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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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