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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.

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