CT®, translation, terminology, electronic health record, software tool

Introduction

The use of information technology has a high penetration in the Danish society and in the healthcare sector. Hospitals, laboratories and pharmacies have implemented it-systems. Nearly all primary care doctors are using electronic health records (EHR), and around 50 % of all hospital beds are served by EHR. Electronic messages based on national standards are extensively used by all parties.

In order to harmonise the data content and structure in EHR, the National Board of Health (NBH) has developed a national model for EHR. The model supports a problem-oriented, longitudinal, cross professional and cross sectorial EHR for the purpose of continuity of care. The intention is to improve semantic interoperability using structured data for clinical documentation as well as secondary use of EHR data. A comprehensive and granular, multi professional clinical reference terminology then becomes a prerequisite.

Methods

NBH have assessed possible terminologies to support semantic interoperability. SNOMED CT® with it's more than 380.000 concepts, 900.000 terms and 1400.000 relationships, was found to be the most comprehensive and detailed terminology. The poly-hierarchy and different levels of granularity were seen as an advantage. The reference model for SNOMED CT® was considered robust and offered an evolutionary development, handling of multilingual use and language extensions.

However, it has been important ensuring the terminology is adjusted to Danish conditions and that professionals, patients and relatives can recognise and understand the terminology used. Therefore the entire human medical domain of SNOMED CT® will be translated into Danish. Instead of just translating the terms, a concept based translation method is used. The terms' position in the terminological network, the relations and the attributes, are mapped to a corresponding Danish concept model. This requires extensive use of healthcare domain experts in a distributed process.

A translation tool has been developed supporting the actors, manage the authoring process and monitor the quality.

The translation process

During the process, the National Board of Health (NBH) cooperates with a translation agency, language specialist, terminologists and Subject Matter Experts (SMEs). (See figure 1.)

Each month 10.000 concepts are selected for translation and distributed to the translators - a 1st translator and a 2nd translator for review. The 2nd translator can accept the suggested translation and forward it to NBH for approval. He may also ask the first translator to revise the term. If specific clinical knowledge is required, he may consult the SMEs. In more difficult cases, the editorial board may be consulted. The editorial board consists of terminologists, medical domain experts, and representatives from the NBH.

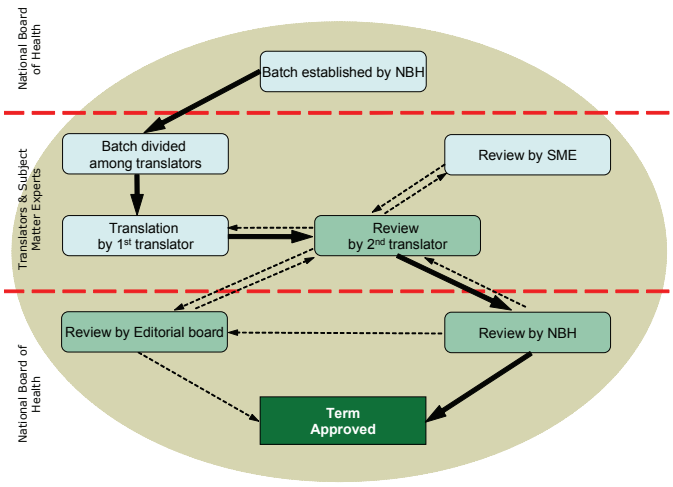

Figure 1 - The translation workflow process

The translation tool

The Danish National Board of Health has partnered with the IT supplier Carecom, to develop a web-based IT system, containing the functionalities necessary for the management of the entire SNOMED CT® translation: A common space for translators and the reviewers where all documentation of the translation takes place; Management of the translation workflow, showing the current stage for each term, and providing statistics on progress; Access to similar already made translations and supporting of addition of synonyms and modelling of new concepts for the Danish extensions; Development of discipline oriented subsets or subsets for specific purposes; Access to terminologies, updated translation guidelines, medical textbooks etc.

Results

The translation is progressing according to the plan with 10.000 concepts translated each month. In the first phase of the project only concepts are translated and only one term per concept is produced. In a second phase the synonyms will be identified. The entire human medical domain of SNOMED CT® is expected to be finished within 2-3 years with a cost of 6 million USD. By December 2007 200.000 concepts of the expected 250.000 are translated.

Approximately 80% of the concepts have been processed without problems, i.e. followed the direct path shown with broad arrows in figure 1. In case of doubt or questions were raised, the Editorial Board and SMEs were consulted. To avoid overload of the Editorial Board, precise translation guidelines were developed.

The translation is an intensive process, and especially the costs of the review board experts are substantial. To control the cost and achieve a high quality, the review feedback loop (between the 2nd translator, NBH, and the Review board) must be strictly managed and optimised.

Discussion

SNOMED CT® is today translated into Spanish, German and GB-English. There is an extensive experience of mapping between SNOMED CT® and other terminologies and meta-thesauruses as well as using natural language techniques. These techniques require that the "natural language" text and the terminology are in the same language. By processing bilingual parallel text corpora it has been possible to identify translations of medical terms in controlled vocabularies, including SNOMED CT®.

These methodologies have not been found to substitute the manual translation of SNOMED CT® to Danish, since the Danish work has been focusing on the concepts behind the terms. A similar focus has been demonstrated feasible in a project where ontology driven tools were used for bilingual translation of coding systems for clinical procedures.

To ensure the provision of scientific and psychological accepted terms is has been crucial to have a close cooperation with clinicians from different specialities and disciplines.

Earlier translation experiences have demonstrated the possibility of semantic drift when synonyms are translated. Therefore synonyms for the preferred Danish terms will be provided in a second phase of the translation.

Provision of synonyms and subsets/catalogues for use in specific situations is seen as crucial to get clinical acceptance. The maintenance of these as well maintenance of the terminology itself, will be a substantial task.

Exchange of experiences on SNOMED CT® translation and multilingual issues is needed. A new International Health Terminology Standards Development Organisation (IHTSDO) will support this. It has been established January 1st 2007 and is hosted in Denmark.

Conclusion

Health care provision is internationalised, and there is an increased demand for valid, structured, and globally standardised data supporting clinical and administrative processes.

Many countries need to manage translation process and the use translation tools, and it is imperative to evaluate the processes closely and exchange experiences. The newly formed IHTSDO is expected support this efforts.

The implementation of SNOMED CT® in practical use must take place in cooperation with the clinical community. Only if a structured terminology can facilitate clinical work processes and provide relevant decision support, the clinicians will produce valid data for the clinical documentation as well as secondary use, i.e. for quality development and management.

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MEDINFO 2007
HISA Ltd Australia

An Analysis of Skin Integrity Alerts Used to Monitor Nursing Home Residents

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[b]*Department of Health Management and Informatics, University of Missouri—Columbia, USA*

Abstract

Few computerized systems have been implemented and evaluated in nursing home systems. The purpose of this descriptive study is twofold: 1) assess the frequency of active alerts occurring in two nursing homes implementing an electronic health record (EHR) with a clinical decision support system; and 2) determine if clinical responses of health care workers are different when a clinical alert is active versus not active. A secondary analysis of de-identified data was performed to derive conclusions about use of alerts to monitor residents' skin conditions in the nursing homes. The percentage of residents who had active skin integrity alerts ranged from 8% to 52%. The majority of time resident skin integrity alerts were active for 1-3 consecutive days. In one facility, 6% of the residents had an active skin integrity alert for 20 or > consecutive days. A total of 118 alerts were analyzed from 59 residents in the analysis of documented clinical responsiveness. No significant difference was found in clinical documentation for responses when alerts were active versus when alerts were not active (N=59, p=1.00). There were just as many clinical responses documented to conditions when alerts were active than when they were not active.

Keywords:

decision support, clinical, computers, handheld, nursing home, information technology

Introduction

Continuing concerns about quality, costs, accessibility, adequacy of oversight, and regulation of nursing homes are driving the need to implement computerized clinical information systems in these settings. Key capabilities of clinical information systems recognized in nursing home settings include improved patient safety, more effective delivery of patient care services, better management of chronic conditions, and greater efficiency [1]. However, in order for nursing homes to adopt and invest in clinical information systems more research and dissemination is need to understand how electronic environments affect clinical processes in the nursing home [2]. This paper describes a secondary analysis of de-identified resident level data obtained from an electronic health record, called One Touch Technologies (OTT). OTT had a clinical decision support system with an automated skin integrity alert system to alert nursing home staff of potential resident skin integrity problems and to facilitate clinical management. The purpose of this evaluation was to 1) describe the frequency of active skin integrity alerts occurring in two facilities during the seventh month (31 days) following implementation of the clinical information system; and 2) determine if significant differences existed between clinical actions documented by healthcare workers when alerts were active compared to when alerts were not active in the EHR.

Background

Technology is changing the way healthcare providers are performing clinical work [3]. Potential uses of computerized technologies in nursing homes include clinical decision support, improved financial analysis, and safety and quality improvement initiatives ([4;5]. Long term care strategists have placed a high priority on educating concerned citizens about the potential for nursing home technology and stimulating interest in the implementation of interoperable EHR's in long term care settings [6;7]. Historically, the process of adopting new technologies has been slow in long term care with as many as 14% of USA's 17,000 Medicare, Medicaid, and dually certified nursing facilities reporting having no computer system at all within the last decade [8;9]. However, this is changing as the benefits of computerization such as better recordkeeping and improved decision making are realized in other nursing systems [10;11].

Clinical Decision Support and Automated Alerts

A CDSS is a computer program that has the ability to facilitate a healthcare provider's clinical decisions. CDSS should aid in problem recognition and should lead to clinical actions that improve resident outcomes. In some cases, these mechanisms have shown to significantly improve clinical practice [12].

In nursing homes, resident assessment data usually associated with the long term care minimum data set is used to document resident conditions in the health record. Predetermined criteria or triggers within the resident assessment data can be used to build electronic decision support tools including alerting mechanisms. Few of these clinical information systems have been implemented in nursing homes.

Even fewer have been studied to determine there effectiveness to enhance clinical actions documented by nursing staff.

Nursing home technology

The OTT system uses wireless real time automated information processes at the point of care. This system incorporates electronic technologies not previously available to the nursing home industry, such as decision support. This new level of data manipulation should have positive effects on the quality of individual resident care by improving detection of potential resident problems through the automated alerts in the CDSS. Recently, evidence of the positive effects of CDSS has been found in healthcare practices using automated alerts to evaluate patient specific clinical variables and clinical decision making [12;13].

One of the defining features of the OTT clinical information systems is the ability to collect data at the patient's bedside using a handheld PDA at the point of care. The technology combines the use of magnetic technology located in the resident ID bracelet and caregiver ID badge to facilitate caregiver accountability for resident care and documentation while being alerted to individual resident needs. The PDA clinical modules provide a template for complete verifiable documentation and interactivity of specific items in the resident record.

The skin integrity alert in the OTT CDDS assists healthcare providers to identify when a resident may be experiencing a skin integrity problem. The skin integrity alerts have an electronic alert calculation that defines the triggers in the data that activate the alert. Alerts and triggers are incorporated into a relational database that uses detailed data elements to make an alert active or not active. Using the infrastructure of the OTT, the goal of this study was to describe the frequency of active skin integrity alerts during one month and to evaluate the skin integrity alert in the CDSS to determine if significant differences existed between clinical actions documented when alerts were active versus when they were not active.

Methods

Two nursing homes, A & B, participated in the study and ranged in size from 180 to 240 beds, respectively. Facility A was in a rural setting and was a government owned facility. Facility B was located in a urban setting and was a not for profit. Both nursing homes were participating in a larger federally sponsored research project designed to evaluate the use of bedside technology to improve quality of care [14]. According to the Centers for Medicaid and Medicare Nursing Home Compare database in February 2005, one month prior to the beginning date of collection, the lowest percentage of occupied beds was in facility A (72%) with the highest in facility B (95%). During this same time period as few as 40% (facility A) and as many as 80% (facility B) of the residents were categorized as having bowel and bladder control issues; these conditions could potentially predispose residents to an increased loss of skin integrity.

Data collection

De-identified data were collected for one month (31 days) following the 6 month post implementation date in both facilities. Data were provided by OTT after fictious, unique nursing home and patient identifiers were assigned in the data sets.

Data collection involved querying each facility EHR during the day at 0700 AM, the start of day shift, on the first day of the month and ending at 0700 AM on the last day of the month. Query data from the alerts was used to assess the average length of time that skin integrity alerts were active on consecutive days at 0700 AM. Finally, while controlling for periods when skin integrity alerts were active, time of day alert occurred, and resident, clinical actions documented in the EHR were counted. Six electronic administrative reports and clinical reports in the HER were used to determine clinical actions documented including: 1) care plan changes, 2) nurse assistant task lists, 3) skin and wound reports, 4) turning and repositioning reports, 5) toileting reports, and 6) progress notes.

Data analysis

To meet the goals of the research the analysis plan involved three steps. During the first step the average number of residents occupying the facility per day was determined, overall average frequency of active skin integrity alerts per day that were active at 0700 AM was calculated and the range of active skin alerts/day active at 0700 AM for all patients was recorded for each facility (Table 1).

Table 1. Frequency of active skin integrity alerts

Facility	Ave. Number of Residents	Ave. Frequency of Active Skin Integrity Alerts/day	Range of Active Skin Integrity Alerts/day
A	136	21	11 – 34
B	225	93	68 – 118

During step two the length of time skin integrity alerts were active on consecutive days at 0700 AM was tabulated. This step enabled us to calculate the number of residents in each facility that had no active alerts versus those that had 1 or more active alerts during the same period on consecutive days. Categories for active skin integrity alerts in consecutive days were operationalized by counting the number of days at 0700 AM when an alert was active; for example, if a resident had no active alert on

Monday, an active alert on Tuesday, and no active alert on Wednesday of the same week this episode was added to the 1-3 day category. Categories for length of time alerts were active were created where natural breaks appeared in the data. Categories included no alerts during the month, alerts that were active consecutively for 1-3 days, 4-9 days, 10-19 days, and 20 or greater days. The category no alerts, was an indicator of the number of residents who had no active alerts occurring during the 31 day period (Table 2).

Finally, in step 3 the frequency and types of clinical actions documented by staff during an active skin integrity alert versus when the alert was not active for the same resident was calculated. The day of the week and time of day alerts were active and not active was controlled for to offset any confounding affects of changing staff schedules during the week. For example, if an alert was active on Monday, a similar time period

Table 2: Length of time in consecutive days skin integrity alerts were active

Facility	Ave Number of residents	Total Number of Days in month	No Active Alerts	1-3 Days	4-9 Days	10-19 Days	20 or > Days
A	136	31	44	293	18	3	1
B	225	31	17	834	137	31	13

one week later when an alert was not active was selected to compare clinical responses documented on the same resident. Only alerts from facility B are analyzed here to minimize differences in documentation and clinical practices between homes. To test the hypothesis that there would be differences in the proportion of clinical actions during a period when a skin integrity alert was active versus not active a McNemars test was calculated. All statistical processes were performed using SPSS 13.0.

Results

Comparisons of the daily alert frequencies for home A and B were tabulated (Table 1). Facility A had fewer residents than facility B and also had few average active alerts during the day. The percentage of residents with an active skin integrity alert on their EHR at least once during the day ranged from 8% in facility A to 52% in facility B. The range of active alerts in facility B was also larger than facility A during the study period.

Results of the average length of time skin integrity alerts were active as measured by the number of consecutive days alerts were active in the EHR at the 0700 AM query are shown in Table 2. In facility A, 44 of 136 residents (32%) had no active skin integrity alerts during the month. Conversely, 78% of the residents had an active skin integrity alert in their record. The majority of those active akin integrity alerts in facility A occurred over 1-3 consecutive days. Only 1 resident had an active skin integrity alert for 20 or greater consecutive days at 0700 AM.

In contrast, only 8% (17/225) residents in facility B, which had a higher daily census, had no active skin integrity alerts during the month (Table 2). Ninety two percent of the residents had an active skin integrity alert; the majority of these were present for 1-3 consecutive days at 0700 AM. Thirteen residents (6%) had an active skin integrity alert over 20 or greater consecutive days. Skin integrity alerts had a very frequent change of status from active to not active with most lasting from 1-3 consecutive days.

The final analysis in this project compared clinical responses documented during periods when alerts were active and not active to determine if this could be a factor in the frequently changing status of the alerts activity. A total of 118 alerts were analyzed from 59 residents residing in facility B. Table 3 illustrates that there was no significant differences in clinical responses during periods when alerts were active versus when alerts were not active (N=59, p=1.00). There were just as many clinical responses documented to conditions when alerts were active than when they were not active.

However, further investigation using the administrative turning and repositioning reports in the EHR revealed that 39 out of 58 residents (67.2%) who had no documentation on the date a skin integrity alert became active had documentation on turning and repositioning when the alert was not active at the exact same time a week later. In comparison, electronic nurse assistant task lists,

Table 3: Analysis of Clinical Responsiveness to the Skin Integrity Alert

		Alert Active		Number residents	††Exact sig. *P*
		Clinical Response Absent	Clinical Response Present		
Alert Not Active	Clinical Response Absent	1	6	7	*1.00*
	Clinical Response Present	6	46	52	
Number of residents		7	52	59	

††McNemar's Test

used to communicate important resident tasks between nurses and nurse assistants, were used very little to delegate skin integrity care planning. Of 46 residents that had no documentation on the task list related to skin integrity when the alert became active, 100% had no documentation a week later when the alert was not active.

Discussion

The results of this study indicate there is substantial difference in the average daily frequencies of active alerts between the participating nursing homes. Even after adjusting for daily occupancy differences by calculating the average daily percentages of residents with active alerts, facility B had substantially more 41% than facility A (15%). One possible reason for the differences could be that 50% fewer residents had been reported nationally in NHC in facility A vs. facility B with bowel and bladder control issues [15]. Fewer residents with incontinence problems might reduce the frequency of skin integrity alerts that occurred in facility A. This makes intuitive sense since bowel and bladder voiding are two data triggers in the EHR relational database that can cause an alert to become active.

The frequent change of status in the alerting mechanism from active to not active could not be explained by the clinical responses documented by staff in the EHR. Documentation of clinical responses in care plans, skin and wound reports, toileting, and information in progress notes were not significantly affected by active alerts in the HER. Finding indicate a uniformity in clinical interventions whether alerts were active or not. Such consistency can contribute to quality assurance and prevention. It also raises questions about responsiveness to new clinical information generated by a CDSS.

An exception is seen in the administrative turning and repositioning reports. In more than half the cases where active alerts existed, it appeared that documentation on turning and repositioning residents occurred during a one week period starting with an alert being active and ending with the alert being not active. This is a positive finding because another trigger which can active a skin integrity alert in this specific EHR relates to the frequency of occurrence of turning and repositioning. Although there was not significance found between the clinical responses documented and active/not active clinical alerts, there was increased documentation on turning and repositioning following an active alert. However, interventions for skin integrity following an active alert, such as turning and repositioning, do not appear to be carried through on documentation contained in automated nurse task lists. This raises the question whether, ideally, alerts should automatically generate selected, evidenced based nurse aide tasks such as more frequent turning and repositioning for residents for which this is authorized by a nurse.

Prevention of skin ulcers is a central goal of nursing homes. This study contributes to knowledge about the potential role of CDSS technology in effectively pursuing this goal. Limitations of this study include the small sample size, small time frame for gathering alert data, and reliance on secondary data analysis to confirm clinical responsiveness.

Application

Widespread adoption of CDSSs such as OTT will largely depend on how much they contribute to effectiveness and efficiency of nursing care. Staffing levels in nursing homes make it challenging to meet all of the physical needs of residents. As compared to acute care, there is a higher proportion of nurse aides to licensed nurses and onsite physician visits are less frequent. CDSSs have potential to contribute to effectiveness in care by identifying and alerting nurses to patterns in EHR data that indicate possible resident problems, thus facilitating earlier interventions. They could contribute to efficiency by reducing nurse time in assessment and detection of some problems and by recommending and possibly even facilitating some interventions.

As an active [16] CDSS, the OTT alerts nurses to potential skin breakdown based on underlying risk factors. Such risk scenarios may sometimes otherwise be missed, leading to development or worsening of pressure ulcers. In this way, the CDSS functions as an additional intelligent processor of otherwise discrete data inputs in the EHR. Ideally, CDSSs are supplemental in assisting nursing home staff in delivering care.

In addition to assisting in assessment, CDSSs like OTT recommend and can even facilitate associated interventions. For pressure ulcers, more frequent turning and repositioning is one recommendation. This can be automatically added to nurse aide task lists, thus increasing efficiency for nurse case managers and possibly facilitating more timely response by aides. Other tasks that might be automated include ordering and increasing inventory levels of associated supplies. Furthermore, CDSS alerts may influence staffing assignments and allocation.

CDSS information, including alerts and associated responses, can potentially enhance a facilities quality assurance oversight and quality improvement analyses. CDSSs and other electronic documentation should reduce time otherwise involved in manually compiling summary information form chart reviews. In addition to improving quality, this may be helpful in meeting facility licensure and other regulatory requirements. To the extent that CDSSs contribute to quality, they may contribute to market demand for a facility and thus to its occupancy level and associated financial viability. Word of mouth about quality is the most important factor in nursing home selection [17].

Lastly, CDSSs may contribute to research-based knowledge of nursing home performance. Electronic documentation facilitates faster tabulation of data than manual chart review. This could contribute to research

with larger samples, thus allowing generalization and associated advancement of theory. CDSSs in particular allow for examination of process responses to alerts and recommended interventions, and their differential effects on clinical outcomes.

Conclusion

This study does not conclusively show that a CDSS with alerts is beneficial to nursing home residents and staff who care for them. Further research is needed to evaluate these types of electronic tools in nursing homes to determine effectiveness. Important considerations for future research using CDSSs for skin integrity include association of alerts and evidenced based clinical process responses with skin integrity outcomes.

Acknowledgements

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An Analysis of Skin Integrity Alerts Used to Monitor Nursing Home Residents

by

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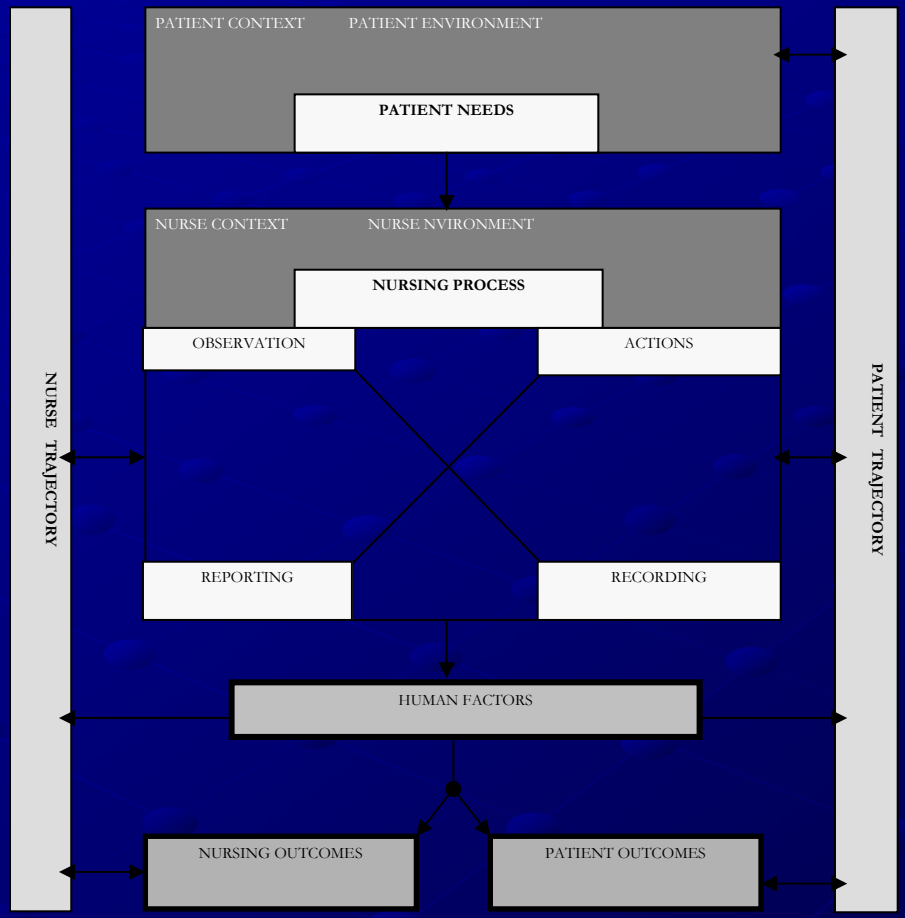
Study Objectives

The objectives are twofold:

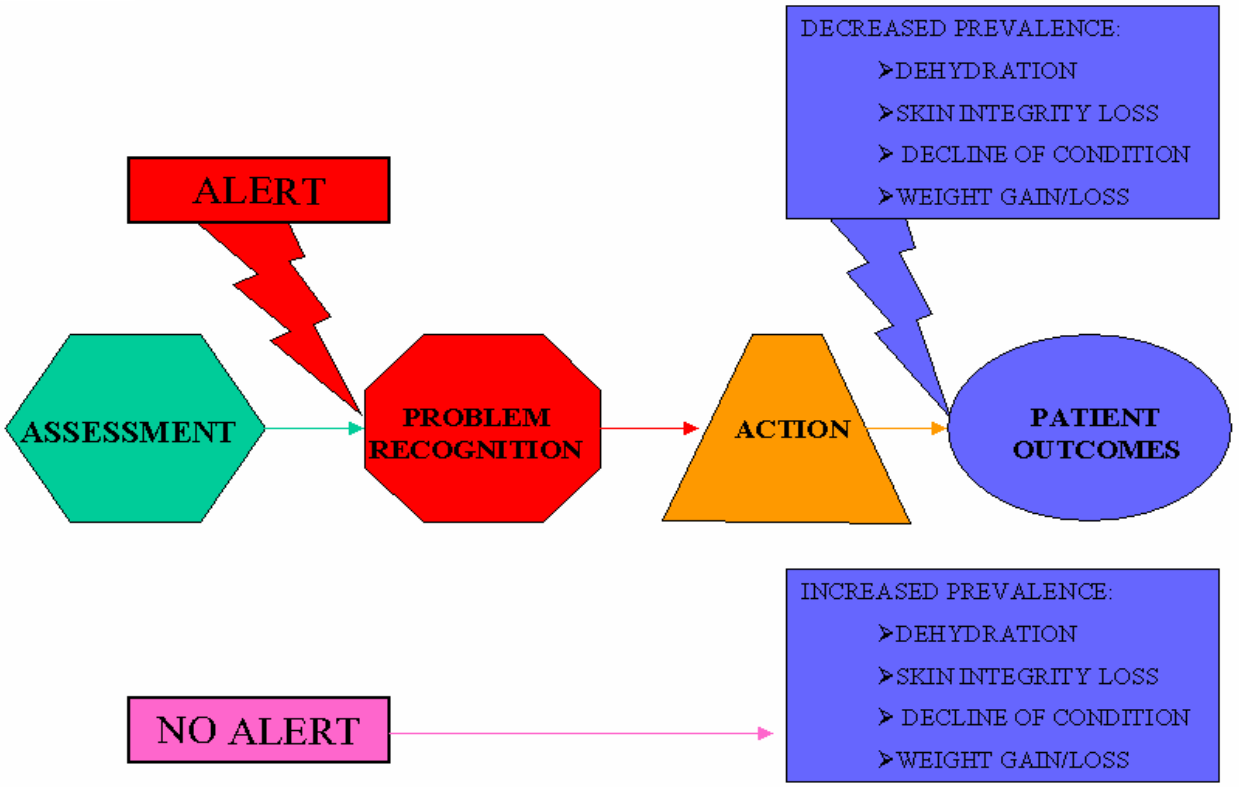
1) Assess the frequency of active skin integrity alerts occurring in two nursing homes implementing an electronic health record (EHR)
2) Determine if clinical responses of health care workers are different when a clinical skin integrity alert is active versus not active.

The Nurse-Patient Trajectory Framework



Alexander, GL (2007)

A Model for Clinical Decision Support Systems in EHR



Automated Clinical Decision Support in Nursing Homes

- Information systems using automation to direct nursing home staff are absent in most nursing homes
- There is limited research that considers electronic medical records (EMR) and clinical decision support in nursing homes.

(Schnelle, Bates-Jensen, Chu, & Simmons, 2004)

Background and Definitions

Clinical Decision Support System: Automated system that supports clinical decision making

Clinical Alert System: System that monitors a continuous stream of data and automatically generates a message (alert) in response to patterns that may require action

Clinical Alert: A decision support mechanism which serves as a part of an alert system that automatically detects changes in critical assessment data and notifies the healthcare provider

Example: dehydration

Trigger: Established criteria for when an alert will become active

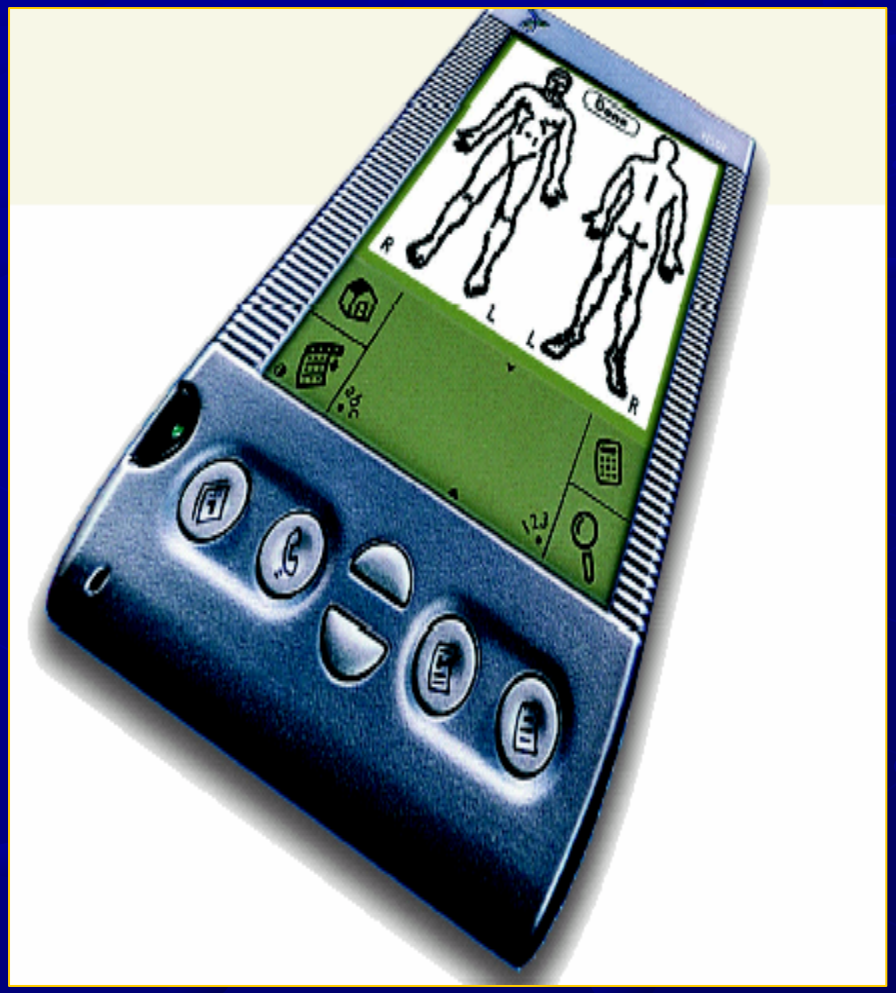
Example: Fever reported in last 24 hours

Description of Study

- Design: Descriptive analysis of 6 months of clinical alert data (beginning 6 month post implementation of OneTouch Technology)
- Setting: Two nursing homes
- Participants: Midwestern nursing homes where administrative staff had committed to implementing OneTouch clinical decision support system.

Partnerships in Nursing Home Technology

OneTouch Systems



- Bedside data collection using handheld and wireless devices
- Electronic charting and reporting
- Automated Minimum Data Set and Risk Assessment Protocols
- Accountability for caregiver activities and risk management
- Automated clinical alerts and triggers
- Electronic Medication Administration Record (eMAR) using wireless touchscreens on medication carts.

Results Objective 1

Table 1. Frequency of active skin integrity alerts

Facility	Ave. Number of Residents	Ave. Frequency of Active Skin Integrity Alerts/day	Range of Active Skin Integrity Alerts/day
A	136	21	11 – 34
B	225	93	68 – 118

Table 2: Length of time in consecutive days skin integrity alerts were active

Facility	Ave Number of residents	Total Number of Days in month	No Active Alerts	1-3 Days	4-9 Days	10-19 Days	20 or > Days
A	136	31	44	293	18	3	1
B	225	31	17	834	137	31	13

Results Objective 2
Clinical Responsiveness to Active Skin Integrity Alerts

		Alert Active		Number of residents	††Exact sig. *P*
		Clinical Response Absent	Clinical Response Present		
Alert Not Active	Clinical Response Absent	1	6	7	*1.00*
	Clinical Response Present	6	46	52	
Number of residents		7	52	59	

††McNemar's Test

Discussion

- There is substantial differences in average daily frequencies of active alerts in NH (Facility B had more than Facility A.)
- The frequent change of status in the alerting mechanism from active to not active could not be explained by the clinical responses documented by staff in the EHR.

Application

- Widespread adoption of CDSSs in NH will largely depend on how much they contribute to effectiveness and efficiency of nursing care.
- CDSSs have potential to contribute to effectiveness in care by identifying and alerting nurses to patterns in EHR data that indicate possible resident problems, thus facilitating earlier interventions.
- CDSS information, including alerts and associated responses, can potentially enhance a facilities quality assurance oversight and quality improvement analyses.
- CDSSs may contribute to research-based knowledge of nursing home performance.

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European Biomedical Informatics Gateway

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Abstract

In 2004, the European Network of Excellence INFOBIOMED (http://infobiomed.org) (IST-507585) was set to consolidate a stable and lasting European network with BMI as an essential discipline for the future of healthcare through the work carried out in the four pilots in which the 17 European partners participated. INFOBIOMED had six work packages one of which was Dissemination & Communication that coordinated all the information policy of the NoE both to the scientific community and to other stakeholders. The objective of this paper is to describe the development and implementation of the INFOBIOMED Gateway, a repository for compiling, organizing and disseminating the latests news about Biomedical Informatics, mainly in Europe but also in the rest of the world.

Keywords:
bioinformatics, medical informatics, biomedical informatics, repository, INFOBIOMED

Introduction

The EU's sixth framework program that is about to finish (2002-2006) has had as one of its main priorities life sciences, genomics and biotechnology for health. In February 2003, the EU BIOINFOMED project (http://bioinfomed.isciii.es/) "Prospective Analysis of the Relationships and Synergy Between Medical Informatics and Bioinformatics" [1, 2] ended with the publication of a White Paper [3]. The document detailed 18 research lines identified and prioritized to help consolidate the integration of the genetic information in the field of public health through the application of the Information and communication technologies. It analysed in detail all synergies that take place between two well established disciplines, Bioinformatics (BI) and Medical Informatics (MI

The Network of Excellence (NoE) INFOBIOMED [4-8] titled "Structuring European Biomedical Informatics to Support Individualised Healthcare" is funded by the Information Society Directorate-General of the European Commission within the VI Framework Programme for Research and Technological Development. The Network is composed of 17 research groups from 9 different European countries. Its main objective is to establish a stable and lasting European network in BMI. With this objective in mind they designed 4 pilots in which collaborative work between heterogeneous (MI, BI, BMI, Health care) research groups is essential.

The network is divided into six work packages (WP): Coordination, Dissemination and communication; Training and Mobility; Data Interoperability & management; Methods, technologies & tools and Pilot applications. Under the umbrella of this work package some communication materials such as newsletters, web page, brochure, oral communications, posters, etc have been developed to disseminate the work carried out in the network. However, dissemination is a still a challenge when it is necessary to keep the community updated about the wide spectrum of possibilities available through the Internet. Lots of resources are necessary for this task.

The great variety of resources available, the heterogeneity, the geographic distribution of the different research groups and the large number of publications indexed in pubmed prompted the development of a tool that specifically gathers together all materials produced in the world about BMI.

Materials and methods

New Biomedical data is mainly reported through journals and conference proceedings. These publications do not present a structured pattern which would make possible the use of data mining or knowledge discovery techniques and tools to include in an automatic manner this new information into ontologies. It is also important to take into account the increasing number of publications with biomedical information. This makes it very difficult for human curators to extract all the information. Some companies are trying to tackle this problem, in particular IBM is working on the development of a Semantic Web for Life Sciences. The idea is to use lexico-syntactic patterns to find biomedical relations in the internet. [10]

The BIOINFOMED Study compiled a resources guide that listed a large number of biomedical information resources grouped into the following categories: Standards in BI, BMI and MI, Scientific Societies and Working Groups, Journals in BMI, Congresses in BMI, Groups and Projects,

Papers in BMI, Books in BMI, Training programs in BMI and Links in BMI.

One of the main objectives of the INFOBIOMED project is to keep the guide updated, as an essential tool for classifying, organizing and disseminating the ever increasing number of research projects, groups and articles about BMI. With that objective in mind basic aspects such as searches and storage of the information included in the guide has been notably improved. These processes are now more efficient that the traditional list of links in html web page, that had to be edited by hand.

Informatics specialists built for INFOBIOMED the "Biomedical Informatics Gateway", a database designed with SQL server and implemented with PHP so that it could grow indefinitely. It can be updated from any computer through a secure access protected by a user id and a password. The INFOBIOMED webpage is hosted in the servers of one of the partners, which is also the coordinator of the project, the "*Fundació IMIM"* (FIMIM), in Barcelona, Spain. Data capture in the data base can be done from any computer with an internet connection from the restricted area of the website. However most of the loading and filtering of the contents of the Gateway is done by the ISCIII. For this purpose and for preserving gathered data a secure access interface has been implemented.

Once the user has been validated, the user accesses the main administration screen, organized into four sections: *Events and Announcements, Training, Repository and Links*. Each section includes its own fields which will later be seen in the Gateway. For example, the fields included in the section *Events and Announcements* are table ID, that is the primary key, title, which also is the hyperlink to a webpage, date the event takes place, location, country, status (it shows if the entry has any information and whether it has been filtered by an authorised user), insert Date, last Updated, user that has updated the contents and Topics/ Entities. This is the only field that can be edited by the user through a pop up window. It provides information about the user that is validating the data, the title of the event which corresponds with the hyperlink to its web site, the dates and the location of the event. The filtering of the events is done by clicking on the boxes that characterise them and places them in their place in the Gateway.

The hierarchy of the resources was developed following two organizing criteria: topics & entities. There are 19 topics, 18 of which coincide with the 18 research lines initially identified and a general topic titled "Initiatives integrating several Research Lines".

The loading data in the Gateway can only be done by a authorised user but the information can be proposed for entry by any of project partners or any other stakeholder interested in their information appearing on the web. The filtering of the data captured by an authorised user taking into account the topics and entities is what determines whether or not the information will appear in the database and under what topic.

Results

The INFOBIOMED Gateway (http://infobiomed.org) is a free access tool for the compilation, storage and retrieval of biomedical informatics information. This is structured in a database and it is regularly updated. Queries are simple and direct through a web interface and are divided into two categories: topics and entities. The tool was developed with the idea of disseminating all activities carried out in the field of BMI to the scientific community in a filtered and organised manner. The topics coincide with the 18 lines identified in the BIOINFOMED project with the addition of another general line: *Initiatives integrating several Research Lines.* Through this we can retrieve all the information included in those entries in the database that involve several research lines simultaneously.

The interface of the Gateway resembles a chess board in which the topics are in the row and the entities are in the columns. There are different ways to make the queries: i) free-text query, there is a box for free text queries that opens a popup window with the results of the query if there are any; ii) query by topics: if you click over any of the 19 titles of the columns, you will get a new window that will show all the entities related to the subject, such as standards, congresses, working groups; iii) query by entities: it is possible to visualize all Congresses in all the topics if we click on the column titled "Congresses" and iv) individual queries: each of the squares makes an individual query for the chosen topic and entity. All queries are visualised by hyperlinks that take directly to the website to which they refer.

Conclusions

One of the main objectives of the NoE is to provide the bases for a stable and durable European structure in the field of BMI. The dissemination to the scientific community and other stakeholders of the objectives, work methodology and results help achieve this goal. This is usually done through the traditional channels but it has now also found in the Internet a way of globalising its discoveries and communicating information.

The easy access and the low cost of the infrastructures help publish and disseminate making it easier to share research results and all new information. However, with the increasing amount of information published, storing, organizing and disseminating all the available biomedical information are the new challenges faced by our society.

The INFOBIOMED Gateway is a tool that tackles this challenge and meets all the criteria: free and easy access through the Internet, updated information and specific to one field: Biomedical Informatics. It is a point of reference, just like the website, for finding the latest news about the 19 lines of research that were identified and detailed in the agenda developed by the BIONFOMED project and that are now part of the INFOBIOMED project.

European Biomedical Informatics Gateway

TOPIC: *The impact of genomics research in clinical information systems*

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“INFOBIOMED Gateway is a repository for compiling, organizing and disseminating the latests news about Biomedical Informatics, mainly in Europe but also in the rest of the world.”

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The **10th INFOBIOMED Consortium Meeting** was held in **Girona, Spain**, last **12th and 13th of February, 2007.**

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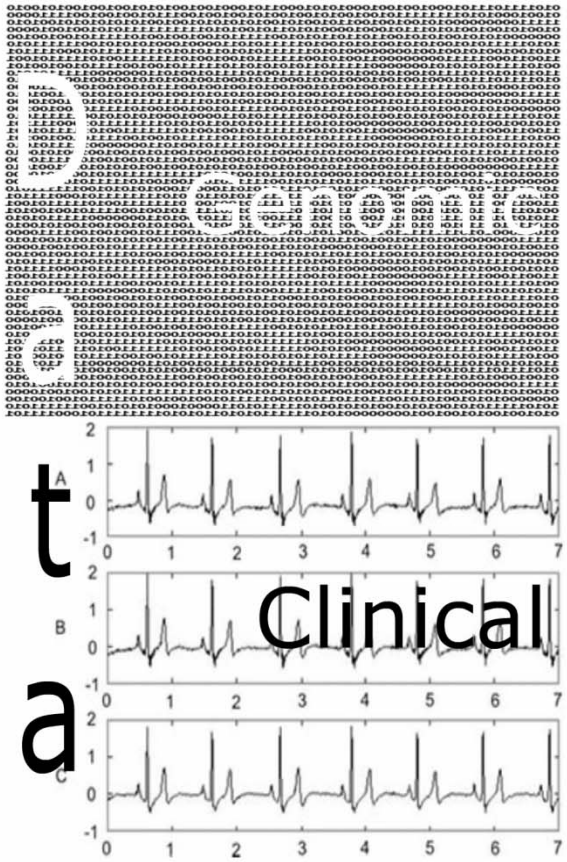
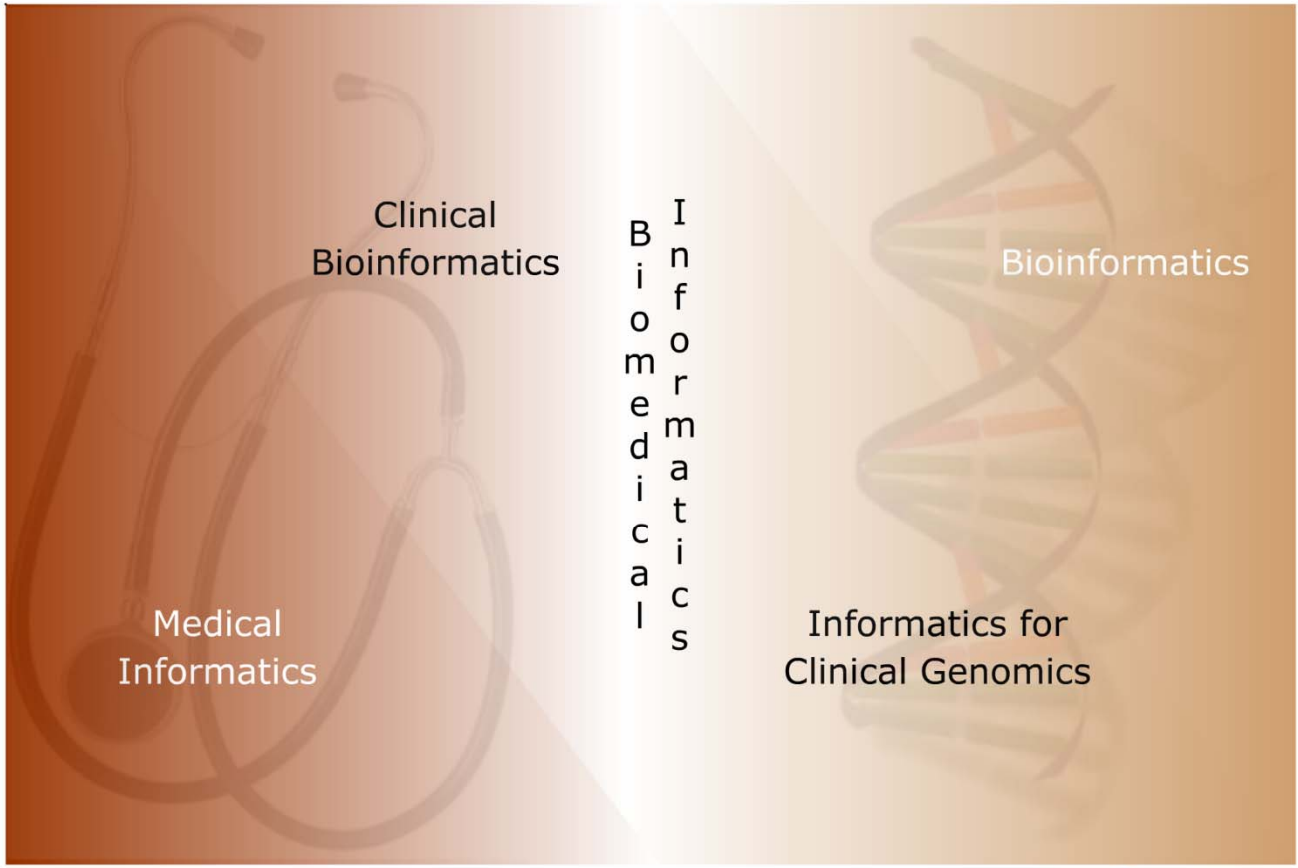
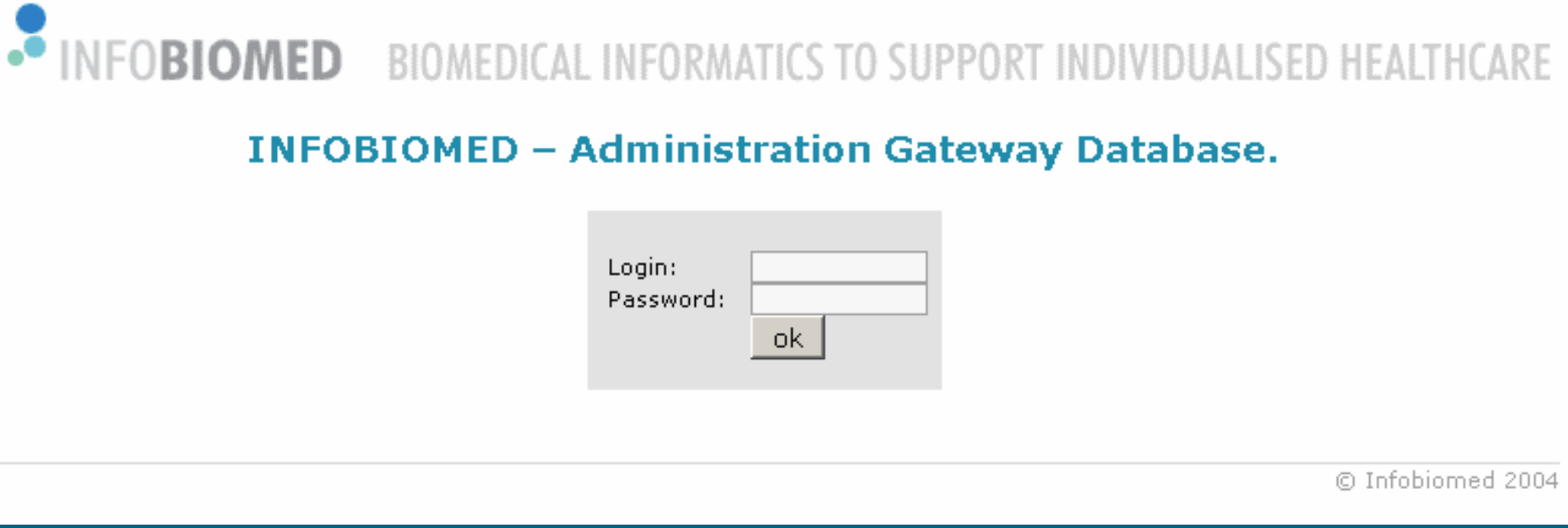




“Biomedical Informatics Gateway” is a database designed with SQL server and implemented with PHP so it can be scale easily and updated from any computer through a secure access protected by a user id and a password.



Administration Gateway Database: structure

Events & announcements	Training Repository	Links
ID Title Date Location Country Topics/Entities Status Insert Date Last Updated User		ID Title Topics/Entities Status Insert Date Last Updated User

Links

ID	Title	Topics/Entities	Status	Insert Date	Last Updated	User
128	A Developer's Overview of OGSI and OGSI-based Grid Computing		✔	20/04/2005	04/05/2005 12:48	fjvicente
244	ACM Special Interest Group on Knowledge Discovery and Data Mining (SIGKDD)		✔	06/05/2005	16/05/2005 14:19	fjvicente
321	AHIMA: American Health Information Management Association		✔	14/10/2005	07/12/2005 10:47	fjvicente
194	AMIA - Formal (Bio)Medical Knowledge Representation Working Group (KR-WG)		✔	26/04/2005	07/12/2005 10:47	fjvicente
267	AMIA - Genomics Working Group (GEN-WG)		✔	12/05/2005	07/12/2005 10:47	fjvicente
246	AMIA - Knowledge Discovery and Data Mining Working Group (KDDM-WG)		✔	06/05/2005	07/12/2005 10:47	fjvicente
178	AMIA - Open Source Working Group (OS-WG)		✔	25/04/2005	07/12/2005 10:47	fjvicente
383	AMIA - Working Groups Clinical Trials (CT-WG)		✔	10/03/2006	03/05/2006 11:24	fjvicente
345	American College of Medical Genetics		✔	08/11/2005	07/12/2005 10:48	fjvicente
210	American Medical Informatics Association (AMIA)		✔	26/04/2005	16/05/2005 14:20	fjvicente
427	American Society for Microbiology (ASM)		✔	18/05/2006	03/07/2006 10:43	fjvicente
495	American Telemedicine Association		no data	22/01/2007	22/01/2007 14:15	NVILLAHOZ
269	Applied Bioinformatics		✔	12/05/2005	07/12/2005 10:48	fjvicente
197	Asian Institute of Technology - Knowledge Representation Laboratory		✔	26/04/2005	04/05/2005 12:49	fjvicente
494	Association of Telehealth Service Providers		no data	22/01/2007	22/01/2007 14:15	NVILLAHOZ
236	BIOHEALTH NORWAY		✔	06/05/2005	16/05/2005 14:20	fjvicente
36	BIOINFOMED		✔	21/12/2004	13/01/2005 14:50	fjvicente
37	BIOPATTERN		✔	21/12/2004	11/09/2006 10:59	fjvicente
35	BioGRID		✔	21/12/2004	23/05/2005 12:55	fjvicente
192	Bioinfomed Study: Standards		✔	26/04/2005	26/04/2005 13:58	fjvicente
237	Bioinformatics		✔	06/05/2005	16/05/2005 14:21	fjvicente
323	CLEF - integrating information for the clinical e-Scientist		✔	14/10/2005	07/12/2005 10:48	fjvicente
171	CORBA Interoperability approved as ISO Standard		✔	25/04/2005	26/04/2005 13:56	fjvicente
403	CPOCT Division (Critical and Point of Care Testing) of the American Association for Clinical Chemistry (AACC)		✔	17/05/2006	11/09/2006 11:00	fjvicente
351	Canadian Paediatric Society: Guidelines for genetic testing of healthy children		✔	01/12/2005	07/12/2005 10:49	fjvicente
497	Cancer Genetics - Virtual Outreach Clinics Pilot		no data	22/01/2007	22/01/2007 14:20	NVILLAHOZ
235	Chinese Gene Variation Database (CGVdb): 90 Phenotypes Online		✔	06/05/2005	16/05/2005 14:21	fjvicente
433	Clinical Discovery		✔	19/06/2006	03/07/2006 10:52	fjvicente
350	Clinical Genetics Society		✔	01/12/2005	07/12/2005 10:50	fjvicente
426	Clinical Microbiology Reviews		✔	18/05/2006	03/07/2006 10:46	fjvicente
337	Clinical Molecular Genetics Society: Best practice guidelines		✔	08/11/2005	07/12/2005 10:51	fjvicente
262	Computer Scientists Develop Tool for Mining Genomic Data		✔	10/05/2005	16/05/2005 14:22	fjvicente
376	Contract Research Organization (CRO) for Clinical Trials		✔	10/03/2006	03/05/2006 11:28	fjvicente
170	CoreGRID		✔	25/04/2005	26/04/2005 13:56	fjvicente

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A Developer's Overview of OGSI and OGSI-based Grid Computing

Entities

- [x] Standards
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Topics

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June 8 - 10, 2007 - Amsterdam, Netherlands

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June 20 - 23, 2007 - Dagstuhl, Germany

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June 25 - 27, 2007 - Barcelona, Spain

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International Symposium on Bio-Medical Informatics and Cybernetics: BMIC 2007
July 8 - 11, 2007 - Orlando, Florida, United States

CIMED2007: Third International Conference on Computational Intelligence in Medicine and Healthcare
July 25 - 27, 2007 - Plymouth, United Kingdom

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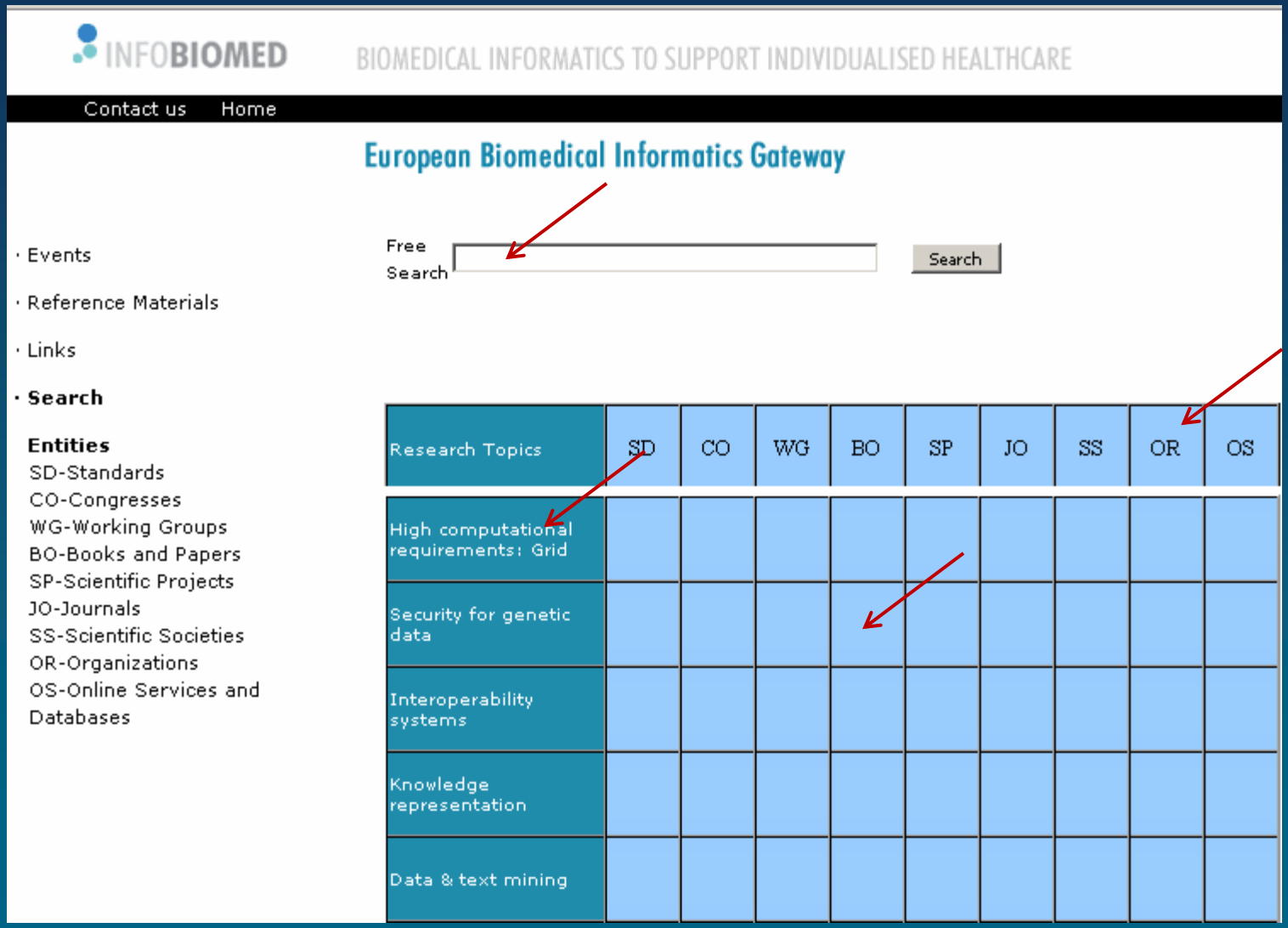

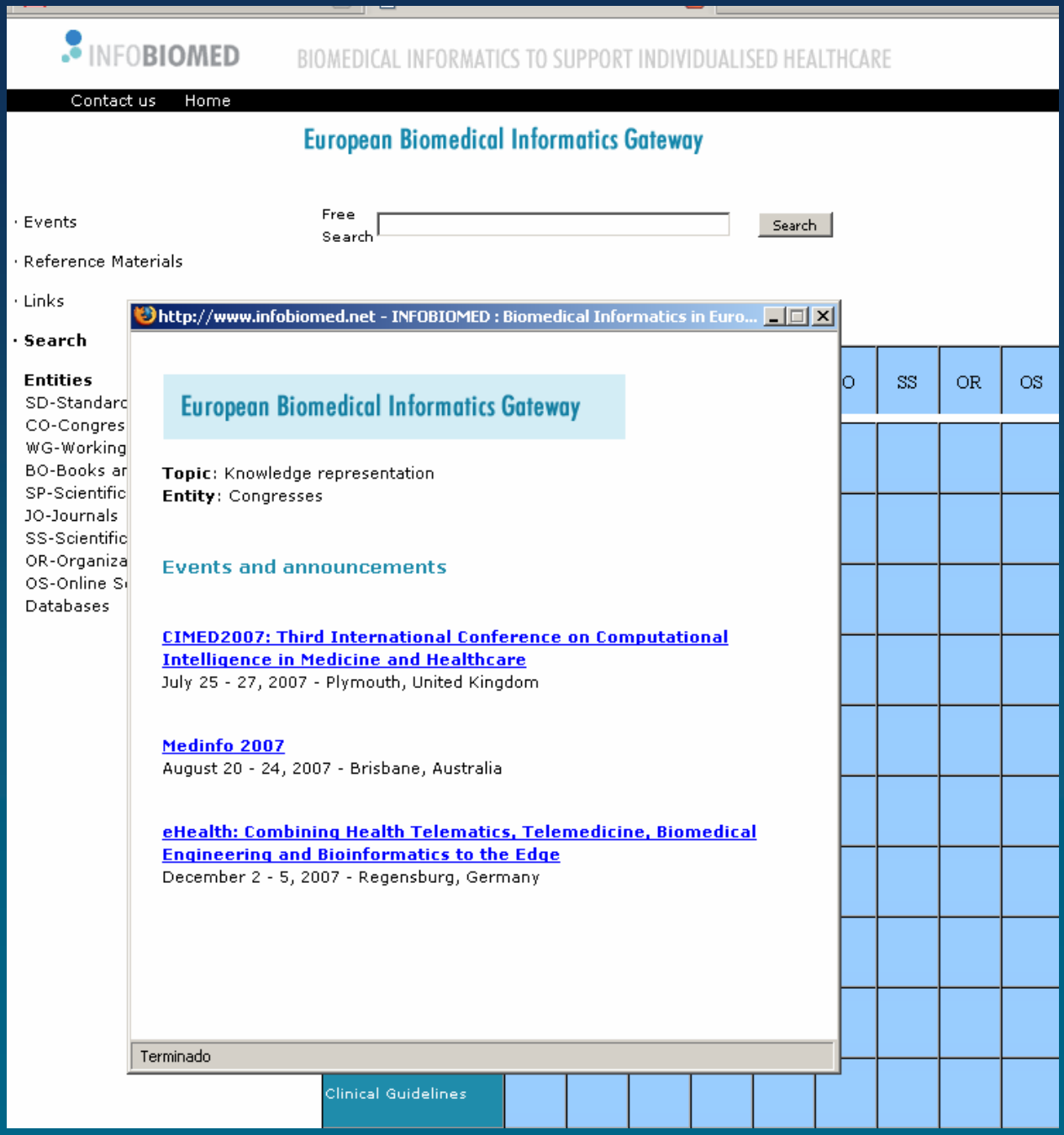
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CIMED2007: Third International Conference on Computational Intelligence in Medicine and Healthcare
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December 2 - 5, 2007 - Regensburg, Germany
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Acknowledgments

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Monitoring Clinical Pathways

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Abstract

This paper describes the development of a monitoring system for Clinical Pathways. Data are collected from existing data sources, which proved much more efficient than manual data collection. The DBC, the recently introduced Dutch equivalent of the DRG, proved to be a useful data source. With the system it is possible to monitor several indicators for a given pathway.

Keywords:

critical pathways, quality indicators, total quality management, information storage and retrieval, diagnosis-related groups

Introduction

Health care organizations are seriously challenged to deliver cheaper and better services. To achieve this goal, improvement programs are launched on the local or national level. An example of a national improvement program is 'Sneller Beter', Dutch for 'Quicker Better', which was launched in the Netherlands in 2004 [1]. The program started out in 8 hospitals, with 16 more in the following two years. These 24 hospitals were selected to set examples of good practice for the other 80 hospitals in the Netherlands.

Improvement requires measurement[2]. In all quality improvement methods, like Six Sigma or TQM [3], measuring plays an important role. Measuring can be done either manually or with the help of a computer. Of course, if automation is possible, this will be much more efficient [4].

A widely accepted method of improvement of hospital care is the implementation of Clinical Pathways. Clinical Pathways (also referred to as Critical Pathways or Care Paths) are multi-disciplinary plans of best clinical practice for specified groups of patients with a particular diagnosis that aid the coordination and delivery of high quality of care [5]. Just like other improvement methods, this method requires measurement to assess the standards of care as they evolve during and after the Clinical Pathway implementation [6].

In the Netherlands, the interest for Clinical Pathways was boosted by the 'Sneller Beter' improvement program. Many hospitals have started to develop Pathways within or outside of the 'Sneller Beter' program. However, many hospitals also struggle with the measurements that are needed. If this is done by hand, this poses a serious question to available resources. What if this could be automated?

The VUmc Hospital is one of the eight hospitals that participated in Sneller Beter from the very first start. The question of automation of measurements for Clinical Pathways came up at the end of 2005, when several Pathways were implemented, but there was no permanent monitoring of results, because manual data collection was too labor-intensive.

In this article the method of constructing such an automated monitoring system is discussed, with the difficulties encountered, and the results are shown.

Methods

The construction of a monitoring system for Clinical Pathways comes down to the following steps:

1. Selection of patients
2. Calculation of indicators
3. Presentation of indicators

An additional step is necessary beforehand, if the data that is going to be used is not available in an easy-to-access database. In that case extractions need to be built, to load the data from one database into another. In the VUmc we could use the hospital data warehouse, therefore this extra step was not necessary.

The three steps will now be discussed in more detail.

1. Selection of patients

Many hospitals implement Clinical Pathways, but do not run an automated Clinical Pathway planning system. The VUmc is not an exception. This makes the first step of building a monitoring system the hardest one. Which patients are 'in' the pathway, and which patients are not? Only if a correct patient selection can be made, it is possible to calculate indicators for these selected patients. There are several data sources available to solve this question. In the VUmc we used the recently introduced DBC, the Dutch equivalent of the DRG. DBC stands for Diagnosis Treatment ('Behandeling' in Dutch) Code. Linking DBCs/

DRGs to Clinical Pathways is not uncommon [7]. Table 1 shows the items which are included in the DBC registration. An exception is the last item, the DBC Profile. This is a collection of procedure data, which is automatically linked to a DBC by a special algorithm. We include it here, because we will discuss its usability for the monitoring system.

Table 1 - DBC items

Item	Description
Patient ID	Unique patient number for the VUmc hospital
Treating Medical Specialty	E.g. internal medicine, gynaecology, orthopaedic surgery
Opening date	The date of the first encounter with the medical specialist
Closing date	The date the specialist refers the patient back to the GP or to another specialist
Type of Patient	Either new patient or known patient
Diagnosis	A classification of the disease of the patient, on a slightly higher level of granularity than ICD9 or ICD10
Treatment	Depending on the specialty, e.g. operation with hip replacement. This item includes the setting, e.g. inpatient or outpatient
DBC Profile	all the necessary procedures which were applied for this patient, between opening date and closing date, for this medical specialty. On the basis of the DBC profile, the hospital is able to calculate the average cost of a certain DBC.

For the patient selection, the items Treating Medical Specialty, Opening Date, Type of Patient, Diagnosis and Treatment were used. Only "new" patients were selected, and for some pathways only those patients with an inpatient treatment.

The dashboard shows the results only for patients from the current year, therefore selection is also made on Opening date.

For every particular pathway, the selection criteria of DBC-items should be identified that match the pathway. However, this is not a single-step-process. After a first selection is made, the selected patients should be matched with some other data source. In the VUmc it was possible to use spreadsheet-administrations of nurses who had been assigned this task. If there is no matching data source available, then a doctor or nurse who is strongly involved in the Clinical Pathway should check the DBC patient selection. This matching process can be the basis for a refinement of selection parameters. After a new selection is made, the result should be validated again. The process repeats itself until a sufficient level of confidence in the DBC selection method is reached.

The results of the matching process in the VUmc will be discussed in the results section.

2. Calculation of indicators

There are several types of indicators for Clinical Pathways [8].

The most important are Clinical, Financial and Process indicators. In the Sneller Beter program, process indicators were the main focus of the CP development. Examples of indicators are waiting time for an operation and length of stay.

Many of the indicators are shared between Clinical Pathways. This means that if an indicator is developed for one Pathway, it can be used by many other Pathways, if appropriate patient selection is applied.

We searched the hospital database for appropriate data items.

One of the difficulties encountered here, was that Clinical Pathways are, in fact, multidisciplinary. Therefore it was not possible to use only procedure data from the DBC profile. DBCs are monodisciplinary, so only procedures from a single medical specialty are part of it. For this reason, database selection needed to be extended beyond the DBC data.

Table 2 shows indicators and data sources from which they can be drawn.

Table 2 - Indicators and data sources

Indicator	Data sources
Access time to first encounter with specialist	DBC Opening date, Outpatient planning system
Time to diagnosis	DBC Opening date, Procedure data
Number of visits before admission	Procedure data, ADT data (admission-discharge-transfer)
Waiting time for admission	Inpatient planning system
Length of Stay	ADT data
Time between diagnosis and surgical operation	Procedure data, operating system data
Time between diagnosis and radiotherapy	Procedure data
Costs	DBC profile
Readmissions	ADT data

Of course, similar as with the selection of patients, the quality of the data sources should be checked before they can be used. If, for instance, procedures are not properly coded in the hospital, a lot of these indicators cannot be calculated. Fortunately in the VUmc the quality of these data sources was sufficient. The 'Costs' indicator was limited to the costs of the DBC, used for the patient selection.

For some indicators the problem is not data quality, but simply the availability in electronic format. This was the case for the indicator 'number of complications'. The VUmc does not yet run an organisation-wide complication registration system.

The indicators are first calculated per patient, and then an aggregation is made to the level of the Pathway. The aggregates are calculated on the basis of

- median values (e.g. waiting times, length of stay)
- percentages (e.g. operated patients, readmissions)
- totals (e.g. number of patients in the pathway)

3. Presentation of indicators

We developed a dashboard based on Cognos [9] and HTML technology. For management information, this type of dashboards already existed in the VUmc hospital, showing indicators like production rates, absence ratio of personnel and average waiting time for admitted patients. This dashboard is accessible through the intranet. An important feature of the system is the possibility to enter target values, e.g. a length of stay of 4 days. If reality shows that the median value for length of stay is more than 4 days, a "red flag" is shown, indicating that length of stay is above the target level.

In the results section three screen examples are shown.

Results

At the time of writing of this article (November 2006) dashboards have been developed for three Clinical Pathways, Head-Neck Oncology, Carotid Surgery and Abdominal Aorta Aneurysm repair. These Pathways showed a good agreement between manual and automated (DBC) data sets.

An important finding was the fact that manual data collection did cost the nurses, who were assigned this task, up to 4 hours a week for a single Pathway. The development of the dashboard system for the three Pathways did cost about 200 hours (mainly from the first author, a database specialist).

We show three examples from the application. The indicator values which are shown are not completely based on reality, but are only provided for illustration purposes.

Figure 1 shows an example dashboard for head-neck oncological patients. The report shows three subsections: Financial, Logistics (which contains the most indicators) and Clinical. Every indicator line displays name of the indicator, target value, current value and previous value. At the right part of the screen there are 2 hyperlinks, which give access to additional information.

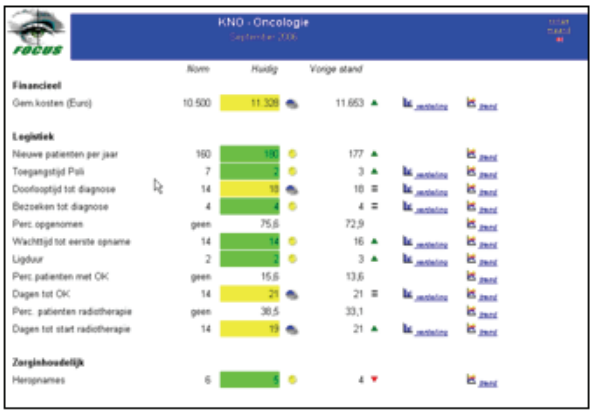

Figure 1 –Monthly overview of indicators for a certain Pathway

Figure 2 shows an example of what shows up from the first hyperlink, a bar chart of indicator values for all the individual patients in the Pathway. This particular graph shows the number of visits to the outpatient clinic, before admission. This graph gives a good insight in the number of outliers. Notably, not for all patients a value is presented. This is due to the fact that for this Pathway included patients do not need an inpatient period. If no inpatient period is found, then the indicator "Number of visits until admission", can not be calculated for this particular patient.

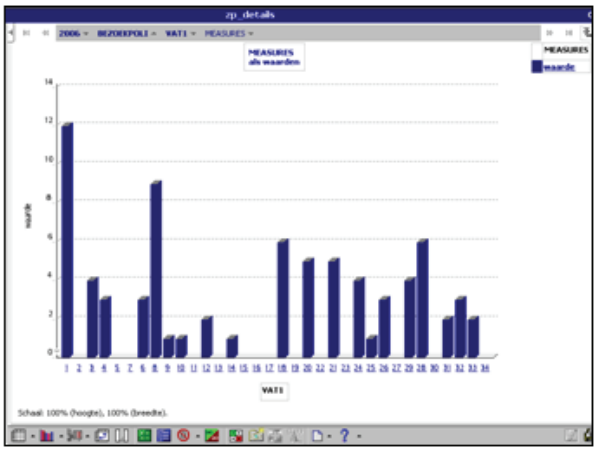

Figure 2 -Indicator scores per patient

Figure 3 shows the development of a certain indicator through the year, together with the target value (horizontal line). The values are based on aggregates (median values) for all patients from January up to the specific month. This example shows the access time for the outpatient clinic, which was seriously improved, but on aggregate still remained above the target of 7 days.

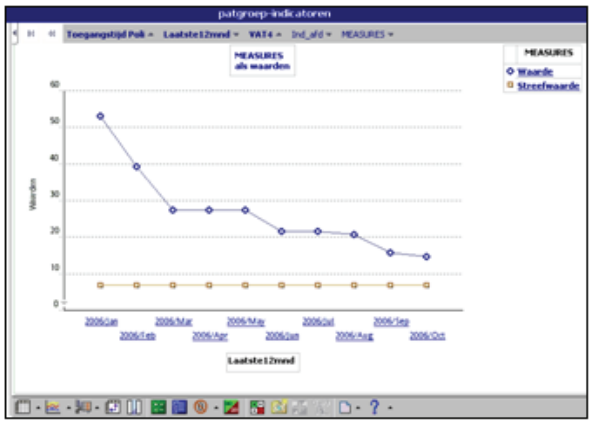

Figure 3 – Development of indicator through the current year

Discussion and future developments

From the hours estimated necessary for manual versus automatic data collection, it is clear that the investment in developing a system for automatic data collection is quickly returned. If for the three Pathways we estimate 10 hours of work a week by a nurse, then the 200 hours by the database specialist are returned in just 20 weeks. Moreover, the system can be used for additional Pathways, which will lower the cost per Pathway. As we described in the method section, once an indicator is developed, it can be used by all the Pathways defined in the system. However, additional effort will always be necessary for the first step of the process, setting up the right criteria for patient selection. The VUmc is planning to develop more than 100 Clinical Pathways in the coming five years.

A difficulty with the system is that it is not completely clear who its users are. Primary users of dashboards in general, are those who are responsible for the particular management unit. Because Clinical Pathways are multidisciplinary, it is not always easy to find an 'owner' of the Pathway, who is also a primary user of the monitoring system. This management question is still to be addressed by VUmc senior management.
Secondary users, who have an interest in the Pathways, but are not primarily responsible, are for example quality assurance staff, who are assisting with Clinical Pathway development, and senior management.

The system was first developed in the VUmc hospital, but another hospital, the Atrium in Heerlen, asked to do the same there. A prototype was developed, using the method as described above. The main difference was that the patient selection was not carried out on the basis of DBC data, but on planning data. However, no results are available from a matching analysis between automated and manually collected data, as carried out in the VUmc hospital.

A drawback of the system is that in the first part of the year, the number of patients will be relatively low, therefore indicator values will not be as reliable as in the second part of the year. This will be particularly true if registrations are lagging. For example, it can take a while before a DBC is completely coded. If this includes the items which are necessary for the selection for the dashboard, then the patient will be 'missed'. In the VUmc, the care administration staff has a major job in keeping the DBC registration up to date.

Conclusion

The monitoring system is a valuable tool for the VUmc to develop and maintain Clinical Pathways. Although in this case information technology does not bring any improvements to the care process itself, it does support the improvement potential of Clinical Pathway implementation. In this sense, it also contributes to the realization of a sustainable health care system.

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Development and Implementation of Physician Profiling Tool

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Abstract

Physician Profiling is an analytical tool used to provide information on health care processes and it is based on the generation of different indicators whose purpose is to optimize clinical outcomes. The Hospital Italiano de Buenos Aires created a Physician Profiling Program for family physicians in its Health Maintenance Organization (HMO). The indicators used were based on the Health Plan Employer Data and Information Set (HEDIS). In order to generate and view those indicators, a software program that showed results of every indicator in graph format was developed. The aim of the present study is to describe the development and implementation of such software.

Keywords:

physician profiling, HEDIS, quality indicators, health care

Introduction

Quality monitoring and quality improving are usually related important issues in health care organizations. They both attempt to promote medical care through clinical guidelines and patients' satisfaction.

Deficiencies in healthcare account for the need of monitoring quality patterns. Quality monitoring is usually reported in the medical literature under three categories: (A) Patients who do not get health care benefits; (B) Patients who get unnecessary treatments; (C) Low-frequency use of some interventions [1].

Physicians' work overload as well as their multiple daily duties often result in small deficiencies in health care, which can be easily detected through monitoring tools. Health care quality can be measured either by watching health care processes (e.g. preventive practices delivery) or by health outcomes (e.g. morbidity and mortality rates) [2].

A useful tool for measuring health care processes is **Physician Profiling**, which generates information on health care processes usually by means of data from electronic transactions which provide medical care indicators.

The Hospital Italiano in Buenos Aires is a high-complexity University Hospital with 650 inpatient hospitalization beds and 23 outpatient health care centres distributed between the City of Buenos Aires and the surrounding metropolitan area. It has a pre-paid medical insurance plan called *Plan de Salud* with 140,000 members at present. It delivers 150,000 outpatients visits and 3,000 inpatients admissions monthly. Since 1998, both clinical and administrative issues are registered in a comprehensive health information system [3] . Due to the need to monitor the health care quality of our Hospital Italiano *Plan de Salud*, a physician profiling program has been implemented to measure the performance of interventions at our Institution. The program was created following HEDIS measurements and the indicators were shown to different primary health care physicians by means of a software program which allows for the graphic representation of these indicators. The aim of the present study is to describe the development and implementation of this tool destined to profile primary health care physicians at the Hospital Italiano in Buenos Aires.

Methods

In 2003, to carry out this project, the Family Medicine Unit together with both the *Plan de Salud* Quality Area and the Department of Medical Informatics started the development of a number of health care indicators based on Health Plan Employer Data and Information Set (HEDIS) measurements [4]. HEDIS was created by the National Commission for Quality Assurance (NCQA) in the USA to assess and compare different health plans.

In our case, we used HEDIS to measure intervention performance at the population level. It was not our aim to compare results with other institutions.

Fifteen HEDIS measurements –out of approximately 60— were selected for the creation of these indicators, which were based on cancer screening and control of most frequent diseases. Each indicator was determined by an

equation whose numerator and denominator emerged from an adjustment of the HEDIS measurement selected. For example, the indicator for screening breast cancer was composed as follows:

NUMERATOR: Women with a biannual breast echography or mammography.

DENOMINATOR: 40-75 year old women. No limit to number of patients.

Once indicators had been determined, data was collected and entered into a database. Collected data included patient identification and some other information like period of time measured, age, birth date, hypertension readings, diabetes, last glycosylated haemoglobin (HBGli), LDL and HDL measurement, etc. It later became necessary to establish the source of the data being fed into this database, namely, whether it came from clinical or administrative databases.

Having determined the parameters and collected the data, a web-technology-based interface was designed. The programming language used was PHP 4.0 and MySQL was used as a database. This interface allowed for the graphing of indicators over a year both from the individual viewpoint of each physician and from the institutional standpoint. Figure 1 shows the graph that depicts indicators and their local outcomes in one column (Outcomes) and the desired outcomes according to the bibliography in the other (Goal).

This software was accessible from the Personal Information Section of the Hospital Intranet. For Privacy and Confidentiality reasons regarding personal information, and in order to avoid either political or personal conflicts between our professionals, each physician had access to his/her own results only.

Results were presented in a radar graph, where each axis represented one of the 15 indicators selected.

On the other hand, it was also possible to establish comparisons through a dispersion graph in which the results of a particular physician were compared to the results of the rest of the physicians at our Institution.

Discussion

The tool developed allowed to assess the performance of interventions under the *Plan de Salud* of Hospital Italiano in Buenos Aires. This information was then fed back to the physicians to analyse indicators outcome and to discuss with them the implementation of strategies for continuous improvement. In addition, many of the indicators were deemed difficult to improve solely from the primary health care standpoint and so, other strategies, like Programs for Chronic Disease Management were supported.

At present, work on stratification according to the different profiles is being carried out. The following criteria are being taken into account:

- Health care effectiveness indicators.
- Taking part in institutional resources, like using the Electronic Medical Record (EMR), participating of training courses, making presentations at the hospital discussion groups, attending congresses, etc.
- Scoring health care received (user's degree of satisfaction) through the different available tools.

Another strategy proposed for improvement consisted of making indicators dynamic, even to have hidden indicators for a strategically monitoring in order to avoid the risk posed by the use of profiling indicators, namely, that of working only in terms of the information provided by the indicators and leaving aside other aspects of health care.

In the future, this tool will hopefully enable us to measure the impact of having implemented the Support Systems for the Decision-making Process, which includes alerts or reminders on preventive practices.

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Development and Implementation of Physician Profiling Tool

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HOSPITAL ITALIANO de Buenos Aires

Department of Medical Informatics

Introduction

- Physician Profiling is an analytical tool used to provide information on health care processes and it is based on the generation of different indicators whose purpose is to optimize clinical outcomes.

- The Hospital Italiano de Buenos Aires created a Physician Profiling Program for family physicians in its Health Maintenance Organization (HMO).

- The Hospital Italiano de Buenos Aires is a high-complexity University Hospital with 650 inpatient hospitalization beds and 23 outpatient health care centres.

- It has a pre-paid medical insurance plan called Plan de Salud with 140,000 members at present.

- It delivers 150,000 outpatients visits and 3,000 inpatients admissions monthly.

Introduction (cont.)

- Due to the need of monitoring the health care quality of our Hospital's Plan de Salud, a physician profiling program has been implemented to measure the performance of interventions at our Institution.

- The program was created following HEDIS measurements.

- The indicators were shown to different primary health care physicians by means of a software program which allows for the graphic representation of these indicators.

Objective

- The aim of the present study is to describe the development and implementation of this tool destined to profile primary health care physicians at the Hospital Italiano de Buenos Aires.

Methods

- In 2003 started the development of a number of health care indicators based on Health Plan Employer Data and Information Set (HEDIS) measurements.
- HEDIS was created by the National Commission for Quality Assurance (NCQA) in the USA to assess and compare different health plans.
- We used HEDIS to measure intervention performance at the population level. It was not our aim to compare results with other institutions.
- Fifteen HEDIS measurements –of approximately 60– were selected for the creation of these indicators

Methods

Indicators	Description
CA COLON	Colorectal cancer screening
CA Mama	Breast cancer screening
DBT BMI	Documentation of BMI in Diabetic patients
DBT HbGli	Request for Glycosylated Haemoglobin
DBT HbGli < 7	Percent of diabetic patients with HbA1C < 7%
DBT HbGli < 8	Percent of diabetic patients with HbA1C < 8%
DBT LDL	Request of LDL-c in DBT population
DBT LDL<100	Percent of diabetic patients with LDL cholesterol <100mg%
DBT LDL<130	Percent of diabetic patients with LDL cholesterol <130mg%
EnfCor LDL	Request for LDL-c in (IAM-CRM-PTCA)
EnfCor LDL<100	Percent of coronary heart disease patients with LDL cholesterol <100mg%
HTA Controlados	Percent of hypertensive patients under control (140/90)
HTA Registro TA	Documentation of BP measurement
PAP < 65	Cervical cancer screening < 65 years old
PAP < 75	Cervical cancer screening < 75 years old

HTA: Hypertension. CA: cancer. DBT: diabetes. HBGli: glycosylated hemoglobin. BMI: body mass index. Enf Cor: coronary disease PAP: PAP smear. LDL: low density lipoprotein. IAM: acute myocardial infarction. TA: arterial tension. CRM: myocardial revascularization surgery.

Methods

- Each indicator was determined by an equation whose numerator and denominator emerged from an adjustment of the HEDIS measurement selected. For example:

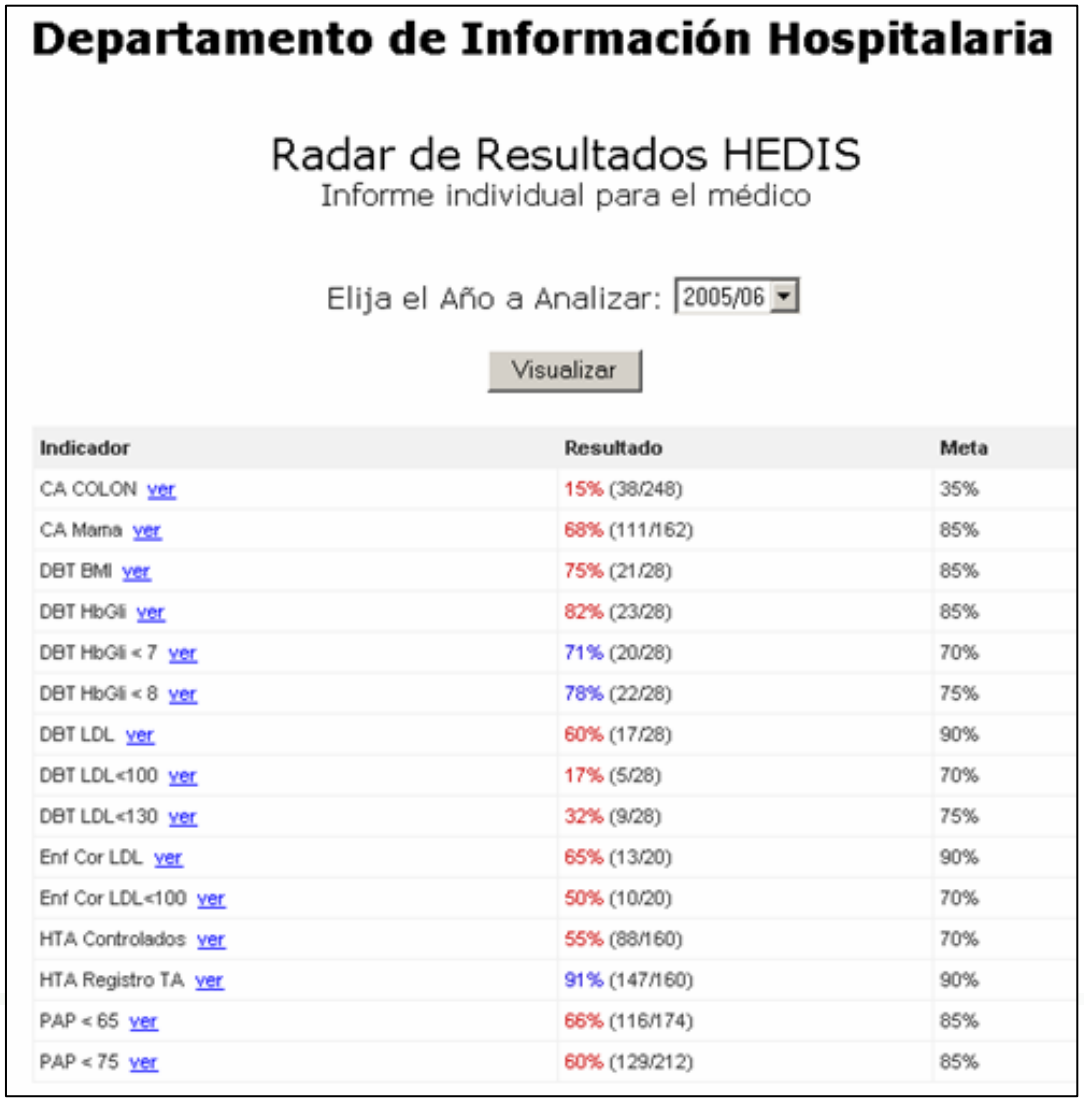
Breast Cancer Screening

$$\frac{\text{Women with a biannual breast echography or mammography}}{\text{40-75 year old women. No limit to number of patients}}$$

- This web-technology-based interface allowed for the graphing of indicators over a year both from the individual viewpoint of each physician and from the institutional standpoint.

- Results were presented in a radar graph, where each axis represented one of the 15 indicators selected.

HEDIS Indicators



Departamento de Información Hospitalaria

Radar de Resultados HEDIS

Informe individual para el médico

Elija el Año a Analizar: 2005/06

Visualizar

Indicador	Resultado	Meta
CA COLON ver	15% (38/248)	35%
CA Mama ver	68% (111/162)	85%
DBT BMI ver	75% (21/28)	85%
DBT HbGli ver	82% (23/28)	85%
DBT HbGli < 7 ver	71% (20/28)	70%
DBT HbGli < 8 ver	78% (22/28)	75%
DBT LDL ver	60% (17/28)	90%
DBT LDL<100 ver	17% (5/28)	70%
DBT LDL<130 ver	32% (9/28)	75%
Enf Cor LDL ver	65% (13/20)	90%
Enf Cor LDL<100 ver	50% (10/20)	70%
HTA Controlados ver	55% (88/160)	70%
HTA Registro TA ver	91% (147/160)	90%
PAP < 65 ver	66% (116/174)	85%
PAP < 75 ver	60% (129/212)	85%

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HEDIS radar

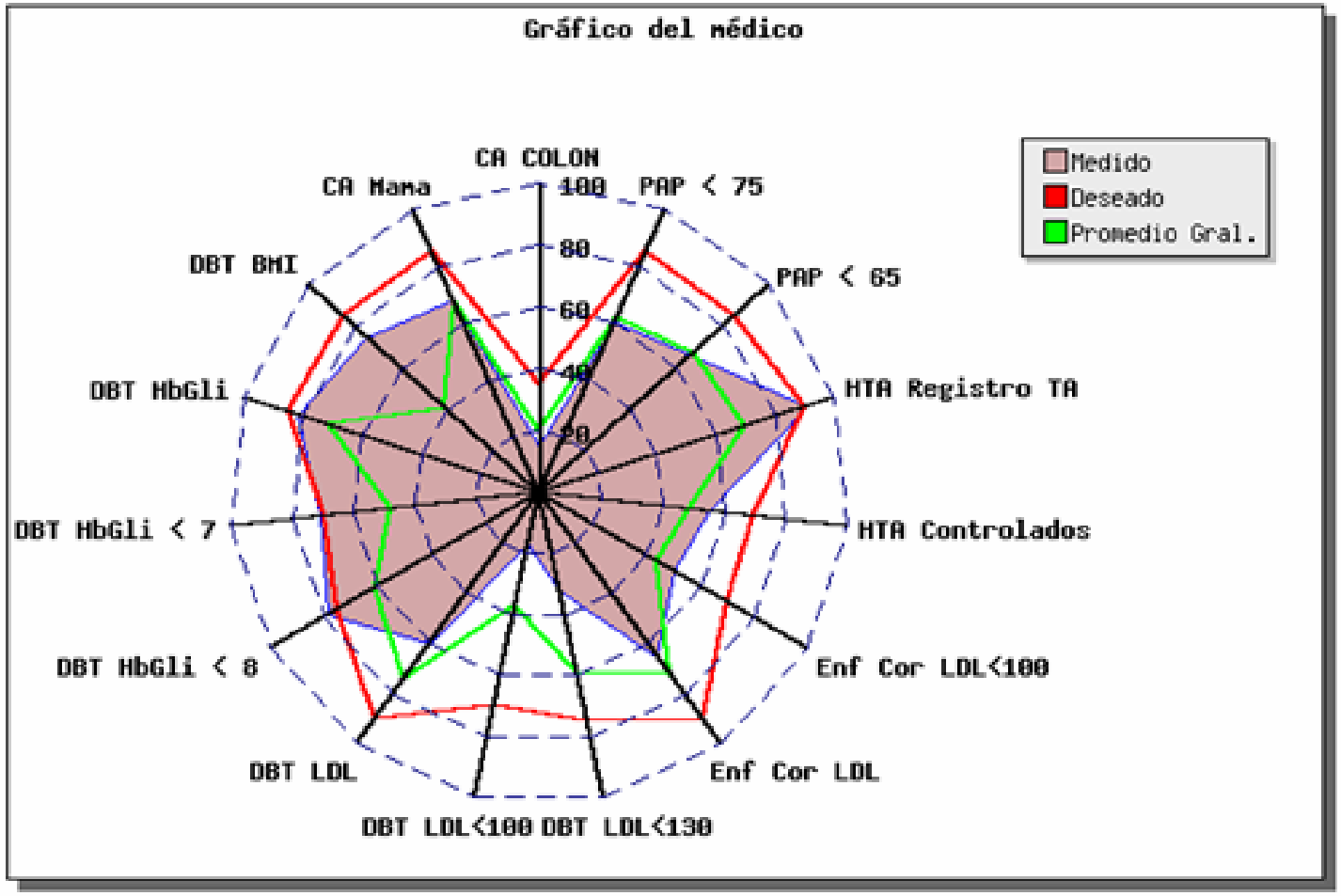
Gráfico del médico
Medido
Deseado
Promedio Gral.
CA COLON
PAP < 75
PAP < 65
HTA Registro TA
HTA Controlados
Enf Cor LDL<100
Enf Cor LDL
DBT LDL<130
DBT LDL<100
DBT LDL
DBT HbGli < 8
DBT HbGli < 7
DBT HbGli
DBT BMI
CA Mama
100
80
60
40
20

Discussion

- The tool developed allowed to assess the performance of interventions under the Plan de Salud of Hospital Italiano de Buenos Aires.

- This information was then fed back to the physicians to analyse indicators outcome and to discuss with them the implementation of strategies for continuous improvement.

- At present, work on stratification according to the different profiles is being carried out.

Comments

- Another strategy proposed for improvement consisted of making indicators dynamic, even to have hidden indicators for a strategically monitoring in order to avoid the risk posed by the use of profiling indicators, namely, that of working only in terms of the information provided by the indicators and leaving aside other aspects of health care.

- In the future, this tool will hopefully enable us to measure the impact of having implemented the Support Systems for the Decision-making Process, which includes alerts or reminders on preventive practices.

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Ontology Design for the Development of Semantically Interpretable Clinical Practice Guidelines

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Abstract

Clinical practice guidelines (CPG) are becoming an essential help tool in medical care. Despite their continuous evolution and dissemination, their application in the context of the new Information and Communication Technologies is not sufficiently developed. A fair amount of work still remains to be achieved in the area of CPG execution, and as a consequence, it is difficult to find even medium sized repositories of formalized and executable CPG. In this context, we present an initiative for modeling and executing clinical guidelines, named SCPG, where a new, ontology based approach is proposed to fill this gap. The proposed model aims to be a novel contribution to the representation and organization of knowledge in this area. In this paper we provide new model to represent CPG focused in sharable and reusable elements, derived from the application of CPG among several healthcare institutions in Spain.

Keywords:

Practice Guidelines, medical practice management, Clinical Decision Support Systems, integrated health care systems, semantics

Introduction

Major efforts are being undertaken in the health domain today towards the standardization of healthcare processes, which have undergone a considerable development in the last few decades, in terms of both magnitude and complexity . Such complexity is due to the universalization of medical care among the population, at all the levels of the health organization. The collaboration between the different agents involved in the health system is a key problem in order to provide a high-quality care. This cooperation must be made possible by some degree of ubiquity in processes and organizations. From the point of view of business organization, the need for personalization and standardization is becoming increasingly clear. This is so because medical care tends to be individualized and homogeneous at any point of the system. Individualized in the sense that each patient has their own attention process but based on common resources for all the patients in the health system. We said homogeneous in the sense that all patients are over the same clinical environment. The existence of an integral clinical information and process management system in hospitals has a positive impact on the quality of assistance and the efficiency of the health personnel . Achieving this successfully saves institutions from dedicating an excessive part of their human resources, included doctors themselves, to documentary and bureaucratic routines. Furthermore, a more efficient information management can be achieved, better supporting the work of doctors, who are thus not constrained to do without relevant information about her/his patients because retrieving it at the right time is not feasible. To achieve this combination of goals it is essential to rely on suitable organizational means, such as Business Process Management (BPM) methodologies , and appropriate Information and Communication Technology (ICT) infrastructures for knowledge management in health structures. For this reason, enterprise management techniques need to be implemented in healthcare organizations, along with normalization standards, e.g. driven by symptomatology, techniques, or diagnosis. In this sense, the standardization of patient care through clinical practice guidelines (CPG) provides significant benefits, since:

- Procedures are normalized, as guidelines establish the standard to guide the doctor's action.
- Clinical evidences are systematized, allowing a fast knowledge transfer between organizations sustained by contrasted clinical evidences.
- Guidelines establish the relevant information domain for a process, simplifying the access and management of this information.
- Patient care is personalized. Guidelines define the specific care system activity for a particular patient, rather than all possible patients. Assistance can be proactive and planned instead of reactive and spontaneous.
- Guidelines help the fast dissemination of new work practices, and help structure all the knowledge of a healthcare organization. When a new evidence or technique suggests the modification of guidelines, these are modified and transmitted to all the personnel in a homogeneous and immediate way.

CPG are a helpful tool for the administration of medical care. They should not be just a set of rigid regulations. They should be characterized by their flexibility, clinical applicability, clarity, documentation and elaboration after a suitably planned revision. A large number of CPG are cur-

rently available that have been developed by different public and private organizations. The application of CPG in the context of the new ICTs is still fairly scarce today , , . Much work remains to be done in the scope of the automation of CPG execution, and despite important initiatives on repositories of formalized guidelines, there is a lack of a wide public repository of interpretable CPG. The overall goal of our work is to provide support for the execution of guidelines in heterogeneous and distributed health systems. Our research, by the date, is focused on the validation of our ontology for the representation of CPG, which is described next.

Some reasons to adopt ontology as a representational model to CPG

It is a need, in the actual scenario of health, to share, reuse, distribute and understand the enormous amount of information daily generated in any health institution, laboratory, research centre, etc. in a similar way. The representation and dissemination without ambiguities of the complex medical concepts described is a foremost question in order to achieve this objective. By means of clinical domain ontologies it is possible to solve this need . However, in the context of CPG, there is a lack of a normalized, semantically representative and generally adopted definition of what does a clinical guide means. Ontologies, as formal representation tools, are natural solutions to fill this lack.

In the design or redesign of CPG modeling phases, the use of ontologies lets the users a high flexibility and easy reutilization of elements. Some individual elements of a guide like, for example, the way by means a clinical analysis must be done or the monitoring of a treatment in a concrete patient, could be easily reused in other guide or adapted to cover the special needs of a new guide. This is a natural reuse of elements of the ontology, which facilitate the design of new guides with common elements from other previous CPG. By the reutilization of information shared between CPG, unique and commonly accepted, it is possible a quick and efficient deploying of innovative information not only within the organization which adopts the guide, but also between different organizations. As an example of the reutilization of concepts we have the action *degree of tabaquism* is modeled in different processes like *Cholesterol* and *Tabaquism*. The reutilization of elements of huge clinical guide repositories could lead to an enormous and very difficult work. This is the reason to define explicit relations between all the elements sharing the same elements or being specializations of some more general ones of the ontological models. This guideline conception enables the reutilization of elements in a different way to those used in GLIF guidelines, as we show in figure 1.

All the previous reasons are something enough to adopt ontologies as representation formalism for the definition and interoperability of CPG. In addition and based on the aspects that characterize a CPG definition formalism identified in , SCPG addresses further areas not covered by prior proposals, concerning the organization of plans and the representation of goals.

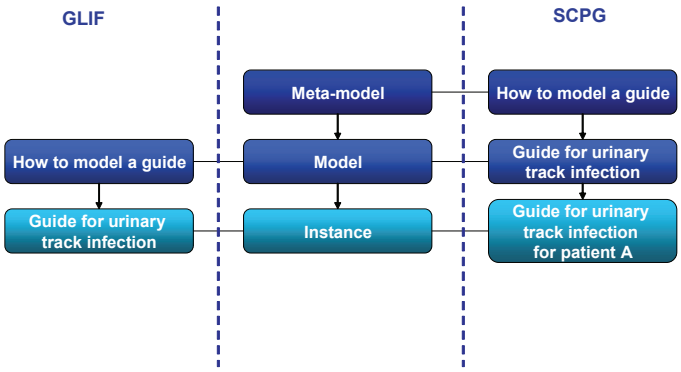

Figure 1 – Differences on SCPG conceptual model

In the remaining aspects, namely, action models, decision models, expression languages, interpretation of data and abstractions, medical concept models, and patient information models, a similar functionality is covered, but based on ontologies. Furthermore, SCPG incorporates the notion of roles, typically not included in this type of representations to date.

Concrete new proposals for our model

In SCPG we are introducing a kind of new concepts in order to enrich the descriptions of the clinical process to be modeled. The foremost ones are described in advance.

In the area of plan organization, SCPG introduces the concept of encounter, which represents the interaction between the patient and the medical staff in a certain space and time. The encounter represents the context in which a set of clinical activities take place. With SCPG there are different ways to represent a clinical attention process. For example, in the clinical guideline for VIH, here is a first encounter which is followed by an undetermined number of encounters for the continuous patient supervision. But in contraposition to this model, the guideline on *Cholesterol* has up to eleven different encounters. The encounter labeled *Middle Risk with LDL<130* has a total of eight actions, but when the LDL Cholesterol is over 160, the related encounter has a total of eleven actions. The difference between the two encounters is based on actions that analyze hormones (like TSH) or enzymes (like CPK, ALT or AST). Figures 2 and 3 (both in Spanish) shows the Protégé ontology model for the first encounter *Cholesterol* and a partial fragment of the actions involved in that

encounter. With this modeling freedom, SCPG is not restricted to a linear conception of medical care.

The representation and exploitation of clinical goals has been only addressed to a limited extent in the available literature on clinical guidelines representation formalisms. This is addressed in SCPG for two fundamental reasons: a) in the clinical domain, it is particularly true that there is a difference between performing an action, and the action having the desired effect; and b) the goals can be extremely useful to exploit the formal representation, enabling a better evaluation of the care processes, the recommendation of clinical guidelines, goal based planning, etc. This way, each action, encounter, and process in SCPG can have a set of associated valuable goals, which describe the guideline in terms of what is the intended purpose, rather than what has to be done.

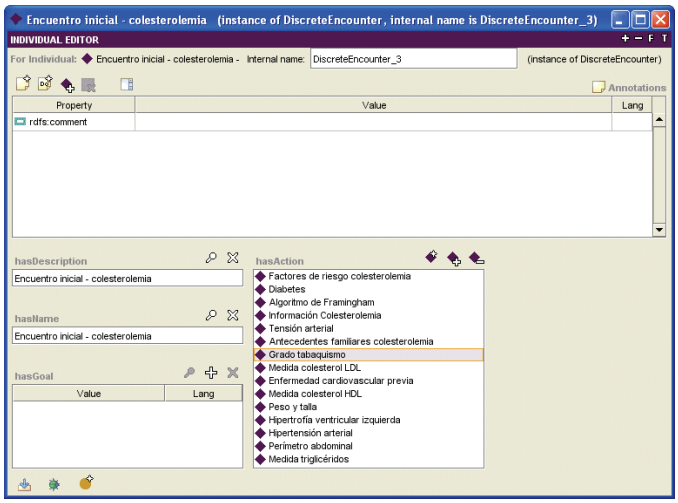

Figure 2 – Protégé definition for the first Cholesterol encounter

Regarding roles, they represent the skills of the medical personnel in charge of actually carrying out the actions prescribed by the guideline. Whilst such information might seem of rather institutional than clinical nature, this is not quite exact. Roles have a strong clinical component, insofar as they represent a set of clinical skills required from the personnel assigned to peform a certain action.

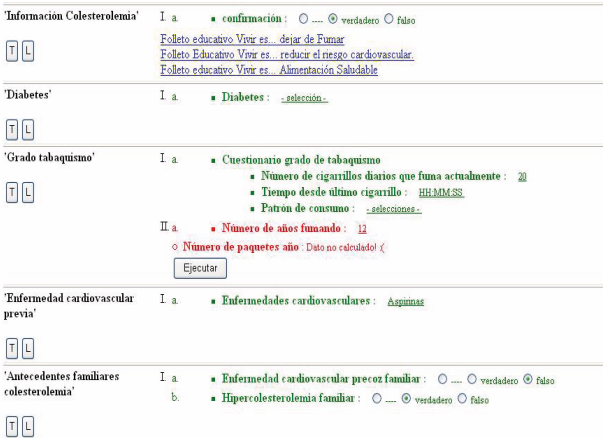

Figure 3 - Partial fragment of the actions involved in a Cholesterol encounter

In addition to the direct advantages of the proposed model in the area of executable CPG representation, the SCPG ontology enables further potential added value in areas such as interoperability, reuse and inference. As mentioned earlier, in realistic settings, CPG need to be executed in heterogeneous and distributed environments, and, in addition, act as transmissions for medical knowledge. Therefore, a high degree of interoperability is required, both syntactic and semantic, between the different involved systems. This problem is addressed in the Semantic Web field by means of the definition of ontologies. Since SCPG is based exclusively on such ontological descriptions, it has the potential to benefit from any progress achieved in the area of interoperability by Semantic Web technologies.

With regards to the problem of the scarce availability of formalized and executable clinical guidelines, the ontology based approach in SCPG allows the definition of a set of classes that represent a complete guideline. Such classes are easily reusable and can be restricted, versioned and manipulated by sub classification, inheritance, and the definition of constraints, in order to produce new guidelines. Thus, SCPG greatly facilitates the formalization of medical knowledge.

Finally, the guidelines represented in SCPG have a much more powerful logic component than other formalizations achieved to date. With our model, represented in OWL, reasoners can be employed to validate the logic correction of guidelines, avoiding potential inconsistencies in the model which, otherwise, would be difficult to detect except by an exhaustive set of system tests, without a completely guaranteed proof of correctness. On the next section we are going to present our proposal for modeling CPG.

Modeling CPG by means of SCPG

SCPG is an ontology for the representation of executable CPG which was conceived in order to apply the Semantic Web vision to the fields of Healthcare and process representation. The ontology has been defined in OWL, using the Protégé environment as an editing tool. SCPG comprise a set of clinical domain related ontologies. Their complete description of classes and relations can be found in [15].

In a common process between a patient and his family doctor, they both have different encounters in the same place but in different times. This concurrency is modeled in SPCG by means of the encounter concept. During an encounter some activities described as actions are carried on. For example, to ask for the patient weight and height, to compute her BMI (Body Mass Index) or to give a diet are example of actions. These actions provide some data about the patient, which are represented in SCPG as data items. In addition to these actions there is an objective associated with the diet: to lose about 5 to 10 kg. In SCPG this is modeled by means of objectives. One of the differences between actions and objectives is that with objectives there is an intention, but there are no guarantees for the consecution. Suppose that 3 months latter there is a new encounter. With the previous data and related with the objective consecution, the doctor has to take a decision: to continue with the diet (previous action), to give some drugs (new action) or to recommend surgery (new action). Therefore, a clinical guide provides the following aspects modeled by means of the set of ontological components:

- The formal representation of the guide, which represents the flow of the attention supplied to the patient. Clinical guides are organized into processes and this has encounters. A formal description of the described process (the order of the encounters carried on in the example), in this formal description, the patient doctor encounters are chained in the basis of the process itself, the patient state, the clinical staff decisions and, finally, due to temporal restrictions. Each encounter is made of a set of actions that must be carried on by the staff. With this model SCPG it is no restricted to a lineal conception of the clinical attention in opposite to other languages proposed to date.
- The clinical actions, which represents the different activities carried out during the attention process by the clinical staff (for example to ask for the patient weight and height; to give a diet, to give some drugs against obesity). An action could represent from a sophisticated surgical activity over a patient, to the supply of a drug or the acquisition of a concrete data from the patient. One can guess that the set of clinical actions it is too large, with lot of possibilities. Therefore it is a need to represent all the actions and their possibilities in a flexible way. With SCPG it is possible to link each action with a clinical objective in order to justify the reasons for that action and to harness such a kind of information also. There is also a link between actions and clinical roles. Each action could be taken off by a specific clinical staff, and this thing is possible to be modeled also.
- The patient data, which has the entire data patient related, previously acquired or acquired during the attention (weight, height and BMI). It is necessary to take into account the amount of data derived from the application of any monitored process to a patient. These data could be modified also in a period of time, so it is desirable to increase the relevance of a good data model.
- Clinical roles, which define the skills of the clinical staff giving attention. They are commonly used in the business management description context. In the previous example, the doctor must have some endocrinology knowledge to give some diet or some drugs.
- Clinical objectives, which represents the set of desirable objectives as a result of the supplied attention.

Integrating vocabularies

Finally it is significant to remark that all the factors included are by means of ontology descriptions, in order to achieve the objectives pointed at the beginning of the 2nd heading. As we mentioned above, in order to use and to annotate elements of a clinical guide to reach a general common understanding, we need to get domain ontologies. And this is a very important question. How we can do this?

As is well known and generally accepted, nowadays there is a set of clinical vocabularies like (ICD ; LOINC ; SNOMEDCT ; UMLS ; etc.) which represents different clinical knowledge. UMLS try to assemble a set of these languages, extracting and integrating the semantic associated from each one in order to get a common representation. However, there are some semantic defects mainly derived from polysemic words. The UMLS creators admit these defects that could be palliated by means of semantic analysis techniques as in ONIONS . In ONIONS it is described a methodology for the semantic analysis and integration of clinical vocabularies. This methodology is a part of a big project called GALEN whose objective is to supply with a common ontology and a language to represent vocabularies to allow the definition of terminologies that could be integrated in a common ontology . In our ontology we are integrating vocabularies by means of a specific class in the model. This class allows

us to refer to different actions in an encounter by means of the concept they are defined with. For example, an action that has to order a laboratory test for the enzyme CPK, could be defined as an instance of that class, which is an entry of the UMLS vocabulary also.

Conclusions and future work

The proposed approach to the formalization of clinical processes aims to bring novel contributions in several aspects. First, SCPG introduces new concepts in this area, such as the definition of patient encounters, and the explicit consideration of clinical goals. On the other hand, techniques imported from other areas, such as the Semantic Web, are brought to meet recently identified needs, such as the execution of guidelines in distributed and heterogeneous environments.

The value of the SCPG model is such insofar as it is possible to exploit the model to automate and improve the quality of medical assistance. In this respect, we are pursuing further investigation in diverse areas, such as the semiautomatic recommendation of guidelines, the semiautomatic generation of guidelines for a given symptomatology, and the optimization by aggregation of parallel guidelines over a single patient. Currently, we are completing the development of the SCPG guideline representation model, and implementing care assistance prototypes in several county level healthcare institutions (servicing above 150.000 patients). It is our goal to achieve, along the present year, the first executable clinical guidelines on SCPG, using the BMPS-e3 process management engine developed by BET Value.

Acknowledgments

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The International Classification for Nursing Practice (ICNP®) Programme:Terminology Management and Maintenance

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Abstract

Clinical terminologies must be dynamic in order to represent up-to-date and clinically relevant content for use in electronic health records. The International Classification for Nursing Practice (ICNP®) Programme involves a number of management and maintenance processes in order to assure quality and facilitate use of the ICNP® terminology. Some of these processes include (a) research and development activities, (b) a formal review process, and (c) applications in healthcare systems. Terminology management processes must be formal, while still being open and facilitating participation. Although the ICNP® Programme is centralized, it is essential to have mechanisms that support worldwide involvement of experts at the regional and local levels. Examining the ICNP® Programme management and maintenance processes can identify issues that need to be addressed to assure the continuous high quality of the programme

Keywords:

unified nursing language system, nursing terminology, International Classification for Nursing Practice, terminology maintenance

Introduction

ICNP® Version 1.0 was launched in May 2005 at the International Council of Nurses (ICN) Congress in Taipei, Taiwan. ICN is a federation of 129 national nurses associations. It was founded in 1889 and has headquarters in Geneva, Switzerland. ICNP® has been under development since 1989, with an alpha version, beta 1 and beta 2 versions, and now Version 1.0. The ICNP® vision is to be an integral part of the global information infrastructure informing health care practice and policy to improve patient care worldwide. This paper will address the methods by which a global terminology for nursing demonstrates constant advancement by leveraging simultaneous centralized and decentralized research and development, system improvements using transparent processes for participation, and applications in healthcare systems. A state of the art nursing terminology that can be used worldwide will document the work of nursing consistently and accurately and will contribute to safe and effective health care.

Materials and methods

ICNP® is a unified nursing language system and a compositional terminology that facilitates cross-mapping of local terms and existing terminologies. ICNP® Version 1.0 was developed using web ontology language (OWL) within the Protégé ontology development environment to support a unified language and compositional approach. A unified nursing language system allows users' natural language to be mapped to standard meanings. The benefits of using a description logics approach are explicit definitions, the possibility of multiple classifications, greater granularity, and sensitivity to variation in language and culture. ICNP® conforms to ISO Standard 18104:2003, reference terminology models for nursing diagnosis and nursing action [1]. ICNP® is HL7 registered. Experts in nursing, informatics, terminology, and software development are all essential participants in ICNP® research and development, system improvements and applications in healthcare systems.

Research and development

ICN-accredited ICNP® Research and Development Centres provide opportunities for nurse experts and related consultants to advance ICNP®. The work of the Centres is monitored by ICN through a structured process including review of goals and objectives, periodic re-accreditation, annual reports of work progress in the ICNP® Bulletin, and invitations to present work processes and products at the biennial Centres Consortium meetings held in conjunction with ICN conferences.

ICNP® catalogues are subsets of the terminology, specifically nursing diagnosis, outcome, and intervention statements for a selected population and health priority [2]. Catalogues will fill a practical need in building health information systems by describing nursing diagnoses, outcomes and interventions appropriate for the selected area of care.

Translations of ICNP® are a third important area for research and development. Some translations are appropriately done by nurses in one country. Other translations may be multi-country, e.g., Germany, Austria and Switzerland; Chile and Spain.

Review process

ICNP® continues to increase in size and complexity as more concepts are added to the classification and as methods evolve for ontological modeling with attendant software support. A structured maintenance approach [3] can support the consistency and credibility of ICNP® as it is developed, mapped to other classifications, applied in health information systems, and used in clinical practice and research. The three stages of ICNP® review process are data collection, evaluation and revision.

Applications in healthcare systems

The ability to collect data about the work of nursing worldwide will allow for data-based research, decision-making and policy development. ICNP® use in client or patient care settings, either as the interface terminology or as the reference terminology in electronic health records, will allow care data to be stored in data repositories for access by researchers. Real-time ICNP® data are currently being generated in several regions and countries.

Results

Research and development

ICN-accredited ICNP® Centres activities include concept validation, bibliometric analysis, the development of ICNP® catalogues, translations, electronic health record applications, organizing conferences, intra- and inter-country collaboration, presentations at professional conferences and professional publications.

In addition to ICNP® Centres, nurses in many settings worldwide work with ICNP® to further its development and application to practice. A list of projects worldwide is available on the ICNP® website as interested experts comply with the request to sign a Use Agreement with ICN. Projects are organized by country and by topic, including research (concept validation, description logic models, model testing), development (ICNP® catalogues, translations, browsers), integration (cross-mapping, minimum data sets), and health information systems (electronic health record, telehealth, computer-user interface). In addition to the projects, a reference list of publications about ICNP® is also available on the ICN website.

ICN has developed a prototype catalogue titled "Partnering with Clients and Families to Promote Adherence to Treatment." Pre-coordinated concepts for the catalogue's nursing diagnoses, interventions and outcomes will be given unique identifiers and added to ICNP® Version 1.1. ICN's intent is to collect ICNP® catalogues that are in use and to facilitate validation of catalogues with nurse experts in various practice areas or dealing with particular client health conditions (e.g., diabetes, mental health) or nursing phenomena (e.g., pain, self-care).

Translations have been completed in Korean, Japanese, Portuguese (Portugal) and Arabic. While some translations are appropriately done by nurses in one country, other translations are conducted across a number of countries, e.g., Germany, Austria and Switzerland. An open source, web-based translation tool has been developed and used by the German Speaking User Group ICNP® Centre. The ICNP® translation tool facilitates the distribution of work among geographically separated participants. There are plans to test the tool with other language work groups. ICN requires that a Translation Agreements be signed by anyone planning translation of ICNP®, in order to coordinate efforts across countries and languages.

Review process

The ICNP® Review Process is available in print and on the ICN website so that submitters, reviewers and users are all aware of the process by which concepts may be added, modified or deleted. Since the publication of the alpha version of ICNP®, hundreds of terms have been added to the ICNP®.

ICN moderates the process of review but the key decisions about submissions are made by expert nurse reviewers around the world. It is essential that domain experts participate in the review of ICNP® content. The use of expert nurse reviewers also helps to ensure evaluation across cultures and languages. New concepts may be submitted from nurses in the field, found in the literature or in clinical data, or they may arise during cross-mapping projects. The concepts of dignified dying [4] and informal settlement [5] are examples of validation studies conducted by nurses for potential revisions to ICNP®.

During the evaluation phase, the characteristics of the concept, or its definition, are reviewed. The concept's position and use in different cultures or nursing contexts is also considered. Each concept is then modeled in OWL and its place in the 7-Axis model representation of ICNP® is described. During the evaluation phase, the concept is examined for its compatibility with ICNP® Version 1.0 and any synonyms are identified. Expert nurses then review the concept and its related documentation. Concept recommendations may be incorporated (add, retire existing concept, revise existing concept), rejected, or sent out for an expanded review.

During the revision phase of review, the accepted concepts must be coded, definitions finalized, and modeled in OWL Protégé for addition to ICNP® Version 1.1. Concepts may also be added to one or more ICNP® catalogues. This iterative process is supported by experts from nursing, modeling and informatics.

Applications in healthcare systems

Nurses in several countries, in concert with their health ministries and health care systems, and supported by infor-

matics specialists and technicians, have integrated ICNP® Version 1.0 into their electronic health record systems. Hospitals in Korea and Portugal are, for example, using ICNP® as the standard for collecting nursing data in point-of-care documentation of nursing practice in electronic systems. The data can then be stored and retrieved for re-use, e.g., research, with appropriate safeguards for human subjects protection. The developers and users of these applications provide valuable feedback to the ICNP® Programme.

Discussion

ICN aims to expand the number of ICN-accredited ICNP® Centres for Research and Development. The centre members are seen as leaders in the worldwide dissemination and implementation of ICNP® with the ultimate goal of large data sets for research-based health care delivery, decision-making, and policy development.

The compelling need in catalogue development is to foster creativity, collaboration and product development while also ensuring a consistency in quality and representation of nursing practice content. Nurses at the point of care delivery cannot reasonably be expected to use ICNP® as a whole in their work. Rather, nurses are focused on selected client populations and health priorities to include various combinations of health conditions, particular specialties or settings, and nursing phenomena, e.g., pain, self-care.

The process of translation is challenging in that the English ICNP® concepts cannot simply be translated word for word from the source language to the target language. Rather, each concept's meaning and usefulness in the health care environment of the target language must be analyzed and agreed to by the translation team. ICN is establishing guidelines for translation based on existing standards and experience from teams undertaking ICNP® translations.

An established, well-tested process for system maintenance will ensure that sound decisions are made concerning existing or new ICNP® concepts. The process is also designed to integrate new technologies and ontological capabilities in order to remain state of the art for worldwide dissemination and use.

With a unified nursing language system such as ICNP®, the nursing profession is finally able to articulate its practice and generate worldwide data for research-based clinical care, administrative and clinical decisions, and the development of healthcare policy.

Conclusion

ICNP® is a large and robust clinical terminology for nursing. Its contribution to the nursing community and to worldwide healthcare requires formal centralized and decentralized processes. These processes involve the work of hundreds of nurses worldwide, the support of health ministries, healthcare organizations, and collaboration among experts in nursing, terminologies, informatics and technology. Ongoing examination of the ICNP® Programme management and maintenance processes is essential to assuring continuous quality improvement.

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ICNP® Programme: Terminology Management & Maintenance

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ICNP®

- Programme of the International Council of Nurses
- Version 1.0 launched in 2005
- Unified nursing language
- Compositional terminology that facilitates cross-mapping local terms and existing terminologies
- Conforms to ISO Standard 18104:2003

ICNP® Vision

ICNP® is an integral part

of the global information infrastructure

informing health care practice and policy to improve patient care worldwide.

Materials and Methods

- **How a global terminology for nursing demonstrates constant advancement by leveraging**
  - **Simultaneous centralized & decentralized research and development**
  - **System improvements using transparent processes for participation**
  - **Applications in health care systems**

Research & Development

- Translation Guidelines from ICN
- ICN requires signed Translation Agreement
- Translations
  - Arabic, Japanese, Portuguese, Korean completed
  - Eleven translations in-progress

Research & Development

- **ICN-accredited ICNP® Research & Development Centres**
  - **Concept development**
  - **Translation**
  - **NMDS, iNMDS**
  - **Knowledge development, data repositories**
- **Five centres to-date**
- **Annual updates in ICNP® Bulletin**
- **Three-year cycle for re-accreditation**

Research & Development

- **Catalogue Guidelines from ICN**
- **Catalogues**
  - **Subsets of ICNP® for use at point of care**
  - **Address nursing phenomena, specialties, settings, health conditions/diseases**
  - **New catalogues: adherence, palliative care**

Research & Development

- R&D project descriptions on website
  - Concept validation, ontologies, logic models
  - Catalogues, translations, browsers
  - Cross-mapping, NMDS, telehealth
  - EHRs, computer-user interface
- ICNP-related publications on web site
- All work with ICNP® requires Use Agreement

Concept Review Process: Add, Modify, Delete

- Concept analysis using research methods
  - Literature review
  - Definition and defining characteristics, e.g., using Delphi technique
  - Clinical testing
- Submission of concepts for
  - Addition, modification, deletion
- Volunteer to be a reviewer (see website)

Concept Review Process: Pre-coordinated concepts

- Identification of pre-coordinated concepts from catalogues
  - Nursing diagnoses, interventions, outcomes
- All accepted concepts
  - Modeled in OWL in Protégé software
  - Given unique identifiers (codes)

Applications in Healthcare Systems

- **Integrate ICNP® with EHRs**
  - **E.g., Portugal, Korea**
- **Collect and analyze iNMDS data for**
  - **Nursing and patient care information**
- **Data repository supports re-use of data for**
  - **Clinical research at progressive levels**
    - **Local, regional, national, international**
  - **Decision-making and policy development for healthcare worldwide**

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Supporting SNOMED-CT Implementation Through a Solution Capability Model

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Abstract

Whilst SNOMED-CT has developed extensively as a terminology, it has done so at a pace separate from that of the vast majority of end users and products. The experience and lessons learnt from implementation projects have highlighted significant clinical achievements and variation between solution capabilities and user expectations. This has resulted in an understanding of what factors impact on success including the need to address what a "SNOMED-CT enabled", or a "SNOMED-CT supported" application actually means, the need for cross-vendor consistency, and convergence of terminology support.

A solution capability matrix for SNOMED-CT, which assists in promoting communication and understanding between stakeholders has been developed. Care will be required by all stakeholders when, in the future, local solutions comprise a mix of solution support levels as they cannot readily interoperate without restrictions being imposed. Only when all solutions are at the highest level described in the model, Level 2, will the full benefits of SNOMED-CT be realised. Until that time sophisticated and iterative workarounds will need to be in place and utilised by all users and systems.

Keywords:

systematized nomenclature of medicine, stakeholders, software implementation

Introduction to SNOMED-CT

Systematized Nomenclature of Medicine - Clinical Terms (SNOMED-CT) is an international medical terminology which has been developed over time, from several source terminologies, by the College of American Pathologists and the UK National Health Service. This comprehensive clinical language is used to encode clinical data in electronic patient records, which may subsequently be used within decision support. It currently consists of 400,000 healthcare concepts, over 1 million descriptions and nearly 1.5 million semantic relationships. As with all clinical terminologies it is, and will always be, a work in progress. SNOMED–CT differs from most previous health terminologies because it aims to achieve domain completeness throughout healthcare. As such it is capable of representing the minutiae of clinical information and is designed to be used by generalists, specialists, indeed all clinical practitioners, including doctors, nurses and allied health professionals.

However whilst SNOMED-CT has developed extensively, it has done so at a pace separate from that of the vast majority of end users and software products.

Value of SNOMED-CT

SNOMED-CT is the foundation stone for achieving the vision of continually improving healthcare outcomes and efficiencies by enabling communication and data analysis at patient, local, national and international levels as indicated in Figure 1. As such, the successful implementation of SNOMED-CT is imperative to patients, care professionals, healthcare organisations, product vendors and the nation as a whole. All parties need to be aware of their role and responsibilities in that achievement. Failure to adopt SNOMED-CT and standardise its use, will ultimately impact:

- safe interchange of clinical information
- decision support's ability to provide consistent responses for safer care delivery
- secondary use of data for research, healthcare improvement and commissioning decisions

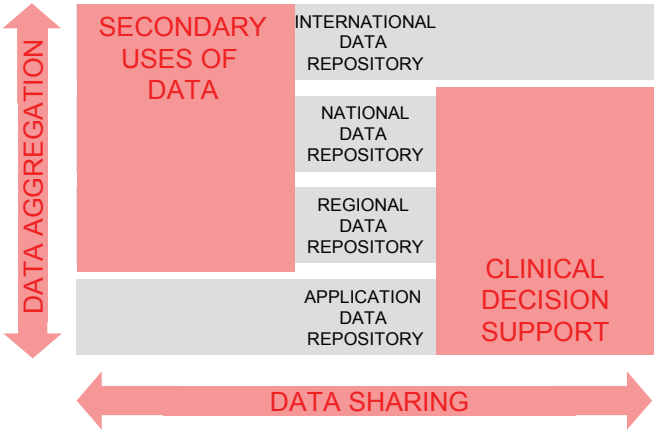

Figure 1- SNOMED-CT enabled data utilisation

Increasingly, clinical information is exchanged at national and international levels for individual and epidemiological use. Countries such as Denmark have used SNOMED-CT as the lingua franca in outsourcing radiology reports to India, so that local resource constraints can be managed. However, product and messaging limitations have compromised the efficiency and effectiveness of this.

In the arena of clinical terminology and messaging there is an immediate benefit, and therefore clear need, for a defined approach to terminology use if communication between different healthcare organisations is to become more effective. In the longer term, benefits of a common terminology used at the point of care will enable clinical statements to be understood and reused, not only at the individual patient level but also when aggregated. This will derive benefits in clinical audit, research and governance, epidemiology and healthcare commissioning.

Supporting clinicians

Clinical terminology supports what clinicians care about by ensuring clinical records meet their needs. Clinicians desire system components that work reliably together; the ability to easily express the clinical information they wish to enter; and the ability to retrieve information to support delivery of care and analysis of aggregated data.

Effective use of codes and medical terminology within clinical information systems is fundamental to maximising the benefit of much of the clinical functionality. This will have an impact on information:

- presented in the system outputs (e.g. discharge summary)
- shared with other organisations or aggregated in a data warehouse
- used to trigger care plans and care pathways
- available in patient medical summary views
- available for clinical decision support
- shared with third party systems (e.g. pharmacy)
- used for clinical/management reporting

Lessons learnt from early implementation

The experience and lessons learnt from implementation projects Dolin RH, Mattison JE et Kaiser Permanente CMT Team. Kaiser Permanente Convergent Medical Terminology. Medinfo 2004. M.Fieshi et al (eds) Amsterdam ,Lopez et al. A Practical Approach to Advanced Terminology Services in Health Information Systems. 2006 Medical Informatics Department, Hospital Italiano of Buenos Aires, Argentina have highlighted significant clinical achievements and variation between solution capabilities and user expectations.

In England the new and ambitious challenge of implementing SNOMED-CT has resulted in a greater understanding of what factors impact on success. These include the need to address what a "SNOMED-CT enabled", or a SNOMED-CT supported" application actually means, the need for cross-vendor consistency, and convergence of terminology support

Semantic interoperability and SNOMED-CT

Semantic interoperability will be the key to successful development and implementation of future Electronic Health Records (EHR)[1] and integrated Electronic Patient Record[2] systems that deliver complex clinical functionality spanning care settings. Such functionality will include clinical decision support, integrated care pathways, enterprise scheduling, and workflow management.

There is increasing awareness and interest from software providers and their purchasers, who are investigating, and in some cases acting on, the application of international standards to help achieve semantic interoperability.

The development and adoption of international standards for patient record interoperability is essential for:

- sharing patient health and care information between health professionals in a multi-disciplinary, shared-care environment
- interoperability between organisations within an enterprise-wide, regional or national healthcare system, and perhaps in the future across national borders
- supporting functional and semantic interoperability between software from different vendors

Such standards cover the important tools within health informatics including messaging, health record architecture, health record extracts, terminology, and logical data models. SNOMED-CT is the internationally adopted standard for terminology and is core to the achievement of semantic interoperability. However, SNOMED-CT must be constrained to be used effectively as there are innumerable ways to express clinical information using SNOMED-CT. Such flexibility left unconstrained will prevent meaningful queries, data extraction and data comparison.

Whilst standards exist for messaging (HL7 v3), health record architecture (openEHR), health record extracts (prEN13606 soon to be CEN13606, HL7 v3 CDA), reference models (openEHR, HL7v3 RIM) and terminology (SNOMED-CT), it is far less clear how they interrelate or should be used together in harmony. One such area of

1 We define Electronic Health Record as the combination of a patient's electronic records held in different systems to form a combined patient electronic record.

2 We define Electronic Patient Record as the patient's electronic record held within a facility (e.g. Hospital)

ambiguity is reference models where HL7 v3 has defined a Reference Information Model for messaging purposes which is insufficient as a reference model for a healthcare record architecture. Whereas the Reference Model and associated models in openEHR are designed for a health record architecture, and are used in CEN13606 for health record extracts. There is clear overlap between the reference models provided by both standards. Figure 2 attempts to crudely illustrate the complexity of how these standards currently overlap.

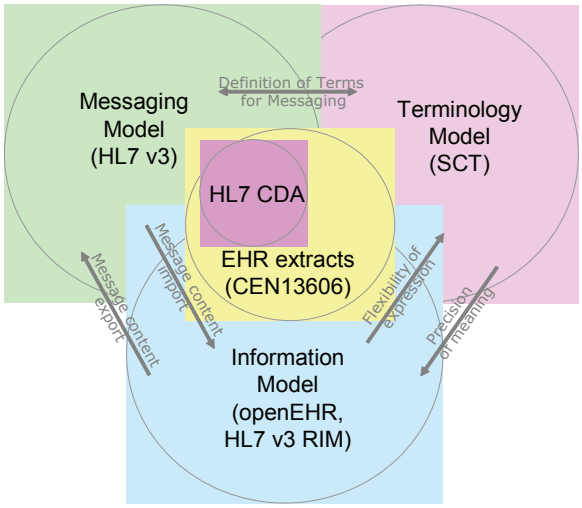

Figure 2- A view of the complexity of how standards overlap

There are several pieces of work underway that will help address how these standards will work together, for example:

- TermInfo – relationship between HL7v3 and SNOMED-CT
- HL7 13606 Implementation Guidance project – relationship between HL7 v3 and CEN13606

The output of such work will guide software vendors in design of their systems to ensure that SNOMED-CT is implemented in a controlled and interoperable way. Successful applications of the future will embrace these standards and learn to unify them into a cohesive application.

In this way SNOMED-CT will assist in:

- translating data entered by users using an interface terminology or SNOMED-CT directly
- transmitting clinical data between applications via messaging or other means whilst maintaining data integrity and meaning
- transmitting aggregated data to common data repositories for secondary use such as reporting

Stakeholder interface

Increasingly the assumption of purchasers will be that SNOMED-CT is used as the common terminology which drives the clinical functionality within products. However the majority of systems and applications have not been designed around a terminology as large and complex as SNOMED-CT.

There is an ever increasing user and customer demand for SNOMED-CT based products with a driver on the vendor community to develop their products and their data models accordingly. This demand for SNOMED-CT based products will increase as all nations are faced with the complexities of an aging population and workforce, with associated complex disease management requirements. Those vendors who have made the investment in developing their products to use SNOMED-CT at its core will be best placed to compete within this evolving market.

Electronic clinical record system providers or solutions who can support post co-ordinated SNOMED-CT will still be constrained by the limitations of others, especially departmental solutions (pathology, radiology, pharmacy being key) for some time to come. These new SNOMED-CT based vendors will add their voice to the increasing demand for SNOMED-CT based solutions.

The implementation of SNOMED-CT requires software applications that exploit its features to meet the real and perceived needs of users. The users of SNOMED-CT are not restricted to end-users who enter or retrieve clinical information experiencing SNOMED-CT through a configured application that uses the terminology. Users also include those who design, commission and configure software for use in a particular clinical environment and those who utilise population and other aggregated data.

Solution capability matrix

A significant risk to SNOMED-CT implementations is that financially and politically costly user implementation and technology strategies are developed and implemented without a clear vision of the end point. It is therefore imperative that there is national and international agreement on the role of SNOMED-CT and the level of support required

The adoption of SNOMED-CT will, by necessity, be incremental. In this extended implementation period, solution providers will need to support workarounds such as maintaining separate clinical terming and classification coding processes. Therefore, there will be a mixed population of systems and users that either can or cannot support SNOMED-CT. This presents new problems. A solution capability model for SNOMED-CT has evolved during the process of implementing at a multi organisational, depart-

mental and cross health care boundary level, which assists in promoting communication and understanding between the stakeholders. This model considers solution capabilities as follows:

Level	Description
0	Systems do not internally support SNOMED-CT. They may not be capable of working in a SNOMED-CT world at all, or may be provided with a mapping function to map outbound messages containing local codes into messages containing SNOMED-CT codes to support communication with other systems or for reporting.
1	Systems support SNOMED-CT internally but with restrictions, which may include shortened descriptions, restricted subsets of terms and limited hierarchical browsing. They will not support inbound post-coordinated expressions. Most existing systems with some SNOMED support would be in this category. Some systems (in the US) have pushed the upper limits but require extensive maintenance overhead to maintain pre-coordinated ('ready defined') terms in line with needs.
2	Systems support post-coordinated expressions and can communicate with other Level 2 systems using messages containing post-coordinated expressions (which adds additional qualifiers to 'terms' to improve clinical detail). They will have potentially many styles of user interface to support different users and user contexts (eg nurses on wards, surgeon in theatre) and their requirements to add information to patient records. These systems would also be able to exploit the encoded data within decision support rules. With its ability to store detail and fully interoperate with similarly supportive systems, level 2 would need substantive development of the existing solutions in terms of user interfaces, processing and database structures, to support the encoded data meaningfully. They also need configuration tools to enable the system to relate to the appropriate SNOMED-CT subsets (also known as reference sets) and hence inbuilt maintenance processes to respond to changes in SNOMED-CT content.

Table 1 –SNOMED-CT Solution Capability Model

This model and its presented levels do not constitute a roadmap for solutions and their development. Level 0 solutions, by definition, cannot be readily engineered to become Level 1 and similarly for Level 1 to Level 2. At best, software vendors need to understand how they can achieve higher support for their products within a level, recognising the constraints imposed by that level. They will then need to determine the re-engineering required to provide an equivalent solution at a higher level.

The model is being further extended to incorporate the roles and impact on other stakeholders. The combined effect of solutions with mixed capabilities in supporting SNOMED-CT, combined with disparate purchasers, timetables, political, economic and clinical imperatives, results in a complex picture. However, building on the model will enable understanding of the interplay, and interaction of each stakeholder's issues.

Conclusion

Going forward, care is required by all stakeholders when, in the future, local and national solutions comprise a mix of Level 1 and 2 solutions. Level 1 solutions cannot interoperate with messages from Level 2 solutions unless the Level 2 solutions comply with the restrictions imposed by each of the Level 1 solutions. As a result, only when all solutions are Level 2 will the full benefits of SNOMED-CT be realised. At this stage solutions will be built around SNOMED-CT and will likely provide sophisticated native SNOMED-CT terminology services. At this point, external (standalone) terminology services are likely to be limited to the distribution/syndication of maintenance releases for clinical content.

The Solution Capability Model has value in enabling understanding of the complexity of the environment in which implementation is to take place, so that careful planning can be undertaken, and a successful outcome achieved. The Solution Capability Model also makes it clear that this will not be achieved overnight.

Acknowledgments

We would like to thank many colleagues and friends who have contributed their thinking and experiences, this includes associates at BT, Ernst and Young and those who agreed to be interviewed as part of evolving the thinking behind this paper.

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[2] Lopez et al. A Practical Approach to Advanced Terminology Services in Health Information Systems. 2006 Medical Informatics Department, Hospital Italiano of Buenos Aires, Argentina

Related reading

[1] Cimino JJ. Desiderata for Controlled Medical Vocabularies in the Twenty-First century. Methods Inform Med 1998;37:394-403

[2] Campbell J. Developing and maintaining SNOMED Extensions for Clinical practice Needs. Royal Society of Medicine Implementing SNOMED CT 29 – 30th March 2006

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Supporting SNOMED-CT implementation through a Solution Capability Matrix

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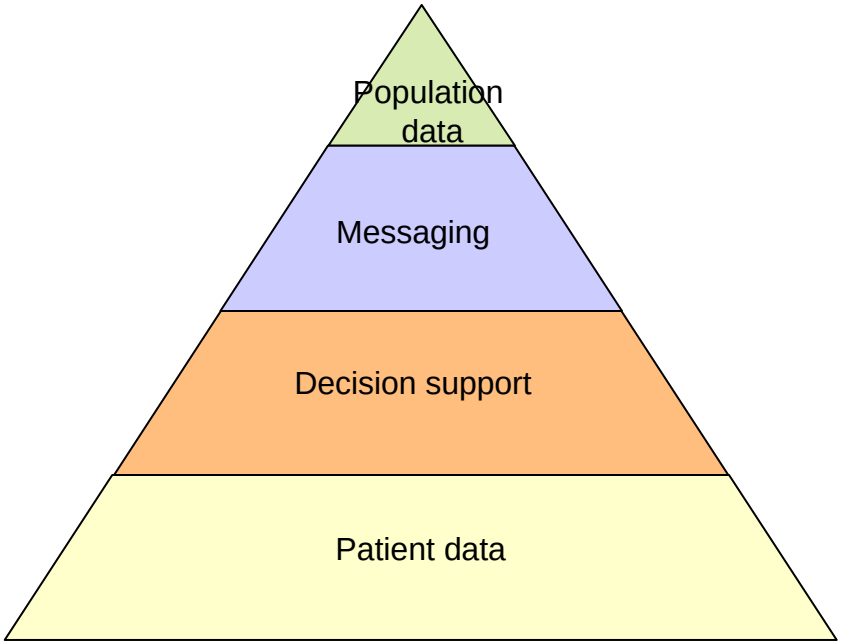
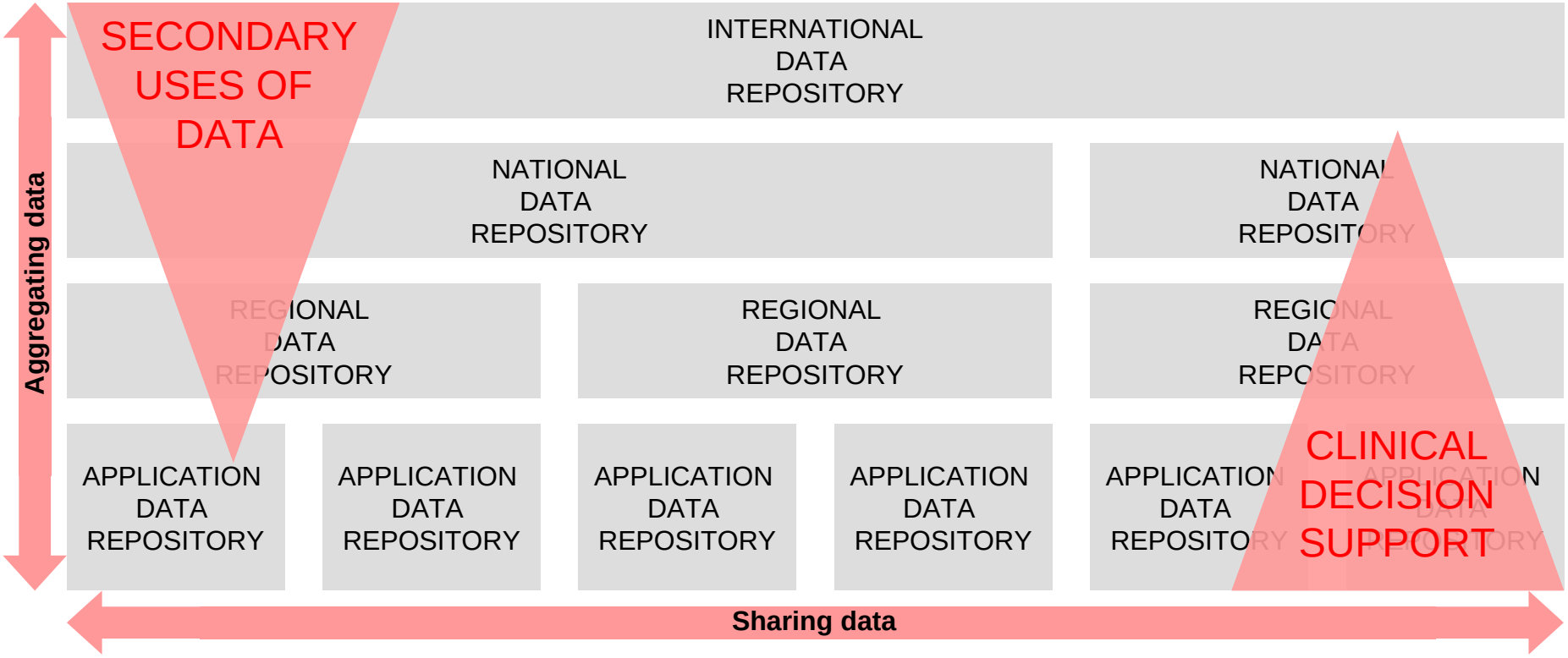
Introduction to SNOMED-CT

- International medical terminology used to encode clinical data in electronic patient records
- In 2006
  - 400,000 healthcare concepts
  - over 1 million descriptions
  - nearly 1.5 million semantic relationships
- As with all clinical terminology it is, and will always be, a work in progress



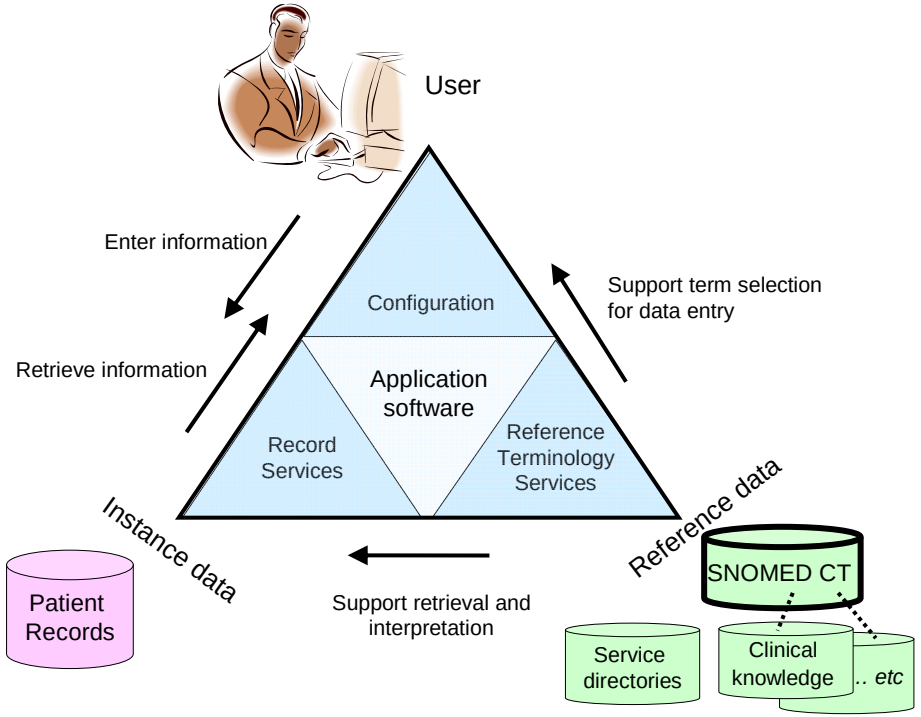
SNOMED-CT use

Vision of SNOMED-CT use



SNOMED-CT is the foundation stone for achieving the vision of continually improving healthcare outcomes and efficiencies by enabling communication and data analysis at patient, local, national and international levels

SNOMED-CT in single organisation



In supporting clinical practice, several different applications are used and these may be separately configured for users in different specialties and disciplines.

The role of SNOMED CT is to enable processable representation of meaning in forms that can be shared between a diverse range of disciplines, specialties and software applications.

Failure to adopt & standardise SNOMED-CT use, will impact on:

- *safe interchange of clinical information*
- *decision support to provide consistent responses for safer care*
- *use of data for research, healthcare improvement and commissioning*

SNOMED-CT lessons learnt

- SNOMED-CT has developed extensively at a pace separate from that of the vast majority of end users and products
- The lessons learnt from implementation projects have highlighted significant variation between solution capabilities and user expectations
- Now we have a better understanding of what factors impact on success, including the need
  - to address what a “SNOMED-CT enabled”, or a “SNOMED-CT supporting” application actually means
  - for cross-vendor consistency and convergence of terminology support

We have learnt a lot from current and past implementation projects

Supporting software vendors

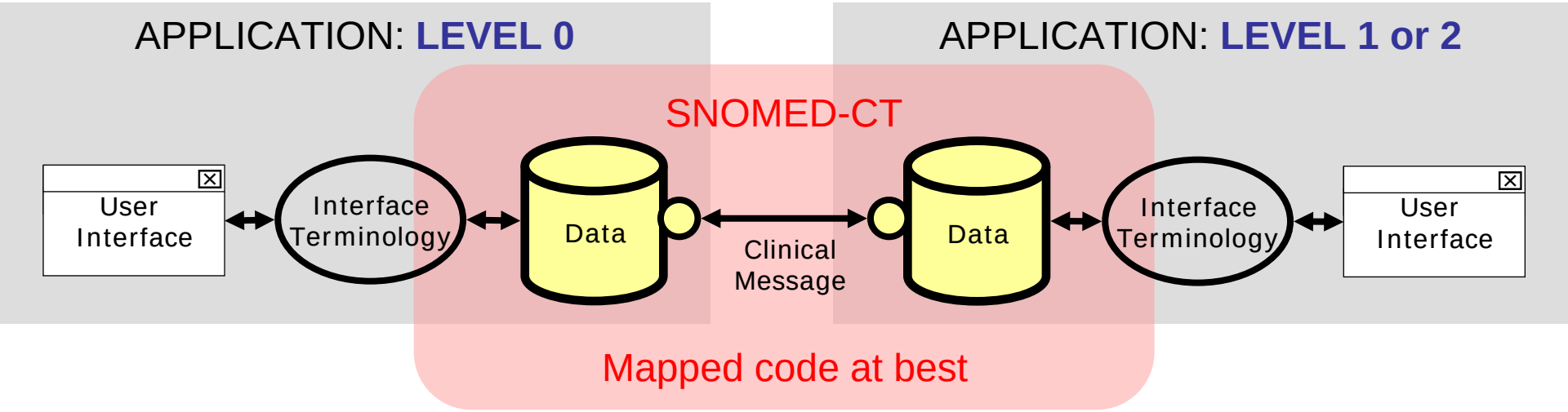
- The adoption of SNOMED-CT will, by necessity, be incremental
- In this extended implementation period, solution providers will need to support workarounds such as maintaining separate clinical terming and classification coding processes
- Therefore, there will be a mixed population of systems and users that either can or cannot support SNOMED-CT
- This will present new problems

A Solution Capability Matrix is required to support software vendors to promote communication & understanding between stakeholders

Solution Capability Matrix

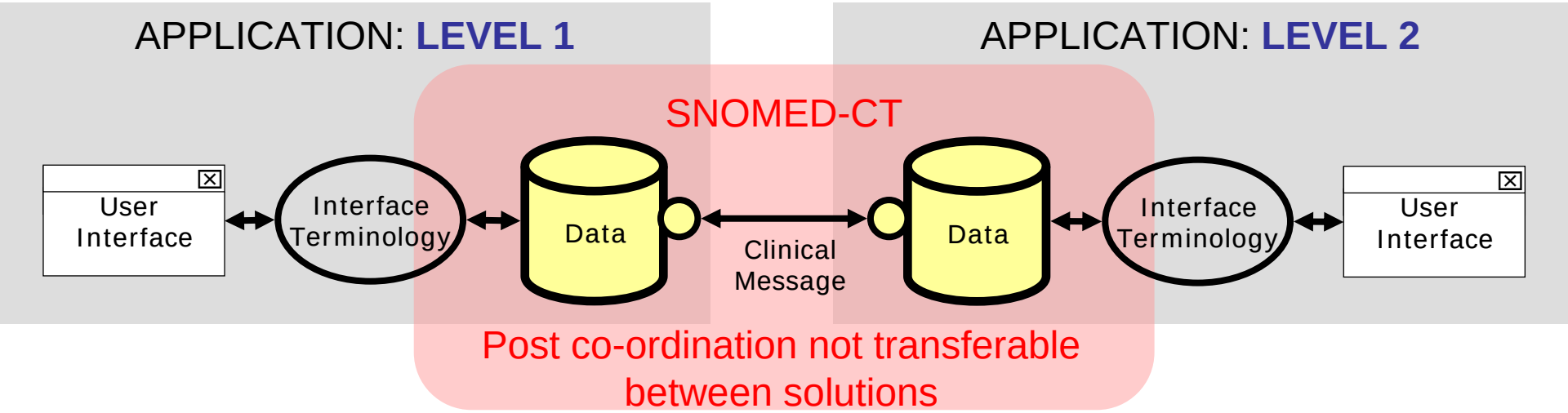
L0	Systems do not internally support SCT. They may not be capable of working in a SCT world at all, or may be provided with a mapping function to map outbound messages containing local codes into messages containing SCT codes to support communication with other systems or for reporting.
L1	Systems support SCT internally but with restrictions, which may include shortened descriptions, restricted subsets of terms and limited hierarchical browsing. They will not support inbound post-coordinated expressions. Most existing systems with some SCT support would be in this category. Some systems have pushed the upper limits but require extensive maintenance overhead to maintain pre-coordinated ('ready defined') terms in line with needs.
L2	Systems support post-coordinated expressions and can communicate with other Level 2 systems using messages containing post-coordinated expressions (which adds additional qualifiers to 'terms' to improve clinical detail). They may have many styles of user interface to support different users and user contexts (eg nurses on wards, surgeon in theatre) and their requirements to add information to patient records. These systems would also be able to exploit the encoded data within decision support rules. With its ability to store detail and fully interoperate with similarly supportive systems, level 2 would need substantive development of the existing solutions in terms of user interfaces, processing and database structures, to support the encoded data meaningfully. They also need configuration tools to enable the system to relate to the appropriate SCT subsets and, inbuilt maintenance processes to respond to changes in

Solution Capability Matrix: Level 0



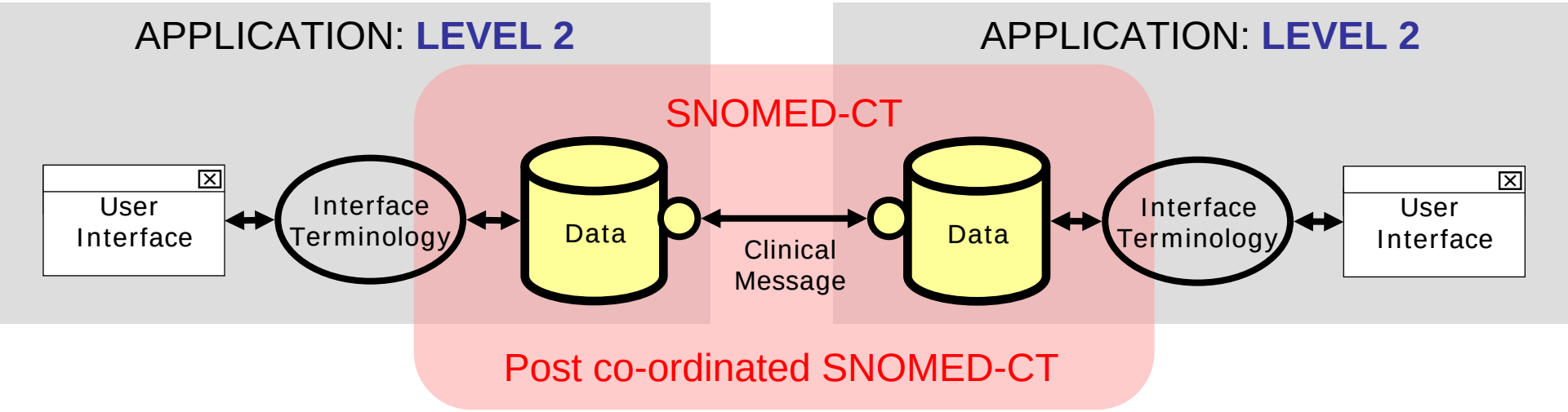
- Systems do not internally support SNOMED-CT
- Systems may not be capable of working in a SNOMED-CT world as they have not been designed and built around a terminology as large and as complex as SNOMED-CT
- Systems may be provided with a mapping function to map outbound messages containing local codes into messages containing SNOMED-CT codes to support communication with other systems or for reporting
- Post co-ordination is impossible and mapping restricted
- Sharing of termed data, and semantic granularity is limited
- Decision support is limited to the lowest level of system in which data is held
- Level 0 solutions cannot be readily engineered to become Level 1

Solution Capability Matrix: Level 1



- Systems support SNOMED-CT internally but with restrictions
  - e.g. shortened descriptions, restricted subsets, limited hierarchical browsing
- Systems will not support inbound post-coordinated expressions
- Most existing systems offering some SCT support would be in this category
- Some systems have pushed the upper limits but require extensive maintenance overhead to maintain pre-coordinated (‘ready defined’) terms in line with needs
- Sharing of data and decision support using data from more than one system is compromised
- Level 1 solutions cannot be readily engineered to become Level 2

Solution Capability Matrix: Level 2



- Systems support post-coordinated expressions and can communicate with other Level 2 systems using messages containing post-coordinated expressions (which adds additional qualifiers to ‘terms’ to improve clinical detail)
- Systems will have potentially many styles of User Interface to support different users and user contexts (e.g. nurses on wards, surgeon in theatre) and their requirements to add information to patient records
- These systems would also be able to exploit the encoded data within decision support rules

Drivers for SNOMED-CT adoption

- The implementation of SCT requires software applications that exploit its features to meet the real and perceived needs of users. Users include those who enter or retrieve clinical information, who utilise population and other aggregated data. and those who design, commission and configure software for use in a particular clinical environment
- Increasingly the assumption of purchasers is that SCT is used as the common terminology which drives the clinical functionality within products. However the majority of systems and applications have not been designed around a terminology as large and complex as SCT
- An increasing user and customer demand for SCT based products will drive the vendor community to develop their products and their data models accordingly
- Those vendors who have made the investment in developing their products to use SCT at its core will be best placed to compete within this evolving market
- Electronic clinical record system providers or solutions who can support post co-ordinated SCT will still be constrained by the limitations of others, especially departmental solutions (pathology, radiology, pharmacy)

New SNOMED-CT based vendors will add their voice to the increasing demand for SNOMED-CT based solutions

Conclusions

- The effect of products with mixed capabilities in supporting SNOMED-CT, combined with disparate purchasers, timetables, political, economic and clinical imperatives, results in a complex mixture
- However utilising the proposed capability matrix enables understanding of the interplay, and interaction of each stakeholders' issues
- Software vendors need to
  - understand how they can achieve higher support for their products within a level, recognising the constraints imposed by that level.
  - determine the re-engineering required to provide an equivalent solution at a higher level
  - recognise that such a model can not constitute a roadmap for their products
- To achieve Level 2 and support the encoded data meaningfully will need substantive development of many solutions in terms of user interfaces, processing and database structures
- Care is required by all stakeholders when, in the future, local and national solutions comprise a mix of Level 0, 1 and 2 solution support.
  - Level 1 solutions cannot interoperate with messages from Level 2 solutions unless the Level 2 solutions comply with the restrictions imposed by each of the Level 1 solutions
  - At this stage solutions will be built around SNOMED-CT and will likely provide sophisticated native SNOMED-CT terminology services
  - Until that time sophisticated and iterative workarounds will need to be in place and utilised by all users

Only when all solutions are Level 2 will the full benefits of SCT be realised

- **References**
- Dolin RH, Mattison JE et Kaiser Permanente CMT Team. Kaiser Permanente Convergent Medical Terminology. Medinfo 2004. M.Fieshi et al (eds) Amsterdam
- Lopez et al. 2006 A Practical Approach to Advanced Terminology Services in Health Information Systems. Medical Informatics Department, Hospital Italiano of Buenos Aires, Argentina

- **Related reading**
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Establishing Sustainable Electronic Communication Across the Continuum

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Abstract and objective

Without healthcare partners across the continuum having timely access to accurate information relating to patients' treatment, patients' health outcomes are placed at risk.

This paper documents a case report of the approach adapted by the Sunshine Coast Health Service District to establish sustainable electronic communication across the continuum.

The paper identifies how the Health Service District:

- Identified barriers and constraints to uptake (such as spoken and written language barriers, constraints impacting on introduction of appropriate technology, etc)
- Benchmarked key performance indicators to establish a baseline for assessment of introduction of electronic communication
- Established monitoring and registration processes
- Developed "change templates" to establish sustainable electronic communication in a community of health care partners

Most significantly, prior to the establishment of electronic communication in the District, discharge summaries were not available to GPs within 48 hours. In the first month of the capability being available 30% of summaries from all medical units across the District were available to GPs within 48 hours.

Testimonials from primary care community partners are positive. For example Dr Sandra Peters GP from Chancellor Park Medical Centre: "Timely discharge information sent electronically is accurate and we can follow up without delay."

Keywords:

continuity of patient care, communication barriers, confidentiality, referral and consultation, organizational innovation

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ICT for Health System Sustainability: Needs and Challenges

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Abstract

This study highlights the role of Information and Communication Technologies (ICTs) in developing novel health systems in Saudi Arabia. A model for sustainability of the Saudi health system is proposed that provides a framework for developing generic e-health services. Existing and future challenges of procuring and implementing the e-service framework are discussed.

Keywords:

informatics, sustainability model, Saudi Arabia

Introduction

The health infrastructure of Saudi Arabia and its diagnostic, therapeutic and health prevention services have made important and increasing progress during the past decade [1,2]. The Kingdom's medical colleges and hospitals provide specialist diagnostic and therapeutic services and medical education and training programmes, while they also conduct health research in collaboration with other research centres [1-3]. However, Saudi health care is facing new challenges. Financial constraints are now forcing the Saudi Government to re-evaluate their health care policy in order to ensure the continuous upgrading of health services for its people [4]. Accordingly, the Saudi Ministry of Health has privatised some government hospitals, while encouraging and creating more opportunities for private sector participation in the health sector to lessen the burden on its budget [2]. A factor that affects the sustainability of Saudi healthcare is that hospitals are established individually and independently with no consideration for co-operation and co-ordination [5]. In practice, Saudi health is the least fortunate sector in utilising ICTs and most hospitals have a poor information infrastructure [6]. The majority still rely on traditional practices of 'pen and paper' [7]. There is no strategic plan for health information in the country [8,9] and many health professionals have insufficient ICT knowledge, experience and skills [7-10].

Methods

The research methods used to uncover the needs and challenges include: a review of the relevant literature, observation of activities and interactions, a web-based questionnaire survey of individual perceptions of needs and document analysis. A model-based sustainability component was developed from the findings of the application of these methods.

Results

Health professionals in Saudi hospitals view 'lack of training' as the major factor in introducing ICT into hospitals, followed by 'lack of co-ordination', 'poor management', 'lack of IT staff' and 'lack of IT policy'. Qualified management will play a major role in overcoming problems and obstacles which might cause failure in ICT implementation [8,10]. This highlights the need for a health information policy which is currently lacking [9]. The anticipated problems also raise again the issues of training and co-ordination.

Discussion

Saudi hospitals have been under tremendous pressure to reform to seek sustainability of their healthcare system. This has been driven by escalating costs and increased demands for healthcare development. The most difficult barrier to the full implementation of ICT in hospitals is their traditionally bureaucratic, complex and highly departmentalised structure within their leadership style. Potential conflicts exist: hospital relationship with health professionals and the need to avoid various dissatisfaction; and, hospital management philosophies and the need for organisational changes and development.

In discovering the challenges facing the health system in Saudi Arabia, a planning committee, involving professionals and experts, reviewed issues related to health system and ICT. The committee reached some vital conclusions and required urgent solutions to the problems. Part of which is: 1) the need to unite and define clinical computing and health information systems, 2) the importance of developing information infrastructure and a health information network among the Saudi Hospitals and research centres, and 3) the need for automation in the health sector and its administration. Crucially though, there have been no actions to impose these views [6].

In relation to the implementation of National Health Information Network, one of the challenges to be faced is designing a system network that meets users' needs, while reflecting a continuously changing organisational environment and to develop ICT that supports various organisational demands [10]. The ICT development process should avoid any possible confusion, poor quality, inefficiency, and unnecessary costs. The main tasks appear to be to coordinate the different visions and, in particular, clarify them, as well as to establish the impact that these visions would have on the forthcoming ICT application. In the process of development, hospital management and authorities should understand thoroughly what it is they are committing to, and what barriers they will encounter [10,11].

The proposed model comprises four components: knowledge management and diffusion; ICT implementation; health professional oriented approach; and, patient oriented approach.

Knowledge Management and Diffusion: in relation to information access and dissemination, there are two cultures - access or network-friendly culture; and a holdings or network-averse culture [11]. Information-sharing is essential between health professionals and hospitals. However, this vision would not be possible in the absence of a health information network [10]. Sharing of information, however, is a huge task that cannot be accomplished without a well designed information policy and formal co-operation [9,10]. The communication and sharing of health information has an important role in the delivery of quality healthcare in Saudi Arabia [6].

ICT implementation: ICTs promote various channels of communication and co-operation in the healthcare environment. Importantly, they will help the healthcare environment to move towards the establishment of a flourishing health information society by popularising the use of electronic resources, and describing the benefits and advantages of the electronic learning programmes.

Health Professional-Oriented Approach: this model component represents the delivery of knowledge on a convenience basis according to the various needs of health professionals. The health professionals-oriented approach may promote web patient/practitioner relationships. The combination of both health knowledge and ICT skills allows individuals to participate in e-health programmes.

Patient Oriented-Approach: the health system in Saudia has produced inevitable programmes of care for the public. However, there is a lack of patient-oriented educational programmes designed according to patients' local cultures and educational level.

Conclusion

There are numerous challenges to be overcome before ICT can achieve its full potential and successful implementation in the healthcare environment in Saudi Arabia. The country's decision makers, planner and professionals should work in establishing a clear strategy of implementation based on field projects and research considering the human factor as it described in the proposed sustainability model. Therefore, they should take a holistic view of the situation, as an integrated part of their plans for the development of the health system utilising the potentiality of information and communication technologies (ICTs).

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ICT for Health System Sustainability: Needs and Challenges

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Outline

- Introduction
- Methods
- Saudi Health Service
- ICT in Saudi Healthcare System
- Challenges
- Needs
- Sustainability Model
- Conclusion

Introduction

- Saudi Healthcare System
  - Grown organically but ready for a step change
- Factors peculiar to Saudi Arabia
  - Including free access to health system at point of care
- Expectation of Development
  - Saudi population expects a high standard health service

Methods

- Literature Review
  - From 1986 to date
- Document Analyses
  - From Ministry of Health; Ministry of Planning; and individual Hospitals
- Observation
  - Non-participative observation across 11 Hospitals in Riyadh
- Sustainability Model Components
  - People aspects and System aspects

Saudi Health Service

- Saudi Healthcare Service is planned to provide efficient health services for increasing population through utilisation of resources and more equity in service provision and distribution.
- Studies revealed a Health-Service-Gap in metropolitan and rural areas.

ICT in Saudi Healthcare System

- Healthcare System infrastructure
  - Poor national health system infrastructure
- Healthcare Technology
  - High Tech devices vs. Health Information Technologies
- Health Information System
  - Hospitals, Primary Care Clinics
- Electronic Health Records (EHR)
  - Integrates health and social need

Challenges

- Health Services Management
- Hospital Management and Operation
- Stakeholders' Development Role
- Health Information Policy
- Health Information System
- System and Human factors
- Implementation (Success and failure)

Needs

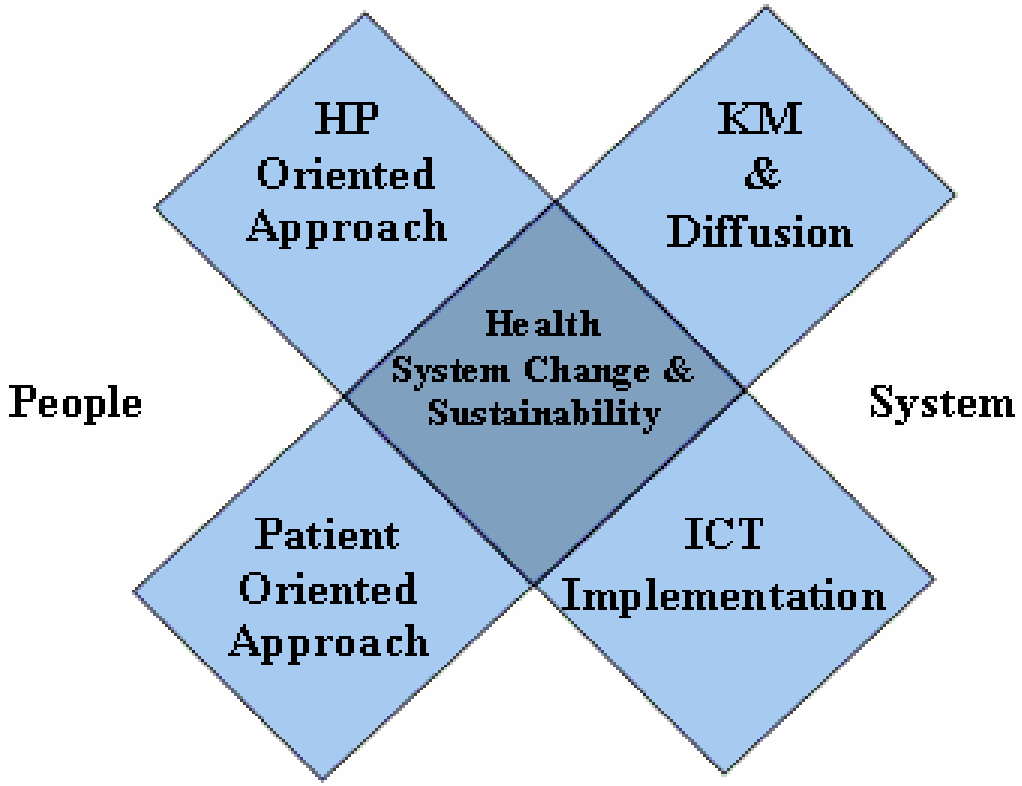
- Review of Administrative and Financial Systems
- National Information System Infrastructure
- National Health Information Policy
- Increase usage of Health Information Systems
- National Research Projects in HIS
- Holistic View of Approaches and Implementations

Sustainability Model (1of 2)

Sustainability Model Components

- Knowledge Management and Diffusion
- ICT Implementation
- Health Professional Oriented Approach
- Patient Oriented Approach

Sustainability Model (2 of 2)



Conclusion

- Saudi Health System ready for development
- Able to integrate innovative health technologies as there are few legacy systems
- Provision of standards-based electronic health records
- Holistic view taken of implementation

Thank You

Ahmad Khudair and Ron Summers

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The First Japanese Implementation of IHE-ITI EUA/PSA and the Impact of Visual Integration

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Abstract

In Japan, two PCs (for example: EMR and PACS viewer) are commonly used for the Hospital Information System in one clinical unit. Many physicians have to enter a user ID and password to login to these systems. To solve the troublesome manipulation, we developed the function of the IHE-ITI Enterprise User Authentication (EUA) and Patient Synchronized Applications (PSA). We developed middle-ware for the EUA/PSA to reduce the implementation load among the EMR, PACS-viewer, report-viewer, radiation scheduling system and radiation information system. The EUA/PSA was based on the HL7 CCOW standard and did not support multi PCs. So we enhanced the EUA/PSA mechanism for use with several PCs. We realized that EUA/PSA were essential in a multi-system environment. Our middle-ware resolved the complexities of the application implementation. The established guideline was useful to unify the user interfaces of each application. We found that the EUA/PSA function will be inevitable for visual integration.

Keywords:

IHE IT Infrastructure,
Enterprise User Authentication (EUA),
Patient Synchronized Applications (PSA),
Context Area Manager

Introduction

In Japan, many large-scale hospitals have Computerized Physician Entry Systems. Recently, PACSs (Picture Archiving and Communication Systems) have also been rapidly spreading in the clinical environment. In the hospital physicians have to simultaneously manipulate these systems in out-patient clinics and wards. To reduce operation time, the concept of visual integration is necessary. Some methods of visual integration have been proposed, for example, the HL7 CCOW (Clinical Context Management Specification) [1]. By the definition of CCOW, the context manager is limited to one workstation or personal computer, which is not suitable for Japanese institutions. We analyzed the physicians' workflow and found that multiple workstations and/or personal computers should belong to the same context unit. We expanded the context unit to a "context area", which can cover several workstations and/or personal computers in one clinical unit.

For the implementation of visual integration, we adopted the EUA (Enterprise User Authentication) and PSA (Patient Synchronized Applications) integration profiles [2] that IHE (Integrating the Healthcare Enterprise) IT-Infrastructure [3] defined. To simplify the implementation we developed middle-ware that enables the EUA/PSA mechanism and modified our existing six systems. Our hospital specializes in particle radiation research and the hospital information system consists of the EMR, PACS, a reporting system (Report), radiation oncology-RIS (RO-RIS) and radiation schedule system (RSS). We thought that these systems should adopt the EUA/PSA.

The aims of this paper are (1) analysis of the effectiveness of the EUA/PSA, (2) the usefulness of the EUA/PSA middle-ware and (3) verification of the expanded function of the context manager defined by HL7 CCOW.

To study the effectiveness we counted the number of physicians' operations. We prepared middle-ware conforming to the EUA/PSA integration profile, developing several actor functions that the IHE ITI technical framework defined. We developed four types of libraries to satisfy the application's running environments. In this process we aim to know the validity of the library's algorithm.

The last purpose was to investigate the concept of the "context area" enhanced from the CCOW definition. The mechanism of the context area is the same as the context unit defined by CCOW. The management space was expanded to multiple computers from one computer.

Materials and methods

The CCOW Standard defines the specification of implementation only for a single desktop, one workstation or one PC. In the standard, there is one "Context", which is data set for the shared information between applications, and one "Context Manager", which is the process that controls the context information. A number of applications maintain information synchronized by the CCOW mechanism. IHE/ITI has defined the Integration Profile as the EUA and PSA with CCOW. EUA is an integration profile that recognized a single sign on by using shared user information, and PSA is an integration profile that maintains patient information among a number of applications by using shared patient information.

EUA that supports a single sign on is implemented by using "CCOW User Subject". First, each application joins the Context to send some messages to the Context Manager when an application starts. If the Context already has user information, the application retrieves the user information and then starts under the scope of authority of the user information. If not, the application presents a dialog box for the user to obtain the required information by user authentication, for example, user ID, password and so on. IHE has requested the Kerberos Authentication for the EUA. The authorized user information is sent to the Context Manager and then the information is set to the Context, after which other applications will use the information. This is the mechanism of the single sign on in IHE and CCOW.

The PSA that supports synchronized patient information is implemented by using "CCOW Patient Subject". When each application joins the Context and the user selects one patient in one application, that patient information is sent to the Context Manager and then set the patient information to the Context, after which the Context Manager send a message that one patient has been selected by other applications. This is a trigger that requests setting the patient for applications. When a user changes the patient, the same procedure is applied. All other applications then know that new patient information should be set. This is the mechanism of synchronized patient information.

Context Area Manager

We developed a new synchronized mechanism adapted to a number of desktop environments with Hitachi Medical Corporation. We expanded the mechanism of IHE and CCOW specifications, because it is useful and is easily understandable to use a standard procedure that has been already defined, so transactions and related information items in the new mechanism are the same as the specification and guide of CCOW and IHE. From an application point of view, some standardized functions or methods should be called up only when needed. The application is not concerned with the environments, whether a single desktop or a number of desktops. The developed environment supports such features.

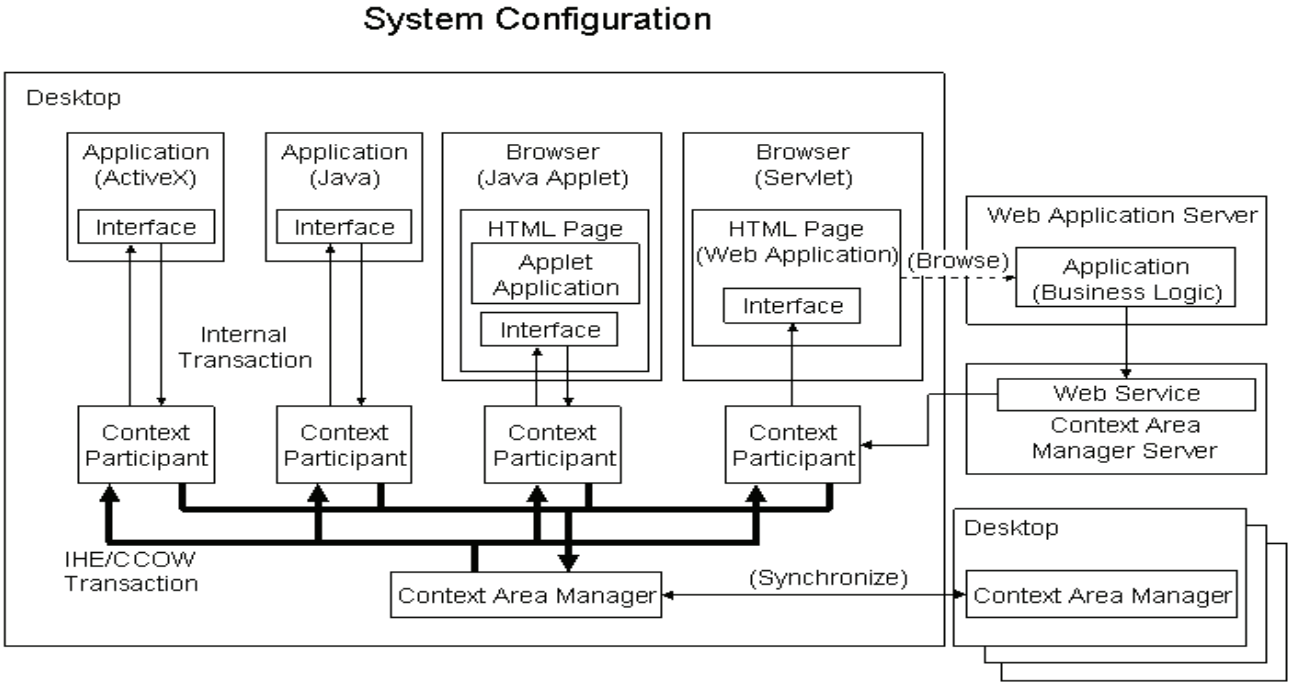

Figure 1 - Configuration of the context area manager and the relationship between the context area manager and applications

As shown in Figure 1, we defined "the Context Area Manager" and "the Context Participant" for a multi-desktop environment. The Context Area Manager is a new process that has expanded functions compared with the Context Manager specification. The Context Area Manager has the same functions as the Context Manager. The expanded function of the Context Area Manager is for communication with the Context Area Manager on other desktops (workstation and PC). If an application requests to change the Context, the Context Area Manager would broadcast that information to other Context Area Managers to synchronize the Context on all desktops. This mechanism allows synchronization of the Context on a number of desktops. From a user viewpoint, the information handled on a number of desktops remains synchronized.

The Context Participant is a special process that receives messages from the Context Area Manager and sends them to an application which receives messages from an application and sends them to the Context Area Manager. The Context Participant would be generated for each application. The relationship between the application and the Context Participant is one to one.

An application sends messages to the Context Participant by using libraries or methods or Java scripts. It is dependent on the implementation of an application. There are 4 types of implementations: ActiveX application, Java application, Java applet and Servlet. A library that sends and receives messages from/to the Context Participant for ActiveX application and for Java application has been developed. Also, for the Java applet, some Java scripts are written as applets to enable communication from/to the Context Participant. In the case of the Servlet system, the logic that allows the communication from/to the Context Participant is implemented on the server side. There are various complicated configurations for the Servlet system, but all systems have a basic configuration, the Context Participant and the Context Area Manager, and all applications communicate from/to the Context Participant to send messages from/to the Context Area Manager. The Context Area Manager enables communication to the Context Area Managers on other desktops to synchronize information in the Context Area.

Next we established guidelines for the implementation of the EUA/PSA. Table 1 shows the guidelines. The venders of the existing systems modified their applications according these guidelines.

Table 1 - Guidelines for implementation of the EUA/PSA

NO	Items
1.	To manipulate a context manager, unified procedures and man-machine interfaces are used.
2.	The conditions according to participation and breakaway from the context manager did not depend on the applications.
3.	We can confirm the participation/breakaway visually.
4.	When an application works with context manager, the application checks that the context manager is running correctly.
5.	When the context is changed, each participating application with un-saved data will ask the user to save the data.
6.	The displayed terms regarding the context manager are decided. Every application uses the same words and icons that show the status of participation.
7.	The dialog: Each application is set to default maneuvers: (1) always permit, (2) ask a user with a dialog box and (3) always refuse to change the context.

Target systems

The target systems were (1) EMR, (2) PACS, (3) report system, (4) RO-RIS and (5) RSS. The EMR is the HOPE/EGMAIN-EX C/S Edition, HOPE/DrABLE-EX and HOPE/LAINS-PC by Fujitsu. The EMR can open six patients simultaneously. We decided the synchronization using the PSA. The first patient is opened by the Context Area Manager, whereas, the last patient was synchronized by another application.

Our PACS consists of two systems, SDS-DicomViewer (PACS-1) by TechMatrix, and the SYNAPSE (PACS-2) by Fujifilm. The Report is F-REPORT by INFOCOM. The RO-RIS is RIGIA by Global-for. The RSS is the Particle Radiation Schedule Management System by Nippon Telegraph and Telephone East. Figure 2 shows the configuration of the NIRS Hospital Information system. When the EUA/PSA library was installed in all applications, the most suitable library was carefully selected from the four types (ActiveX application, Java application, Java applet and Servlet).

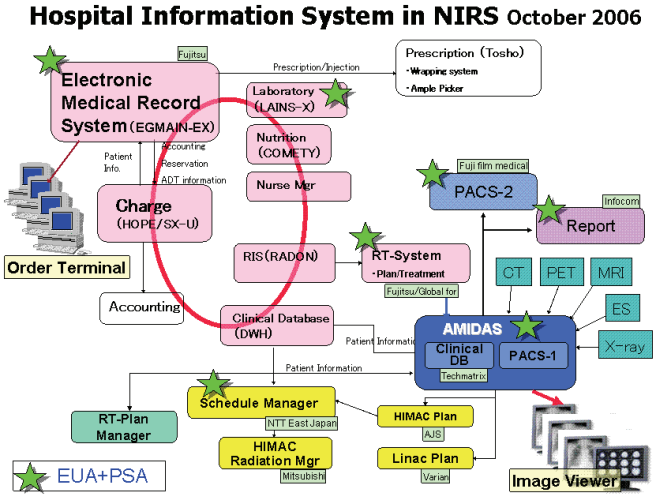

Figure 2 - Existing Hospital Information Systems. The star sign denotes the function of the EUA/PSA

Results

Our EMR has been running since October 2006 and uses the ActiveX module. PACS-1 uses the Java module. PACS-2 uses the ActiveX module. The Report uses ActiveX. The RSS uses the Java applet. RO-RIS uses the ActiveX. No system uses the Servlet module.

We set up the context area in our hospital. There are 23 context areas in the out-patient clinic and wards. Each context area covers several applications (EMR, PACS-1, PACS-2, Report, RSS and RO-RIS). Each context area consists of 2 personal computers, one which is used mainly for EMR and the other which is used mainly for the PACS/Report application and RSS application.

We examined the number of actions for the login and the selection of patients in each application. Table 2 shows the differences between operation with and without the EUA/PSA function. Each application can omit 2-3 operations by using the EUA/PSA mechanism.

Table 2 - The number of the actions we can omit during Login and Patient Selection by the EUA/PSA function

Application	Login	Patient Selection
EMR	2	2-3
PACS-1	2	3
PACS-2	2	2
Report	2	2
RSS	2	3
RO-RIS	2	3

(We count one for a mouse click and/or a consecutive keyboard input.)

The enhanced Context Area Manager is working with no serious problems, but if the number of participants in the same context area increases, the response time of the Context Area Manager also increases. We found that with two participants in the same context area, the response time was less than one second.

Discussion

Our hospital has six existing information systems. We wanted to reduce implementation problems and to unify the application interfaces: middle-ware could resolve these problems. We prepared guidelines for modification of the workflow. These guidelines include icons that indicate the status of an application, as shown in Figure 3. We developed two types of icons (small and large), which are useful for physicians to understand the status of the context manager. The "Participating" status means that each application communicates with a context manager and all applications cooperate. In this status, all applications are coordinated for the same log-in user and the same patient ID.

Figure 3 - The left two icons show "Participating", the right two icons show "Non-Participating"

The validity of the enhanced context area was confirmed. Our hospital information system consists of six systems (EMR, PACS-1, PACS-2, Report, RSS, RO-RIS). In the future, the necessity of t visual integration will increase, and implementation of the IHE ITI EUA/PSA will be popular among medical institutions and hospitals. The unified procedure for visual integration is very important, and we developed guidelines and icons. We consider that hospital information staff should prepare guidelines and rules to utilize the visual integration effectively.

The context manger function of the patient subject is limited to the patient ID. In future, integration of the patient ID should be enhanced to details of patient information such as the examination ID or image ID, especially for PACS/Report applications. The EUA/PSA defined by IHE ITI uses CCOW version 1.4, which defines the patient subject as the patient ID. CCOW version 1.5 defines detailed information about a patient such as DICOM objects. In future we want to improve the function of the PSA to support DICOM objects.

It is natural to be afraid of malpractice in clinical procedures. With a multi-vender information system it is troublesome for physicians to enter a user ID and a patient ID or to select a patient. The EUA/PSA mechanism will

solve such onerous problems, but if the Context Area Manager is down, the implications will become serious. We made the related applications foolproof and robust to eliminate malpractice. Each application can be executed without the EUA/PSA function and will ignore the Context Area Manager when the manager will not respond to a participant.

Conclusion

We developed four types of EUA/PSA middle-ware. Each application used suitable middle-ware for running environments and also enabled the simple implementation of a single sign on and patient selection. We modified six existing information systems to use the EUA/PSA middle-ware. These modifications require the considerable effort, but otherwise we achieved good seamless operation by the EUA/PSA functions. We believe that the EUA/PSA function will be indispensable for multi-vender information systems and useful for clinical safety.

References

[1] Clinical Context Management Specification Version 1.4, The Health Level Seven, ANSI/CMS, V1.4-2002.
[2] EUA/PSA integration profile, Integrating the Healthcare Enterprise. website http://www.ihe.net/Technical_Framework/index.cfm#IT
[3] ITI Integration Profile, website http://www.ihe.net/Tecnical_ Framework/index.cfm#IT.

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The first Japanese implementation of IHE-ITI EUA/PSA and the Impact of Visual Integration

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Introduction

- Our hospital is specially designed for the heavy particle radiation therapy. Systems (HIS, PACS, clinical database and schedule management system) are running. Some systems were recently replaced. Then we made a modification to use the IHE ITI profiles.
- We planed to study the effectiveness and availability of IHE[1][2] IT-Infrastructure profiles in the Japanese environment. The final aim is to evaluate the availability of the integration profiles in Japanese environment.
- We expand the function of the EUA and PSA, because one clinical unit includes 2-3 personal computers in the outpatient clinic and the ward. We defined the context area for the context manager defined by the HL7 CCOW (Clinical Context Management Specification)[3]. We developed the middleware to realize the function of the EUA (Enterprise User Authentication) and PSA (Patient Synchronized Applications).

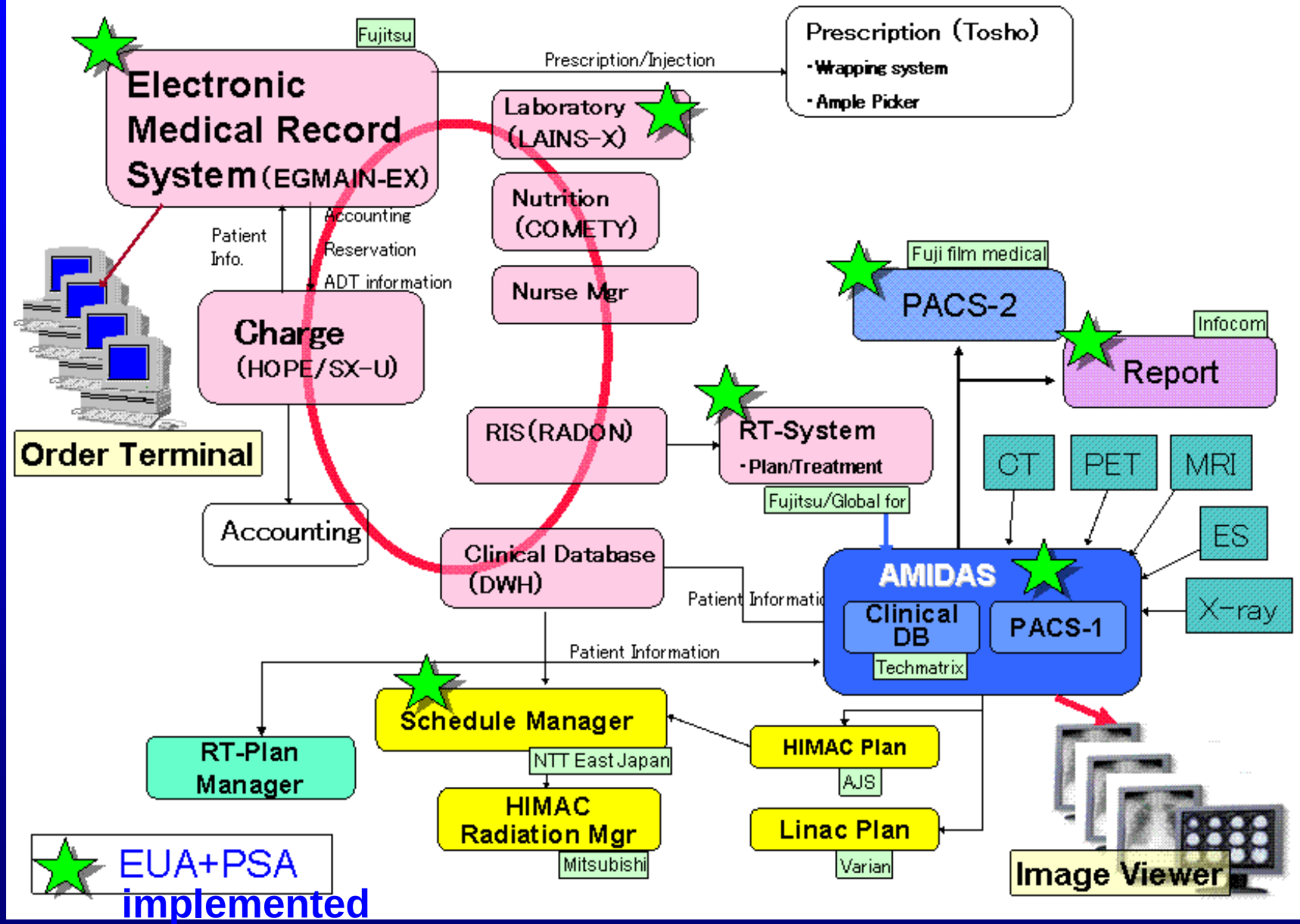
National Institute of Radiological Sciences Hospital

- Located at Inage, Chiba
- Beds for inpatients: 100 beds
- Outpatients: 70-100 patients/day
- Specialized for a radiation therapy with the heavy particle
- Film-less environment (August 2005)

Purpose

- To evaluate IHE IT Infrastructure Integration Profile (EUA, PSA, CT）
- To adapt the EUA and PSA to the Japanese clinical environment
- IHE IT Infrastructure Profile:
  - EUA: Enterprise user authentication
  - PSA: Patient synchronized application
  - CT: Consistent time

Hospital Information System in NIRS October 2006

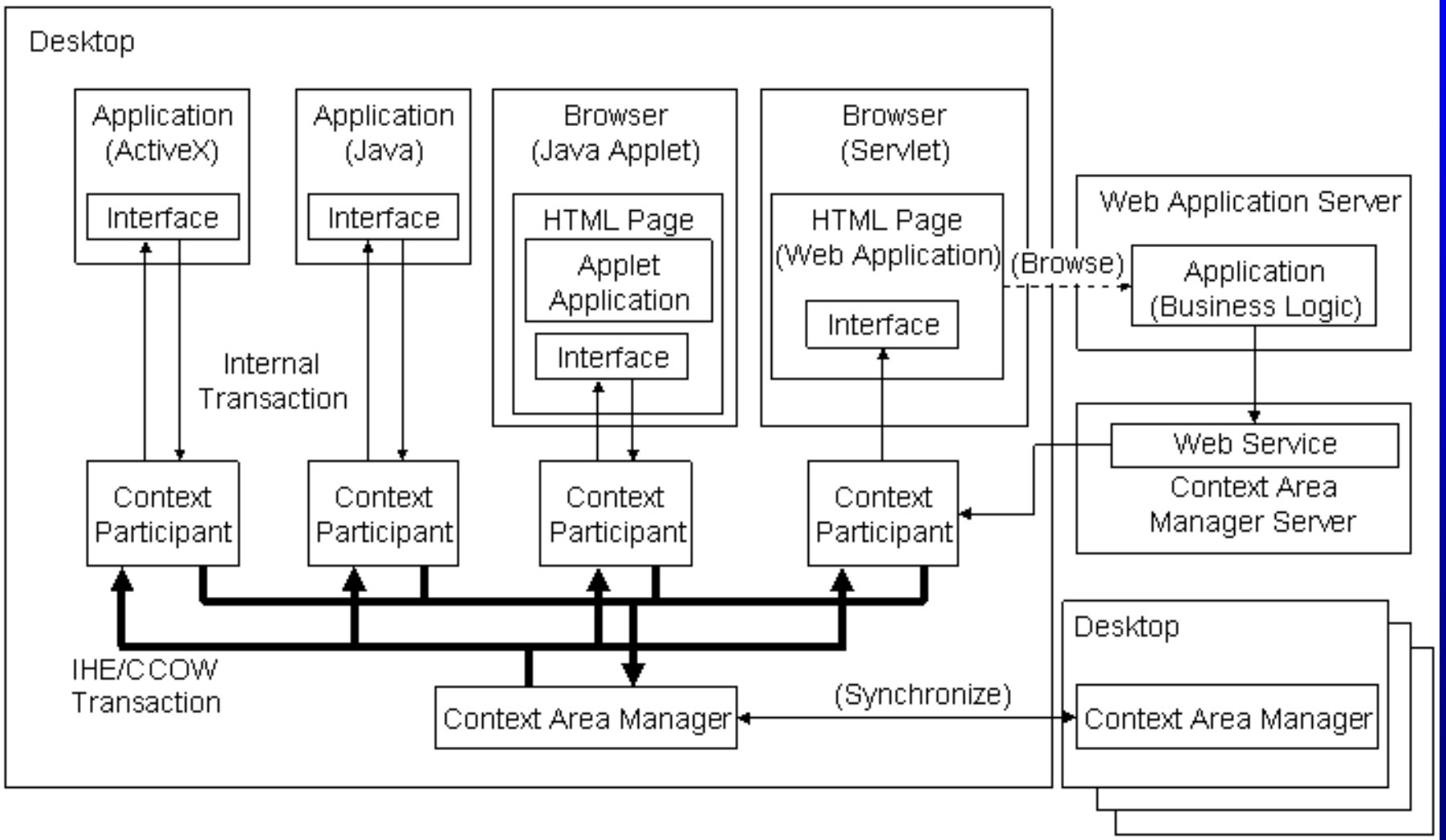


Target Systems

- (1) EMR: HOPE/EGMAIN-EX C/S Edition®, HOPE/DrABLE-EX®, HOPE/LAINS-PC® (Fujitsu)
- (2) PACS-1: SDS-DicomViewer® (TechMatrix)
- (3) PACS-2: SYNAPSE® (Fujifilm)
- (4) Report system: F-REPORT® (INFOCOM)
- (5) RO-RIS: RIGIA (Global-for)
- (6) Radiation schedule system: RSS (Nippon Telegraph and Telephone East)

These six systems were adapted by each vender.

Configuration of the context area manager and the relationship between the context area manager and applications



Methods

- We developed four types of EUA/PSA middle-wares (ActiveX application, Java application, Java applet and Servlet).
- We use this middle-ware to communicate the context area manager each other. We analyzed the flow of the applications. We implemented the function of the EUA and PSA into the existing applications.
- Next we established guidelines for the implementation of the EUA/PSA. The venders of the existing systems modified their applications according these guidelines.
- We evaluate the functionality of the EUA and PSA by using the each application.

Result

- Our EMR has been running since October 2006 and uses the ActiveX module. PACS-1 uses the Java module. PACS-2 uses the ActiveX module. The Report uses ActiveX. The RSS uses the Java applet. RO-RIS uses the ActiveX. No system uses the Servlet module.
- We set up the context area in our hospital. There are 23 context areas in the out-patient clinic and wards. Each context area covers several applications (EMR, PACS-1, PACS-2, Report, RSS and RO-RIS). Each context area consists of 2 personal computers, one which is used mainly for EMR and the other which is used mainly for the PACS/Report application and RSS application.

Discussion

- We wanted to reduce implementation problems and to unify the application interfaces: middle-ware could resolve these problems. We prepared guidelines for modification of the workflow. These guidelines include icons that indicate the status of an application.

- The validity of the enhanced context area was confirmed. In the future, the necessity of t visual integration will increase, and the unified procedure for visual integration is very important.
- The EUA/PSA defined by IHE ITI uses CCOW version 1.4, which defines the patient subject as the patient ID. CCOW version 1.5 defines detailed information about a patient such as DICOM objects.

Conclusion

- We developed four types of EUA/PSA middle-ware. Each application used suitable middle-ware for running environments and also enabled the simple implementation of a single sign on and patient selection.
- We modified six existing information systems to use the EUA/PSA middle-ware. These modifications require the considerable effort, but otherwise we achieved good seamless operation by the EUA/PSA functions. We believe that the EUA/PSA function will be indispensable for multi-vender information systems and useful for clinical safety.

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HISA Ltd Australia

A Case Report of First Steps Taken at an European Agency, ECDC to Introduce Knowledge Management Services (description of knowledge sources and 'extraction' of metadata in practice)

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Abstract

As part of efforts toward building knowledge based services at the new European Centre for Disease Prevention and Control (ECDC), authors investigated content and extracted metadata from a large document base.

ECDC has been created to strengthen Europe's defenses against infectious diseases, aims to pool health knowledge, to develop authoritative scientific opinions about the risks. A quickly accumulating body of ~ thirty thousand electronic documents was analyzed. As a way out from the provisional, start-up state, it was found that a set of systematic measures among them notably introduction of metadata enhanced templates (using Dublin Core NSMetadata Initiative) and ontology based tagging should be applied. As an innovative approach we used the existing arbitrary file and folder structure to be translated to content characterizing metadata. We hope that the in the next future we will be able to build up a knowledge repository with enhanced navigation facilities, using the existing electronic content – but made it much more transparent and easy to use source of knowledge for internal and external users at ECDC.

Keywords:

information management, public health informatics, communicable disease control, knowledge based services, document management, standard tools, European Centre For Disease Prevention and Control, ECDC

Introduction

This paper describes the first steps taken at a European agency, European Centre for Disease Prevention and Control, ECDC to introduce knowledge management (KM) services. Describing the chain of thoughts while planning the services and the experiences of the analytic work hopefully help others with similar tasks to understand the nature of information handling at their organization and to plan better KM services.

ECDC is an EU agency that has been created to help strengthen Europe's defense against infectious diseases. The mission of ECDC is to identify, assess and communicate current and emerging threats to human health posed by infectious diseases. To achieve this mission, ECDC works in partnership with national health protection bodies across Europe. ECDC aims to pool Europe's health knowledge, so as to develop authoritative scientific opinions about the risks posed by current and emerging infectious diseases. The Centre, currently staffed with ~ 80 experts and management, will have an over € 50 million budget by 2010 and its staff will grow to 300 over the coming years.

Establishing a knowledge-base (KB) and a set of knowledge-based services (KBS) is clearly a key issue for the full blown operation of ECDC. KBS's developed for human- and KBS's developed for machine (that is software) users will serve all activities / all units of ECDC.

ECDC has a matrix organization with three technical units, an administrative unit and seven horizontal disease-specific projects. The three technical units are the following: The Scientific Advice Unit (SAU), the Unit for Preparedness and Response (PRU), and the Surveillance and Communication Unit (SCU). SAU's main tasks are to provide sound and independent technical and scientific advice; do and maintain an inventory of communicable disease related resources; build an operational network of experts and scientists in Europe; build further on the scientific competence and experience of the scientific community for communicable diseases, actively participate in all key scientific conferences and meetings. PRU's main task is to keep track of emerging health threats inside and outside the EU, provide rapid risk assessment and coordinate a timely response to such threats, done by operating the Early Warning and Response System (EWRS), organizing training programs for public health, and supporting outbreak missions of MS experts. SCU's main task is to take over and operate the surveillance of communicable diseases at the EU level from the designated surveillance networks. Data will be analyzed and the information disseminated to those who need it for public health decision taking in Europe. The ECDC disease specific activities are organized within seven horizontal projects with team members from all technical units: 1) influenza, 2) tuberculosis, 3) food- and water-borne diseases, 4) other diseases of environmental and zoonotic origin, 5) vaccine preventable diseases and invasive bacterial infections,

6) HIV-STI and blood-borne viruses, and 7) antimicrobial resistance and nosocomial infections.

In ECDC we plan to establish a knowledge base for human users to serve as electronic information source, enhanced / supported by specific services i.e. knowledge mapping, intelligent search, cross-referencing, and other tools to navigate in the information space. It might be equally, or on the long run even more important to establish KB services that can be used also directly by other information systems, the surveillance networks, the Early Warning and Response System such as terminology services and later also by other advanced systems / functions, enabling high level, standardized reporting, (semi-) automated extraction of critical information, semantic crosschecking of information gained form independent sources, etc.

At planning these services, we want to avoid 'reinventing the wheel' and as a strategic decision, we want to stick to international standards ensuring interoperability and long run transparency of emerging systems/modules/functions. Fortunately, recently, a number of general and medical informatics knowledge representation and handling tools became more and more mature, and available as tools for such tasks on several levels from data formats to knowledge representation and process & system modeling (the XML family, UML, OWL, etc). The buzzwords 'semantic web' and 'web 2.0' describe a set of emerging tools / methods that should be considered at planning a future proof solution portfolio.

The below described work is one of the first steps taken toward the realization of KM services at ECDC. A knowledge needs assessment revealed that there is a pressing need for better information retrieval, handling of the already existing and rapidly growing electronic document set of ECDC. It is clear, that on the long run, as part of the integrated ICT services, ECDC will have to have an integrated electronic content management system dealing with the internal documents and also the ever-growing, mostly open partly restricted web content. Planning, procuring and implementing such a system takes at least 1,5 – 2 years, so we needed an interim solution, that serves also as a sort of sandbox for the final application. We describe here the analytic parts of the work, the thinking about metadata, some innovative methods we choose and show the results of these preparation tasks.

Materials and methods

Materials

Our objects, materials to study were the electronic documents accumulated on the drives of ECDC since its operations started in May 2005. The 'snapshot' of the files – folders structure was taken in August, 2006, after roughly one and half year of ECDC operations. Only files and folders of the technical (scientific) units were analyzed – that of the administration, financing, human resources and routine emailing were not drawn into the analysis. All files generated during this period were taken in account, classified into documents[1], spreadsheets, presentations, and 'all others' categories.

Methods

To prepare later seamless introduction of content management, we decided to take three steps

- an analytical step to understand the build-up process, the accumulation of information
- extraction of metadata and setting up a keyword library
- establishing a set of metadata "augmented" documents

This paper focuses on the first and on the second, closely related steps of this process.

To achieve the goals, simple tools were used as follows:

- command line tools and disk cataloging utilities for extraction of file / folder structures
- a Unicode text editor for building/editing xml files
- an online word processor for producing ODF compliant document templates
- a spreadsheet application for file statistics

Results

ECDC stores its electronic documents on file servers, where a shared space (a 'drive') was set up to store documents that should be reached across all the units, and 'unit specific' spaces (virtual 'unit drives') were assigned to the three above mentioned units, the SAU, the PRU and the SCU. The data characterizing file accumulations and distribution of the first one and a half year were analyzed in depth. The following numbers just summarize the most characteristic aspects. The document distribution in folders was investigated with the following results – see table1:

Table 1 - The number of folders/ subfolders existing at each level of the folder- tree

Subfolder depth level:	No. of folders in "shared" drive	PRU drive	SAU drive	SCU drive
root folder	14	30	41	42
2nd	44	156	84	187
3rd	177	240	152	276
4th	384	183	68	142
5th	661	178	24	81
6th	383	91	9	42
7th	245	12	12	39

1 (working) docs, and (to be published) pdfs

Subfolder depth level:	No. of folders in "shared" drive	PRU drive	SAU drive	SCU drive
8th	194	8	1	
9th	188	1		
10th	109			
11th	80			
12th	27			
13th	9			
14th	1			
Sum of folders	**2516**	**899**	**391**	**809**
Total no. of folders:	**4615**			

These numbers and some others following below are analyzed in the discussion section of this paper. It has to be noted, that the folder structure is the result of a non-regulated, 'organic' growth of the document set in a just formed, new organization, where highly autonomous and highly educated experts worked mostly either alone or in ever changing, problem oriented, ad-hoc teams on emerging problems. Roles and tasks were not yet 'frozen', most experts did extensive multi-tasking and took part also in building up activities. Information communication technology services were focused on providing a stable, robust office services background and electronic communication services, with no emphasis on electronic workflow support or organization of content – due to lack of capacities. However the amount of accumulating documents was / is staggering – be aware that the value axis below is logarithmic! See figure 1.

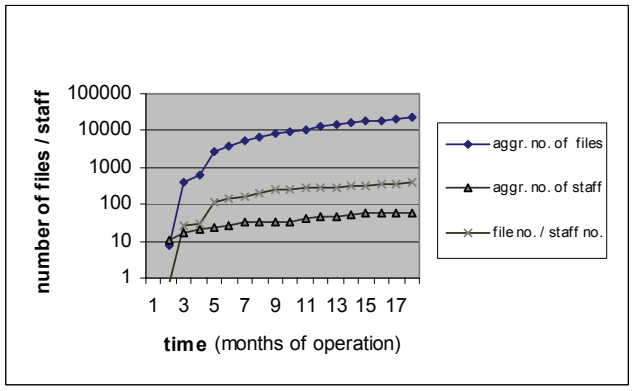

Figure 1 - The growth of staff and the aggregated numbers of scientific document files on ECDC servers

The distribution of files is detailed according to the most frequently used file types in table 2.

Table 2 - file type distribution

location of files		documents	spreadsheets	docs to publish (pdf-s)	presentations	miscellaneous (jpgs, html, txt, rtf, etc.)	all
shared 'drive'	abs	5797	557	4048	1167	6695	18264
	rel	32%	3%	22%	6%	37%	100%
PRU 'drive'	abs	2508	328	897	390	3337	7460
	rel	34%	4%	12%	5%	45%	100%
SAU 'drive'	abs	880	758	163	58	1618	3477
	rel	25%	22%	5%	2%	47%	100%
SCU 'drive'	abs	2022	609	341	149	1926	5047
	rel	40%	12%	7%	3%	38%	100%
total	**abs**	**9185**	**1643**	**5108**	**1615**	**11650**	**29201**
	Rel	**31%**	**6%**	**17%**	**6%**	**40%**	**100%**

Discussion

Discussion of the results focuses on understanding and interpreting what is behind the numbers.

First, the files / folders structure: It is obvious, that it is almost hopeless to navigate efficiently (i.e. quickly and easily) in such a tree. The depths of more than ten levels and the (sub-)folder numbers ranging from one to more than six hundred (on depth level 5 of the 'shared drive) is remarkable. According to a classic, widely accepted paper [1] of cognitive science the pan of short time memory allows us to handle 7(+-2) "chunks" of information at any give time, due to inherent limitations of short term memory. Working in complex folder hierarchies, we use short term memory, therefore this well documented phenomenon should push us to reorganize our file/folder structure into embedded hierarchies of roughly 7 by 7 matrices (not much more than 7(+- 2) subfolders in a folder and not much more than 7(+-2) files in folder). The material, we deal with, however does not allow such a grouping. Concerning searching and retrieval in such a large, complex information space, does a simple or even an enhanced "brute force" search engine help? We think not, as desktop search engines have a significant limitation: they can search only by the string existing within the information object. If we have thousands of documents on very similar topics, the search by strings (words or parts of them) will be never specific enough to find a particular information object among them. Such a search will also be not helpful to find a set of related documents, connected not just by having the same words, but by some other characteristics, as e.g. referring to a geographic region, whilst in the text only countries or cities are named (e.g. in case of an out-

break investigation). Using metadata is of course the answer to this problem [2]. If a well maintained keyword vocabulary is used to tag the content and other characteristics of the documents, such problems can be solved. Even better if the 'vocabulary' is based on a logically sound ontology, meaning that later on we will have the option of semantic operations, of complex searches at hand. Before discussing the metadata issue, it is worth to discuss *a second aspect: the growth of the information heap*, resulting in almost thirty thousand information objects in one and half years, as seen on figure 2. below.

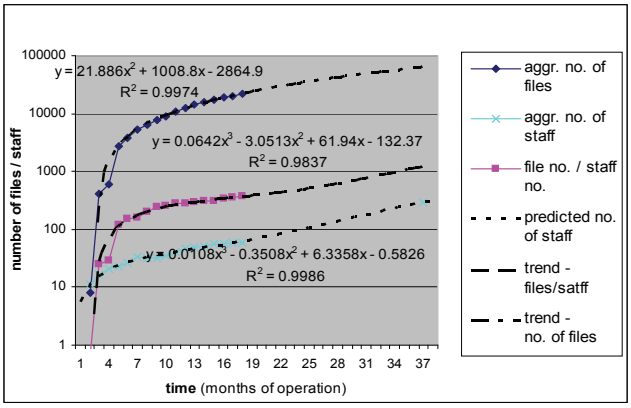

Figure 2 - trends of the growth of staff and the aggregated numbers of scientific document files on ECDC servers

ECDC will grow to the predicted staff of ~ 300 in the coming two years. Using this number trends can be examined concerning the future number of files and the file to be handled by a given staff member. Well fitting trend lines show that the number of files will reach nearly a hundred thousand and each staff member will be 'responsible' for more than a thousand file. This predictions might be disputed as more and more 'services' of ECDC will become 'operational': like the surveillance networks and the organization will turn to a 'normal operation' mode from the current build–up period. However most of the functions 'producing' information are already functional, even if only in skeletal format, and the curves show that the characteristics of the buildup period (sort of 'combinatory growth' of staff & information) became already more 'leveled' after the first nine months.

The last, third issue before we can discuss the required metadata in details, is the *distribution of files types* and its consequences: *Table 2* shows us, that while the single most frequent information object is the 'document' file (31% of all), there is a huge heterogeneous set, containing raw txt, html, gif, jpg, rtf, eml, etc. and some other, special files used to develop databases and applications. The difficulties to reach, to make available the information 'hiding' in these files if using normal search tools, stresses again the need for proper metadata tagging.

As a result of the discussed facts, we can conclude, that an inescapable condition of a consistent, transparent knowledge management at the ECDC is to establish a common, shared metadata structure for all information objects. In keeping with our commitment to internationally accepted standards and protocols, we think, that an appropriate metadata structure can be created using the Dublin Core Metadata Initiative [3]. The goal of this initiative is to standardize the names of the metadata elements with which an object is tagged. This results in great benefits with respect to electronic processing, since the metadata set of an object will be portable across different systems. As the DCMI matures, more DCMI-aware applications will become available, increasing the usefulness of the metadata.

As a preparation step to managing metadata, a set of document templates has been provided which incorporate the recommended metadata structure. The templates were selected to cover a set of common documents which are created at the ECDC on a regular basis. The specific types were selected based on the observed recurrence of documents in the shared folders and using feedback from semiformal interviews. The motivation for using these templates is that a significant subset of the metadata will be preset for each document. Since the templates are linked to each other based on a principle of inheritance, creating new templates is a more straightforward process. In other words, an SCU mission report template was created by extending the generic mission report template which was in turn created by extending the basic ECDC root template. As a result, all templates inherit the metadata of their parent template and add new elements specific to their additional characteristics. By using templates staff members will be relieved from the bulk of metadata tagging, only content specific metadata (akin to traditional 'keywording') has to be added.

What are the sources of these content–specific metadata elements, in DCMI terms: subjects and keywords?

Term Name: subject	
URI:	http://purl.org/dc/elements/1.1/subject
Label:	Subject and Keywords
Definition:	The topic of the content of the resource.

Figure 3 - DCMI definition for content specific metadata

ECDC has to run in the future among others the integrated database of surveillance networks of communicable diseases operated for the EU, the Threat Tracking Tool that monitors suspicious events, publishes Eurosurveillance, a periodical that has many decades experience in keywording papers related to communicable diseases. Variables of all the mentioned databases and the corpus of Eurosurveillance provided the core set of key word list that is under

evaluation of the ECDC expert staff at the time of writing this paper.

However, the folder/subfolder/filename structure of the present document library can be seen also as metadata characterizing the information object: See some typical examples:

> 'Directory of R:\Epidemic Intelligence \ RiskAssessment \ Guidelines\Retrospective on U_S_ Health Risk Assessment_files'

or

> 'Directory of T:\Surveillance Networks\+Evaluation docs\Evaluation documents\Web Questionnaires\Epi-ContactPoint.aspx_files'

These character strings, although presently part of an arbitrary folder structure are actually describing the documents with features, characteristics that are not necessarily availably from within the object. Therefore we are using the folder (subfolder names as candidates for future keywords and also they will be used as "subject metadata" in a later planned migration to a metadata using content management system. Besides parsing there is obviously a data-cleaning, filtering step, that has to be done, finding redundancies, correcting misspellings etc. and establishing preferred set of terms.

All the resulting terms will be collected and will be used to establish the ECD core terminology, behind that a 'core ontology' will serve to maintain consistency and transparency of the terms set as well.

Conclusions

Numerous off the shelf solutions exist which could address the issues of knowledge management in ECDC. Software such as document management systems and virtual file systems will at least partially solve these tasks. However, they are designed mostly to integrate into a business workflow model and address archival requirements which differ from an organization such as the ECDC. Largely, the solutions available are still document-centric and target a different set of priorities. As the official European source for information on, and related to, communicable diseases, the ECDC has a specific set of requirements which differ from those of both private companies and academic institutions. ECDC needs

- efficient data archival and retrieval:

Unlike information such as accounting data, processed and stored using well-defined methods, the scientific information in ECDC is more open-ended and has more complex inter-relationships, requiring something more feature-rich than a basic filing system. The experts working at the ECDC will not be primarily concerned with the administrative processes of archiving and retrieving information, but with the content. Archiving and retrieval should happen as transparently as possible, reducing procedural overhead. Unlike academic institutions, ECDC may not always have a single standard mode of operation. During, for example, a serious outbreak, information may need to be found, processed and stored within much narrower time constraints ("peace mode" – "war mode" procedures)

- easy referencing of information:

A document-centric approach solves the problem of relating a set of data with a set of conclusions by embedding both into a single document. Inter-document references are handled using citations the most efficient of which make use of identifiers such as ISBN or ISSN numbers. For ECDC an equally unambiguous solution is required but intended for a more heterogeneous knowledge management solution, which goes even further, allowing many-to-many relationships. The method of referencing information must also be usable by both human and automated agents (this follows from the previous requirement).

- a long information life cycle:

While the length of information retention at an average IT company may be measured in years, the length of information retention at the ECDC may be estimated in decades (in this case we are not considering backups, but information stored in primary storage and readily accessible). This includes the raw and processed data, the ability to flexibly process the data, and any references that exist between sets of data and between data and analysis results and conclusions. This profoundly affects all of the information requirements. We must consider that most of the popular file formats in use today are only a few years old and that users are already experiencing problems when attempting to read files only two decades old. In order to address these requirements in a way that will provide the most benefit to the organization in the years and decades to come, some groundwork needs to be laid out.

Policies and mechanisms are required which standardize the following across all units and horizontal activities:

- establishing and using a core ECDC terminology, with ontological basis
- establishing a metadata set which can be applied in whole or in part to all individual information entities and which will incorporate also the keyword set
- a well-chosen set of acceptable data formats for use in the knowledge repository

  (Note: there is a need to decouple of data formats from the applications used to read and write the data. Any file which can only be read using a particular proprietary application is not suitable for an information life cycle of the length which we are considering here)

- having a commitment to formats and protocols conforming to internationally accepted standards

Summing up our experiences, an envisioned implementation for managing the information contained by the internal electronic document set will incorporate several key methods and tools:

- using open document format and general XML encoding
- using metadata embedded into documents for redundancy (using metadata enriched templates)
- establishing a database which will hold the extracted metadata for processing during normal execution
- using controlled vocabularies with ontology 'back-up' to enforce consistency
- establishing a unified search interface making the entire knowledge space available to the end users.

We hope, that the above presented experiences and ideas will help others to establish similar services at different organizations.

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[1] Miller GA. The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information, The Psychological Review, 1956: 63, pp. 81-97

[2] Handschuh S, Staab S, Maedche A. CREAM: creating relational metadata with a component-based, ontology-driven annotation framework . In: Proceedings of the 1st international conference on Knowledge capture, ACM Press, Victoria, British Columbia, Canada, 2001, pp 76-83

[3] DCMI Usage Board DCMI metadata terms. http://dublincore.org/documents/2003/03/04/dcmi-terms/, 2003.

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A case report of first steps taken at an European scientific agency,

European **C**entre for **D**isease Prevention and **C**ontrol

to introduce knowledge based services

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Abstract

This paper reports author's work toward building knowledge based services at the new European Centre for Disease Prevention and Control (ECDC). As part of this work, electronic content was analysed and metadata were extracted from a large document base.

ECDC, a scientific agency has been created to strengthen Europe's defenses against infectious diseases, aims to pool health knowledge, to develop authoritative scientific opinions about the risks. A quickly accumulating body of ~ thirty thousand electronic documents was analyzed.

As a way out from the current start-up phase, it was found that a set of systematic measures among them introduction of metadata enhanced document templates (using Dublin Core Metadata Initiative) and ontology based tagging should be applied.

As an innovative approach we used the existing arbitrary file and folder structure to be translated to content characterizing metadata. We hope that the in the next future we will be able to build up a knowledge repository with enhanced navigation facilities, using the existing electronic content – but made it much more transparent and easy to use source of knowledge for internal and external users at ECDC.

Introduction

ECDC[1] is a **scientific agency,** strengthening Europe's defence against infectious diseases.

The agency has four technical units **(Scientific Advice - SAU**, **Preparedness and Response - PRU**, **Surveillance - SUN** and **Health Communication – HCU - units**), an administrative unit and seven horizontal disease-specific projects[2]:

1) influenza,
2) tuberculosis,
3) food- and water-borne diseases,
4) other diseases of environmental and zoonotic origin,
5) vaccine preventable diseases and invasive bacterial infections,
6) HIV-STI and blood-borne viruses, and
7) antimicrobial resistance and healthcare associated infections.

Knowledge-based services (KBS) for human- and for machine users will be a key issue.

The *planned knowledge based services* are:

(a) electronic information sources service (content management)
(b) terminology services;
(c) other advanced systems / functions as knowledge navigation, decision support

In the area of knowledge management ECDC wants to avoid 'reinventing the wheel' and to stick to standards[3] ensuring semantic interoperability and transparency.

[1] ECDC will have a >50 M€ budget by 2010, staff will be ~ 300.
[2] At the time of the 'snapshot' for document analysis three units, SAU, SU and PRU were active, HECO was established later.
[3] on several levels: as the XML family, UML, OWL, DCMI etc.)

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Materials and Methods

Our **materials** were the electronic documentation, accumulated since May 2005. Documents are stored on file servers, a common space serves shared documents, while virtual drives were assigned to relevant organizational units. A ‘snapshot’ of this structure was taken in August, 2006.

Files were classified into documents[1], spreadsheets, presentations, and ‘all others’ categories. **Methods:** Command line tools and disk cataloging utilities for extraction of file / folder structures were used; a text editor served for building/editing xml files, a spreadsheet application for file statistics.

[1] (working) docs, and (to be published) pdfs

Results

Characteristics of file accumulation and distribution were analyzed.
Numbers in **table 1** summarize just the most characteristic aspects.
The folder structure is the result of a non-regulated, ‘organic’ growth in a just formed organization, where highly autonomous and highly educated experts worked mostly either alone or in ever changing, problem oriented, ad-hoc teams on emerging problems and most experts did extensive multi-tasking.
However **the amount of accumulating documents was / is staggering[1] (fig1.)**
The distribution of files is detailed according to the most frequently used file types in **table 2. Trends were calculated concerning file numbers (fig1)**.

[1] be aware that the value axis of fig. 1 is logarithmic!

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Table 1

The Number of Folders / Subfolders

Subfolder depth level:	No. of folders in			
	"shared" drive	PRU drive	SAU drive	SUN drive
root folder	14	30	41	42
2nd	44	156	84	187
3rd	177	240	152	276
4th	384	183	68	142
5th	661	178	24	81
6th	383	91	9	42
7th	245	12	12	39
8th	194	8	1	
9th	188	1		
10th	109			
11th	80			
12th	27			
13th	9			
14th	1			
Sum of folders	2516	899	391	809
Total folders:	4615			

Table 2

File Type Distribution

location of files		Documents					
			Spreadsheets				
				docs to publish (pdf-s)			
					presentations		
						miscellaneous	
							all
shared 'drive'		*32%*	*3%*	*22%*	*6%*	*37%*	***18264***
PRU 'drive'		*34%*	*4%*	*12%*	*5%*	*45%*	***7460***
SAU 'drive'		*25%*	*22 %*	*5%*	*2%*	*47%*	***3477***
SUN 'drive'		*40%*	*12 %*	*7%*	*3%*	*38%*	***5047***
Tot.	abs. no	**9185**	**1643**	**5108**	**1615**	**11650**	**29201**
	rel. no	**31%**	**6%**	**17%**	**6%**	**40%**	

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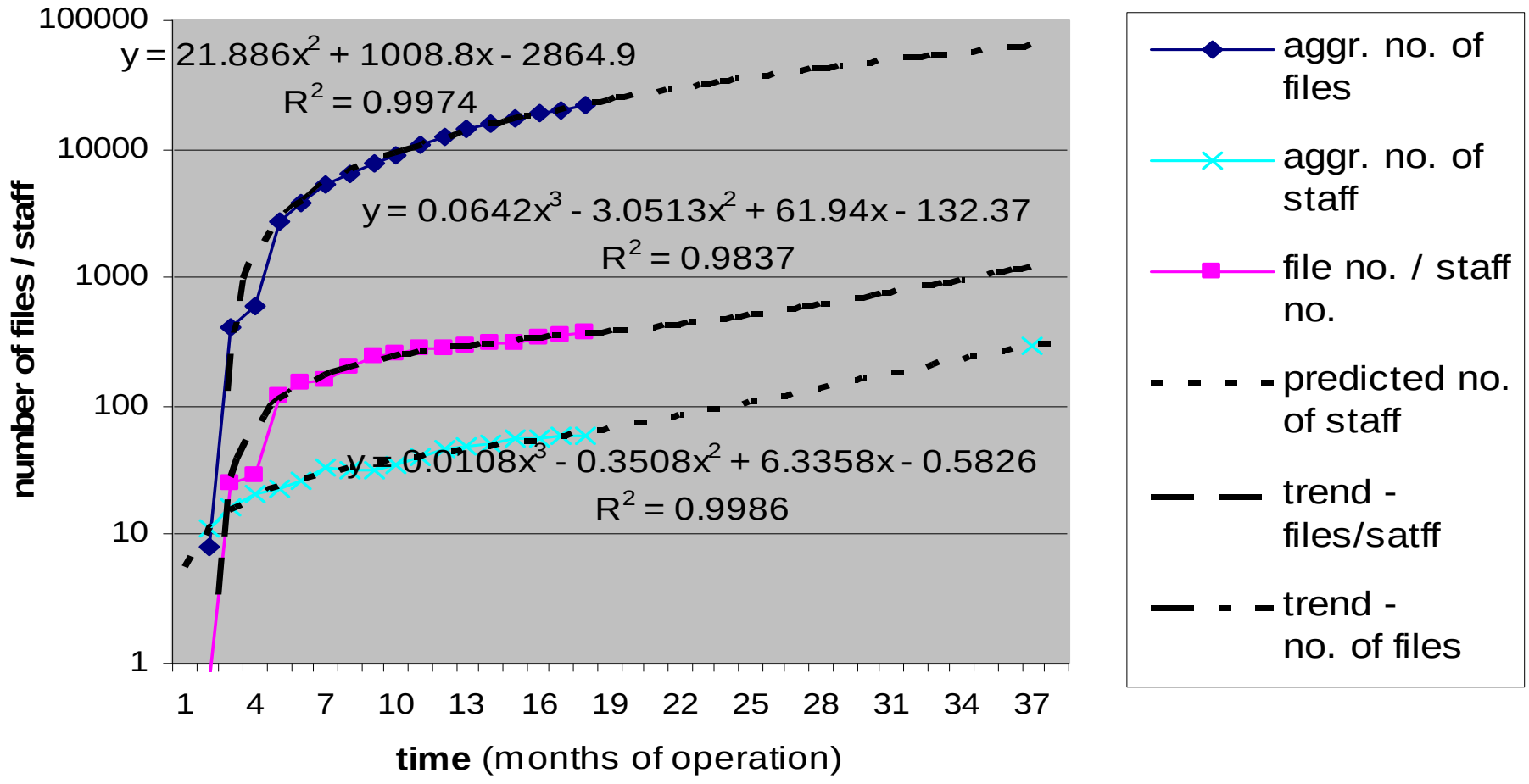
Figure 1 - **Trends of the Growth of Staff and the Aggregated Numbers of Scientific Document Files on ECDC Servers**



Discussion

Discussing files / folders structure:

It is almost hopeless to navigate efficiently in such a complex folder hierarchy tree. (Table 1)

The pan of short time memory (while working in folder hierarchies), allows us to handle 7(+-2) “chunks” of information at any given time [1]. The material, we deal with, however does not allow such a grouping – we have to opt for other organization methods as e.g. multidimensional localization by metadata.

Concerning search and retrieval:

Having thousands of documents on very similar topics, a conventional search engine will be never specific enough. Also, such a search will not find sets of (conceptually) related documents. Using metadata is of course the answer to this problem as well [2].

The metadata ‘vocabulary’ should be based on ontology, so that later on we will have the option of semantic operations as well.

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Discussion – continued ….

Concerning the growth of the information heap:

ECDC will grow to size of ~ 300 staff in two years.

Well fitting trend lines (fig. 1.) show that the **file numbers will reach nearly a hundred thousand** and each staff member will be ‘responsible’ for more than a thousand file.

These predictions might be disputed even to be low-key, as more and more ‘services’ of ECDC will become ‘operational’.

Distribution of files types:

Table 2 shows us, that while the single most frequent information object is the ‘document’ file (31% of all), there is a huge heterogeneous set, containing raw txt, html, gif, jpg, rtf, eml, etc. and some others.

The difficulties to reach, to make available the information ‘hiding’ in these files if using normal search tools, stresses again the need for proper metadata tagging.

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Conclusions

We can conclude that an inescapable condition of a consistent, transparent knowledge management at the ECDC is to establish a common, shared metadata structure for all information objects.

We suggest that an appropriate metadata structure can be created using the Dublin Core Metadata Initiative [3]. Besides the 'mundane' metadata as contributor etc., the content–specific metadata elements[1] are the most crucial.

ECDC has to run in the integrated EU database of surveillance networks of communicable diseases, a Threat Tracking Tool that monitors suspicious events, to publish Eurosurveillance etc.

Variables of all the mentioned databases and ECDC texts can nd will provide the core set of terms that is under evaluation of the ECDC expert staff.

[1] in DCMI terms: subjects and keywords

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Conclusions – continued ....

The folder structure of the document library can be seen also as metadata characterizing the information object, a typical example is ‘Directory of R:\Epidemic Intelligence \ RiskAssessment \ Guidelines\Retrospective on US Health Risk Assessment_files’.

These strings are actually describing the documents with characteristics that are not necessarily availably from within the object. Therefore folder / subfolder names are “subject metadata”.

All these resulting terms will be collected and will be used to establish the ECDC core terminology, behind that a ‘core ontology’ will serve to maintain consistency and transparency of the terms set as well.

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Summing up our future plans, we want to progress towards:

- establishing **a core ECDC terminology, with ontological basis**, later to be extended to a full terminology
- using core terms as **a metadata set applied to all information entities**, remaining committed to standard document formats;
- Using a core ontology as a source for **a unified search function,** making the entire ECDC knowledge space transparent, easy to navigate and available to the wide variety of end users.

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Determining Appropriate Window and Level Settings for Displaying DICOM Images in a Desktop Publishing Format

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Abstract

When harvesting images from a Picture Archiving and Communication System (PACS), window and level settings continue to present a major obstacle for the conversion of images from the Digital Imaging and Communications in Medicine (DICOM) standard file format to the Joint Photographic Experts Group (JPEG) image format, a desktop publishing format. Evaluation of the window and level values in the DICOM header demonstrated that they cannot be relied upon for generation of useful JPEG images for key image selection. An algorithm was developed to automatically calculate window and level settings for Magnetic Resonance (MR) images. As images are received by a vendor-neutral digital teaching file server, pixel data is read and a histogram of the grayscale values is generated. A portion of the grayscale values are then used to calculate the appropriate window and level settings for image conversion, allowing exported series to be displayed in JPEG format. The algorithm was evaluated and found to be effective for appropriate window and level calculation for key image selection.

Keywords:

radiographic image enhancement, data display, radiology information systems

Introduction

Window and level settings are a major obstacle in exporting Digital Imaging and Communications in Medicine (DICOM) images from a Picture Archiving and Communication System (PACS) in desktop publishing format.[1] In a vendor-neutral environment, a digital teaching file (DTF) has limited ability to retrieve image metadata without requiring direct access to PACS or without receiving specific information from PACS.[2] Therefore it must rely on the metadata available in the image DICOM header. The window and level values contained in the DICOM header are assigned at the point of acquisition and are rarely subject to verification by the radiology technician. In addition, these values are not overwritten by the last viewed or optimum window and level settings applied by the radiologist at the PACS workstation. The DICOM header window and level values were evaluated for their reliability to generate identifiable JPEG images.

An algorithm has been developed to automatically calculate appropriate window and level settings for initial DICOM-to-JPEG conversion. It solves the window and level problem for conversion of Magnetic Resonance (MR) DICOM images to JPEG file format and allows for efficient key image selection without requiring user interaction.

This manuscript describes the innovative integration of open source technology and information management in solving the window and level problem encountered in the development of a vendor-neutral DTF based on ideal characteristics.[3] It outlines the obstacle of window and level settings in exporting MR DICOM images from PACS and the automatic window and level calculation algorithm as a proposed solution.

A word about window and level settings

An important aspect of medical imaging is the ability to manipulate the manner in which images are presented on the PACS workstation screen. In a digital format, the spatial resolution of an image is based on the number of pixels in each row and column (i.e., 128 x 128 or 512 x 512). Each pixel contains information regarding the color attribute and intensity of a specific location on the image. The collection of this information is the pixel data, which is referred to as contrast resolution. The range of grayscale values for typical medical images often far exceeds that which can be perceived by the human eye. For example, a Computed Tomography (CT) image may contain grayscale values from -1000 to +3000, defined as Hounsfield units (HU), that are physical representations of the density of the body part imaged (where 1 unit = 1/10 of 1% of the density of H_20 and H_20 density is set equal to 0 HU). MR images are also on a 12-bit or 4096 unit scale, however, the pixel values have no specific physical representation, and therefore are relative and unpredictable.[1] Although MR image pixel data may represent up to 4096 unique shades of gray, the human eye can only process ~256 grayscale variations.[4]

Manipulation of image presentation is necessary to solve the grayscale limitations of the human eye. In addition, visualization of specific tissue types or anatomical locations requires presentation of the image utilizing only a portion of the total grayscale range. Therefore, DICOM images employ settings to limit presentation of the image to only display the pixels within a more narrow range (window width or "window") with its midpoint applied at a specific location (window center or "level") within the total range of values. In the CT example above, a typical setting for appropriate demonstration of brain tissue is a window of 100 applied at a level of 50 resulting in an image with 256 shades of gray that represent 0 to 100 HU. "Windowing" and "leveling" an image is particularly important for display of the correct diagnostic and educational focus. It also plays an essential role for correct conversion from DICOM to another image file format.[5]

Materials and methods

DICOM header evaluation

During a 6 month testing period, 116 MR studies were sent from PACS to the Radiology Interesting Case Server (RadICS), a vendor-neutral DTF, by radiologists for the purpose of creating interesting cases.[2] The DICOM images from these studies were converted to JPEG files using the DICOM-specific WindowCenter and WindowWidth values from each DICOM header. One study was excluded because it did not contain physical body parts, but rather showed lines and graphs (a quality control study). Image studies were scored "-" if they were predominantly white or black and unidentifiable; otherwise they were scored "+". Evaluation of the included 115 studies (comprised of 778 total series) was conducted by the author (AK).

Automatic window and level calculator

In RadICS, the image server manages the DICOM Receive and DICOM-to-JPEG conversion process.[2] A DICOM Storage Server Class Provider (SCP), from the open source OFFIS DCMTK, handles all incoming DICOM files and moves them to a temporary directory.[6] A PERL script constantly monitors the temporary directory and the presence of a DICOM file initiates the rest of the image server processes. The image server parses the DICOM header using the OFFIS DCMTK and specific data is retrieved. The automatic window and level calculator (AWLC) is called on to determine appropriate window and level settings. These window and level settings are automatically communicated to the PERL script and are passed as parameters to the OFFIS DCMTK to generate new full-size and thumbnail JPEG files. Finally, the original DICOM and newly generated JPEG files are moved to the temporary file storage on the server. At this point the JPEG images are available for key image selection in the RadICS web application.[2]

The AWLC was built using the C++ programming language and uses the automatic window and level calculation algorithm. The algorithm follows a 5-step process: (1) read the image pixel data, (2) generate grayscale histogram, (3) exclude extreme values, (4) calculate median and standard deviation, and (5) calculate window and level settings.

The algorithm begins by reading the pixel data of the MR image. The BitsAllocated, BitsStored, HighBit and PixelRepresentation of the image, as retrieved from the DICOM header are required to read the pixel data. Once read, the pixels are grouped according to their grayscale value, the sum total of pixels per value is calculated, and a histogram is generated. Figure 1 illustrates the histogram. Large spike in the low values of the historgram corresponds to the black pixels surrounding the body part. The bottom fifteen percent (line #1) and top fifteen percent (line #2) of the grayscale range are excluded to account for the large number of black and white pixels in the image. The median and standard deviation of the remaining values are calculated. The median (line #3) is used as the level and a multiple of the standard deviation (line #4) is used as the window for the DICOM-to-JPEG conversion. For MR images with a pixel value range greater than 1000, the standard deviation is multiplied by four. For MR images with a pixel value range less than 1000, the standard deviation is multiplied by six. The fifteen percent exclusion threshold and the 1000 pixel value range threshold were determined empirically.

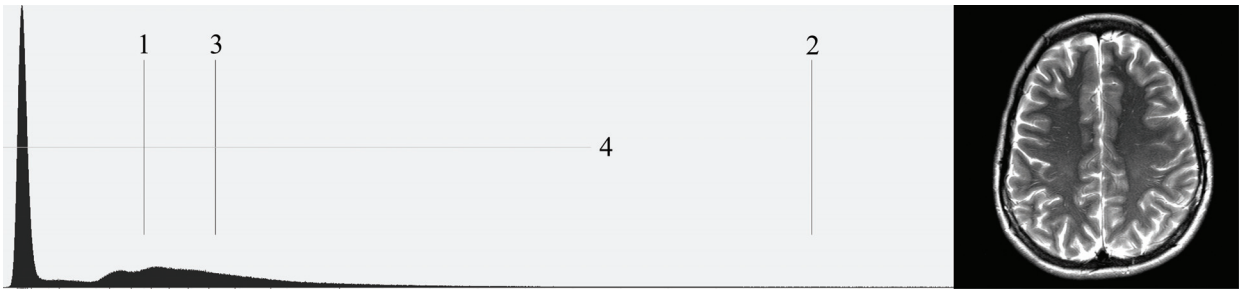

Figure 1 – Grayscale histogram (left) of a Magnetic Resonance (MR) image (right)

Algorithm evaluation

The algorithm was tested on 75 MR images: 25 each of abdomen, brain, and head and neck images. Two Certificate of Added Qualifications (CAQ) board certified radiologists (DEA and RHW) evaluated the automatic window and level calculation algorithm for its ability to generate JPEG images with appropriate window and level settings for key image selection. In addition, they evaluated the similarity between the JPEG image using optimum window and level settings, as defined by the evaluators, with the JPEG image generated using the automatically calculated window and level settings. They evaluated images within their area of expertise. The following evaluation procedure was used. First, a web application was developed to randomly select one MR image at a time from studies already sent to RadICS. The image then was displayed in an open-source, web-based Java DICOM viewer, obtained from the Nagoya Institute of Technology.[7] The evaluators made appropriate window and level changes to achieve optimum settings. At this point, the evaluators were blind to the automatically calculated image. After clicking the done button, the user-defined settings were used to convert the DICOM image to JPEG file format. In addition, a second DICOM-to-JPEG conversion took place using the window and level settings that were automatically calculated via the algorithm. The evaluators were then presented with both JPEG images, side-by-side on the same webpage, and were asked to score the following two comments: (1) The automatically calculated image is appropriate for Key Image Identification; (2) The automatically calculated image is identical to the optimal image (comparing w/l settings). The five possible responses are: (1) Strongly Disagree, (2) Somewhat Disagree, (3) Undecided, (4) Somewhat Agree, and (5) Strongly Agree.[8] Figure 2 is an example of the webpage presented to the evaluators. Scores were tallied for each comment.

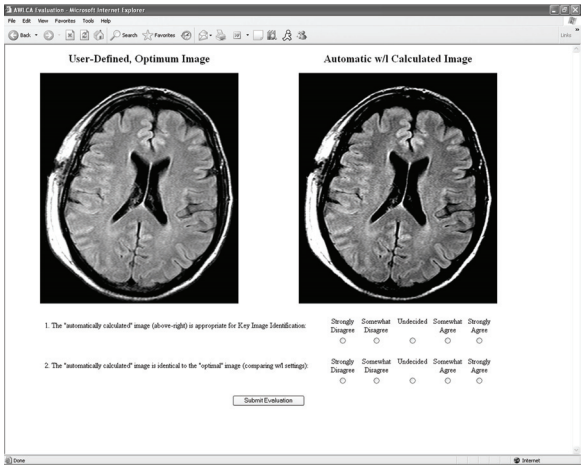

Figure 2 - Example evaluation webpage

Results

DICOM header evaluation

Evaluation of the window and level values in the image DICOM header found 18/115 (15.65%) of studies to be predominantly black or white and therefore unidentifiable.

Algorithm evaluation

Evaluation of the algorithm results in 25/25 (100%) of abdominal MR images, 24/25 (96%) of brain MR images, and 20/25 (80%) of head and neck MR images recorded as appropriate for key image selection. One head and neck MR image was recorded as undecided and the rest were recorded as inappropriate for key image selection. Overall, 69/75 (92%) of the study MR images were thought to be appropriate for key image selection, while 5/75 (6.67%)

Table 1 – Evaluation of the Automatic Window and Level Calculator

			5 Strongly Agree	4 Somewhat Agree	3 Undecided	2 Somewhat Disagree	1 Strongly Disagree
Appropriateness for KIS	AVG	N					
MR Abdomen	5.00	25	25	0	0	0	0
MR Brain	4.72	25	20	4	0	1	0
MR Head and Neck	4.36	25	19	1	1	3	1
Total	**4.69**	**75**	**64**	**5**	**1**	**4**	**1**
Similarity Comparison	AVG	N					
MR Abdomen	4.48	25	15	8	1	1	0
MR Brain	3.80	25	9	9	0	7	0
MR Head and Neck	3.52	25	8	8	0	7	2
Total	**3.93**	**75**	**32**	**25**	**1**	**15**	**2**

were thought to be inappropriate for key image selection and 1 was undecided (Table 1).

In addition, although not a goal of the algorithm, it was found that 23/25 (92%) of automatically calculated abdominal MR images, 18/25 (72%) of automatically calculated brain MR images, and 16/25 (64%) of automatically calculated head and neck MR images were scored as strongly agree or somewhat agree to being identical to their associated user-defined optimum images. One abdomen MR image was recorded as undecided and the rest were not considered identical. Overall, 57/75 (76%) of the study MR images were scored as strongly agree or somewhat agree to being identical to their associated user-defined optimum image, while 17/75 (22.67%) were not considered identical and 1 was undecided.

Discussion

The purpose of this project was to evaluate the reliability of DICOM header window and level values for MR and develop an algorithm to automatically calculate appropriate window and level settings for DICOM-to-JPEG image conversion in a vendor-neutral environment. This is the first automatic window and level calculator seamlessly integrated into the harvesting function of a radiology teaching file reported in the literature. Based on the results of the DICOM header evaluation, the window and level values in the MR DICOM header are unreliable. Therefore, this calculator provides the much needed ability to automatically process MR images into a desktop publishing format.

The algorithm was found effective for appropriate window and level assignment for DICOM-to-JPEG image conversion of MR images. The results demonstrate that these JPEG images are appropriate for selection of key images for case creation. The automatic window and level calculator was successfully implemented in RadICS which is in use at a large academic radiology department.[2]

Even though our objective was to generate JPEG images appropriate for key image selection, as a side note, the authors were interested in the degree of similarity between the automatically calculated JPEG image and a user-defined optimum JPEG image. The results demonstrate that a majority of the calculated images appeared identical to their associated optimum images. Although 22.67% of the images were not identical, the fact that 92% of the images were appropriate for key image selection demonstrates that the objective was met.

The algorithm was designed and tested specifically on MR studies. This modality was selected for its high degree of variable window and level settings from one image to the next and the inability to apply standard, pre-set window and level settings to the study as a whole, such as is possible with CT studies.

In reviewing the results, it is noted that six images scored a three or lower for the appropriateness for key image selection comment. Of these six images, one was in the MR brain group and the other five were in the MR head and neck group. Further evaluation of these images revealed that the one MR brain image was a scout image and not a diagnostic image. In addition, of the head and neck images, one contained a ferromagnetic artifact and a large amount of subcutaneous fat, and the other images were inhomogeneous MRI fields with fat saturation technique and contained areas of loss of fat saturation. A larger variability of calculated window and level settings in MR head and neck images is expected due to the diverse intensity of signals acquired. Also, when selecting a key image for a teaching file from a soft tissue neck MRI study, the ideal window and level setting for the entire image may be significantly different from the perfect window and level setting to best demonstrate a lesion, due to the extreme contrast differentiation between the extracranial head and neck fat, soft tissues, and the pathology of interest, such as a focal soft tissue mass. These factors likely affected the accuracy of the window and level calculation.

The automatic window and level calculation algorithm was designed and developed based on a training set of MR abdominal and MR brain studies. Thus, it is not surprising that it performed well during evaluation in those image groups. The results obtained from the MR head and neck group demonstrates that the algorithm can be efficiently generalized to MR images of other anatomical locations.

While the algorithm has been shown effective in MR images, formal evaluation should be completed to measure the generalizability for use with other image modalities. We anticipate that more sophisticated methods could address other modalities as well as the individual characteristics of images with different educational, anatomical, and diagnostic foci. The empirical exclusion threshold and pixel range cutoff could also be refined by expanding the test set used in their creation. Despite the limitations of the algorithm, it specifically addresses the problem of unreliable DICOM header data in MR images and could be adapted for use in applications other than DTF such as upon post-acquisition arrival of studies to PACS.

Incorporation of the automatic window and level calculator in the RadICS image server provides a fully automated solution for harvesting key MR images into a DTF. Once an interesting study is sent to RadICS, appropriate window and level settings are automatically calculated, and the images are automatically processed and made available for key image selection. Therefore, there is no disruption in clinical workflow.[2]

Conclusion

With the integration of the automatic window and level calculator in RadICS, users can efficiently send MR studies from PACS and access the images in desktop publishing format from a workstation with access behind the radiology department PACS firewall. All processes from the DICOM Receive to web-presentation of JPEG images are automated, enabling the flexibility of sending studies and creating interesting cases at the clinician's leisure.[2] The method described overcomes the obstacle of window and level settings for appropriate DICOM-to-JPEG conversion, without requiring user interaction.

Acknowledgments

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[2] Kamauu AW, DuVall SL, Robison RJ, Liimatta AP, Wiggins RH, 3rd, Avrin DE. Informatics in radiology (infoRAD): Vendor-neutral case input into a server-based digital teaching file system. Radiographics 2006;26(6):1877-85.

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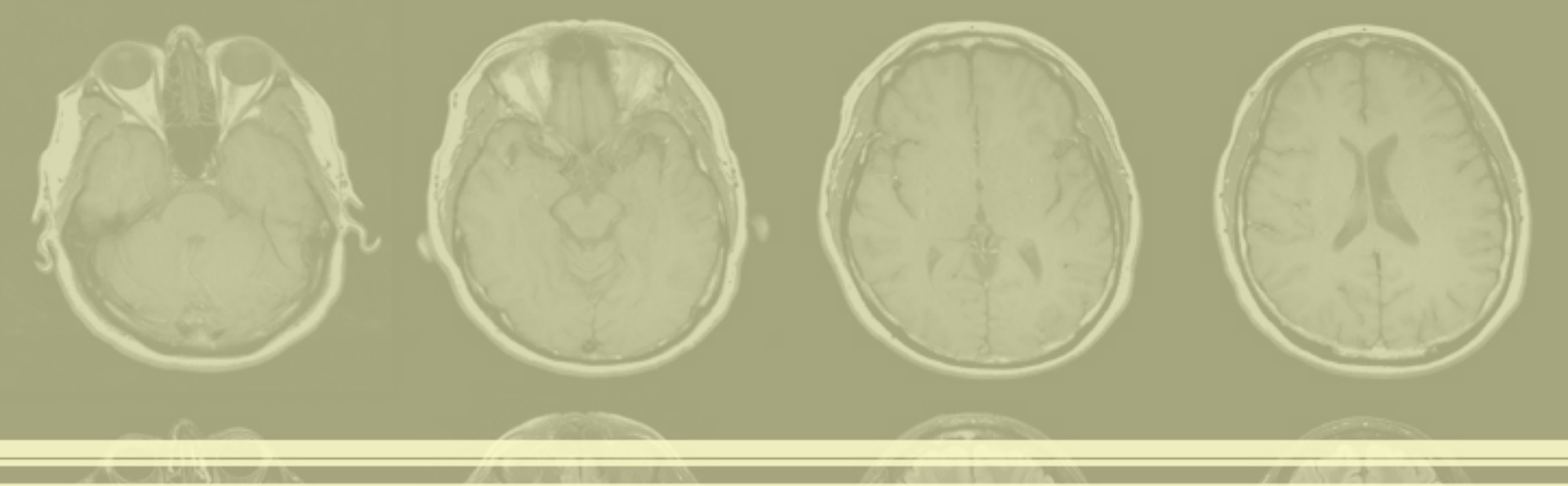
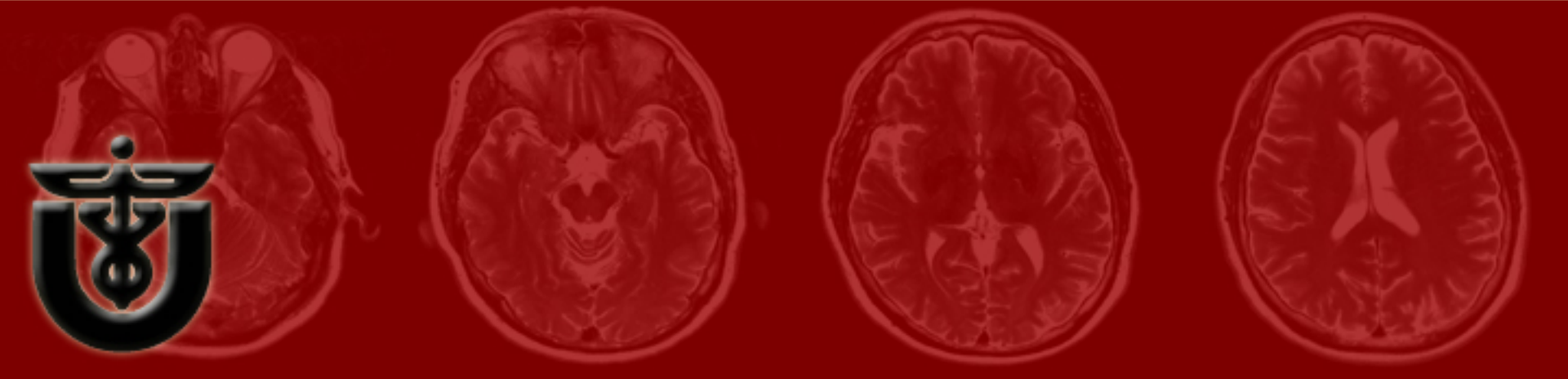
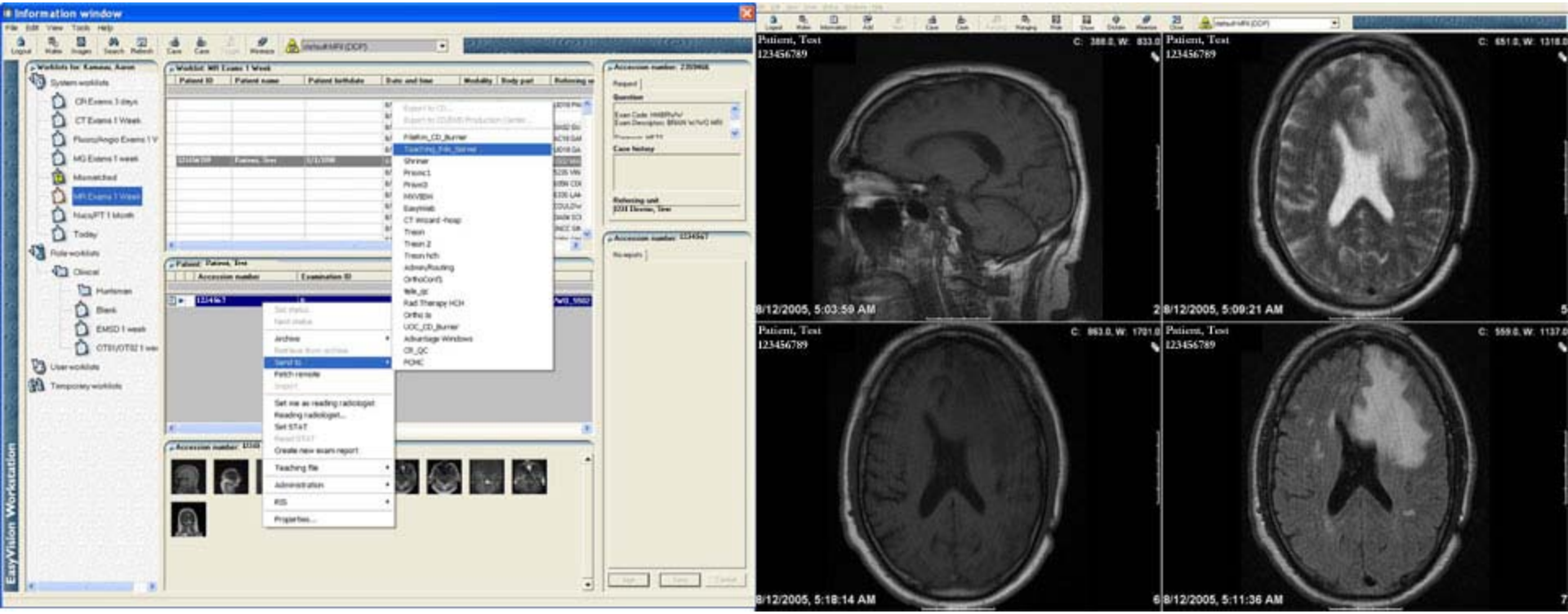


Automatic Window and Level Calculation for Magnetic Resonance DICOM to JPEG Conversion

Aaron W C Kamauu MD MS MPH, Scott L DuVall BS, Andrew P Liimatta BS,
Richard Wiggins III MD, David Avrin MD PhD



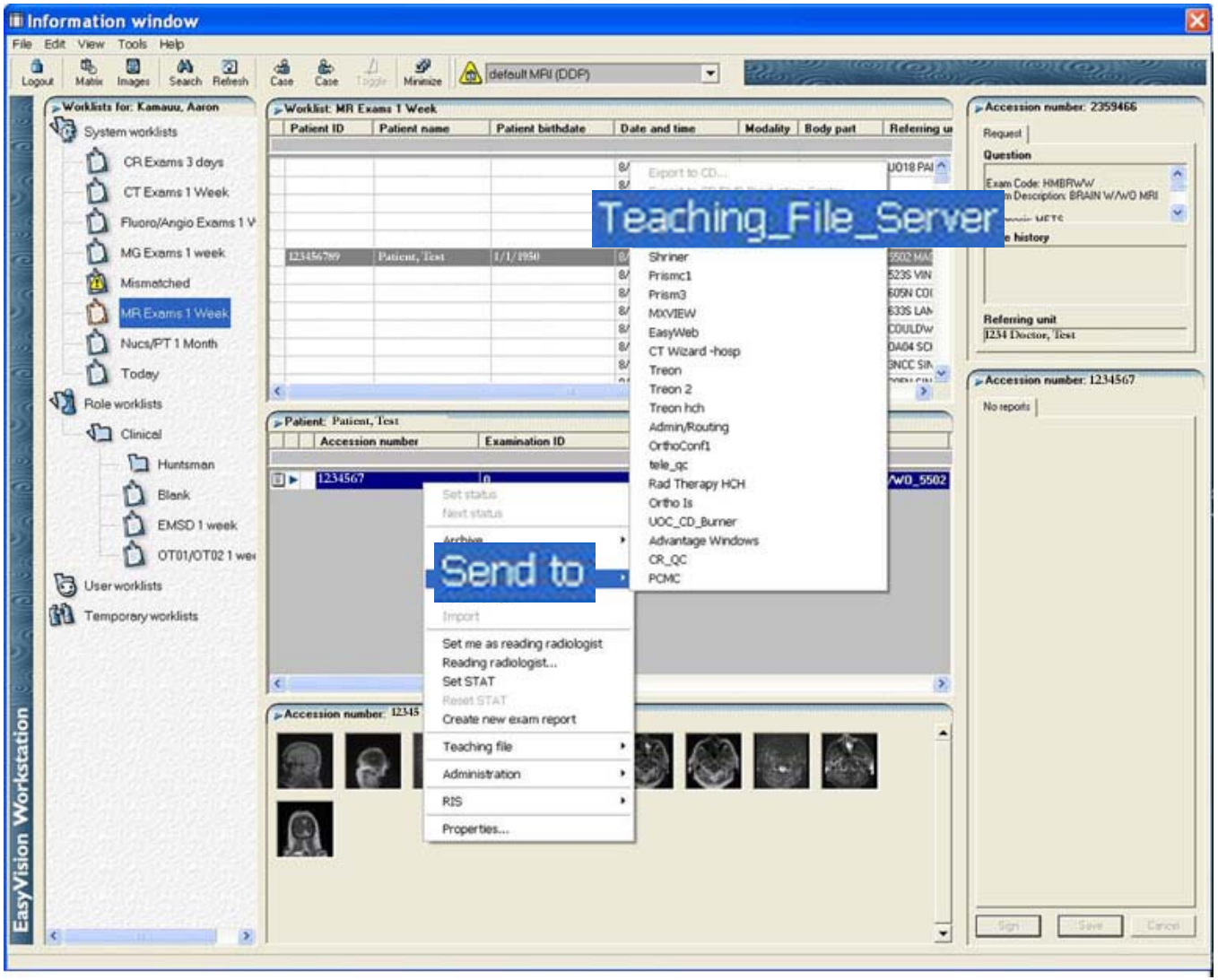
PACS Workstation



From the PACS workstation, the radiologist identifies an interesting case.

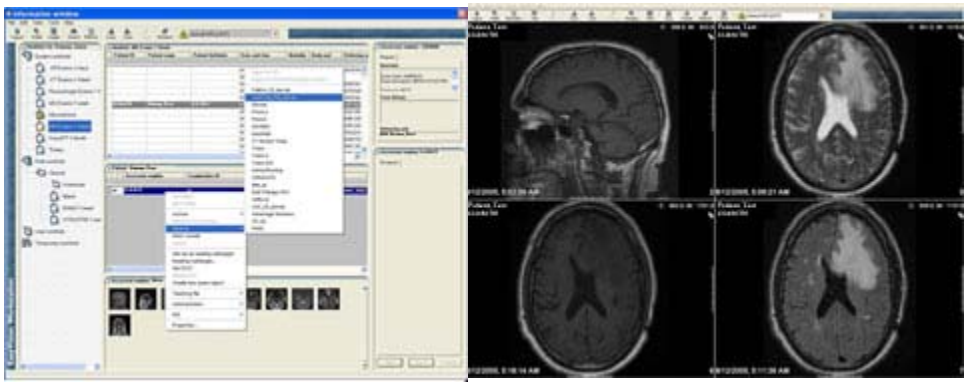
RadICS

Using the teleradiology functions built in to all PACS, the interesting case can be sent to the Radiology Interesting Case Server (RadICS) with just a few mouse clicks.



PACS Workstation → RadICS

RadICS

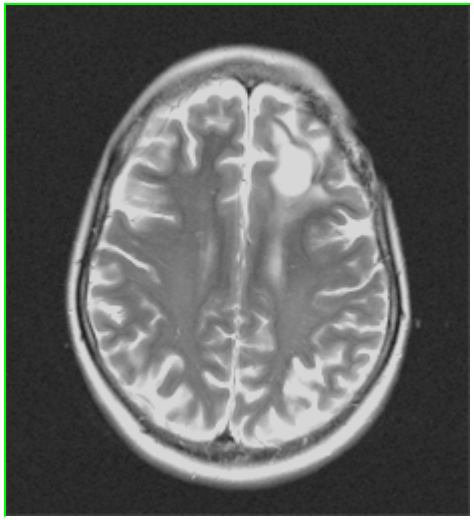


PACS Workstation

Because RadICS uses the standard DICOM RECEIVE, no vendor specific adjustments need to be made. As soon as RadICS is plugged in behind the Radiology department firewall, it is ready to receive interesting cases.

Automatic Window and Level Calculator

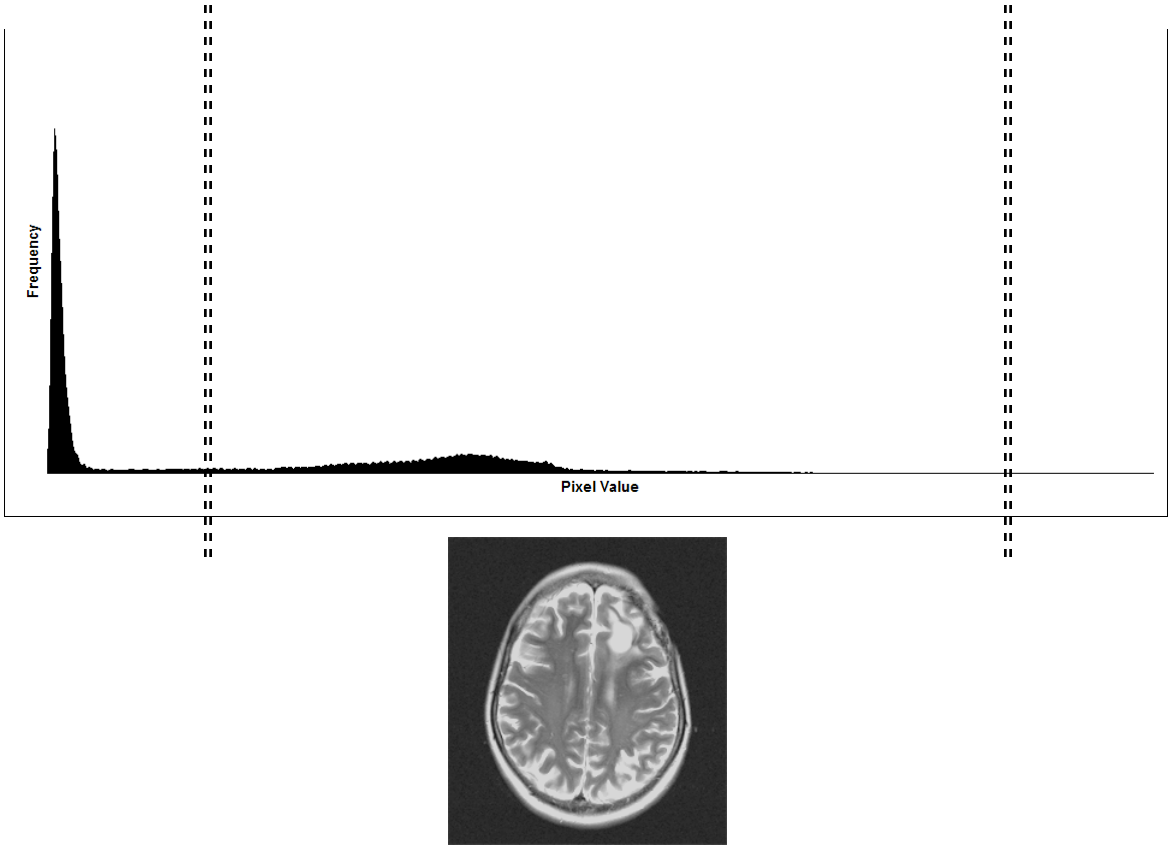
Vendor Neutral Teaching File



When cases arrive at RadICS, each image is analyzed and a near optimum window and level setting is calculated. These window and level adjustments allow the DICOM images to be converted into JPEG images for display and key image selection.

Automatic Window and Level Calculator

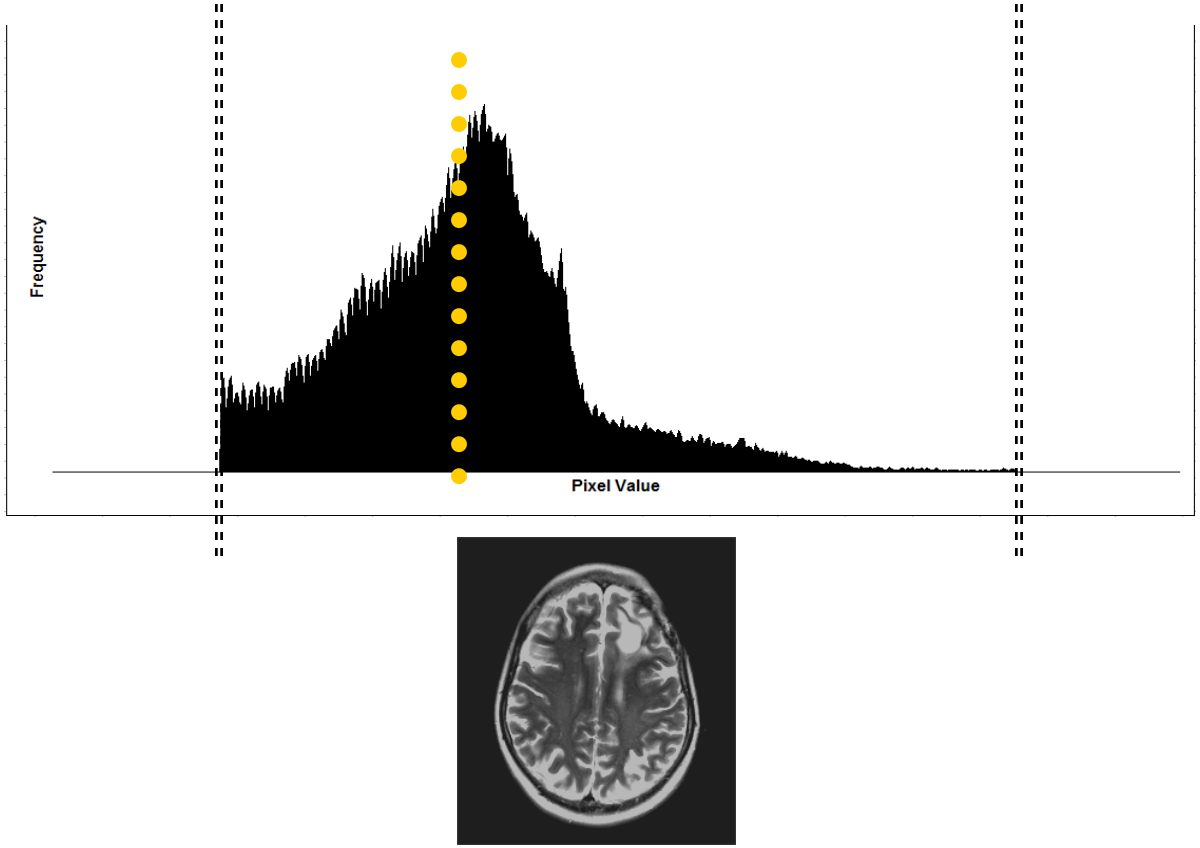
Vendor Neutral Teaching File



A histogram of the image is created and the top and bottom 15% of pixel values are truncated. The large spike of low values represent the black pixels surrounding the image.

Automatic Window and Level Calculator

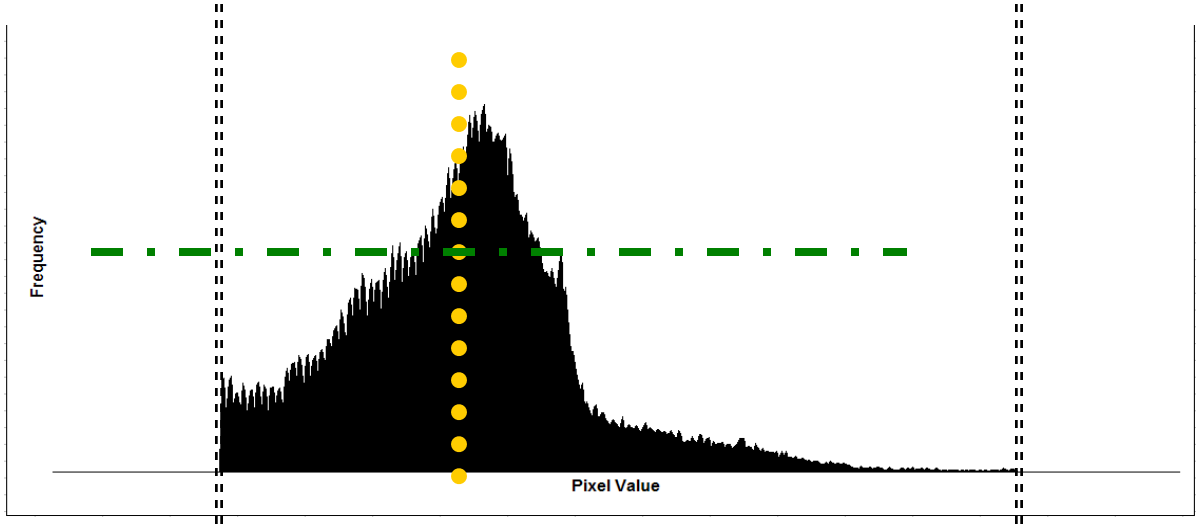
Vendor Neutral Teaching File

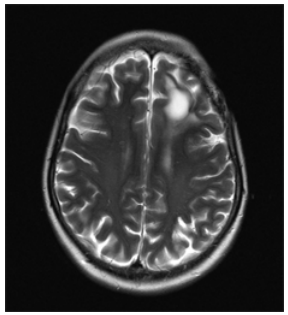


Zooming in after the top and bottom 15% of the histogram are truncated reveals the portion of the image containing the detail. The median is calculated and used as the level setting.

Automatic Window and Level Calculator

Vendor Neutral Teaching File

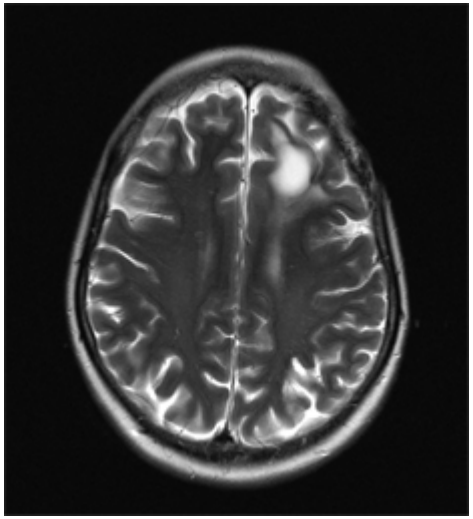




The standard deviation of the pixel values is also calculated and a multiple of the standard deviation is used as the window setting.

Automatic Window and Level Calculator

Vendor Neutral Teaching File



The calculated window and level settings are then applied to each image. The DICOM images are converted into JPEG images for display and key image selection. This entire process happens automatically each time an interesting case is sent from a PACS workstation.

Results

The algorithm was tested on 75 MR images: 25 each of abdomen, brain, and head and neck images. Two CAQ board certified radiologists evaluated the algorithm for its ability to generate JPEG images with appropriate window and level settings for key image selection. The evaluators were asked to score the following comment against each image: The automatically calculated image is appropriate for Key Image Identification.

			5 Strongly Agree	4 Somewhat Agree	3 Undecided	2 Somewhat Disagree	1 Strongly Disagree
Appropriateness for KIS	AVG	N					
MR Abdomen	5.00	25	25	0	0	0	0
MR Brain	4.72	25	20	4	0	1	0
MR Head and Neck	4.36	25	19	1	1	3	1
Total	**4.69**	**75**	**64**	**5**	**1**	**4**	**1**

References

1. Dreyer KJ, Mehta A, Thrall JH. PACS: A Guide to The Digital Revolution. New York: Springer; 2002.

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Facilitating Hospital-at-Home Therapy Through Advanced Remote Patient Monitoring

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Abstract

Resource shortages in the healthcare system has called into question its sustainability and has generated interest in alternative forms of service delivery. Delivering of complex services in the home at a lower cost and with improved outcomes has proven to be elusive. In this study, we discuss the development of a comprehensive remote patient monitoring system that facilitates self-care of nocturnal hemodialysis patients, a complex hospital-at-home therapy. An ethnographic analysis was undertaken, determining the barriers to adoption and design criteria for a system that would facilitate mediated patient self-care for a complex therapy. These data were then used to inform the development of a remote patient monitoring system. In our pilot testing, patients developed a dependency on the system, when it was expected to be needed only for their transitional phase. Patient accountability was increased through the use of the system when it was found that patients did not always dialyze as frequently as they reported. The development of a blood disconnect monitor proved to be a critical component of the system. The resultant system provided an increased level of comfort and reduced anxiety for patients, and for family caregivers in particular.

Keywords:

monitoring, ambulatory; hemodialysis, home; self care

Introduction

End-stage Renal Disease (ESRD) is a complex medical illness that is becoming more prevalent. Estimates of increased prevalence are as high as 7.5% per year. [1] The most common form of renal replacement therapy for ESRD is hemodialysis (HD), a costly, resource – intensive therapy that artificially sustains renal function, but can also contribute to a poor quality of life. The present form of therapy is what the health system can afford to deliver and what a patient can tolerate in terms of disruption to their lives. This treatment pattern is mostly a systemic limitation of the delivery of healthcare services, rather than what is medically efficacious for the patient.

Nocturnal hemodialysis (NHD) is essentially a more frequent form of the therapy, delivered for longer periods of time, as the patient sleeps at home. The improved health outcomes are dramatic. Patients enjoy improved cardiovascular health, improved peripheral circulation, improved sleep quality (despite undergoing dialysis treatment), and the elimination of dietary restrictions. [2, 3] Patients experience greater autonomy by being freed from institutional care. Despite the capital costs of providing a dedicated hemodialysis machine to a patient, the cost-effectiveness of NHD is clear when factoring in the greatly reduced nursing care and the reduction of medications. [4]

Although NHD has been shown to provide significant improvements in health outcomes and improved resource utilization for the health care system, the adoption of the therapy has been slow. NHD would require major changes to the way dialysis programs are delivered.

Beyond these systemic problems, there exist patient-related barriers to the adoption of NHD. Patients fear they will fail to perform dialysis adequately. They also fear that they will receive substandard care and that they will be socially isolated. [5]

Given the significant improvement of health outcomes associated with NHD, it is important that a means to reduce and overcome these barriers be developed to improve adoption.

To address these barriers, we proposed a method of supporting the patient in performing NHD by means of a virtual support system, replacing an aspect of the nursing support they received in the conventional setting. This will take the form of a remote patient monitoring system, which will relay vital signs and dialysis treatment parameters to hospital staff, which in turn, can act on information received as needed.

It is hypothesized that patients will have less anxiety and perceives greater self-efficacy with the notion of this support. This may lower the barrier to adoption of NHD as a therapy option. In addition, family members are also hypothesized as being more supportive of NHD therapy

with the inclusion of remote patient monitoring. There is some evidence that home hemodialysis adds a significant burden to family members [6]. Ultimately, the goal of the system is to have the patient reach a level of "supervised autonomy" in performing their therapy.

Research question to be addressed was "What specific design criteria must be met by the system, such that the patient will accept the system and feel that it contributes to their overall security and confidence to perform NHD?"

Methods

The assumptions of the use of remote patient monitoring as an intervention to reduce the barriers to the adoption of NHD were challenged through the use of patient-centric design method, beginning with ethnographic interviews of dialysis patient groups (nocturnal hemodialysis (NHD), conventional hemodialysis (CHD), and pre-dialysis patients). Specific data was gathered to inform the first iteration of the system development.

The number of informants used in the study was to be determined when sufficient saturation was achieved. In the end, saturation was achieved with seven patients in the NHD group, and six patients in each of the CHD and pre-dialysis patients groups.

A general inductive method was using in the analysis of the transcripts. Transcripts were read repeatedly and text segments were coded for potential themes. As the coding framework developed, transcripts were reanalyzed in light of new themes that may have emerged as a result. Once completed for a specific treatment group, major themes were derived that were relevant to the research question. Qualitative analysis software was used to code the interviews for emerging themes. These findings were then validated through a member-checking exercise with a focus group of NHD patients and family caregivers.

These data then informed the development of design principles. The purpose of these design principles was to guide the engineering team in their deliberations around specific functionality and design aspects of the system. In some sense, these principles become a rulebook for the engineering team, in which assumptions that are made through the course of development are tested against these principles to ensure adherence. Violations of these principles will likely result in a sub-optimal system and would no longer be adhering to a user-centric method of design.

Once implemented after a number of iterations, a small pilot study of eight patients were monitored for 3 to 10 months. Interviews of the patients were performed throughout the pilot to determine the outcomes in terms of perceived safety and facilitating adoption and adherence to NHD.

Results

Without exception, all the participants found the concept of remote monitoring for NHD patients as a positive development, although there were significant differences of opinion on specific aspects. There was varying opinion on the patient-type which remote monitoring should be applied to, as well as the duration, form, function, and purpose of the technology.

- Patients already had an expectation of the use of remote monitoring. Some patients presumed it was already in place and that they were to receive it upon installation of the machine in their home.
- Patients supported the transitional use of remote monitoring. Although some patients felt they required some form of monitoring on a permanent basis.
- Patients had varying levels of need for remote monitoring. From no monitoring to all, to monitoring through the transition, to a permanent installation. As well, patient had varying needs in terms of specific components of monitoring.
- There was some concern over privacy and the "Big Brother" effect of using remote monitoring. Patients expressed concern over the detailed knowledge their caregivers would have of the schedule, frequency and habits when dialyzing at home.
- Use of a camera was suggested by patients, and would be used by minority of patients. They viewed its purpose as useful for trouble-shooting as well as for safety.
- Remote patient monitoring is particularly supported by family-caregivers and is viewed as a surrogate to nursing care. Family caregivers viewed it as a backup, or safety net for themselves to reduce their anxiety and to address what they perceive as a lower level of care in an emergency, than what they would receive in-centre.
- There is concern by the patients of the physical obtrusiveness of monitoring and that this would produce adherence issues. Patients are concerned how further tethering themselves to the machine will affect their sleep and the mobility when addressing alarms.
- The suggestion of the use of wireless monitoring was well received and may address the issue of the obtrusiveness.
- The need for monitoring the integrity of the bloodlines was identified, as potential blood loss one of the most significant fears amongst patients.
- Patients were comfortable with the use of automation for alerting caregivers in an emergency. However, they expressed a need for human intervention in immediate response to this alerting.
- Pre-dialysis patients, unfamiliar with the process of hemodialysis, expressed concern over the need for

monitoring. Unless the patient is already aware of the risks involved in performing hemodialysis, patient may become alarmed at the need for monitoring.

Design principles

Based on these findings and the detailed themes as discussed above, the following design principles were developed:

1. The physiological sensors will be unobtrusive as possible to the patient, allowing them freedom of motion and will not be uncomfortable so as to interfere with their sleep.
2. The system will not add to the training requirements of the NHD patients.
3. The system must communicate more than just the status of the dialysis machine.
4. The system must communicate more than just the status of the dialysis machine.
5. The system will allow for transitional monitoring, such that installation can be done quickly and removed equally so.
6. The system will be entirely automated from the patient's perspective, leaving them only to apply the physiological sensors as necessary.
7. The patient will have the option to decline the use of any or all of the components of the system, including the camera, so as to respect their privacy and to meet their individual needs.
8. The system will address the need for ensuring bloodline integrity, without adding to complexity of the existing setup.
9. Automated alerting will result in direct contact by the caregiver-on-call to the patient. The system should scalable to allow a call-centre approach to addressing these alerts.
10. Data acquisition and transmission will be done securely and will comply with the standards of the healthcare organization and relevant legislation.
11. The system will be modular, where components can be removed and added as needed or appropriate.
12. The system architecture will be generic and abstracted, so that interfaces to other devices can be easily added as needed.The system will not add significantly to the cost of NHD delivery, be scalable, and will leverage existing data infrastructure.
13. The system will work within the existing workflows of the current NHD program.

These use of these design principles resulted in an initial system design consisting of the acquisition, transmission, storage, and processing of patient vital signs (heart rate, respiration rate, blood oxygenation, and blood pressure) and selected hemodialysis treatment parameters of the hemodialysis systems. Rules were developed through discussions with domain experts including nephrologists, nursing staff, and renal technologists. These rules would be applied to the data in real-time and alerts generated. In the first iteration of the system, these alerts would be sent to on-call staff who will receive the alerts and assist the patients as necessary. See figure. below.

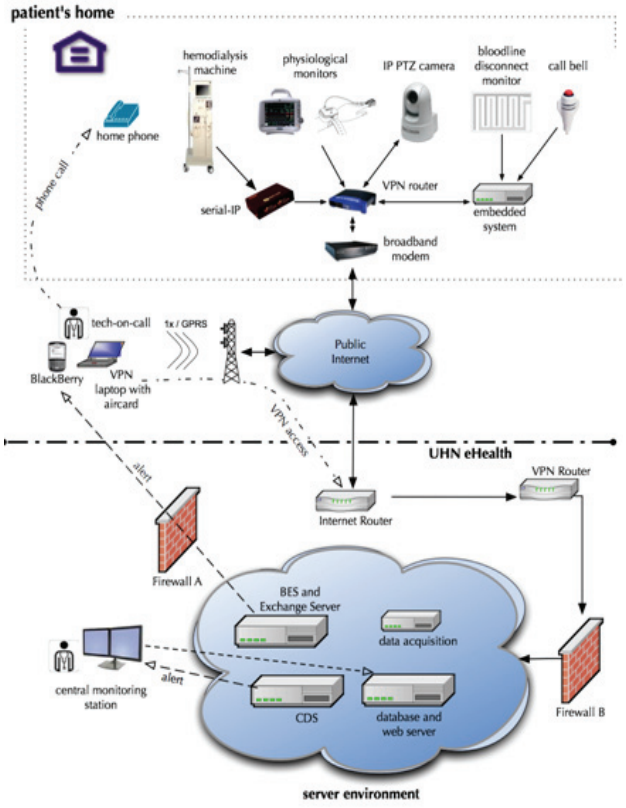

Figure 1 - UHN HEalth

Additional components included an IP-based pan-tilt-zoom (PTZ) video camera, to allow staff to observe remotely at the patient's discretion. This would aid in remotely troubleshooting the dialysis machine as well as have the ability to check on a patient during a serious alarm condition.

Also developed was a bloodline disconnection detector, utilizing a liquid-sensitive pad that would lie under the

patient and trigger an audible alarm if blood were to come into contact. The detector also cuts power to the HD machine, disabling the blood pump and stopping further blood loss. An IP-based message is then sent back to the technologist-on-call to notify them of the event. Incorporated into the system, was a patient call bell system. Much like the systems found in an in-patient setting, patients could simple press the call-bell button to alert the on-call staff via IP messaging.

The clinical decision support component of the system generates alerts based on criteria being developed by domain experts. These alerts are sent to the technologist-on-call through a mobile communication device. The alerts contain relevant information, current patient vital signs, and the patient's home phone number for quick access via the device's telephony capability. For further follow-up to the alert, the technologists can VPN into the system, access more physiological and dialysis data, and take control of the IP camera if necessary.

A clinical pilot of eight patients has been underway since January of 2006 and refinements to system are being made through feedback from clinicians and patients. Preliminary analysis of this phase of the study has found the following.

- Patients develop a dependency on the system, despite initially expecting only to need the monitoring during their transition. Particular aspects of the system they feel they cannot do without, including the bloodline disconnect monitor and the call-bell.
- The incidence of bloodline disconnects appears to be higher than is commonly reported. One incident occurred after only 3 months of deployment with only four patients being monitored.
- One patient felt that their privacy was being invaded when the nursing staff would challenge them on the frequency and duration of their dialysis. The patient was not adhering to what was prescribed and was alarmed that the hospital was aware of this level of detail in treatment information. This incident has demonstrated an added a level of accountability for patients that are being monitored that did not exist before. This has resulted in concern that patients are not adhering to their prescribed treatment levels and are therefore not fully benefiting from the therapy. The negative aspect of this finding is that use of the system in this manner could lead to trust issues between patient and provider, harming this relationship.
- Adherence to the use of vital signs monitoring remains a challenge, as patients are still fatigued using wireless sensors that are uncomfortable and interfere with their sleep and range of motion.

Conclusion

The study demonstrated the use of a patient-centric design method to facilitate the adoption of a hospital-at-home therapy. Therapies such NHD, which has been shown to deliver improved outcomes at lower costs, are vital for the future sustainability of the healthcare system. The delivery of hospital-at-home services will likely require some form of remote monitoring to mitigate risk and to improve patient adoption. A patient-centric approach to the design of this system has permitted the development of a scalable and flexible remote patient monitoring system to allow other hospital-at-home applications including CHF, chemotherapy, TPN, and palliative care.

Acknowledgments

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Enabling Biomedical Research in Europe: Using the Dutch Experience as a Template

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Abstract

Medical centers in the Netherlands contain a wealth of patient information that could be leveraged by healthcare researchers to drive breakthroughs, to deliver innovation in healthcare and improve the quality of life for Dutch citizens. However, the sensitivity of this data, the fragmentation of patient records and the complexity of retrieving this information have inhibited advances in this arena. In order to open up clinical data to researchers, the Academic Medical Center (AMC) in Amsterdam has implemented a framework that addresses the problems outlined, mitigates the risk for practitioners and patients and enables medical innovation to proceed. In this paper, we describe the AMC environment, we present the system implemented and highlight the benefits of employing this technological approach. We purport that the AMC model can be used as a template for Biobanks across the world.

Keywords:

Biobank, healthcare research, data integration, data abstraction, privacy

Requirements

The main problems faced by the medical researchers at the AMC were how 1) to acquire data from multiple disparate systems within a reasonable timeframe, 2) to ensure that patient privacy is respected, and 3) to enable natural interaction with the computer systems (i.e. not mandate that medical researchers become computer specialists). These concerns raised three higher-level base requirements for a solution system:

- Data Integration – providing a consistent, global view of a patient, regardless of the locations of the records, the data formats or the database vendor.
- Disclosure Control – ensuring that patient privacy is not violated, organization security policy is adhered to and that proactive compliance is possible
- Usability – providing a simple interface that hides the complexity of the underlying infrastructure and allows researchers to easily query the system.

The deployed solution dealt with all the above problems, by leveraging a subset of IBM's Clinical Genomics Framework (Figure 1).

Query System: Data Discovery and Query Builder

DDQB provides an easy-to-use way of extracting information from data sources by allowing non-IT professionals to create queries using their own terminology. DDQB's central component is the Data Abstraction Model (DAM), which bridges the gap between the technical complexity of databases and the language and concepts that are familiar to end users. DDQB is accessible by means of a standard Internet browser (i.e. Microsoft Internet Explorer, Mozilla Firefox, etc.)

Disclosure Control: Hippocratic Database Technology

HDB receives user queries from DDQB and rewrites the queries so that the database will only return data that is consistent with company policies, applicable legislation, and customer preferences. Data that is not consistent is suppressed or encrypted.

Data Integration: WebSphere Federation Server

WFS uses federation technology to abstract a common data model across diverse and distributed data and content sources, and to access and manipulate them as though they were a single source. The federated system acts as a virtual database in which remote objects can be accessed similar to local tables.

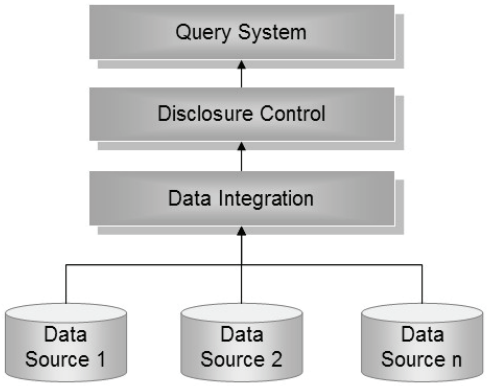

Figure 1 - Solution Architecture

Usage scenario

In a typical scenario, a researcher, let's call him Carlo, wants to retrieve information from systems in the departments of Internal Medicine and Clinical Chemistry in order to perform an analysis on pharmacological treatment of patients with Crohn's Disease. Carlo knows that each of these systems uses a different platform, different terminology and database technology, i.e. Internal Medicine uses Microsoft SQL Server on a Windows platform, and Clinical Chemistry uses a proprietary database on Linux. A further complication is that AMC's corporate policy states that for research purposes, patient numbers should never be shared in an unencrypted form and that medicinal doses should be disclosed on an opt-in basis per patient.

Carlo logs into the DDQB system, and verifies his user id and password with AMC's existing user directory. He pecifies a query through the menu-driven interface of DDQB. Carlo wants to select patients diagnosed with Crohn's Disease, between the ages of 25 and 50 years old, who have been treated with azathioprine. Carlo also instructs the system to retrieve plasma concentrations of liver enzymes, so that he can evaluate the toxicity of this drug for the liver. Fields are organized in a tree structure. Carlo selects the fields that represent the desired information by clicking on a link. Selection values can be chosen from a list, e.g. for the diagnosis field (Figure 2 Selecting patients based on diagnosis2), or entered using the keyboard, e.g. for the age limits. Carlo also select lab tests 'ALAT' and 'ASAT' from the Clinical Chemistry category. The system builds a list of query conditions (Figure 3) and fields to be returned. When Carlo indicates that his specification is complete, the application translates it into an SQL statement and submits this to HDB through its JDBC interface. HDB compares this statement to the policy rules that apply, and determines if Carlo has requested any information that he has not been granted access to. If this is the case, HDB rewrites the SQL statement, eliminating this information from the result list. It also determines at this stage if any information must be encrypted, and modifies the SQL statement accordingly. In this scenario, HDB will rewrite the SQL statement to display encrypted patient numbers and ensure that only patients who have consented will have their medicinal doses disclosed. The resulting statement is then returned to DDQB, which passes it to WFS.

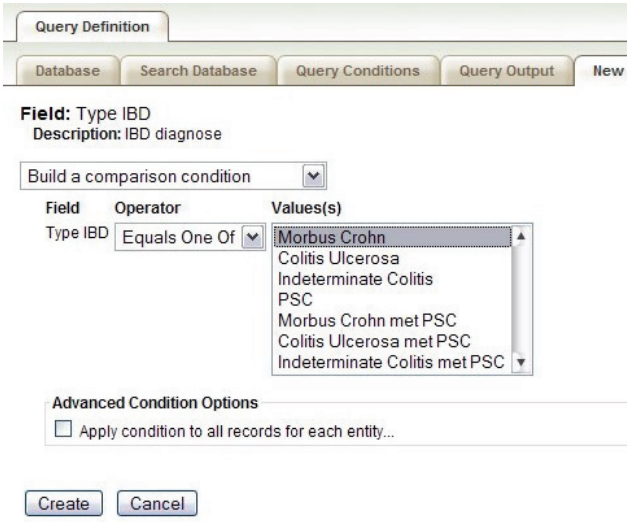

Figure 2 - Selecting patients based on diagnosis

WFS uses its knowledge of the location of the requested information to break up the SQL statement into parts, and submits each part to the appropriate data sources. It combines the result sets returned by the data sources into a single result set. This result set is then returned to DDQB. Finally, DDQB for mats the data and sends it back to Carlo's workstation (5). Note the encrypted patient id values in the 'patientnummer' column. Carlo can inspect the result of his work, store it in DDQB or in a file on his workstation, or feed the retrieved data into an analysis tool. He does not have to perform any manual data manipulation. Specifying and executing a query using the Clinical Genomics application can be completed in minutes. A complex query can be specified and executed in less than an hour, which is a few orders of magnitude faster than previously possible.

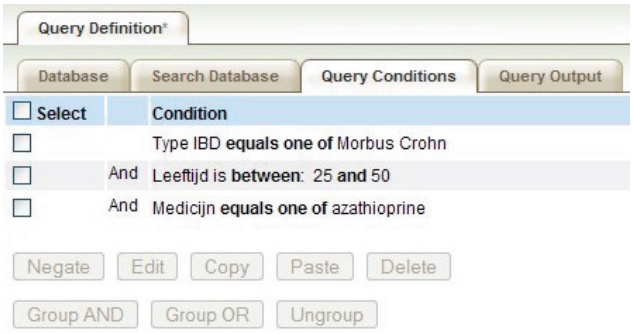

Figure 3 - Query conditions

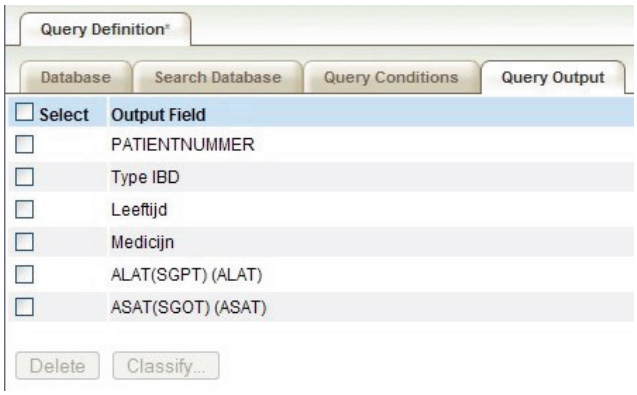

Figure 4 - Query output

System benefits

AMC's new system enables medical researchers to get the data they need efficiently. It is no longer necessary to manually obtain exported data from different systems that must be manipulated manually. This reduces the probability of errors occurring in the data. The researcher is not expected to understand the gory details of all the computer systems used across all the units he interacts with. The dependency on system administrator has been elimi nated. Privacy and security issues, often ignored in the manual process, are enforced (at the technology level) by the system. The process of selecting patient cohorts can now be completed in minutes or hours rather than weeks or months. This is a significant enhancement of researchers' productivity.

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A Prototype of Electronic Home Care Visit Platform: Nurse's e-Bag

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Abstract

In this study, an electronic home care visit platform: Nurse's e-Bag integrating popular distributed technologies, mobile hardware, and bio sensor was developed. This implementation is based on the service model of the home care center at National Taipei College of Nursing(NTCN) Hospital, which is one of the branch hospitals of National Taiwan University Hospital(NTUH) and serves as the disposition and case management for long term care. For enhancing the efficiency and quality care for home visiting nurses, e-Bag was introduced to integrate with a mobile electronic home care records system and become one application part of NTUH U-Care system and also an electronic home care visit platform. Light weighted Nurse's e-Bag not only reduces the loading comparing to the traditional home healthcare, but also provides the teleconsultation when home visiting nurse encounters problems at the patient's home.

Keywords:

home visiting nurse, home care, ubiquitous healthcare, electronic health records, nurse's bag

Introduction

E-Health (healthcare activities based on Information and Communication Technologies) is probably the most prominent of these e-business services that can have a major visible impact on the development of the society, as endorsed in the World Health Assembly in May 2005. Ubiquitous Healthcare (u-Health) focuses on e-Health applications that can provide healthcare to people anywhere at anytime using broadband and wireless mobile technologies.

National Taiwan University Hospital, one of the most renowned medical centers in Taiwan collaborates with its branch NTCN hospital and industry partners to develop a U-Care system, which is focusing on community healthcare and long term care. U-Care system utilizes the medical, IT and telecommunication environments. U-Care is an important research project of a Mobile Hospital (m-Hosp) research group in National Taiwan University [1]. Mobile Hospital is switched to Ubiquitous Hospital (u-Hosp) from 2006. m-Hosp/u-Hosp recruits many multi-disciplinary faculties and researchers from different colleges and also from several hospitals and other universities.

Nurse's e-Bag,, which was designed to provide the ubiquitous healthcare service and enhance the efficiency and quality care for home visiting nurses, was introduced to integrate with a mobile electronic health records system and become one important application part of NTUH U-Care system.[2] It also plays as an electronic home care visit platform by utilizing the information, communication and biomedical sensor technologies. As an important subgroup of u-Hosp research team, home visiting nurses at home care center of NTCN Hospital have the experience of implementation of electronic health record system and high acceptance of information technologies and collaborated with medical engineering and medical informatics experts to develop this application platform[3].

Methods

The basis of the design in Nurse's e-Bag is the service model of home care center at NTCN Hospital. Usually home visiting nurses at the home care center would receive referral notification of patients who need long term care or follow-up visits after discharge from NTU Hospital. For each referral, they would go to the patient's home for 1st time evaluation of health status. Then they visit the patient twice per month, re-evaluate the health status per four months, and make insurance claims for reimbursement (also per four months) until this case is deceased or home care is terminated. The principle business processes were deliberated as the following:

Mobile electronic home care records

When receiving a new case, a home visiting nurse first vfisits the patient to build personal data, health status evaluation, care plan suggestions, and an insurance claim profile. The health status evaluation contains thirteen

forms, divided into two groups: called 'A forms' and 'B forms'.

The 'A forms' contain data of cardiopulmonary vital sign, nutrition, and others. A nurse fills new healthcare information and adds them into the home care record in every visit. The 'B forms' contain summary data of 'A forms', and some extra data. Such as care plan suggestions, and insurance claims are produced every re-evaluation per four months. A care plan suggestion consists of care problems, care process, and evaluations. Each care problem has its default care processes to adopt. Contents of a care plan suggestion may be updated when necessary.

A home visiting nurse regular visits a patient twice a month, and fills new 'A forms' of the patient and re-evaluates the patient status per four month until the patient is recovery, moved, or dead. When one of these events occurs, the homecare is terminated and a 'closed case record' is built. With the mobile electronic home care records system, the data can be stored onsite and transmit to a server online via accessible Internet connection or synchronize in batch operation after the nurse return to office everyday.

Bio-sensor monitoring

The Nurse's e-Bag can also provides measurement and monitoring of bio-signals such as temperature, blood pressure, glucose, oxygen, respiration, ECG, and other vital signs. A bio-sensor network to record daily health status has been being developed in the U-Care system, so home visiting nurse can connect to the sensor network in the home setting or use the selective portable bio-sensors to records vital signs, and executes the home care record system which access results from sensor database into evaluation forms for the home care management.

Bidirectional Audio-video interaction

Another business process is the audio-video interaction among doctor-nurse and doctor-patient in mobility or at patient's home. A home visiting nurse can initiate a conference call via a built-in videoconference module on the portable computer or using the videoconference module of patient's U-Care system at home setting. The consultant doctor can be in real- time diagnosing the abnormal sign or bio-monitoring results of the patient. The vital sign was transmitted through Asynchronous Digital Subscribe Line(ADSL), Third Generation (3G) or General Packet Radio Service (GPRS) network. Therefore, the home visiting nurse can get more support from physicians to enhance the service quality

Results

System architecture

Full view of the system architecture can be separated into client side on a mobile light weighted computer and central server side (figure 1.). The server side is a simple system provides database management functions and queries. The mobile computer side contains two independent application systems, one is the electronic home care record system and another is the bio-sensor monitoring system.

The home care record system works with a local database which stores patients' records assigned to individual nurse. The mobile computers can be shared among colleagues by taking anyone of them with the e-bag when a nurse is scheduled to do the home visit. A nurse can download patient's data before she go out for work, and synchronize with the server when network available.

The bio-sensor monitoring system connects to sensors with their drivers and save data into another database. We can use thermometer, sphygmomanometer, glucometer, and pulse oximeter, peak flow meter and ECG. . This system works with another local database which retrieves bio-signal data via corresponding sensor drivers. The home care record system further integrates the bio-signal data and stores to its database.

User interface

A nurse can login into home care record system to perform data manipulate, download, and upload functions. If there is a new case, she would call the patient or go for the 1st visit to verify referral sheet come from hospital and fill the basic data forms in the system (figure 2).

When a nurse visits a patient, she can use the bio-sensor system to retrieve history data of biosensor monitoring (figure 3). Data are store into a JET database that a sensor uses a table in it. Data will be read by home care record system when the nurse fills evolution forms.

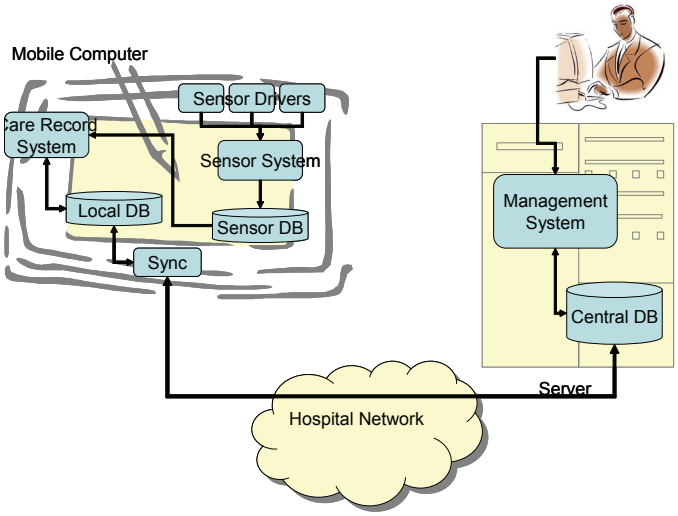

Figure 1 - The system architecture diagram

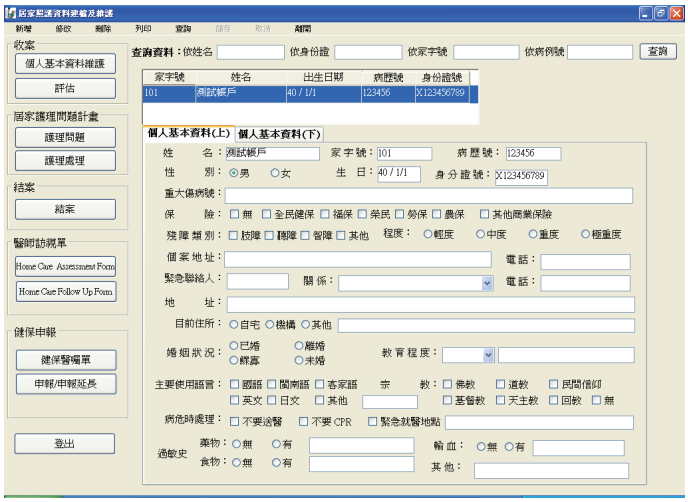

Figure 2 - Personal basic data form of home care records

Figure 3 - A history record of glucose level monitoring

Tele-consultation

If a home visiting nurse needs help from a doctor when she is visiting a patient who has unsolved problem, she may call the on-call doctor or patient's family doctor for consultation. In case it is a serious situation of a patient, the doctor might need to access the home care records in the server via his computer. At the same time he can also link to the patient's medical records from Hospital Information System if the patient is referred from same hospital. In this way, the quality of consultation is much improved comparing to traditional telephone consultation the nurse is the exclusive source of information.

The broadband and wireless telecommunication network such as home ADSL, Fiber to the home (FTTH), and 3G communication network have enabled videoconference function that the doctor can visually evaluate the situation of patient, and interpret the vital signs in real time. Nurse and doctor can use built-in video camera on mobile computers and free software to call videoconference easily.

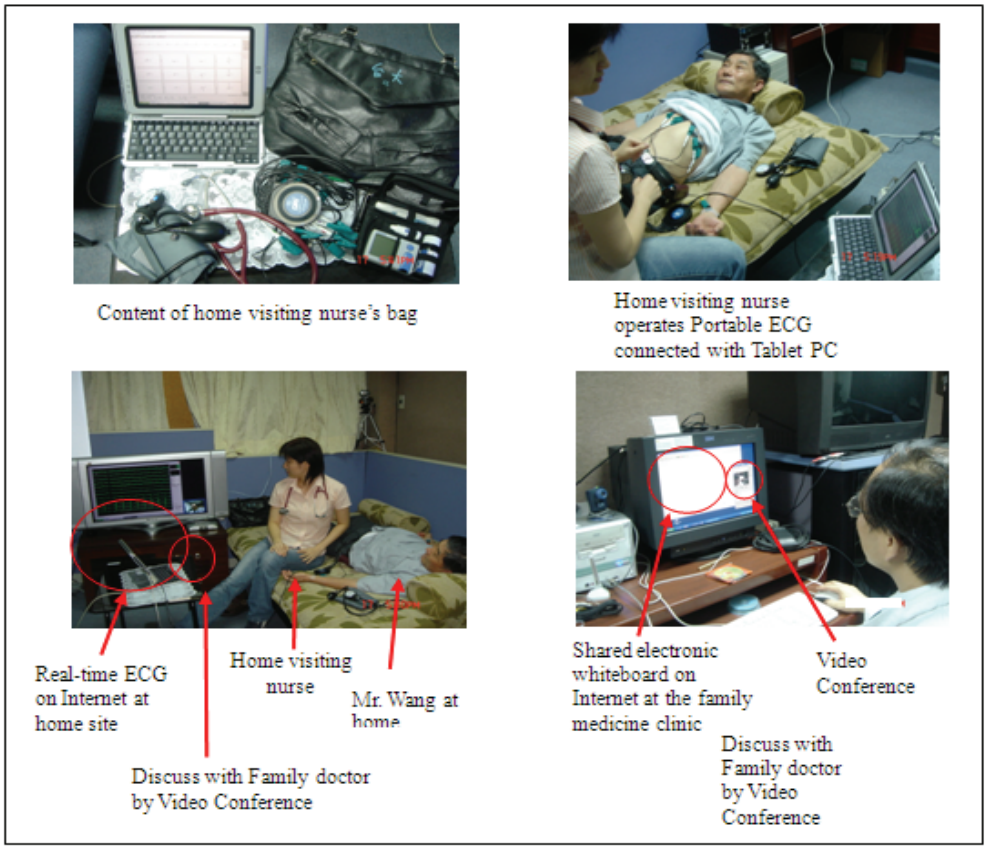

Figure 4 - Tele-consultation at patient's home

Discussion

Studies suggest that home visits can lead to improved medical care through the discovery of unmet health care needs. [4-6] Therefore, home visits will play an important role in long term care, and the electronic home care visit platform can significantly improve efficiency and quality of home healthcare comparing to the traditional nurse home visit. It makes the home care service be linked to a hospital-based health information system more easily. Moreover, the home visiting nurse and the patient's family doctor can easily collaborate to trace the history and clinical condition of patients. It is also convenient for survey or to evaluate the whole patient community through the electronic health records system, so the system can enhance the quality of medical service.

The implementation is fully based on the service model of the home care center at NCTN Hospital. A home visiting nurse visits 5 cases one day. The client of prototype platform using a light weighted notebook less than 1kg with long battery life is good for one day's work without charging. In general, the weight of paper healthcare records of five patients is equivalent to the notebook, and pc-based portable sensor devices are also less weighted than traditional physiological measurement equipment. Moreover, in U-Care system more and more biosensors will become standard remote monitoring devices installed at patient's home. Home visiting nurse will no longer need to carrier these devices. Therefore, home visiting nurse not only reduces the loading of her bag but also get the benefit of efficient case management by using this e-platform[7-8].

However, security and privacy issues are still the major concerns of an e-platform. There are many technologies along with ordinary user id and password which are applied on a mobile computer to ensure security, such as the finger print and Centralized Authentication (CA). Security problems might happen when download and synchronization of patients' data via network were performed. Since the wireless environment is not completely deployed in everywhere, the homecare record system is designed workable as off-line. There is a client program at mobile PC with a local database to store home care records. It raises the security issue that patient's data maybe unauthorized accessed. To reduce the risk of damage, only data of

patients assigned to the on duty nurse can be stored to the computer. If a patient should be reassigned to another nurse, or home care of a patient is terminated, his data in the computer of the original nurse will be clean when synchronizing. On the other hand, the data retrieval of biosignal could probably be another security hole. It is not a good idea to open our database to bio-sensor providers. So we propose a two tiers solution that ask sensor providers to export data of standard format from their sensor and save them into a JET database which is the default function of Windows OS and can be checked easily using Microsoft Access.

To representation of a full function e-platform home care visit rely heavily on high speed wireless and broadband network. At present, the bandwidth is still not enough to show full motion live video to the doctor, but in the near future, Taiwan will build high speed wireless network environment, such 3.5G High-Speed Downlink Packet Access(HSDPA) with 3.6 Mbps, WiMAX (Worldwide Interoperability for Microwave Access),

Conclusion

The prototype e-platform for home care visit materialized as a nurse e-bag which integrated with a mobile electronic home care records system, a biosensor measuring and retrieval system, and a videoconferencing and consultation system. The key element is a light weighted mobile computer with long battery life enhances the efficiency and reduces the total weight of bag content. The platform is flexible upon the working flow of the service model of the home care visit and serves as the disposition and case management tools for long term care. It involves popular mobile technologies and existing sensors that cost not too much. It also shows a good example for interoperability cross domain knowledge; include nursing, information technology, sensor technologies, and the outsourcing vendors. In the future, we expect more application and service models in long term care can be implemented with this e-platform.

Acknowledgements

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A Prototype of Electronic Home Care Visit Platform: Nurse's e-Bag

Yaw-Jen Lin, Mei-Ju Su, Chia-Hui Chen,
Heng-Shuen Chen, Jin-Shin Lai

Introduction
- an electronic home care visit platform

- *For enhancing the efficiency and quality care for home visiting nurses:*
  - Nurse's e-Bag integrating popular distributed technologies, mobile hardware, and biosensor
  - based on the service model of the long term care of the home care center at NTCN and become one application part of NTUH U-Care system
  - integrate with a mobile electronic home care records system
  - Light weighted
  - provides tele-consultation

Introduction
- U-Care system

- *Nurse's e-Bag developed in U-care system:*
  - U-Care is an important research project of a Ubiquitous Hospital (u-Hosp) research group in NTU
  - Mobile Hospital is switched to u-Hosp from 2006. m-Hosp/u-Hosp at NTUH
  - many multidisciplinary faculties and researchers from different colleges and also from several hospitals and other universities.
  - Ubiquitous Healthcare focuses on providing healthcare to people anywhere at anytime using broadband and wireless mobile technologies.

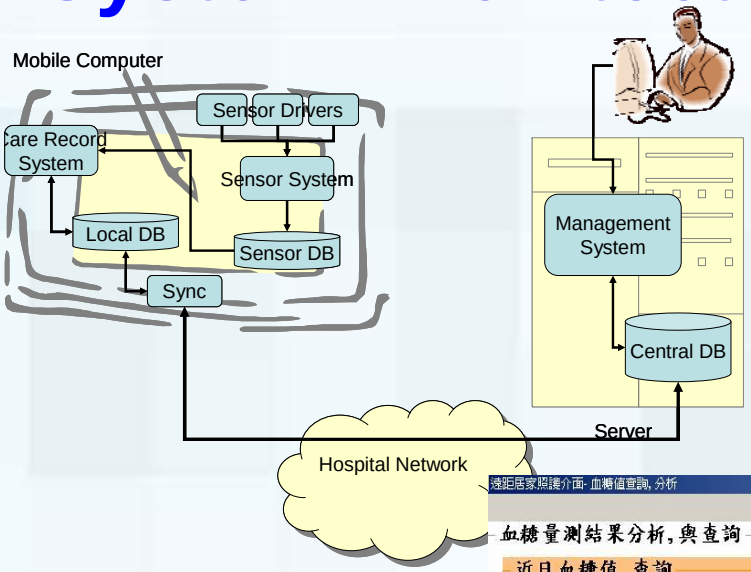
Methods :
Mobile electronic home care records

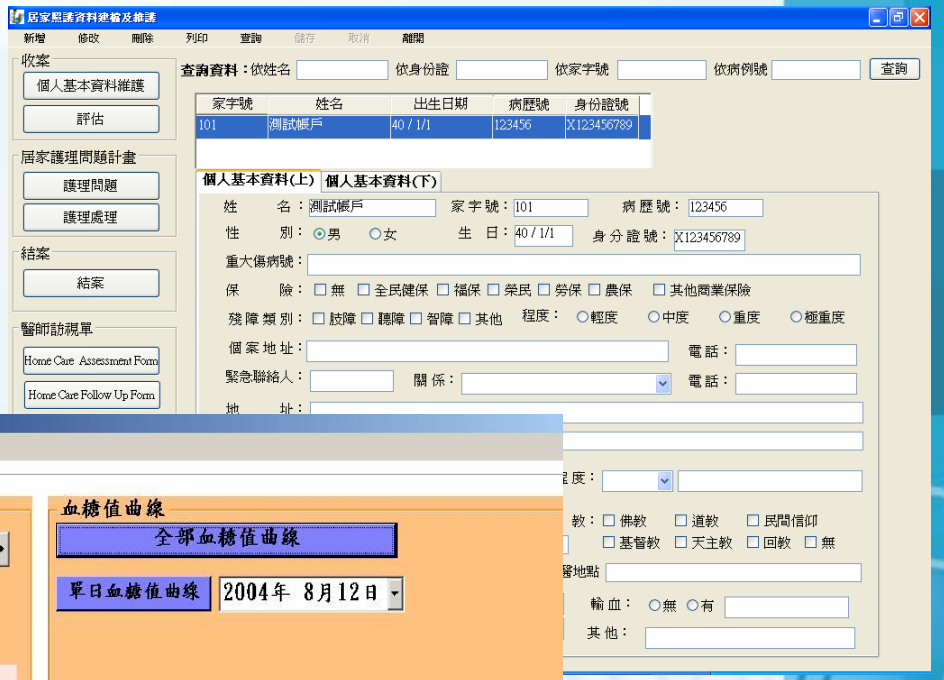
- Mobile electronic home care records system
  - the data can be stored onsite and transmit to a server online
  - or synchronize in batch operation after the nurse return to office everyday.
- A nurse fills new healthcare information and adds them into the home care record in every visit.
- Patient data divided two groups: called '*A forms*' and '*B forms*'.
- '*A forms*' contain data of cardiopulmonary vital sign, nutrition, and others.
- '*B forms*' contain summary data of '*A forms*', and some extra data, plan suggestions, and insurance claims.

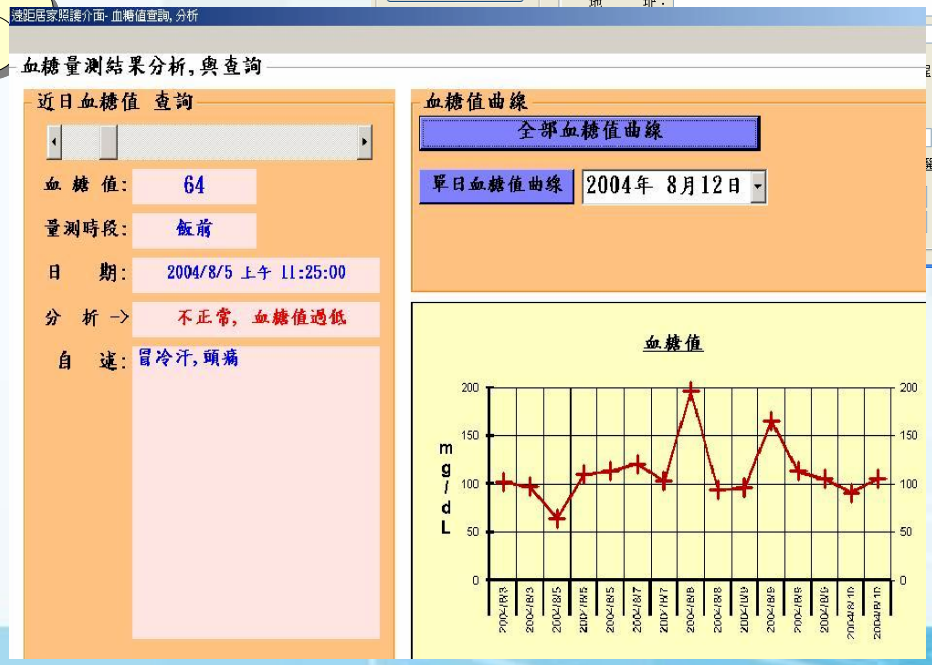
Methods :
Bio-sensor monitoring & Bidirectional Audio-video interaction

- provides measurement and monitoring of bio-signals:
  - temp, blood pressure, glucose, oxygen, respiration, ECG.
- U-Care system
  - record daily health status by the sensor network in the home setting or use the selective portable bio-sensors
- home care record system
  - access results from sensor database into evaluation forms for the home care management
- initiate a videoconference at patient's home
  - interaction among doctor-nurse and doctor-patient
- vital sign transmitted through ADSL, 3G or GPRS
- home visiting nurse can get more support from physicians to enhance the service quality

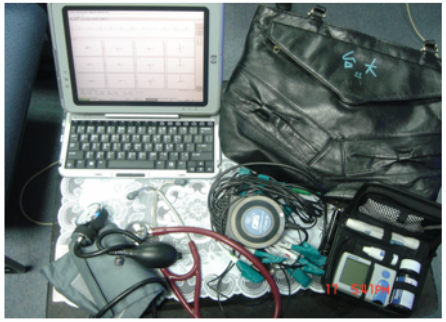
Results :
System Architecture & User interface



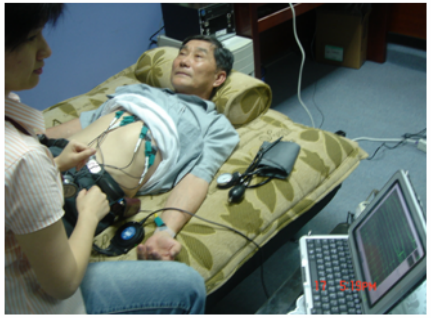




Results：Tele-consultation



Content of home visiting nurse's bag



Home visiting nurse operates Portable ECG connected with Tablet PC

Real-time ECG on Internet at home site

Home visiting nurse

Mr. Wang at home

Discuss with Family doctor by Video Conference

Shared electronic whiteboard on Internet at the family medicine clinic

Video Conference

Discuss with Family doctor by Video Conference

Discussion (1/3)

- Improve traditional nurse home visit
- home visiting nurse and the patient's family doctor can easily collaborate
- Enhance the quality of medical service :home care service be linked to a hospital-based HIS more easily
- based on the service model of the home care center at NCTN Hospital.
- reduces the loading of home visiting nurse's bag
- efficient case management

Discussion (2/3)

- security and privacy issues :
  - such as finger print and Centralized Authentication
- homecare record system is designed workable as off-line
- To reduce the risk of damage, only data of patients assigned to the on duty nurse can be stored to the computer
- data retrieval of biosignal
  - ask sensor providers to export data of standard format from their sensor
  - save them into a JET database

Discussion *(3/3)*

- the bandwidth is still not enough to show full motion live video to the doctor
- Taiwan will build high speed wireless network environment, such 3.5G HSDPA, WiMAX

Conclusion

- The prototype e-platform, nurse e-bag integrated with :
  - a mobile electronic home care records system,
  - a biosensor measuring,
  - retrieval system,
  - a videoconferencing,
  - consultation system
- cross domain knowledge:
  - nursing, information technology,
  - sensor technologies,
  - the outsourcing vendors
- In the future, we expect more application and service models in long term care can be implemented with this e-platform.

- **Acknowledgements**

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Effect of Direct Management of Clinical Documentation and Its Contents (Medical Record Items)

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Abstract

Many clinicians need a rapid creation and change of clinical document according the fast change of medical environment. However, it is not easy to create new clinical document and it is more difficult to change its contents on the system of paper based clinical document. The Severance Electronic Medical Record (EMR) system was constructed and run on the basis of clinical documentation with XML format and its contents under the name of medical record (MR) item as a new concept. Each MR item has its characteristic and own attribute values. In this study, we tried to evaluate the effect of this direct management of clinical document and its contents (MR items) by the changes during 1 year after implementation.

Keywords:

EMR, medical record (MR), MR items

Introduction

The clinical document has a vast of variety by the department and individual clinician. Many clinicians need a rapid creation and change of clinical document according the fast change of medical environment, such as research and new devices. However, it is not easy to create new clinical document and it is more difficult to change its contents on the system of paper based clinical document. The main reason is that those change needs the process of consensus, confirmation, inspection, and registration, moreover this process is not so flexible to accommodate the promptness of clinician, and also impossible to create all the documents as clinicians please.

The Severance Electronic Medical Record (EMR) system was constructed and run on the basis of clinical documentation with XML format and its contents under the name of medical record (MR) item as a new concept. Each MR item has its characteristic and own attribute values.

The system has two main functional modules. One is clinical document editor, which enables creation or change of clinical document, and the other is MR item registration module, which register new MR item and change the attributes of MR item. On the blank board of clinical document editor, the clinicians can select MR items that they want and place them where they want. Through this, the creation or change of clinical documents was very fast and can be created as clinicians needs. MR items were gathered by fractionation of the every content item of paper clinical documents. In order words, it provides the maximum flexibility of customization of clinical document and contents to the clinicians.

In this study, we tried to evaluate the effect of this direct management of clinical document and its contents (MR items) by the changes during 1 year after implementation. We inspected the change of numbers by electronic calculation, and evaluate the process of new adaptive classification, and estimate the controllability of the in time recording. The result shows the dramatic rapider change of the clinical document and its contents than paper-based record.

On the basis of the results, we can conclude that there has been very insufficient reflection of clinician's needs on the clinical document in the previous paper-based recording system. And also we can sure that its main reason is easy and direct management of clinical documents and its item by themselves. So, if an institute wants to implement self evolutional EMR system, the maximum customization should be provided on the modules of clinical documentation and its contents.

Material & method

All data was retrieved from the Electronic Health Record (EHR) system of one hospital, Severance hospital, Seoul, Korea. The hospital has 8,000~12,000 Outpatients per day, 2,000 inpatients, 2,100 beds, 2,500 clinicians, 54 medical department, 57 general ward, 9 ICU, 5 specialized centers. The whole hospital information system has been constructed on the basis of EHR system that contains EMR and Computerized Patient Order Entry (CPOE, order communication system) system. On the EHR system, the other systems are integrated, such as 3 PACS, one Dynamic PACS, Enterprise resource system, Groupware, Dataware house, and Disaster recovery system.

Before retrieval of data, the number of paper based clinical document (PBCD) was checked before and just after revision of clinician for the conversion of electronic form.

During revision process, lots of new paper based clinical document was gathered from the clinical department and nursing field. After then, those are revised for electronic conversion. The number of the original categories and revised categories of PBCD was also checked. And then the number of initial electronic clinical document (ECD) was checked via EHR system.

The follow up of the changes of the ECD and MR item was checked monthly for 1 year. At the time of 8 months after implementation, the data was analyzed by the classification of the database of recording log of CD by

MS SQL according to classification of the ECD, number of new ECD, and the analysis of the changes of attribute of MR item and MR item itself. Through this procedure we postulate common ECD by its frequency of usage according to its clinical objectives. So, the commone ECD is a kind of reestablished current ECD of the institute. For this work, 1,677,434 patient's clinical records were examined. Through this work we identified number of available ECD from total patient's records by using above analysis process.

The estimation of the controllability on actual recording was done four specific limited ECD. Those documents are admission note, operation note. The occurrence time of events of admission and operation were compared with the recoding time of each records, and the existence of the recorded ECD of each records.

Results

Evaluation changes of CD, ECD, and MR items

Table 1 - Change of paper based clinical document

Before revision	After revision*
Medical 18, Nursing 40	Medical + Nursing : 960

*After revision involves not only revised document but also department managed (can be called hidden) document from whole clinical, nursing, and other supporting departments.

Table 2 - Change of ECD from revised paper document

Period	Number of clinical document
Pre-EMR (Paper)	960
Initial in EMR (Nov, 2005)	1,169
6~7 Mon later after EMR	5,370
1 year later, Present (Nov, 2006)	2,707

Table 3- Category of paper based clinical document (PBCD)

Original categories	Revised categories
No category ; Admission note Laboratory result report Examination result report Procedure result report Discharge note, Summary note, Progress note, etc < Other many record that was used without management of the medical record department.>	Four categories ; 1. Progress note – OPD progress note – IPD progress note – Operation note – Consult note – Anesthesia note – Treatment note – Doctor order note etc 2. Result report – Laboratory – Radiology – Pathology – Examination etc 3. Legal form – Consent form – Diagnostic certificate – Refer note etc 4. Education Document and Other

* Revised category was applied to the ECD in same.

	Pre- EMR	Present	Modification
MR Item	15,092	24,858 (+9,488, 41.7% Δ)	240 (1.8%)

Table 4 - Change of number of MR item

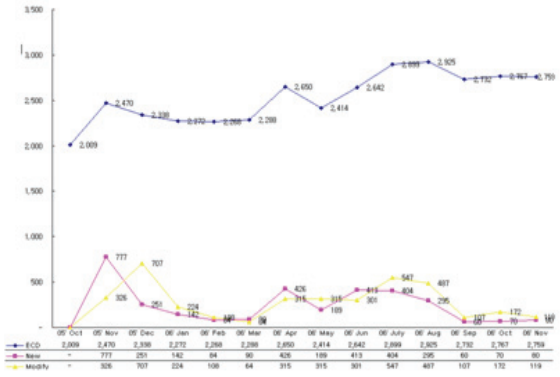

Figure 1 - Transition of ECD, frequency of new generation and modification

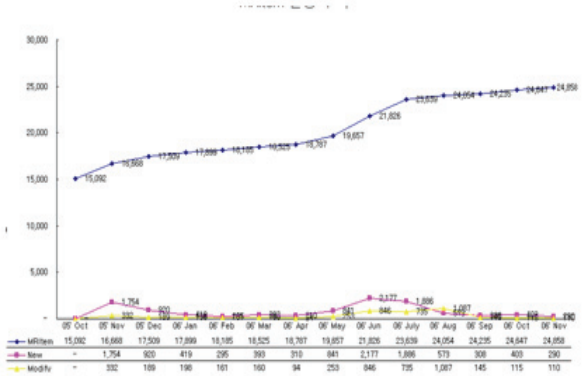

Figure 2 - Transition of MR item, frequency of new generation and modification

Extraction of common ECD at 8 month of implementation.

- Through 1,677,434 patients, 25,074,974 ECD was existed. Among these ECD we can identify available, in other word proper recording was done, ECD is 19,394,233. From these available ECD, we also identify 1,538 of new common

EMR was forced by the massive creation of CD by clinicians and departments which contained different contents (MR item) even though those are CDs of same purpose.

For this extraction, the new creation of ECD was measured in two ways. We treated the CD that has changed more than 50% in its MR item as a new ECD, and treated the others as a changed ECD. And the change of MR item was measured a log of modification of MR item database.

Estimation of controllability of ECD

The recoding time of admission note and operation note was checked. The frequency of completeness of recording within 48 hours has been increase very sharp after 5 months of implementation in admission note (Fig. 3). For the operation record the module of control of recording time was applied at the 11th months after implementation, so the frequency of completeness shows sharp increase at the time of 12th month of implementation (Fig. 4). This means that the adaptation of admission note is faster than the operation record. In other word, the work process of admission note has been changed gradually by ECD environment, but for the operation record, the habit of physician has not changed until the control module (time warning module) was applied. In paper based operation record, this kind of control was impossible.

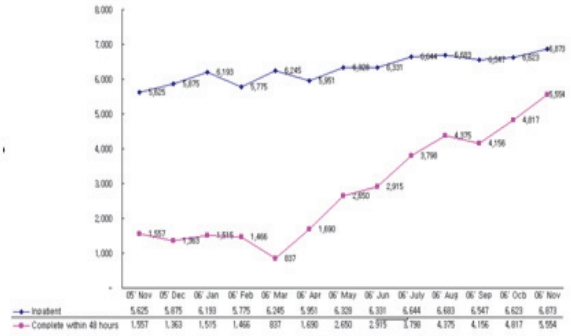

Figure 3 - Recoding time of admission note and number of inpatients

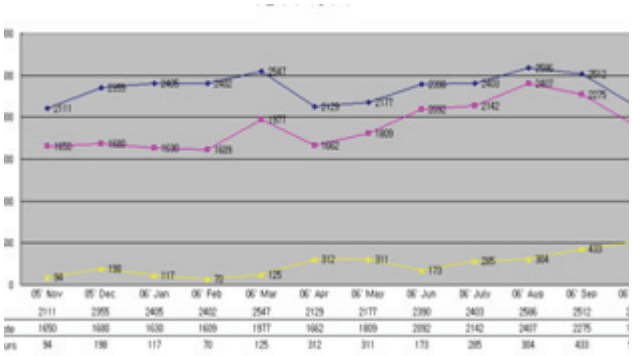

Figure 4 - Recoding time of operation note and number of OP-patients

Discussion

The expansion of medical information makes the evolution of the electronic management of the information. The expansion is not only its amount but also its variety.[1][2][4] In the last decade, it was possible to adapt the changing environment of the medical information through the paper based recording system, however nowadays it is impossible to adapt appropriately because the change is so fast and variable.[2][4] The institute of this study has started one clinical document, so-called discharge summary note, before 60 years. Before implementation of EHR system, the department of medical record has managed and archived only 58 clinical documents, however, there were lots of hidden clinical document that has been managed by individual department. So, the number of whole paper documents was collected up to 960 before implementation of EHR system. This change can be a evidence of hidden need of change of medical document of the institute during last 60 years(Table 1).

Before implementation the clinicians of the institute examined and revised their clinical document forms and its items as a preparation for the conversion of the EMR system.[1][2][3][5] The 5,370 CD was created as new one at the 8 months of implementation, this would be another evidence of need of diversity of clinical document. This 8 months' change of ECD makes a decision of provision of extraction of common ECD. As the result of extraction of common ECD and rearrangement, the 2,707 CDs were existed at 1 year of implementation (Table 2, Figure 2).
To achieve this direct management of CD and its contents by users, we have to create the new concept, so called, MR item. The terminology system is a collection of term.[5] Each term has its own meaning. However, we found that each medical term can have different meaning by specialty and situation, and also we found that medical term can involve image, grid, voice not only text. So, every clinician can not select the term in same meaning, and this makes impossible to select items of ECD by clinician. The concept of MR item was started from this insufficiency of current terminology system. The result of this concept makes two main modules, named *Clinical Document Editor*, and *MR Item Registration.* This enables clinician to create and change their ECD and its content directly whenever they need. The recorded ECD is stored XML format with electronic signature and MR item is stored into database sever. This enables confidentiality of records and reusability of information. From the items of content of revised paper CD, record items were unified, classified, and fractionated into 15,092 MR items at the time of implementation and then has increased 24,824 MR items after 1 year of implementation(Table 4, Figure 2). This change may reflect the clinician's needs of change of the terms.

The main objective of this study is whether clinicians have high need of direct management of CD and its contents. The observation of the change of ECD and MR items reveals that there is a high need (Table 2, 4). The progressive increase of ECD is somewhat unexpected phenomenon because the total revision was done by clinician themselves just before conversion of paper document to electronic one. We can sure that almost triple increment of ECD means explosion of high need for their clinical document. Also this means that there has been a limitation of expression on the previous system paper based clinical documentation.

The result of change of MR item means another desire of clinical documentation. The result shows that there was same need for the term itself. Clinicians want to use accurate term for their documentation. For example, the term 'time' can be a same item in two different clinical documents. However, it can be used year-month-day in one record and can be used hour-minute-second in other document. Previous paper document can hold this term 'time' in one meaning, though the real records is different. However, in the situation of direct management of items, clinician seek proper MR item, create item, and use it as a reflection of their desire of accurate description for better medical record. At this time MR item have different time attribute even though the name of item is same and they saved in different sector. This kind of addition of MR item has been occurred 24,858 times and time of change of attribute has been occurred 4,425 for 1 year. It also shows their adaptation of the new system as much as they use the system frequently. As another meaning, the simple collection of term, the terminology system should have any kind of intermediate tool that accelerate the usage of exact terminology like MR item.

By the above changes, the extraction of common ECD was possible, even though actual ECD is different from department and clinicians. For example, the items of discharge summary note is different in obstetrics and dermatology, however, they can be treated as a same discharge summary under tagging of department name of obstetrics and dermatology. Complete reconstruction of common ECD was possible by analyzing the changes of ECD and MR item at 8 months after the implementation of system. This would be another effect of direct management of ECD and MR items, because clinician left spontaneous consensus as well as difference of their record in the system. This traceable evidence makes easy transition of completeness of recording in time.

The estimation of completeness of medical recording [3] was greatly improved after reconstruction of essential ECD. The result of the time check of 2 time-limited medical records shows sharp increase of completeness (Figure 3). Completeness of operation note also has been more increased than initial of EMR (Figure 4). Clinicians can agree easily the time-limited document and accept the systemic alarming of time limitation. If they did not create their own record item and form of documentation, it is easy to make this kind of high completeness [3].

Other effect of direct management of ECD and MR item, the ECD for the research can be achieved. Even though we can not fully differentiate which one is ECD for research, we can sure that many portion of new ECD except essential ECD would be created for the research.

Conclusion

The direct management of ECD and its contents can satisfy clinician's need of expression, and extract their positive consensus of medical record, and also expected to accelerate their research mind. So, any institute should provide best tool for the direct management of electronic clinical document and its contents, when they implement new system, if they expect better return on investment.

Acknowledgment

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Functional Analysis of Health Information System in Public Health Centers Focusing on Health Business Programs

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Abstract

The purpose of this study is to analyze the functionalities of Health Information System in Public Health Centers focused on Health Business Program. Field research was performed in accordance with the business guidelines of the Ministry of Health and Welfare. After analyzing the users' requirement and the functionalities of the system, we suggest a model of functionalities for interoperable EHR system. This will help to promote application of health information system and to improve efficiency of Public Health Centers.

Keywords:

Health Information System, Public Health Centers, Health Business Program, Health Electronic Health Record

Introduction

The Electronic Health Record (EHR) has evolved to become center-stage in the national health informatics strategies[1].

But many incompatible Health Information Systems that cannot effectively exchange information have been implemented, and substantial duplication of effort has occurred as different jurisdictions address similar information management needs[2].

Health Information System in Public Health Centers has several sub-systems that support direct care, supportive care and Health Business Programs. Various Health Business Programs are performed in Public Health Centers as major business. sub-system that supports Health Business Program has many problems to manage systematically and efficiently. Although the sub-systems are connected among each other, it needs more interactions between Health Business Programs and other systems of health centers in a nation.

In this study we will analyze the process of Health Business Programs and functionalities of the system for EHR implementation.

Methods

There were many Health Business Programs in Public Health Centers. To analyze function, we had to choose several Health Business Programs, which were considered as a important business and each had different work processes.

Nine Health Business Programs which recognized as key Health Business Programs in Public Health Care were selected.

Then, they have classified into following three categories: The First includes the Health Business Program which was managed by the local Health Information System. Second category includes the Health Business Program which was not managed by the local Health Information System but was managed by web system in common. Consequently, the personnel in charge of Health Business Program can't manage the cases by using their own Health Information System. Third category includes the Health Business Program has no Health Information System, so it was performed manually.

The methods of this study are as follow.

Analysis of the work process

Questionnaires and field interview survey were conducted at six Public Health Centers in Korea. And people in charge of each health business program named business manager were interviewed. After their work processes were inspected carefully, the functions of health information system and works performed manually using MS Excel or Word were investigated.

To show the functionalities, Unified Modeling Language (UML) was used, which showed the work process functionally.

Analysis the system of health business programs

The functions of business process of Health Information System that the manager use were analyzed. Functions were categorized into following three: mega process, major process and sub process.

Results

Analysis the work process

The health business managers perform the work of Health Business Program. They register the clients in Health Business Program and perform it. For example, they visit client's home and provided health care service. They also support the medical finance to the clients that allowed to reimbursement. And then the business managers report the results and statistics to the superior part . By these process, the clients are managed.

In short, it was analyzed that they have three mega processes. We called these functions as "registration", "acting" and "management"(Figure 1).

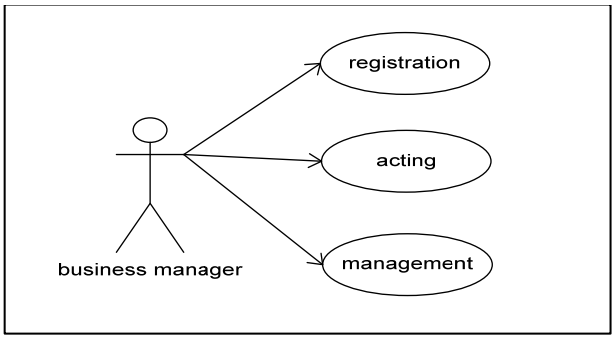

Figure 1. Usecase Diagram: Health Business Program

Each Mega process was analyzed more detail level as following usecase diagram.(Figure2, 3, 4)

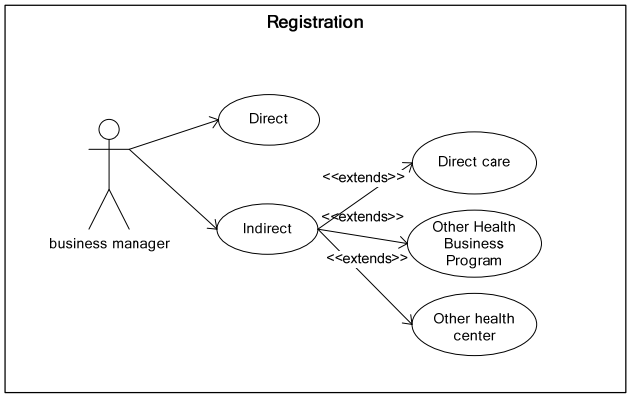

Figure 2. Usecase Diagram: Registration

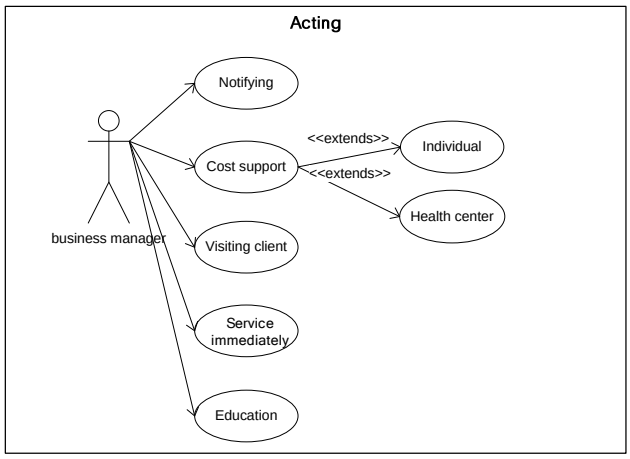

Figure 3. Usecase Diagram: Acting

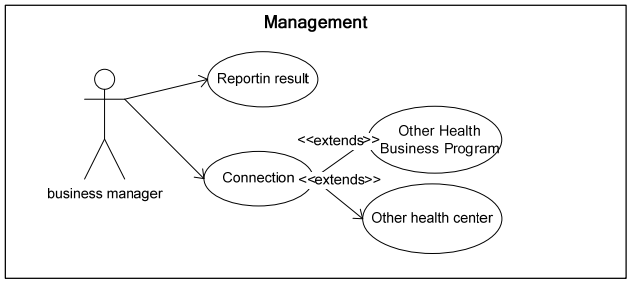

Figure 4. Usecase Diagram: Management

Analysis the system of Health Business Programs

In Health Business Program, Health Information System hardly has been developed . Even in the case that the Health Information System has been developed, the business managers rarely use Health Information System., because the Health Information system in Public Health Centers couldn't support the functions that can interface among other Health Business Programs, and communicate between Public Health Center and other Health Centers. They are the most important functions for the business managers to perform their work. The functions of interface also are the core functions for the interoperable EHR system.

There are categorized processes above Table1. Each Mega processes have Major processes, and also each Major processes have Sub processes. Similarly Each Sub processes have been performed by business managers, but each function was conducted in different ways.

So, several symbols are marked. A Mark "●" means that the function was performed by using Heath Information System in Public Health Center. A Mark "○" means that the function was performed by using website in common system. Finally a mark "◎" means that the function doesn't have any Health Information System, so business managers performed manually.

Table 1. Functional analysis of Health Information System

Mga process	Major Process	Sub Process	1.Using Health Information System†			2.Using website of other health center‡			3.No system (manual work)§		
			A	B	C	D	E	F	G	H	I
Regist-ration	Direct registration	At Health Bsiness Program in Public Health Center	●	●	●	◎	◎	◎	○	○	○
	Indirect registration	Direct care		●	○	○					
		Other Health Business Program			○						
		Other health centers				◎	◎				◎
Act-ing	Notifying cost support	Notifying			○	◎	◎		○	◎	
		Individual				◎	◎				
		Health center				◎	◎				◎
	Visiting client	Visiting client					◎			○	
	Services immediately	Services immediately	●	●				◎	○	○	
	Education	Education			○			◎	○	○	
Manage ment	Reporting results	Reporting results	●	●	●	◎	◎	◎	○	○	○
	Connection	Other Health business program			○				○	○	
		Other Health Center	◎	◎	◎	◎	◎	◎	◎	◎	◎

† Using Health Information System: It means that works were performed by using Health Information System in Public Health Center.

‡ Using website of other health center: It means that works were performed by using website developed in other health center.

§ No system (manual work): It means that works were performed manually. For example, business manager used MS Excel or Word.

The name of each health business program is as follow;

A: Vaccination Program

B: Tuberculosis Control Program

C: Chronic Diseases Management Program

D: Rehabilitation Management Program

E: Sealing Program in Dental Health Care

F: Caner Screening Program

G: Medical Expense Subsidy for Caner Patient Program: Adults

H: Medical Expense Subsidy for Cancer Patient Program: Children

I: Smoking Cessation Management Program

It was analyzed that utility of health information system in public health center was poor.(Figure 2). In Registration, the coefficient of utilization of the System was 25%. Similarly in Acting, was 10%, and in Management was 15%.(Figure 5)

Business managers use other health centers' website or work manually in most of cases. It was showed 75% in Registration, 90% in Acting, 85% in Management when they use website or work manually.. Because of that, business managers feel inefficient and uncomfortable, thus they need the functions which could share the client's information efficiently.

These results showed that the Health Information system was in needs of functions that support interoperability between Health Information System in Public Health Centers and other health centers.

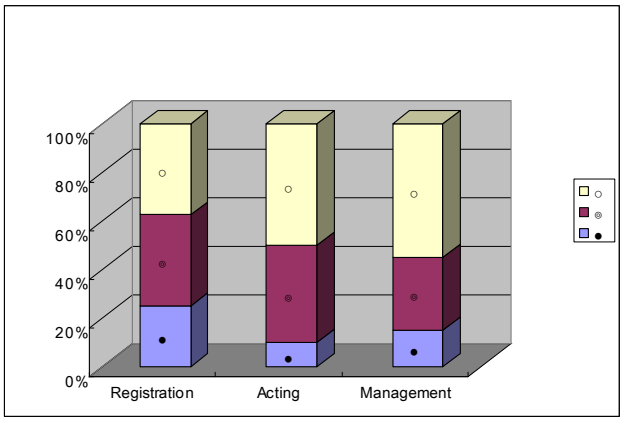

Figure 5. Rate of functional using the Health Information System (Sub process level)

Conclusions

Health business programs in public health center are recognized recently as essential activity of information system in Community Health. But actual condition can not support the effective management because there is little information system developed efficiently. From now on, establishing a health information system will be demanded for EHR system implementation.[3]

Health Information System offers an important infrastructure of efficient delivery and use of healthcare services. To develop the information system, it is important to develop a strategy covering the scope of work processes, public and private activities and adequate use of resources.[4]

So, in this study, we analyzed the function of Health Information System in Public Health Centers focused on Health Business Programs, which are recognized some core businesses in Public Health Centers.

In Public Health Centers, there are many different Health Business Programs. The Health Information System that supports the Health Business Programs was not integrated into a interoperable EHR system, but it has each Health Information System or has no Health Information System. This is why the functional analysis of Health Information System is significant.

We showed that it lacks for interoperability on relations with the Systems of other Health Business Programs and the Systems in other health centers.

For the EHR functionality, health information systems should include functions we suggested. The model for interoperable EHR system will be derived.(Figure 6)

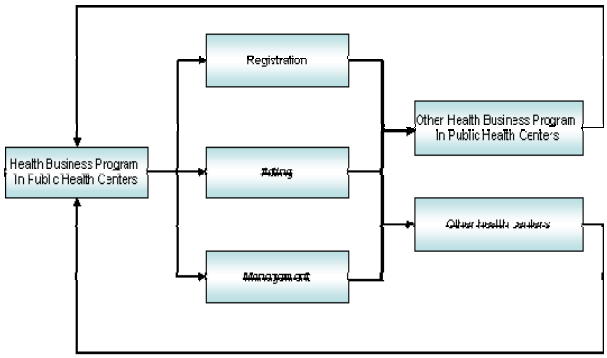

Figure 6. Model for interoperable EHR system in public health programs

Electronic Health Record (EHR) systems need to offer a flexible framework for recording the consultation process, and accommodate the individuality of the clinician.[5]

Health Information System should be developed reflecting the end users' requirements. Our study could be helpful to engineers who develop Health Information System , so they could have a good understanding of medical domain. And that can help to reflect the users' requirements. Furthermore, the Health Information System would be adopted various Health Business Programs. Eventually these make increasing the efficiency of the user's business and make sure the implementation of interoperable Electronic Health Record System.

Acknowledgments

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Demonstration of a Light-weight Mobile Electronic Medical Record for the Homeless

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Abstract

This paper represents a demonstration of custom designed HER for the street homeless.. Numerous barriers keep the street homeless from obtaining healthcare. Medical Street Outreach (MSO) programs are used to reach out to the homeless and offer healthcare services. Gathering relevant clinical information on the streets for the homeless is difficult. Carrying paper records in MSO is cumbersome and inefficient. Multiple complex healthcare record systems are available for collecting health data and for medical reference, for hospitals and outpatient. But, there are no systems designed for collecting health data on the streets. This article will discuss the model of a light weight Electronic Medical Record (EMR) built to address the process of healthcare on the streets. The EMR system has been designed for use on a Tablet Personal Computer (TPC) to collect, organize, and share clinical data between clinicians and provide quality healthcare to the homeless. This design can also be used in emergency situations.

Keywords:

demonstration. tablet PCs, healthcare for homeless, electronic medical record for homeless, medical street outreach

Introduction

Homelessness is a growing problem in the United States. A 2000 study by the Urban Institute estimated 444,000 to 842,000 homeless people. The number of homeless people counted in each state in 2005 totaled to 723,968 [1].71% of survey cities showed an average increase in request for emergency shelter by 6% in 2005 [2]. The homeless population in U.S. is composed of 43% single men, 33% families with children, 17% single women and 3% unaccompanied minors [3]. The majority of homeless population is men. However, studies have found that number of homeless women and families is growing.

In response to the federal government's 10-year plan to end homelessness, MSO programs have become a common feature of many community health service programs for the homeless[4-6]. In such programs, healthcare practitioners encounter homeless people in diverse settings—in meal programs, on the streets, under bridges, in encampments, and in shelters to improve their health, social functioning, or utilization of human services and resources[7].

Handheld technology on the streets

The method used in the Medical street outreach until recently has been to carry paper records. And carrying the paper records around to treat the homeless is very cumbersome. Scrambling through the records to find the patient's paper record is difficult and impractical. This disrupts the care workflow in MSO, resulting in reduced clinician-atient engagement and hence compromised care.

Health information is often poorly organized and not indexed in paper records. The paper records cannot be shared between multiple providers treating the same person. Inability to share records results in redundancy of records and insufficient patient information at the point of care. This inability to share patient information was the main impetus for the introduction of handheld computer technology into the healthcare delivery system for the urban street homeless in Houston.

Handheld technology like personal digital assistants (PDAs) are known for their mobility and flexibility in medical practice in the last few years [8-10]. Updated patient information available at the point of care shareable by all the clinicians enhances quality of care [11]. PDAs have their own limitations in memory, slow processing power, small screen size and a cumbersome input mechanism[8, 12].

Tablet Personal Computers (TPCs) is another handheld technology known for its use in the medical industry. It has a larger screen space, and a pen to write directly on the screen. Tablet PC offers mobility and fits well into the workflow for the MSO clinicians. The downside is that they are more expense and fragile than PDAs.

Two programs have tried to use PDAs for homeless healthcare. Boston's Health Care for the Homeless program used Palms devices to collect biomedical data. And Operation Safety Net (OSN) in Pittsburgh used IPAQ Pocket PCs. However, these were used in traditional clinical settings and not for medical outreach.

Methods

Healthcare for the Homeless – Houston (HHH) began using handheld technology to make medical street outreach more efficient for providers. In January 2001, HHH launched a personal digital assistant (PDA) system.

The use of Palm V Handheld Computers (PalmOne, Inc., Milpitas, CA) combined with customized software made it relatively easy to collect patient demographics and histories, as well as information on physical examination results, diagnoses, and medications. To prevent duplication of patient records, PDAs were synchronized into one main system. Informal interviews with the clinicians who pilot-tested the PDA platform revealed that they were satisfied with it as a method for collecting patient information. However, the limited memory available on the Palm became a major obstacle. Switching to the iPAQ H3765 Pocket PC (Hewlett Packard Company, Palo Alto, CA) improved the reliability of the system, but clinicians found the new hardware too slow.

Although PDAs proved ineffective, the positive feedback from clinicians in the pilot study [13] led to the development of a TPC platform in 2004. TPCs can record data with a digital pen, voice, keyboard, or mouse, while chart notes can be written or dictated. The display size of the Tablet PC is bigger and encompasses more data fields. The tablet PC used for street outreach by HHH is LS800 Mini TPC, from Motion Computing Inc., with a screen size of 21.34 cms and weighing only .997 Kgs. The EMR program is on a .NET framework and a MS Access Database.

EMR design

The Electronic Medical Record has been designed to enhance encounter workflow and data collection in street outreach for the homeless. Building the EMR involved data analysis from the pilot study on PDA[13] and involvement of the clinicians in an iterative heuristic process. Participation of the programmer in street outreach proved helpful in the logical design of the system.

The login on the TPC involves using fingerprints and username, password combination to comply by the HIPAA rules. Due to the mobile nature of the clinicians and the difficulty in bringing the programmers, implementation team and clinicians together, an audiovisual training module was developed. This training module proved effective in initial hands-on training with the system. The Go-live phase of the implementation involved participation of the implementation team in on-site training of the clinicians.

The EMR program has the capability of recording new encounters, new unlinked encounters, finding patient records and linking an unlinked encounter to a patient record. Patient record can be created using his name and demographics or even by any special appearance characteristics noted by the clinician. All fields have free text writing and typing options that makes taking clinical notes easier and quicker for the clinicians. There are drop-down menus for quicker selection for many of fields, for example: ethnicity. When entering a diagnosis the clinician can choose from the 20 most common diagnoses encountered in homeless on the streets or choose to view a list of more diagnoses. The system also has the capability of choosing a diagnosis by the ICD9 codes or by the abbreviations of the diagnoses. A summary page summarizes the patient encounter, goals and diagnosis. The summary page gets automatically populated at time of encounter data entry. Whenever one searches a patient file, it is the summary page that opens up, to give a comprehensive view in a jiffy. Patient file can be searched using his name, gold card number, or appearance characteristics.

The system has been designed to give the clinicians the mobility and flexibility to enter data on the fly. Before and after each street outreach visit the clinician goes to the clinic and synchronizes the data onto a common database. This way, each Tablet PC has the data from the other TPCs. Thus if a clinician has encountered a patient the other clinician encountered last week, he has all the patient data at the point of care. And there is not duplication of patient record. The enhanced information flow between clinicians helps provide improved quality of continued care.

Results

Despite the initial difficulties faced with the PDA and iPAQ use, there were beneficial lessons learned and a new system was designed with those feedbacks. With the Tablet PC, clinical information is accessible at all sites, by all physicians at the point of care. Data is replicated on the TPC hard drives from a repository on SQL Server. It has reduced the redundant documentation time and increased the encounter time for efficient patient care. Patient engagement has increased and clinicians are able to focus on building relationships with the homeless. The clinicians are able to devote time to addressing basic needs of the homeless, in addition to the medical needs.

The patients' attitudes toward and acceptance of technology has been surprising. Patient seemed nonplussed and flattered by the use of high-tech methods with them, instead of feeling anxious or intimidated by it.

From the lessons learned in the PDA development, we knew that user centered design was a critical first part of the TPC design [14]. The result has been an interface that requires little or no training and has been well accepted by the clinicians.

Future

The clinicians have been impressed by the flexibility with TPC use in street outreach medical care.

The research and programming team have been working on a Goal-Negotiated care (GNC) model of EMR [15]. The goal is to focus on patient goals and address patient needs directly, shifting the paradigm from a problem-based focus to a solution-oriented one. Goal negotiated care will help reduce feelings of powerlessness and increase self-efficacy. The GNC model allows clinicians to easily navigate through a care encounter between the goals and the encounter. In traditional care model, clinician moves linearly from history to diagnosis and treatment and the clinician drives the encounter, whereas in GNC, patient drives the encounter. Patient goal is the starting point and the clinician then moves forward or backward through the who, what, how, why, when and where components. An overview of the GNC logic model is presented in Appendix A. A set of goals commonly encountered in homeless patients aids in the process of selecting and generating the clinician and patient tasks. The entire process is more interactive for both clinician and patient, empowering and building the patient's self-efficacy by addressing his/ her specific goals and tasks.

GNC is currently being implemented and will be part of the demonstration.

Acknowledgments

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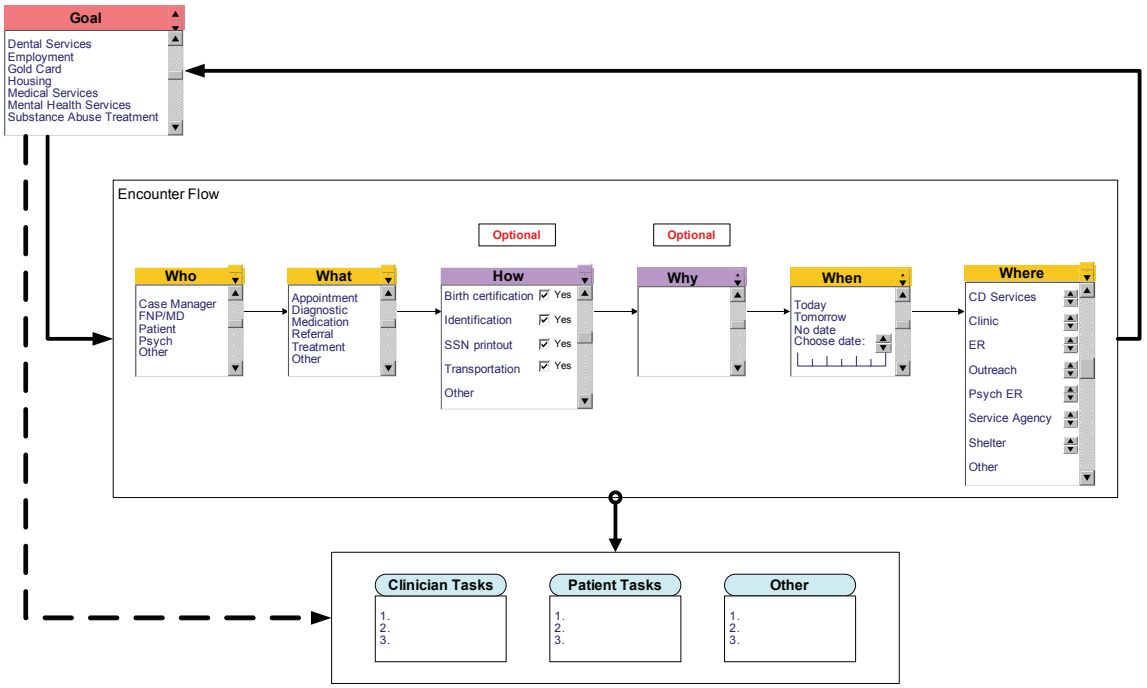
Appendix A
GNC Logic Model



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Computer Simulation and Medical Education: Complementary Tools for the Third Millennium

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Abstract

Background: *Educational change has been especially noticeable in medicine since the existence of virtual campuses. Several campuses have been created in the frame of the French Virtual Medical University.* ***Objective:*** *We present different multimedia resources that have been developed to help medical students with an active and easier understanding of complex physiopathological phenomena.* ***Methods:*** *The on-line course materials were created using original IBC-made multiscale simulators and registered trade-mark software tools.* ***Results:*** *Interactive multimedia resources are freely available for the site's users. Two- and three-dimensional simulations born out of mathematical qualitative and quantitative models at the molecular, cellular or organic level keep students active with regards to fundamental mechanisms by interactively manipulating the simulation environment. Authors comment the already available course materials.* ***Conclusion:*** *Providing evaluation tests, teachers anticipate that the increasing content of this virtual campus will allow users to gain a complete understanding and an integrative view of many physiopathological mechanisms.*

Keywords:

computer simulation, medical education, physiology, virtual reality, multimedia

Introduction

Medicine is an art founded on experiential know-how, the basic sciences, and epidemiological data. There is a universal agreement that physicians must have knowledge of these two basic subjects, human physiology and anatomy. The corpus of data and knowledge underlying medicine is growing exponentially and Medical Education faces the great challenge of training students within this expanding data universe spanning from the "nano" to the macroscopic scales. All biological functions and their modulations thereof can be attributed to the interplay between the variable expression of specific genes, the functional variability and diversity of their protein products within multiple biochemical systems, and the interactions between the cells, tissues and organs in which the said genes are expressed.

Modern approaches to teaching and learning basic science include collaborative learning, problem-based learning and the use of computers. Computers and information and communication technologies (ICTs), the Internet and Internet-related resources are of special interest in physiology [1]. Available computer technology allows the use of dynamic models, making learning more efficient. Many difficult concepts in physiology are truly learned only when the student's brain converts heard or read words, static pictures and diagrams into moving models [2]. Computers are now sufficiently powerful and the Internet sufficiently fast to allow fast distribution of multimedia materials which are especially useful for teaching physiology [3]. Furthermore, the interactive capability of computer-based instruction (CBI) keeps the student involved so that learning is more interesting and not purely passive. Future CBI will also have to tackle the challenge of helping students master the wide and deep corpus of knowledge we evoked in the first paragraph.

Our current approach focuses on the scientific foundations of medicine, and combines Computational Integrative Physiology (CIP), Qualitative Modeling (QM), and Reasoning capabilities. The aim of CIP is to provide computer models of the human body's multi-scale biochemical and biophysical dynamics that are occurring in response to its environment [4].

Qualitative Modeling involves natural-language and common-sense representations of the physical world. Qualitative models can model complex physical systems and processes as well as produce natural language descriptions and summaries of simulated system behaviour [5]. This self-descriptive property conveys a central role to these models since reasoning processes such as tutoring can operate at a symbolic level where qualitative models constitute the *object* level..

Finally, a *trully interactive* CBI must exhibit *intelligent behavior* (e.g, reasoning capability). Indeed, for a CBI to "interact" with a user beyond responding to "start", "forward", or "backward" clicks, it must have an *understanding* of the current user-context and carry-out *meaningful actions* accordingly. Such an understanding

could not hold without the proper representations and semantics describing a user-context nor without the specific inference schemes to carry-out meaningful actions.

In this global conceptual context, our objective was to create freely accessible simulation tools and to put them on the web at learners' and teachers' disposal. In what follows we will focus on some of the multimedia resources that host our quantitative and qualitative computational models. System intelligence will be addressed in subsequent papers.

Materials and methods

Pedagogical content media types

Pedagogical multimedia contents include texts, static images (radiographies, magnetic resonance imaging (MRI), etc…), sounds (voice, cardiac and pulmonary sounds), dynamic recordings (echogram, videogram), dynamic two- (2D) or three-dimensional (3D) simulations. Each pedagogical content includes at least two frames: on the left side of the screen, the title and a short explanatory text of the lesson and on the right side, the multimedia material : videogram, 2 or 3D animation. Different buttons allow the learner to display more detailed explanations about the phenomena, to add sound, music, to hear the reading of the text, to navigate along the different pages of the session.

2D and 3D dynamic computer simulations

The 2D and 3D dynamic simulations of multiscale biological functions were generated using original IBC-made computer models coupled to a generic and multi-domain knowledge base [4] [5]. The IBC computer simulators are able to reproduce normal or pathological cases in a virtual reality context and from the cellular to the organic level.

Set-up and functioning of the website

A part of our 2D and 3D dynamic simulations are present on the website that we created in 2005 and that we described in a precedent paper [6]. This website, called the "Campus Numérique de Physiologie" (CNP) is accessible through the French Virtual Medical University (UMVF) site at the following adress: http://www.umvf.org, "virtual campus" heading. There is also a direct Internet access: http://www.campus-physiologie.org

Our first work was to update the Content Management System (CMS) of the platform with the latest version of Joomla, an open source Mambo-derived CMS which uses a MySQL database. The platform has also been more securized at the Apache webserver level.

Results

More than 30 pedagogical items are now available on the CNP, but for the moment we have focused our effort in the sole domain of the cardiovascular physiopathology: in this medical area, the cardiovascular hemodynamics and cardiac electrophysiology sections present several concepts usually considered to be of special difficulty for the student's understanding. This is the reason why we developed simulator-based 2D and 3D animations in those two sections. We present here some examples of the resources available in each section.

Cardiovascular hemodynamics section

This section allowed also us to introduce into the proposed resources a simplified but very useful 3D anatomical model. The learners can use this virtual human body containing important biological systems like the skin, the muscles, the skeleton or the cardiovascular sytem, as an anatomical relative position reference for various organs (see figure 1).

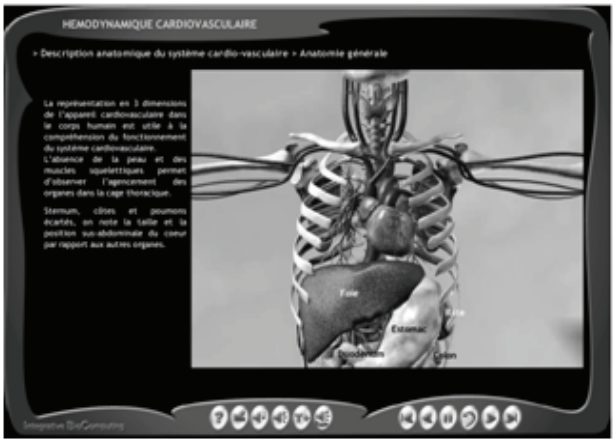

Figure 1 – 3D anatomical relative position reference

.In this section, students can watch in details hard to understand 3D phenomena such as the successive or slightly asynchronous mechanical events of the cardiac cycle and the corresponding cardiac hemodynamic recordings.

Figure 2 gives an example of mechanical and hemodynamic processes viewed in parallel for a better understanding.

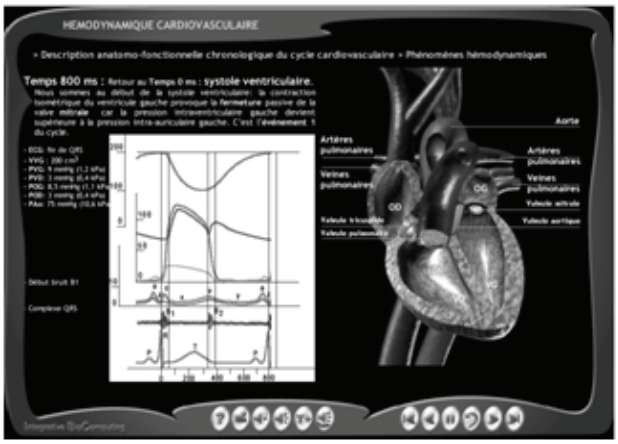

Figure 2 – Hemodynamics

Cardiac electrophysiology section

In this section, learners can watch in two dimensions a myocardic repetitive reentry process associated with the genesis of a ventricular tachycardia (see figure 3).

Figure 3 – A 2D simulated reentry

Students can also start the electric cardiac activation process: using an original IBC-made 3D chromatic simulation program [7], they are able to follow the step by step depolarization and repolarization pathways along the fast conducting system, the endocardium and epicardium. 3D visualization of the cardiac electrical signal moving forward is essential to understand the corresponding genesis of the normal and pathologic human heart EKG, which can be studied in any standard lead (see Figure 4).

Qualitative simulation

New resources are under developpment and we will soon add quantitative simulations to the list of available website resources. Within this new learning context, students will be able to analyse combined impulse formation and impulse conduction disturbances using different means: a crude depolarisation wavefront, a Lewis diagram, and the high level concepts that label (qualify) the simulated

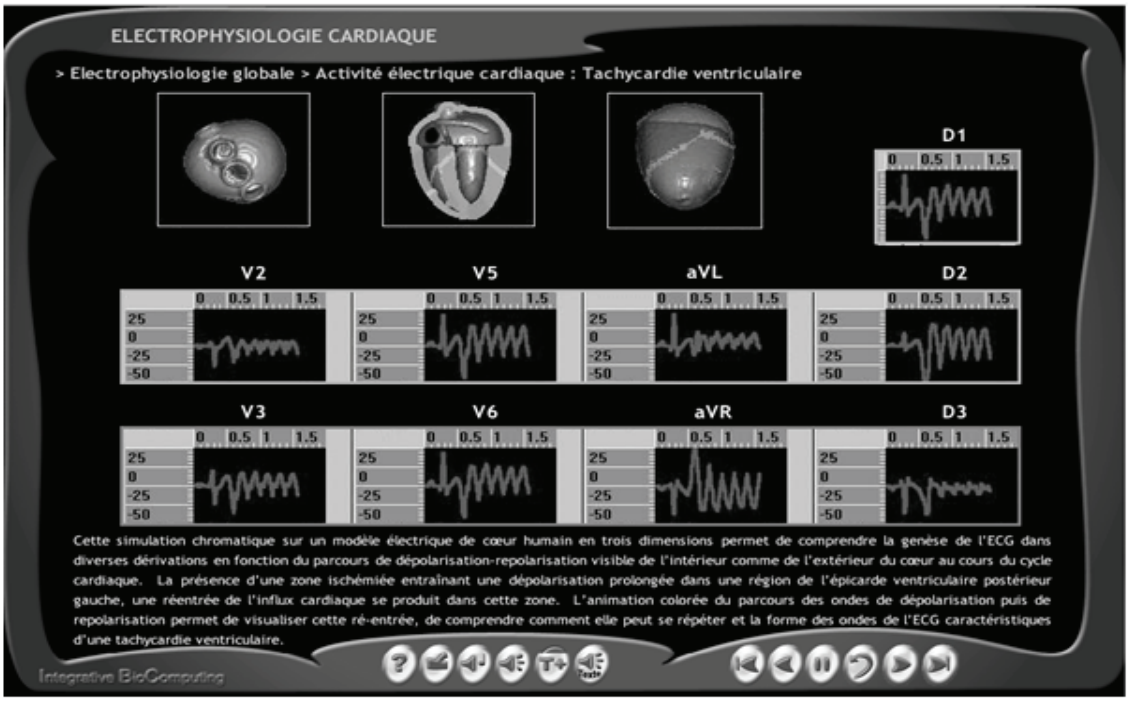

Figure 4 – 3D simulated ventricular tachycardia with a model-generated ECG

arrhythmia (see Figure 5). Given initial conditions, our QM generates these results in an ongoing fashion and in synchrony with the underlying electrical processes [8].

Discussion

Computer-assisted learning is generally assumed to be worth and to have a positive influence on student learning [3], [9-10]. Nevertheless, in agreement with the views of the teachers of the french "Société de Physiologie" and in opposition to classical virtual universities, it was decided before its development that the CNP would not be a web-based course aimed at distance learning. Learning materials of the CNP are not intended to become a surrogate for classical forms of teaching. ICTs and multimedia are uniquely used as tools for learning, providing learners with complementary knowledge in fundamental sciences necessary to scientific and medical education. Choosing to provide learners only with complementary teaching resources, we wanted to keep the possibility of face-to-face Physiology courses for on-campus students and to avoid

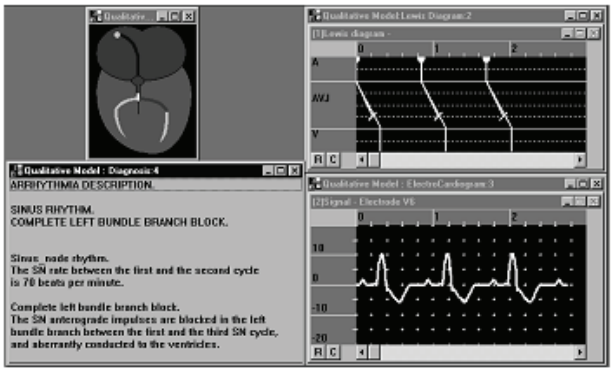

Figure 5 – Qualitative simulation of an arrhythmia

some dangers linked to complete on-line courses and confirmed by different surveys : the will of a physical classroom in preference to a virtual one is expressed by many students whose majority disagree with both synchronous and asynchronous electronic communication tools when a direct interactive aid by dedicated teachers is possible [9] [11].

Though the CNP is for the moment moderately interactive, medical first-cycle students of Rennes and several already graduate practitioners are highly enthusiastic about the complementary use of multimedia resources to improve

the understanding of physiopathological mechanisms and the possibility to re-active their memory before or after clinical reasoning learning or practical workshop sessions. This statement is in agreement with a recent survey [12] showing that medical students mostly use Internet in order to find additional learning information. Nevertheless, the CNP is in permanent evolution in order to improve its technical effectiveness and to come up to the users' expectation [13-14] and thus needs being appraised as precisely as possible: methods of assessing the effectiveness of our e-learning systems will be explored by inquiries about both customer satisfaction and service quality. A general questionary, established from examples of the literature will allow to verify the user's satisfaction level. E-learner satisfaction is linked to learner's performance. Assessment of learners' understanding level will be assessed by specific questionaries written by the authors in each teaching content. To reach this goal, the actual CMS Joomla will be replaced as soon as possible by a learning content management system (LCMS). LCMS are aimed to offer functionalities allowing easy construction of a questionnaire. After a preliminary inquiry in 5 french and 1 canadian universities, unpublished results show that Medical Physiology professors find the simulation tools of the CNP useful as complementary resources for a better understanding of the described biological mechanisms. The loud synthetic reading of the text does not seem to be very useful and more interactivity is required.

A part of the teaching quality of the CNP will be warranted by the teachers validating committee and by the administrator's control of the hardware and software efficiency and updating. Though it has been shown that in basic sciences and Physiology, didactic fashion is more efficacious than too much interactive style [10] and since it was demonstrated that understanding is the most useful in clinical reasoning [15-16], original IBC-made software tools will be used to develop movies from 3D colour images and photographs in the jpeg file format to give the learner the possibility of a real interactive navigation in a three-dimensional cardiovascular environment. Well designed computer-aided learning is useful for conceptually difficult topics [17] [3]. Furthermore, an original IBC-made cardiac simulator is in preparation, soon at teacher's disposal to create different scenarii of pathological affects.

Developing computer assisted learning applications is a lengthy process. Innovators within traditional courses who have often produced creative and high quality material to supplement existing courses are in a minority [14]. We hope that the rising success of the CNP will enhance the creativity of the teachers but the development of teaching scenarii using multimedia and the multiplication of the teaching contents of the CNP for the next years depends on both the vitality of the members of the French “Société de Physiologie” and the acceptation of the different teaching projects to be granted by the UMVF.

Conclusion

We have presented different multimedia resources incorporating quantitative and qualitative models that have been developed to help medical students with an active and easier understanding of complex physiopathological phenomena in the context of the complementary teaching resources of the CNP. It should be noted that the opposing view to classical virtual universities concerns *current* CBI technologies which generally have very little intelligence and therefore limited “real” interactivity with a mitigated acceptance by the students.

Related to this issue, we are currently developing an *interactive* CBI that will exhibit *autonomy* and *intelligent behavior* in a e-learning/e-training context. It will combine CIP and qualitative models with reasoning methods. Such developments are necessary if future CBI technologies have to carry-out the task of performing Problem-Based Learning and Clinical Reasoning Learning sessions in an autonomous fashion. For instance, good medical practice presupposes diagnostic ability that includes a solid grounding in physiopathology. Loosely speaking, in physiopathology-based diagnosis, solutions and explanations are provided by going "backwards" through the causal paths, from the observation to the cause(s) of a mental physiopathological model. This form of hypothesis-formation, called *abduction,* can be mimicked by computers capable of performing model-based diagnosis. Thus CBI technologies that perform abductive inference will be well tooled to tackle PBL sessions in an autonomous fashion.

Although these are long-term goals, we believe that model-based learning resources such as described in this paper and the experiences derived from their use in the classroom will provide valuable inputs to our more advanced developments in CBI technology.

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Demonstration of GuideView, a Multi-platform System for Interactive, Multimodal Presentation of Clinical Advice

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Abstract

There is an increasing need for technologies that can assist in providing medical guidance in situations where physician availability is low. Such situations include the growing number of aging individuals living independently, rural areas in developed countries, and substantial populations in less developed countries. We demonstrate GuideView, a system that enables interactive, structured, multi-modal delivery of clinical advice. It provides clinical guidelines simultaneously using voice, pictures, video, and animation. GuideView is multi-platform, executing on desktops, over the web, on Pocket PCs, and on Windows Mobile cell-phones. GuideView interfaces to medical instruments such as Pulse-Oximeters and can automatically follow treatment or diagnostic pathways depending on the input received. GuideView Author, is a simple GUI-based environment for developing GuideView compatible protocols (GuideViews).

Keywords:

practice guidelines, cellular phone, multimedia, telemedicine, software design, user-computer interface

Introduction

The need for medical and skilled nursing care continues to increase worldwide. In advanced countries aging populations place increasing demands on healthcare systems and in developing countries medical facilities are likely to be poorly staffed and equipped. In these countries, while the availability of medical supplies and drugs is a pressing issue, another problem is the lack of high-quality, standardized medical training.

We demonstrate *GuideView*, a system designed to assist non-physician care providers (NPCPs) such as community health practitioners, nurse assistants, and similar personnel in providing medical care. In addition, GuideView can potentially assist the elderly. The GuideView system enables delivery of structured, multi-modal delivery of clinical protocols on multiple platforms, presenting a very similar look-and-feel on desktops, laptops, Personal Digital Assistants, and cell-phones.

GuideView

GuideView technology was originally developed at NASA Johnson Space Center as an advanced research project exploring technologies for providing medical support to astronauts during deep space exploration missions.

GuideView consist of two components, a) *GuideView Author,* for developing guidelines in the GuideView format, and b) *GuideView Viewer,* used to execute and display these guidelines. For brevity, any guideline that has been developed and saved in the GuideView format, is called a *GuideView.*

Design considerations

The design of GuideView was informed by the following basic objectives.

- The system should be portable and support ubiquity
- It should be highly interactive
- Medical guidance should be provided in a structured manner, as a sequence of *steps*
- Cognitive load should be reduced:
  - At any step in the procedure there should be only a few choices leading to the next step.
  - The task to be performed at any step should be simple
  - Sufficient information, but not an overwhelming amount, should be provided at every step
- Information should be given in multiple, redundant modes
- Presentation and content should be strictly separated. One important benefit is that GuideView protocols can be developed in multiple languages; the GuideView Viewer and Author are agnostic to such content variations.
- The system should be able to acquire medical data from sensors and branch through the guideline accordingly

To achieve the objectives of portability and ubiquity, the Viewer has been designed to be multi-platform, and can execute over the web, stand-alone on Windows desktops and laptops, Personal Digital Assistants (PDAs), and on cellular phones running the Windows Mobile Operating

System. PDAs and cell-phones are an attractive platform due to their portability. Web-based GuideViews can be executed on recent versions of most web browsers running on most client operating systems (Windows, Linux, MacOS), although it has been tested most extensively on Internet Explorer 6.0.

User interaction

User interaction with the system depends on the platform. On desktops and laptops, the mouse is the primary medium of navigation. In addition, GuideView accepts voice commands from a limited vocabulary (currently only on Windows Clients). including 'Affirmative', 'Advance', 'Play Video' etc.. Voice input mode enables hands-free operation, a desirable feature enabling the caregiver to use both hands to assist a patient while receiving guideline instructions.

On Pocket PCs (PDAs), screen tapping using a stylus is used for navigation. On the mobile phone, directional and selection buttons on the phone's numeric pad are used.

GuideViews are highly structured and appear to the user as a sequence of simple steps capable of being accomplished by those without specialized training. Information on how to accomplish each step in a GuideView is presented simultaneously as text, voice, and still pictures or annotated full-motion video. The video can consist of live motion or animation or a combination of both. Presenting information in multiple modes simultaneously enables a rich instruction and guidance environment. The multiple modes enhance understanding by reinforcing and supplementing each other.

Within each step in GuideView the user is given only a limited number of choices for the next step. Thus a GuideView can be thought of as pathway consisting of nodes from each of which multiple branches emerge, leading to other nodes.

The system is able to directly take input from medical sensors when available, and branch the execution accordingly. The input can occur from wired serial devices or wirelessly by BlueTooth. The current implementation accepts input from a serial-port Pulse-Oximeter (Avant ®4000, Nonin Medical Inc, Plymouth, MN, USA) and branches automatically depending on the pulse rate sensed.

The authoring environment

GuideView format guidelines (i.e., GuideViews) are created, typically by teams of physicians and nurses, using GuideView Author, a GUI authoring tool that enables development, editing, and update. Text input for each step is entered directly into GuideView Author. Multi-modal content such as voice and video files are produced separately and merged into the protocol using the Author. Modularity and re-use is supported in the sense that an existing GuideView protocol can be incorporated into another easily using the Author.

The design of GuideView Author supports strict separation of presentation and content, in the sense that the GuideView Viewer software is agnostic to the specific multimodal content presented in a GuideView. Such content can be developed in any desired language, integrated into GuideView format by the Author and saved for later viewing by the Viewer.

Integration with an Electronic Medical Record System

GuideView has been integrated with BMIST-J (Battlefield Medical Information System Tactical, http://www.tatrc.org), an electronic medical record system operating on PocketPCs developed by the US Army Telemedicine advanced Technology Research Center. From BMIST-J GuideView can be accessed in a context-sensitive way. For example, if the chief complaint in a patient encounter is eye pain, foreign object, or redness, tapping on the GuideView button within BMIST presents a GuideView protocol addressing diagnosis and treatment of such problems. Integration of GuideView with BMIST enables delivery of clinical advice as well as automated documentation of differential diagnoses, treatment and related care.

User acceptance

A preliminary study of GuideView in a Human patient simulator environment using 10 subjects revealed positive acceptance of the GuideView system [1]. None of the subjects were trained physicians; all had received some amount of training in CPR or similar first-aid procedures. Voice output received the greatest acceptance and was rated indispensable by 60% of the subjects and useful or very useful by the remaining 40%. Video assistance was rated in the useful to indispensable range by 80%. This has interesting implications for the design of future GuideViews.

GuideViews

So far, a variety of GuideViews have been developed, between them we have airway triage, basic CPR, red-eye, saliva sample collections and decompression sickness. The Red-eye Guideview has been developed in both Spanish and English. A GuideView in a non-medical area has been developed to support maintenance of underwater photographic equipment during NEEMO 12, an extended stay mission at the US National Underwater Research Center, Key Largo, Florida.

Conclusion and Future Work

The demonstration will include all the features described above on multiple platforms including web, stand alone

desk/laptop, Pocket PC (Windows Mobile) and cell phone. Voice navigation will be demonstrated on the laptop implementation.

In general, GuideView may be thought of as a procedure assistant enabling 'virtual experts' to offer guidance in performing tasks (not necessarily from the medical domain) where and when needed.

Future work includes improving the user interface, interfacing to a variety of medical sensors, and improving voice navigation. More extensive usability studies and field testing are in planning stage.

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Implementation of An Integrated Network for Health Research in Quebec

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Abstract

Health data warehouses represent a valuable resource for health research. We have developed an infrastructure capable of providing health researchers in the province of Quebec with a toolkit to access the clinical data warehouses contained in the major academic health centres and the provincial health administrative systems. This demonstration will highlight the components that allowed the successful implementation of an integrated network to accomplish this task. Acceleration of the pace and increases in the volume and quality of health research within the province, in other jurisdictions and possibly world-wide is now an attainable goal.

Keywords:

health databases, information management, patient data privacy, database management systems, computing methodologies, health services research

Introduction

Health research done in the conventional, paper-record environment is tedious, expensive and reliant on data with varying quality. Large repositories of health data are invaluable resources to researchers and planners in health care. In the province of Québec, Canada, these repositories are housed in clinical data warehouses within the large teaching hospitals and the administrative data warehouse at the Régie de l'assurance maladie du Québec (RAMQ) – the provincial health services payer. The Infostructure de Recherche Intégrée en Santé (IRIS) - Québec project is a Canada Foundation for Innovation funded initiative to construct an integrated network for health research in the province. Its goal was to create secure access to these data warehouses, enable the linkage of patient records through the use of a provincial Master Person Identifier (MPI) and ensure that resultant datasets returned to researchers conform to privacy standards.

Methods

The IRIS-Québec architecture is a distributed, federated data warehouse model. The RAMQ already manages the MPI. The research warehouses of clinical data were constructed to ensure the highest standards of data quality. People: Researchers wishing to access these data warehouses no longer have to queue for specialized data analysts and programmers. The researchers' toolkit is a web-based, user-friendly interface that drives a powerful system with the following functions: selection of variables from the extensive data dictionary across the warehouses, building of complex queries using logical operators, a temporal relation tool to define time-dependencies of variables, a crosstabs manager, and a data extraction manager. Previously onerous and lengthy authorization steps have been streamlined into an electronic approval process which is reliable, timely and track able. Privacy: A novel "inference controller" was developed to ensure individual data privacy. This software computes the probability of the presence of an unique, potentially re-identifying profile when multiple databases are linked. The researcher's toolkit allows the dynamic modification of data query parameters in order to achieve the desired data precision without violating privacy rules Processes: Data sharing agreements were established with each partner institution. Software agents were installed at each data source to manage queries, connectivity, linkages, and data flows. Each agent contains a copy of the inference controller engine. Performance: is maintained by de-coupling the phases of a research project from the raw data extractions. The creation of the complete cohort data cube is triggered only on submission of the finalized project profile. We will demonstrate the operation of the Toolkit through sample queries.

Conclusion

The architecture of our system can potentially be extended to other biomedical information sources such as genomics, proteomics and geneology databases and create new capacity for health and bio-medical research. This architecture can also be potentially replicated in other jurisdictions. Scaling such a system to the international level can result in enabling health and bio-medical research in the global community.

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