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Information Technology in Health Care 2007

Proceedings of the 3rd International Conference on Information Technology in Health Care: Socio-technical Approaches

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PREFACE

It is hard to overstate the importance of an international forum which brings together leading researchers studying how information and communication technologies (ICT) can be safely and effectively designed, implemented and used within the health system. The ICT research enterprise has increased substantially in the last decade.

Alongside the research interest, investments in clinical systems have grown and their sophistication and capacity to contribute to health sector improvement continues at a rapid pace. Yet, amongst this growth, evidence regarding the benefits of system introduction remains limited and has not kept pace. For example, good studies of benefits realization remain sporadic, and large scale system failures occur all too frequently. Early studies of health information system failures identified the central role of the human, social and organizational contexts in which information systems operate. They set the challenge for researchers to understand how to obtain the best fit between the technical systems (e.g. the information systems and associated work practices) and the social systems (e.g. organisational culture, social practices and behaviours, and political mileu).

The origins of socio-technical theory can be traced to different strands, one of which is the seminal work undertaken by organizational researchers Trist and Bamforth who originally studied British coal miners in the 1940s and 1950s. Another important strand is the work of Bruno Latour and Steve Woolger who in the 1970s examined how scientific facts are constructed in a laboratory. Since this time many health informatics researchers have adapted this theoretical approach implicitly or explicitly, and have framed their research within a socio-technical perspective.

This has resulted in a new and exciting body of work embracing a socio-technical perspective of health information system design, implementation and evaluation contributed to by researchers from many countries. In 2001 the 1st International Conference on Technology in Health Care: Socio-technical Approaches was held in Rotterdam, The Netherlands. It brought together academics to discuss their research under the common theme of socio-technical approaches. This conference was important in identifying an international community of scholars from a broad range of disciplines. The research discussed revealed aspects of the complexity involved in studying the implementation and impact of clinical information systems within health care organisations. In particular, the research highlighted the value in harnessing a multi-disciplinary and multi-method approach to this topic. In 2004 the 2nd International Conference on Technology in Health Care: Socio-technical Approaches was held in Oregon, USA. This showed how innovative researchers were extending the reach and relevance of their research contributions.

This volume presents the papers from the 3rd International Conference on Technology in Health Care: Socio-technical Approaches held in Sydney, Australia in 2007. Six years on from the first conference in Rotterdam the quality of the research papers has continued to improve as have the theoretical sophistication and empirical methodologies. Considerable advances are evident, though many of the underlying challenges, such as our ability to design, implement and evaluate safe, useable and effective systems within complex health care organisations, remain. Several researchers at the original Socio-technical conference present papers in the current volume and the continued development and contribution of their work can be seen. Importantly, there is also a contingent of newer researchers who present papers which bring new insights. Our field is dynamic, and growing, and is a platform for some of the finest research and researchers in any discipline. These contributions demonstrate the vital role that the socio-technical health informatics research community has in fostering greater research capacity, and translating research findings to improve health care service delivery, health policy and outcomes. We are grateful for the support and conference sponsorship provided by the NSW Health Department and Intel Australia. Continued collaborations between researchers and industry are vital in moving this important research agenda forward.

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Jos Aarts

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Sociotechnologies of Care: Visions and realities

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Lancaster University

This presentation draws from a growing body of research in science and technology studies and participatory systems design to think critically about the development of information systems in healthcare settings. Conceptually, I weave together recent work by philosopher Annemarie Mol on the 'logics of care' with my own attempt to articulate a politics of located accountability based in practices of artful integration with respect to information systems design. Empirically, I turn to two ethnographically based studies of projects in health information systems, located in dramatically different settings. The first, by Judith Gregory (2000), examines an initiative in the 1990s, in the largest Health Maintenance Organization (HMO) in the United States, to develop a comprehensive electronic patient record. The second study, by Ranjini C R (2007), documents government-sponsored initiatives to introduce information systems in primary healthcare settings in rural areas of the State of Andhra Pradesh in Southern India.

Considered together, these rich and thoughtful studies provide a generative comparative frame that illuminates the complex – and often contradictory – relations of governmental, organisational, technological and clinical visions on one hand, and on the ground realities of care on the other. Gregory's research involved an extended ethnographic study (1993-1998) of the prototyping phase of an ambitious electronic health record system, undertaken jointly by the HMO and a state-of-the-art clinical informatics software company. The theoretical focus of the research included attention not only to the technological developments of the project, but also to the various logics, or imaginaries, that informed them. Of those, Gregory identifies three – managerial, technical, and clinical – which together comprised what she names the 'incomplete utopian project' of a comprehensive and fully integrated electronic medical record system. This concept fits well with the initiative traced by Ranjini in rural Andhra Pradesh between 2003 and 2004. Launched by the State's technology-savvy Chief Minister at the time, in the context of intensifying discourses of information and communications technologies as key to national 'development', the aim was a system that would support health care delivery in the most remote areas of the State, and thereby meet the 'development goals' set by the United Nations, World Bank and other funding agencies. Ranjini's analysis of the efforts that followed focuses on what she identifies as key questions of accountability and sustainability. Her argument is that creating sound information practices, including recognition of the potential of local knowledge to improve the provision of care, is a prerequisite for effective health information infrastructures.

I conclude with reflections on what these conceptualisations and the studies that illuminate them can teach us about the problems and possibilities of technological infrastructure-building in the name of improved health and effective patient care.

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Designing and Evaluating Healthcare ICT Innovation: A Cognitive Engineering View

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Abstract. Many healthcare ICT innovations fail in practice because of a failure to take into account user needs. User needs should be identified broadly, encompassing different levels of organization of the healthcare system and different stakeholder concerns. Full-scale simulators are starting to be used to help in the design and evaluation of novel biomedical devices and displays. Although promising, simulators have significant technical and operational limitations for this purpose and they do not address important aspects of the sociotechnical systems context in which healthcare ICT will be embedded. This argument is illustrated with a case study in which advanced auditory displays for patient monitoring were successfully evaluated in a full-scale patient simulator, but many further questions remain prior to successful translation to practice.

Keywords. Medical devices, medical equipment design, healthcare informatics, cognitive engineering, simulation and training, user studies.

1. Introduction

The need for timely, effective information in healthcare has motivated much healthcare ICT innovation but the reality often falls short of expectations and needs. In this paper I introduce some of the conceptual tools that cognitive engineers use to discuss the impact of healthcare ICT. Then I discuss the potential for full-scale simulators to support formative and summative evaluations of healthcare ICT design innovation, focusing especially on advanced auditory display technologies for intraoperative monitoring.

Finally, I conclude that although simulators can be particularly effective for providing objective empirical evidence for display effectiveness, addressing the more local sociotechnical factors at play, it is still difficult to address the full range of factors that will affect translation to practice. Further conceptual tools are needed.

2. Mismatch of healthcare ICT to use

There are many accounts of failed healthcare ICT systems, the failure often caused by mismatch between technology capabilities and the needs and constraints of healthcare workers.[1, 2] According to one estimate, as many as 75% of healthcare ICT implemen-

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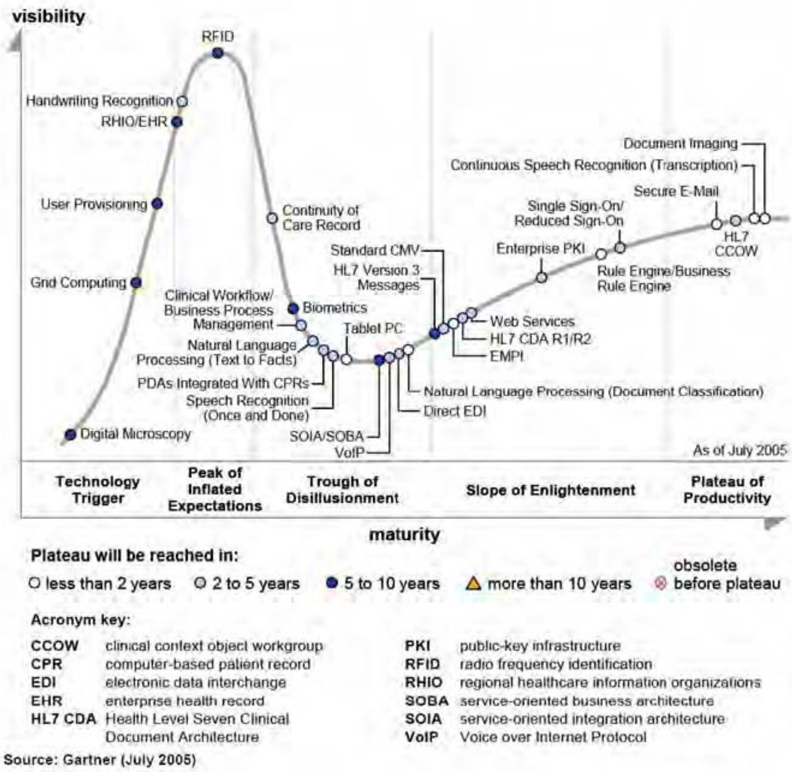
tations are considered failures.[1] Reflecting this, the Gartner Group's "hype cycle" in Figure 1 shows that inflated expectations about healthcare ICT innovation ("peak of inflated expectations") often lead to disillusionment ("trough of disillusionment") as healthcare ICT starts to be rolled out into practice.[3]

The cost to healthcare organisations and to society more generally of such failures can run to millions of dollars.[2] More probing longitudinal assessments can reveal an even worse picture because people's evaluations of healthcare ICT can change over time. In one case, an initial assessment of time gains achieved with a new electronic health record system (EHR) was overturned some months later when users realized that there were areas of use that led to significant time losses as well.[4]



Acronym key:

CCOW	clinical context object workgroup
CPR	computer-based patient record
EDI	electronic data interchange
EHR	enterprise health record
HL7 CDA	Health Level Seven Clinical Document Architecture
PKI	public-key infrastructure
RFID	radio frequency identification
RHIO	regional healthcare information organizations
SOBA	service-oriented business architecture
SOIA	service-oriented integration architecture
VoIP	Voice over Internet Protocol

Source: Gartner (July 2005)

Figure 1. Gartner Group "hype cycle" of healthcare enabling technology. A similar hype cycle exists for healthcare applications. © Gartner Group, 2006.

It has been suggested that the loose coupling of many healthcare systems, where coordination and information flow is achieved through multiple means, is incompatible with the tighter coupling usually imposed by healthcare ICT[5] and so leads to a mismatch between technology and human needs. In addition, the fact that there are stakeholders at different levels of the healthcare system with different priorities and needs means that multiple constraints must be satisfied for healthcare ICT to work effectively.

Figure 2. “Patients to politicians” model (Vicente).

3. Scoping perspectives needed

3.1. Patients to politicians model

The healthcare system is subject to multiple pressures from its various stakeholders, which have been outlined succinctly in Vicente’s[6] “patients to politicans” model (see Figure 2). This model is an application to healthcare of Rasmussen’s[7] analysis of risk management for complex sociotechnical systems—similar diagrams have been developed to show pressures bearing on the power industry, manufacturing and other sociotechnical systems. They are a template from which to start organizing more detailed thinking about the relationship between different stakeholders in a complex sociotechnical system., such as when analyzing incidents or working through the consequences of technology innovation.

Patients and the healthcare practitioners who treat them are at the so-called “sharp end” of the healthcare system (see lower part of Figure 2). The pathologies with which patients present are shaped by epidemiological trends—both acute and chronic—that the healthcare system must accommodate. Healthcare ICT is rapidly changing in response to those needs. We see the introduction of new technologies for sensing, imaging, diagnosing, monitoring, and for storing and retrieving data. As already noted, such technologies almost always require adjustment by patients and practitioners at the sharp end.

At the management and organization levels, healthcare providers must provide resources to meet sharp-end demand with a supply of knowledge, skills, and access to diagnostic technologies and treatments. Increasing healthcare costs and financial pressures restrict how well demand can be resourced, leading to stresses within the system.

At the societal levels, professional associates develop standards of professional practice and manage accreditation. Regulators set standards that must be met. Patients and practitioners themselves are also members of a public whose expectations of the healthcare system have been shaped by their own experiences and by media reports of the healthcare system in crisis

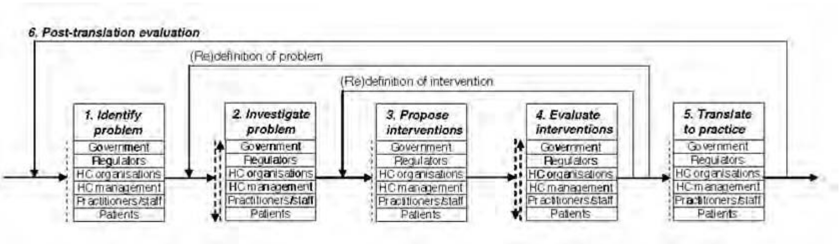


Figure 3. Problem-driven research and intervention in healthcare informatics and patient safety, using the "patients to politicians" model to maintain systems perspectives.

3.2. *Patients to politicians—and translation of research to practice*

A focus on the relationship between different stakeholders can guide the design of research programs with a strong emphasis on transition to practice. Figure 3 shows the patients to politicians model embedded in such a program, outlined in its most abstract form. Problems of any kind, including problems with healthcare ICT, can first manifest themselves amongst any group of stakeholders—from wrong-side surgery for an individual patient to political unrest at delays patients experience in emergency departments—but problems are usually caused by a complex set of interdependencies involving other levels.

As Figure 3 shows, investigating a problem must move from the level at which it manifests itself to explore its potential causes and effects at other levels of the model. Similarly, interventions might be proposed at multiple levels and those interventions evaluated at multiple levels. Finally, after translation to practice, the effectiveness of an intervention must be assessed not only at levels at which the intervention occurs, but also in other places that it might affect practice.

4. Healthcare ICT innovation and full-scale simulators

4.1. *Role of simulators in healthcare*

Healthcare ICT innovation can only succeed if design is deeply informed by practice. There is no substitute for participant observation or, even further, for a researcher being embedded in a community of practice as a learner engaged in "legitimate peripheral participation".[2] However, the behavioural research involved in moving innovative design into practice is considerably more complex, especially if innovation involves medical equipment that will come into contact with patients. Clinicians, manufacturers, healthcare organizations, regulators and, by implication, governments require objective

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[2] As an example, when starting research in the healthcare domain the author trained as an emergency medical technician in the USA in 1996 and was licensed as an EMT-A in the state of Illinois.

empirical evidence of the effectiveness and safety of innovative design—elements at different levels of the patients to politicians model in Figure 2. Such evidence must be collected while preserving patient confidentiality and safety.

Simulation environments provide a partial solution to the problem of acquiring such evidence. Many healthcare systems in developed countries around the world have simulation facilities where healthcare practitioners can learn skills relating to clinical procedures, emergency response, crisis management, teamwork and communication. Simulation centres offer a physical environment for such learning, including part-and whole-task training devices and simulators.[8]

Importantly, simulation centres also offer immersive experiences with devices and simulators. Although there is always an artificiality and sometimes a hypervigilance associated with learning experiences in a simulation centre, participants find their experiences sufficiently compelling and health care systems are sufficiently convinced of the benefits to continue investing large sum in such centres.

4.2. imulators and the system development life cycle

Increasingly, researchers are considering how simulators might be used to help evaluate innovative medical equipment or devices.[9, 10] Indeed, simulators can potentially be useful at all stages of the system development life cycle. Figure 4 shows the system development life cycle and indicates the potential role of simulators.

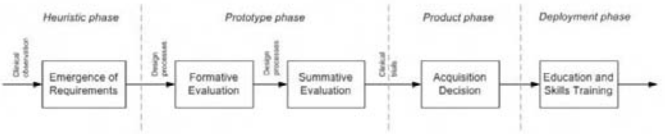

Figure 4. Phases in the use of simulators for healthcare ICT.

Currently, as shown at right of Figure 4, simulators are used almost exclusively for education and skills training in the deployment phase of the system development life cycle. Clearly, skills training is best done on the equipment that healthcare workers will encounter in the field. Still in the deployment phase, some healthcare systems are exploring the use of simulators to introduce new equipment into practice.[9]

From the above point, it is a relatively small step to contemplate using simulators prior to acquisition. For example, simulators can be used at the product phase in order to support an acquisition decision.

Simulators can also be used when a device or system is in prototype form. Summative evaluation of an advanced prototype or pre-release version of a device or system is intended to provide a "summary" or final assessment of performance against a set of benchmarks or standards prior to release.[11] Formative evaluation is more often done on a relatively early prototype in order to help "form" the final design. Design processes therefore surround formative evaluation in a process familiar to practitioners of user-centred design.[12]

Finally, simulators can also provide a context for observation of and discussion about practice that may help unmet requirements and “seeds of innovation” emerge.

4.3. Using simulators to evaluate novel anesthesia displays

Within the Cognitive Engineering Research Group at The University of Queensland, we have been using full-scale patient simulators to evaluate the effectiveness of advanced auditory and visual displays for monitoring anesthetized patients. In terms of Figure 4, our research is best described as being at the early summative stage.

Watson and Sanderson[13, 14] have designed a way of representing in sound (as a “sonification”) the values of vital signs relating to breathing—specifically, respiration rate (RR), the amount of CO2 coming out of the patient’s lungs with each breath (endtidal carbon dioxide or ETCO2) and the amount of gas being forced towards the lungs or being taken in by the lungs on each breath (tidal volume, or Vt). Watson[15] has also developed a way of representing in sound (as an “earcon”) the patient’s blood pressure (BP) as read from intermittent inflations of the non-invasive blood pressure cuff.

Figure 5. Formative evaluations of advanced auditory displays for monitoring anesthetized patients being carried out at The University of Queensland Usability Laboratory. View through control room window.

Formative evaluations were initially performed of the above advanced auditory display designs in a so-called “spartan” laboratory context (see Figure 5). The results gave us an opportunity to make adjustments to the designs.

After the formative evaluations the designs were ready for early summative evaluation, prior to consideration for potential adoption by medical equipment manufacturing companies. The full-scale simulation environment appeared to provide an ideal test-bed for summative evaluation, allowing us to bring together expert professionals, familiar and richly informative intra-operative tools, and familiar medical situations. In collaboration with colleagues at Royal Adelaide Hospital, and using the Adelaide simulator, we performed a summative evaluation of the respiratory sonification and the blood pressure earcons.[10] We also included a test of head-mounted displays of the same information that was in the auditory displays, for control purposes.

Our summative evaluation provided strong evidence that when anesthetists are distracted by other intraoperative tasks, as sometimes happens, the auditory displays were far more effective for alerting anesthetists to significant changes in the patients' status than were the head-mounted displays or current standard monitoring equipment.

Figure 6. Simulated operating theatre at Queensland Health's Skills Development Centre being set up for research on advanced auditory and visual displays for anesthesia monitoring. Photograph by David Liu, 2006.

4.4. Challenges with simulators

Despite the fact that simulators appear to lend themselves to the prototyping phase of the system development life cycle, there are considerable technical difficulties in practice in acquiring the kind of objective empirical data that encourages the interest of investors and medical equipment manufacturers in innovative designs. Full-scale patient simulators have been designed and developed to support training rather than controlled experimentation. When training sessions are run, there is usually a general goal to be achieved. For example, the simulated patient may experience anaphylactic shock and the trainee will try to exercise good crisis management skills in response. The manikin and displays will either be programmed to show the signs of anaphylactic shock at a certain point in the scenario, or the signs of anaphylactic shock will be initiated on the fly. Actors improvise their medical and nursing roles within the professional constraints of those roles, and will either take direction from the trainee or act otherwise, as the training situation demands.

Importantly, a great variety of behaviour results usually results and is improvised, based on the reactions of the trainee which are, of course, relatively unpredictable. Strict control and replication of the exact conditions leading up to the event and following the event are not needed during training, whereas they are needed when novel equipment is being evaluated against existing equipment for the purposes of generating objective empirical data.

As a result, our group needed to make considerable one-off enhancements to the simulator software environment in order to achieve the control and replicability needed.[16] Just some of the technical innovation is evident in Figure 6. This need, however, has stimulated our thinking about how simulator technology might be enhanced to better support some of the other roles that simulators might play apart from training and skills development.

4.5. From simulators back to the sociotechnical systems context

A key concern is how innovative designs might safely move from the simulator environment to clinical contexts, and so back to their full sociotechnical systems context. A summative evaluation is incomplete without such as step. As immersive as simulators might be, they do not function in the full sociotechnical systems context outlined in Figure 2. A summative evaluation in a simulator may answer some questions about how an innovative design fits into the intraperative context, for example, but the sociotechnical system being represented in the simulator is drastically attenuated compared with actual workplace practice.

By performing summative evaluation in a simulator we have addressed some of the factors that (using the terms of the Garner Group "hype cycles" in Figure 1) might cause "inflated expectations" of auditory displays for intraoperative monitoring, and have exposed the displays to some of the factors that might lead it to fall into the "trough of disillusionment" in practice, by no means have all factors been addressed.

For example, we do not know what the long-term effects of attention to auditory displays might be. We do not know whether some operating suites will allow auditory display sounds to penetrate from one operating room to another. We do not know how medical personnel moving between different operating theatres will adapt to the different sounds coming from the patients in different room. Although we have tested the displays with ambient music, as often is used in the real operating theatre, we have not assessed all situations or all relationships between the different professional groups "competing" for the auditory space (or for quiet). We do not know whether anesthetists and their staff will wish to switch between speaker-based listening and earpiece-based listening, and what the impact on other professional groups will be of such decisions. We do not know how default settings for auditory displays will be set on medical equipment and what the role of biomedical engineering departments and executive medical direction of the hospital or clinic might be in determining such settings. We do not know how patients themselves will react to further auditory displays of their own physiological functioning (beyond the existing pulse oximetry or heart monitor beeps), if such further auditory displays are active while the patient is conscious. We do not know if insurance companies will continue to require alarms even if auditory displays might give the same information in a more compelling way.

Two responses are possible. Which response is most practical depends upon resources and safety considerations. First, translating the design innovation to a carefully-selected area in the workplace is the preferred response. The impact of the design innovation on real workplace practice can then be observed. Whether this is feasible depends upon whether a safety case has been successfully answered, whether insurance will cover the trial, and whether consent can be ethically obtained from participants and particularly from any patients affected.

Second, if a trial translation to practice is not possible then simulation might again play a role. Simulation experts are exploring how simulators can be extended to support organizational simulation—in other words, simulating the functions of large-scale organizations using simulator facilities.[17] However, such level of simulation increases the expense of an already-expensive activity and risks to be assessed or benefits to be sought must be overwhelming in order to justify the investment required.

5. Conclusion

Healthcare ICT has a poor track record of enthusiastic adoption in practice. Part of the problem is the failure to address adequately during development the context of use of healthcare ICT. User studies can be effective, but such studies are not always performed at the most appropriate points in the system development life cycle, or in a way that captures the critical aspects of the sociotechnical systems context in which novel healthcare ICT will be embedded.

Simulation technology and full-scale simulators in particular can go part of the way in addressing the above problem, especially when a device or design being developed will directly affect patient care and safety is a consideration. Simulators can be extended beyond their current use for training and skills development to use for formative evaluation of innovative design during development, and summative evaluation prior to production and release. However a full use of simulators for such purposes will require technical development of simulator technology. Moreover, simulators still do not replicate the rich sociotechnical context of healthcare work. Further development is needed for methods for performing formative and summative evaluations of novel designs so that broader aspects of the sociotechnical systems context can be considered. In this way, evaluations with certain assurances can be achieved.

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Does it Work on Sundays, too? Healthcare Technology for Older People

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Abstract. The development of assisted living technology today lies within the realm of ambient computing, making assistance automatic and the systems invisible. Unfortunately, this invisibility is also the reason why the users of these systems have no means to remedy even very simple fault situations. By focusing on the needed complementarities between user control and automation, we identify three main issues which are critical when introducing new technology in the homes of older people: Individual need for representation of data, the need for the user to construct a conceptual model of the system and the need for systems to change over time.

Keywords. Palpable computing, design, home care, technology, older people, assisted living, conceptual model, data representation.

Introduction

We base this paper on multiple sources of work. The conceptual framework originates from our work in the EU PalCom project [1]; the empirical findings stem from studies of the development of healthcare technology for the home, the Eldertech project.

Much of the work done in the domain of assisted living—home health care for older people—are concepts where the homes are equipped with a host of sensors to monitor the daily activities of the person. In case of abnormalities, the system intervenes. For example by notifying the caregivers if the older person repeatedly skips meals, or by sending a message to the caregivers if the resident has fallen. These systems are invisible for the resident, and leave out most—if not all, influence on system activities.

However, invisibility should come together with visibility. In this paper we argue that visibility supports user control and invisibility relates to automation. This notion of visibility and user control is important, not only for obvious ethical reasons such as dignity and self respect, but also for the to be able to detect and correct problems. As such, we propose in this paper an approach derived from the PalCom project, where it is not a question of either user control or automation, but a combination of both allowing for shifts in visibility and user control as it is needed.

The PalCom project—palpable computing—is a new approach to ambient computing. Ambient computing denotes an environment where sensors and other computational technologies are embedded in our surroundings, taking actions or collecting data without this being visible for the users. The project aims to provide a new software architecture, which makes systems comprehensible for the users and supports user control. The challenge of finding a balance between invisibility and visibility in IT systems which is approached in this paper, is just one of several challenges identified and explored in the project.

The work presented in the following reflects upon the fieldwork done in the Eldertech project, through the perspective of visibility complemented with invisibility as defined in the PalCom project. Both projects have a multidisciplinary approach, and the authors of this paper represent three different professions, Social Anthropology, Computer Science and Industrial Design.

1. Related work section

There is a large body of work related to the area of assisted or independent living. Much of this work is inspired by Smart Homes [2, 3] and uses sensor information technology to monitor the activity and health condition of the older person. One such example is the family portrait from Georgia Tech where activity sensors placed in the home of the older person gives hints to the relatives on how the person is doing [4]. Another example is a British Telecom project where various types of sensors—such as sensors on the water faucet, on the fridge and front door—allow for caregivers to monitor the well-being of the older person [5]. Other examples are [6, 7, 8, 9, 10]. Use of sensors allow invisible and automatic monitoring of the well-being of the older person and provides a tool for intervention by caregivers if an emergency situation occurs or if there is a negative development in the older person's condition. In [11] the personal medication advisor, Chester, is an audio-visual interface to the prescribed medication of the users. Chester can answer questions about benefits and liabilities of the medication, how it interacts with other medication, etc. A behavioral agent in the system is the autonomous part that performs intention recognition based on the input from the user.

However, within this line of work very little attention is placed on making the older person an active part—the Chester system is the only one, where the participants initiate interaction with the system. In this paper we want to explore how the older person can become an active player instead of a passive object for monitoring, by providing them the means to understanding the system in use. Our claim is that visibility will enable understandability, which in turn will emancipate the older person to make full use of the systems.

2. The Eldertech study

The paper reflects on findings from a Danish research project, called the Eldertech project, with development of assisted living technology for older persons living in protected residences. The project was carried out in collaboration between the Municipality of Aarhus, IBM Denmark, and the University of Aarhus. One of the main purposes of the system was to increase the quality of life for the participants by, among other things, remote monitoring of their health condition.

Seven older persons participated in the project and had the Eldertech system installed in their homes for a period of up to three months. The participants were between 75 and 88 years old with an average age of 81 years. They all lived in protected residences and all but one received daily visits by healthcare workers who assisted with personal care such as taking baths, getting out of bed, and cleaning as well as more clinical issues such as preparing the medication dosage and care for wounds.

Throughout the project period of 9 months, ethnographic field studies were carried out involving interviews and observations of the participants and their carers. Each participant was interviewed on at least two occasions, each interview lasting at least one and a half hour, sometimes longer. Observations were made of the training classes with the participants as well as the installations and use of the Eldertech system in the homes of the participants.

2.1. Eldertech prototypes

The Eldertech system was designed to monitor blood pressure, weight and medication intake of the participants and was deployed with the following set of devices in each home: (i) A tablet PC with web access to for example a medication administration module, (ii) a one-button wireless scale for monitoring weight, (iii) a one-button wireless blood pressure monitor, and (iv) a wireless hub responsible for gathering the data from the monitoring devices and sending it to the application server (see figure 1).

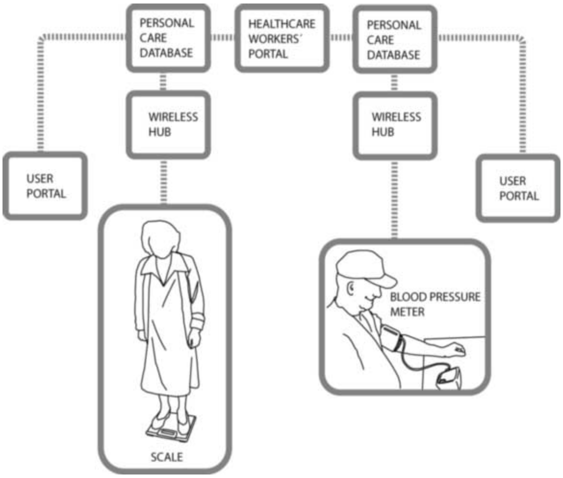

Figure 1. The Eldertech system

During the pilot, the participants used the scale and measured their blood pressure daily or frequently. All but one of the participants liked using the blood pressure equipment. Some emphasized that they themselves could keep an eye on the blood pressure; others mentioned that it was nice to know that others were monitoring it for them. The participants had very different levels of understanding of their blood pressure. Some had a very accurate and clinical understanding of their blood pressure and knew what their blood pressure should be. Others had very narrow understanding of their blood pressure knowing perhaps only that their blood pressure should not be above a certain limit.

Many of the participants liked using the scale—they liked keeping an eye on their weight as they were already used to. The scale was—as they experienced it—primarily for their benefit and something they should monitor themselves and not something that would interest the healthcare workers.

Most of the participants did not consider documenting medication intake as very useful for them. They explained that taking their medication was a steady routine [12], and thus the documentation was mostly for the benefit of others. Furthermore, some uncertainty regarding the documentation existed, as it could be difficult to establish if the medication that the older person is about to take, actually is equivalent to the medication that he signs for on the medication administration module. To establish this, the older people must know the medical name, the dose and what the medication looks like, which not all older people do, even while they are still able to manage their own medication. Lastly, all of the participants experienced some type of difficulty in their interaction with the computer. Thus, by the end of the pilot three had entirely given up using the computer, two participants used the computer regularly, and two had only infrequent interaction with the computer.

3. Visibility and invisibility

As described above, the fieldwork related to the Eldertech study showed that the participants had no specific problems in handling the blood pressure reader, nor the daily use of the scale. However, the underlying software architecture was not comprehensible for the users. The participants had no clear understanding of how the information from the scale was transmitted from the scale to the cell phone and further on to the laptop and to the Internet. Furthermore, they were aware that somewhere remotely the healthcare workers accessed the information, but they did not know when or how this would be done.

While the user was in control of how and when the measurements should be taken, they were not able to conceive what happened to the information. From fieldwork [13] with prototypes in the domain of safety critical emergency work done in the PalCom project, we have identified similar challenges related to the notion of visibility complemented with the notion of invisibility. Invisibility is related to the notion of ambient computing. Palpable computing does not reject the notion of ambient computing, however it recognizes a distinct need for the users to have the possibility of being able to inspect and to see and understand the surrounding systems.

3.1. Visibility in Eldertech

In the Eldertech system, the users were able to control and understand the scale and the blood pressure reader. They were already familiar with the scale, and all but one were happy to use the blood pressure equipment. These devices were visible, and were only activated on initiative from the participants. However, the underlying system for transmitting and collecting the data was only vaguely understood. The participant called Ida measured her blood pressure and used the scale everyday. She had a heart condition and a very unstable blood pressure making the monitoring of her blood pressure very useful. However, as she could not access the computer she did not realize that the data collected was not transferred to the computer. When she was made aware of this error she explained:

> But it was Sunday, and I think it was closed, because there wasn't light in that one [the hub in the shape of a mobile phone] on the nightstand. When I take my blood pressure, right, and weigh myself, then there's light in it. So I thought that it was closed, you see".

The visible response from the system did not support Ida in understanding the system and transmission of data correctly. Instead she inferred that the system must be closed on Sundays—just as many public services are. Making this underlying communication architecture visible relates to the following three issues.

3.1.1. Representation

Firstly and pragmatically, making the representation of data and communication present and visible. For example, the participants were very differently involved in the blood pressure readings. Anna had worked for many years as a secretary for a general physician and was quite capable of understanding the numbers on the blood pressure device. Others had more fragmented understanding and were unsure what the numbers meant or within which limits the numbers should be. Some of these participants had a diagnosis of hypertension and wanted to monitor their condition. However, there was a risk of not getting the optimal results from the monitoring of the blood pressure, as some of were unsure of the numbers and when they should contact their general physician. Some of the participants used the blood pressure device to check their immediate condition if they were feeling dizzy or had headaches. This strategy is similar to the one applied by the participants with diabetes who explained that they often measure their blood sugar level whenever they were feeling a bit uncomfortable—just to check if everything was in order or if they needed to regulate their insulin or diet. Other participants in the study who had little understanding of their blood pressure relied on the healthcare workers to monitor the blood pressure for them. These participants would have benefited from a different level of representation than the former secretary—for them it would have been beneficial to have a level of interpretation indicating if the numbers were fine or if the participants needed to contact his or her general physician. Thus, the data should be represented in a way, which complies with the different levels of interest and understanding, and feedback should be provided when for example the blood pressure device is transmitting the data.

The level of representation has already been addressed in a PalCom project with focus on pregnancy [14] where three levels of data presentation are introduced. Firstly, a flag telling the end user if the values are normal. Secondly the value of the measurement supported with a sort history of previous values. Thirdly, the same as the previous with the values and a short history but supplemented with a medical description of the meaning of the data. A similar approach could have been relevant for the Eldertech project, supplemented with an awareness regarding the network connections, in order for the users to construct a conceptual model as discussed in the following.

3.1.2. Conceptual model

Secondly, and maybe even more important, the older person should have an understanding of the system. The person should have, as already Norman described in [15], a conceptual model of how the system works, meaning that the systems should not be more complicated than a conceptual model can be established by the users: *A good conceptual model allows us to predict the effects of our actions. Without a good model we operate by rote, blindly; we do operations as we were told to do them; we can't fully appreciate why, what effects to expect, or what to do if things go wrong. As long as things work properly, we can manage. When things go wrong, however, or when we come upon a novel situation, then we need a deeper understanding, a good model"* [15, p. 13-14]. Generally, all the participants explained that they were at some point frustrated or insecure about the role of the computer and their interaction with the computer. They described how they found it difficult to use the computer and they were afraid to damage it or leave things in a different state so it would be difficult for them to find their way back to the known pages. The participants thus had not formed a conceptual model that could help them to predict the consequences of their actions and further provide them with a tool to manage a situation where things had gone wrong—e.g. where they had strayed from the known pages; if they received an error report or windows update message; or when the computer came back from repair with a slightly different set up. The lack of a good conceptual model meant that it was hard for the older people to detect problems or correct them.

3.1.3. Influence of time

Lastly, older people are not a static homogeneous group of people. Older people naturally represent the diversity in society regarding social status, education etc. Over a given period of time the older people often experience changes in their physical and mental capability [16]. When designing for older people such development must be taken into account allowing both for the person to monitor his or her own health and with time allowing for healthcare workers to monitor the health condition of the person person, when she is no longer capable of doing this her self.

During the pilot period of nine months, all the involved participants were hospitalized for shorter or longer periods. This naturally resulted in sometimes dramatic changes in the condition of the participant. Occasionally, it changed to the better, but mostly to the worse. Changes in the health condition result in changes in requirements for the system. Functions and devices, which before had a high degree of visibility, user control and understandability due to the skills and interests of the older people, might suddenly need to be invisible with a high degree of automation. For instance, feed back information regarding network connections may become irrelevant, and a representation level may need to move to a more simple level. IT systems for older people thus need to comply with changes in system requirements and changes in demands on representation levels.

4. Palpable IT support

The three challenges described above must be met when designing the system infrastructure and the physical devices. In order to make the necessary details visible, dedicated technology is important. When data flows from e.g. the scale to the system, it should make sense to the user. In order for it to make sense, the user has to have a mental model of the system. This mental model could stem from a well-written manual, but could (and should according to PalCom) also be inherent in the system. In their understanding of the world now, the scale and the blood pressure meter makes sense, and the challenge is to extend this understanding to the system as a whole. The special feature of these two known devices is that they are dedicated and thus easy to get an overview of. In the setting from the Eldertech project, a laptop served as the central processing unit of the system. But the laptop is a device intended for general use, the grand children can play with it, it can be used to access the Internet, etc. This means that it is impossible to get an overview of the possibilities of the device. Also, since a number of unrelated uses take place on it, it makes the users uneasy, both because they are afraid that the system will be broken and because it can be difficult to see how to get back to the right interface.

With a dedicated device for storing and accessing personal measurements, the users will get the visibility that can provide them the understanding they need to feel secure with the system and make use of it. When adapting the system to the user's changing needs and wishes, more devices will need to be added to the system. PalCom has a design proposal for an open architecture, which would be applicable in this setting. The overall architecture is sketched in [17], and described in detail in [18]. A specific part of the architecture is the composition of services into assemblies [19], where the services are the different sub-functionalities provided by the different devices and the assemblies are the assembled functionalities that the users are interested in. The link between the services in the assembly is made visible in PalCom, which makes it easier for the users to create a mental model of e.g. data flow, even with a number of devices in an assembly.

5. Conclusion

Much healthcare technology for older people today lies within the domain of ambient intelligence where the information technology is invisible to the user and reacts automatically to e.g. sensor input. However, with the invisibility comes a loss of user control.

Through fieldwork experience we have identified three issues that needs to be addressed when designing for older people. First of all the need for different levels of representation, as not all users have the same need for information. Secondly, the system should support the older person in construction of conceptual models. Thirdly, there is a need for the system and the system configuration to be able to change over time with the development of the elder.

To meet these challenges, we have outlined an approach to guide the further development and design of healthcare technology—an approach of palpable computing where visibility enables the older person to create cognitive models of the system in use and choose levels of representation continuously over time. This is achieved through a PalCom system architecture, which takes into account the possibility of balancing the needs for visibility and invisibility. Thus balancing automation and user control through continuous construction and deconstruction of physical artifacts of dedicated devices and services.

This approach denotes a new course within healthcare technology for assisted living, making the older person an active subject rather than a passive object for invisible and automated monitoring by remote healthcare workers. This turn is important for several reasons. First of all, it is a matter of dignity. By letting the technology develop with the elder's condition and needs—both in regards to mental and physical conditions and hence in regards to the level of representation of data—it will enable the older person to maintain control in his or her own home for a longer period of time. Secondly, it speaks to more practical issues—namely of deploying and debugging. Having experts deploy more or less trivial healthcare technology is costly and furthermore minimizes the older persons understanding of the system. Likewise, the lack of user control consequently means that all debugging must be carried out by experts, including where the power supply has been switched off accidentally, another window is covering the interface on the laptop, or other obviously simple fault situations apply.

There lies a dignity in deploying and debugging, that the older people can win from using palpable technology.

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Embracing Standard Treatment Manuals: Information Transfer to Primary Health Workers in Papua New Guinea

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Abstract. Papua New Guinean primary health care workers describe their Standard Treatment Manuals as like “a teacher” or “a doctor”. This paper explores this glowing reference, looking at how Standard Treatment Manuals are utilised, through data collected in a study which identifies what influences primary health care workers in Papua New Guinea to access and utilise information for diagnostic and treatment decisions. In addition to presenting a unique perspective on this method for transferring information to health workers across the world, this paper presents an opportunity to consider some of the factors which both enable and inhibit the process of providing information to health workers in a non western culture.

Keywords. Information transfer, Health information, Treatment guidelines, Developing countries

Introduction

Similar to the protocols and guidelines produced by authorities in countries such as Australia and America, Papua New Guinea (PNG) has developed Standard Treatment Manuals (STMs) for paediatrics, obstetrics and gynaecology, family planning as well as more general adult health concerns. Developed by teams of medical experts and overseen by the PNG Ministry of Health, these four STMs provide health works with guidelines for the management of most of the common disorders found in PNG, as well as where applicable detailed tables of drug dosages [1].

The aim of these STMs is to ensure that health workers make decisions based on the best available information [2] and provide standardised treatment, based on the principals of evidence based medicine (EBM) [3]. While in the past EBM advocates sought to replace the decisions made by practitioners with evidence based research findings, the current belief is that EBM is more successful when it *integrates individual clinical expertise with the best available external clinical evidence from systematic research* [4], and this is the goal of the PNG STMs as articulated in the PNG National Health Plan 2001 – 2010 [5].

The Paediatrics STM, first developed in 1974 and currently in its 8th edition, has been particularly successful in working towards the principles of EBM. Approximately every 5 years, proposals for changes to this STM are sought from a variety of sources including paediatricians, senior policy makers at the Ministry of Health; as well as researchers from a variety of disciplines. These proposals are then reviewed by a small committee of senior members of the Paediatric Society of PNG and if considered to meet specified criteria including the reliability of evidence, appropriateness for the PNG context and sustainability, the proposed changes are included in the next edition. Examples of changes made to the most recent edition include the introduction of *zinc for the treatment of diarrhoea, nevirapine for mothers and newborns to prevent vertical transmission of HIV, use of innovative spacer devices in asthma, ceftrizxone for first-line treatment of bacterial meningitis and Hib vaccine*, all of which were based on research conducted either in PNG, or internationally with a PNG context in mind.

While the other STMs in PNG are not always reviewed and/or disseminated in such a systematic manner, they are still in circulation [1,6]. For example the 5th edition of the Adult STM developed in 2003 and although currently out of print has previously been distributed to some health facilities. Where this edition is unavailable, previous versions are being used. The 4th edition of the Obstetrics and Gynecology STM developed in 2000 is currently in use with the next edition under development, and finally the most recent 2nd edition of the Family Planning STM was first produced in 2000.

Although studies have shown that written standards and guidelines which are underpinned by the principles of evidence based medicine, can assist in reducing the burden of disease, particularly in developing countries [7,8] anticipated or hoped for outcomes are not always realised [9,10]. Therefore in addition to exploring the acceptance of these STMs among primary health care workers (PHCWs) in PNG, this paper introduces a conceptual framework which can be used to examine a broad range of factors that may either enable or alternatively inhibit their use.

Literature review

A key factor that has been found to determine the acceptance and use of standards, protocols and guidelines which are similar to the PNG STMs, is the dissemination process which depends on a variety of factors at a national, organisational and individual level for it's success [11,12]. One model specifically developed to better understand this process [13] highlights four distinct but progressive steps. Firstly, according to Freed et al (op cit) [13], health workers must be aware of the resource being disseminated. Secondly, they need to not only understand but also agree with the usefulness of the information it contains. If the first two steps are successful, adoption may proceed, which usually involves a change in practice or practices. However the process does not end there. Dissemination is only realised through the final stage of adherence, which involves the consistent and ongoing use of the information contained within the resource.

Various approaches have been used to study the implementation of these same standards, protocols and guidelines. Rogers' Innovation Adoption Model [14] was employed to investigate one dissemination and implementation process [3] while others have taken a quality improvement approach [15]. However the dissemination of standards, guidelines and protocols may also be viewed as an information transfer process, where health information is developed by a source, in this case teams of medical experts employed through the PNG Ministry of Health, for transfer to and use by a number of recipients, namely health workers in PNG [16].

At it's most simplest level, information transfer such as this may be discussed as a process where information flows from a source to a receiver [17-19]. Yet other studies have shown that it is much more than this, weighing heavily on the shoulders of the individual's involved for success, being particularly influenced by the personalities [20] perceptions and values [21], cognitive capacities [22,23] and the motivations [24,25] of the people involved.

In addition individual factors, the information transfer can be affected by the context in which both the source and the recipient reside. Sun & Scott [26] describe the individual's, team's and organisation's culture as potential barriers to transferring knowledge between individuals. Other barriers could include differences between the languages [27], communication styles [28] and cultural preferences [26] of the source and the recipient, adding to the complexity of the information transfer process.

Building a Conceptual Framework

Symbolic Interaction, a social psychology theory embraces this complexity, believing that individuals are both influenced by, as well as an influence on the context in which they reside [29]. However Symbolic Interaction goes one step further suggesting that in order to better understand activities such as information transfer, it is also important to understand the actions of individuals involved. By studying specific actions we can better understand not only the individual's perspective but also that of the broader group [30], Therefore a conceptual framework for information transfer must not only focus on the "Pre Existing Context" including such things as organisational culture or the prior cognitive capacity of the individuals involved, but also the actions involved in transferring the information, including the "Interaction" between a source and a recipient, the recipient's "Decision" on whether or not to use the information provided and the final "Outcome" if any, of the information transfer. These four separate but interconnecting domains will now be discussed in more detail.

The "Pre Existing Context" includes that which exists at the time of the interaction. This may include but would not be limited to the individual's motivations and perceptions for example, as well as the perceptions of significant others such as family, colleagues or existing groups, and institutions. In addition existing infrastructure, resources technology, geography, space and nature may potentially influence an individual's actions [31] and therefore should also be included in this domain.

The "Interaction" however is never pre ordained by a "Pre Existing Context". Perceptions may change as the "Interaction" takes place. Recipients may be won over by a particularly forceful argument or disenchanted by an over zealous source. Realising that the Pre Existing Context can influence an individual's actions, the process of interacting is the primary focus of this domain.

The recipient's "Decision" about whether to utilise the information provided by a source, will depend on what meaning they give to the "Interaction", which as pointed out earlier may or may not be influenced by the "Pre Existing Context" [32,33]. Their "Decision" may in some cases stimulate further interaction, creating a circular process until the information transfer is finalised in one way or another [33]. What is important in this domain is how recipients make decisions.

The "Outcome" of the information transfer process does not however end with this "Decision" to accept or reject the information provided. The last and perhaps most important domain for the successful implementation of STMs in particular, is whether they are used to change practice [34,35]. Whatever the "Outcome", this in turn becomes part of the "Pre Existing Context" influencing the next information transfer process.

Two unusual aspects emerge from this literature. First it suggests that each part of the process impacts upon all of the other parts [32,33]. The "Pre Existing Context" such as the language used, for example affects the "Interaction", the "Decision" and the "Outcomes". Likewise we can say that in turn, the "Interaction" impacts upon the "Pre Existing Context" because any exchange will affect the individuals involved.

Second it is interesting to note that the key to the success of the process is the person receiving the information [25]. If the recipient either cannot access or does not want to use the information provided, the process from the point of view of the provider, may have failed. It is therefore particularly important that we know about the people receiving the information, in order to provide the most appropriate conditions for a successful information transfer process.

These two key points together with the above four domains of Pre Existing Context, Interaction, Decision and Outcomes have been used to develop a Conceptual Framework for Information Transfer (refer Figure 1), which will now be used as a framework for investigating how STMs are used to transfer information to primary health care workers in PNG.

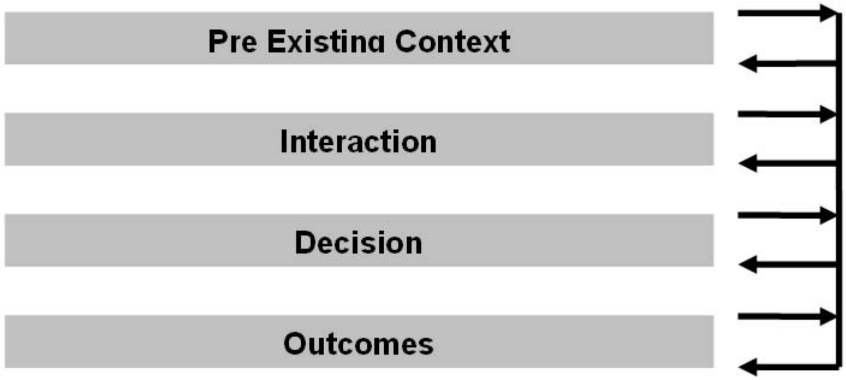

Figure 1. Authors Conceptual Framework for Information Transfer

Methodology

In order to begin to better understand how information is accessed and utilised by PHCWs in PNG, a study is currently underway which is looking at the "Pre Existing Context", what type of "Interactions" already occur, how PHCWs make "Decision" about what information to use and what are some of the typical "Outcomes". This study does not attempt to judge the quality of content provided although of course this is very important. Instead it is trying to identify a way of improving the information transfer process which in turn will assist PHCWs to develop better health services.

Nearly 70 interviews with PHCWs were collected over a 12 month period between 2005 and mid 2006 (refer Table 1). Permission was provided by Provincial Health Advisors and other appropriate health managers to approach staff working in a variety of primary health care facilities situated in the Eastern Highlands, Madang and East Sepik Provinces. After being provided with both oral and written information in Tok Pisin or English, staff were invited to participate in a taped individual semi structured interview which lasted for an average of 45 minutes.

Three levels of PHCWs were included in the study. Community health workers (CHWs), previously known as aid post orderlies, and nursing aids, receive up to two years of basic training. Nursing officers graduate with a nursing certificate after 3 years and are responsible for the provision of basic medical services. Health extension officers (HEOs) who bridge the gap between doctors and nurses qualify after 4 years of training, and often operate in senior management positions [36,37].

These individuals provide services within one of three types of primary health care facilities. The largest, District Health Centres are usually assigned at least one HEO, as well as several nursing officers and CHWs. Sub Health centres, operate under the supervision of these District Health Centres and are staffed primarily by CHWs, overseen by a nursing officer. Aid posts, the third type of primary health care facility usually serves more remote communities, and are staffed by a single CHW [38,39].

Table 1. Details of PHCWs and associated personnel interviewed

PHCW **FACILITY**	**Community Health Workers**		**Nursing Officers**		**Health Extension Officers**		**Other Positions****		
	Male	Female	Male	Female	Male	Female	Male	Female	Total
Aid Post	9	4	0	0	0	0	0	0	13
Sub Health Centres	10	12	2	3	0	0	1	0	28
District Health Centres	6	3	1	5	1	1			17
Other Facilities*							9	2	11
	25	19	3	8	1	1	10	2	69

*Other Facilities Other than PHC facilities, including Provincial and District Health Offices

**Other Positions Other than PHC Workers, including managers, supervisors, health consultants

Results

One of the most common forms of written information in PNG, according to participants in this study, are the STMs. These small A4 size booklets are developed specifically for health workers, provide written information in English on the treatment of common illnesses and other health conditions occurring in PNG including drug dosages. A separate STM is available for children, adults, obstetrics and gynaecology and family planning.

First and most importantly almost every participant described the STM in glowing terms.

> The Standard Treatment Book is our teacher or like our doctor. So we use the treatment, Standard Treatment Book and give them according to their weight.

> It [Standard Treatment Manual] is like my bible.

> The Standard Treatment Books are the easiest.

> They are good. They help us a lot. It is very hard work here. We have forgotten what we learn from school so these books help, they help me.

In particular they felt that this resource supported their initial training, with many participants remembering reminiscing about lecturers or teachers referring to these manuals throughout their course.

> One section of the nursing calculation is based entirely on being able to read and interpret properly the Standard Treatment Book.

Therefore it is not surprising that a lot of these PHCWs said that they referred to the STMs regularly, particularly when they were not sure of the treatment they should give.

> But I cant remember everything. So we use the book [STM] all of the time.

> As soon as I am not sure I used to look up the standard treatment book, either the small children or the adult book. And then I get the information from that and then I treat them

> if something is not clear, I am not clear about the new treatment, I look inside the Standard Treatment Books.

However there were a few participants who were honest enough to say that they hardly if ever used this source of information.

> From experience sometimes I give medicines, I just do what I learn and from what I experience with other cases I go ahead.

> Um. I am not really sure if they use them all the time. Because every time when they refer the patients in I have to go through and check that it is right. And sometimes I see that there is slight differences in medications and a little bit lower so I can adjust it.

> That should not help me to go back to the Standard Treatment Book, I have already memorized.

And still others, including many supervisors suspected that some of the staff rarely referred to them at all.

> I think it will be easy for them to use the Standard Treatment Books. But sometimes they find it hard, they cant understand what is written in there instead they ask one of us.

> Now all this new CHW they know how to use the blue book and they follow. But the old ones, they are unable to. In the aid posts you will find some old CHWs, men they don't go through these books. They just, I don't know how they treat their patients in the remote areas, all these APOs.

Because participants thought so highly of the STMs, we were interested to find out why some people were reluctant to use them. According to our preliminary analysis, there appears to be a variety of reasons that they may not be used. These included several participants who felt that they could rely on their memory and therefore did not need to refer to the books.

> We don't have any things apart from that we use our skills and experiences from which treatment we give the patient and then, we see they are healed and from that past experience we give the same treatment over.

> Sometimes they [PHCWs trained before 1980's] talk a lot on their experiences. And they argue with us, about what changes are coming in now. They think their experiences are best.

> I know from that about the 14 to 15 years of experience, there was nothing that was new.

> So sometimes they just do it by experience, but they can do things this way, they react day to day.

Yet other PHCWs reported that they weren't comfortable using the STMs because they were not always easy to understand. Sometimes for instance the information was too complicated and there wasn't always someone around that could answer their questions.

> Because new things are in there [the STMs] and without them going through with the supervisors I think it is hard, hard for us to understand. Unless we go through the in service and then they teach us what is new treatment around.

Another reason participants gave for not using the STMs was that it was difficult to learn new things by reading alone. They explained that while the information provided was understandable, it was hard to remember, and felt that most primary health care workers would prefer a chance to see or even practice the suggested changes under supervision, prior to use in the field.

> By reading book only won't help us that much, we go for training and practice on a patient, look at it and diagnose it is good. We just sit down and read book, patient comes and tells his story it's not good. But when you go to in service and there's a patient who is sick. I feel his body temperature and say he's sick like this and this, it's good. Sitting down nothing, just reading book is not good.

In some cases the fact that the manuals are written in English prevented people using them. While, very few respondents admitted to not being able to understand English, they knew of "other" PHCWs who they believed may find it a challenge.

> Like, now a days we work with many fathers. It would be better if we have a standard treatment book in pigeon it will be more better.

> So sometimes when I read a book, like this Standard Treatment Book I find it hard to understand the words, about different diagnosis. They use words I don't understand.

> But some men when they look in these books, or some old men they don't know English very well. It is hard now, for treating well.

In many instances staff also spoke of a shortage of basic resources referred to in the manuals such as weighing scales, thermometers and some medicines were not always available. PHCWs could not in these instances use all of the information provided.

> The treatment books, and the drugs, not forgetting the drugs. We can not sit here if there are no drugs. They are all important. The ones here, they work together to help us.

> [we] don't have much equipment, [or] plenty of drugs, the treatment we have been told to use on the patients, the right kind of treatment is not possible. Also we just, we just attend to patients using, improvising things.

In other cases participants comments hinted at a degree of scepticism about the currency of, or ability to provide the necessary information.

> No not 2000. Oh yeah you are right 2000 [year of the STM available at this facility]. But now others have the newer version that this aid post does not have.

> We havent got the others, the newer versions that have not come in yet. We just ran out, and only that one there.

> Some of the cases are maybe not in the standard Treatment Book. So I think that it is best they, you know because new dosage are coming up and doctors

> will be to must look through this again and you know review the Standard Treatment Books.
>
> Because the standard treatment book is a bit alright but generally what those that when we, we work most closely with the special, so we need specialists, so we need STI with changes.

Finally observations suggest that a lot of the rural facilities do not have all four STMs, and some do not have any at all.

Discussion in relation to the Conceptual Framework

The above data suggests that the glowing terms which are used to describe STMs in PNG are in most cases well deserved. Many of the participants not only spoke about their usefulness but were able to provided concrete examples of how they used them. Yet while this positive description remained consistent, the data also suggests that in some cases they are rarely, if used at all. This may appear at first glance to be a contradiction, with no explanation. However the answer may lie in the descriptions that liken this resource to "a bible", "a teacher" or even "a doctor", implying knowledge passed down from a "higher authority" which may be difficult to challenge or criticise. Although discussions of this power relationship are beyond the scope of this paper, the Information Transfer Conceptual Framework (Figure 1) may be useful in investigating why STMs are utilised in some circumstances, but not others.

The Pre Existing Context

Firstly we should consider whether the information being transferred by the STMs, suits the Pre Existing Context. One issue which could potentially inhibit it's use are the varying educational levels of PHCWs. While the manuals are written specifically for Drs, HEOs and Nurses, it needs to be recognised that they are also one of the few resources available to CHWs, who may not have had the same educational opportunities. This is of course not the first study to suggest such a finding. Haynes and Haines [12] noted that pitching information toward the audience's educational level was crucial to effective implementation of guidelines, and Mphil et al [9] found that varying education levels between nurses involved in a dissemination of guidelines study, increased implementation complexity.

As a result of the varying levels of education, some PHCWs may find it particularly difficult to understanding written English. Again, in most cases this applies primarily to CHWs, however with an estimated 820 languages currently used in PNG [40], whatever the level of education, most of the population considers English to be their second language [41].

Finally, the data also suggests that all information providers need to be mindful of the PHCWs environment. While some urban centres for example were reasonably well resourced, other facilities lacked access to the most basic equipment such as weighing scales and thermometers which are often referred to in the STMs. In addition some participants also spoke about a shortage of drugs required to treat the simplest of conditions. The study by Haynes & Haines [12] also highlighed the provision of appropriate resources as an essential factor for promoting the use of guidelines. Providing information without the appropriate resources may simply add to the stress and anxiety of these health workers [42].

The Interaction

The Interaction or interactions between the source and recipient occur, in this case when the PHCW reads the STMs. One of the benefits of written information is that it can be used over and over again, by more than one person. While the use of resources like the STM also promote the use of standardised information, reducing the possibility of inappropriate treatment [2].

However the downside of using this method for transferring information is that it is a one way process. Written information such as this limits or in many cases prevents the degree of interaction that could in other methods such as face to face meetings, take place between the source and the recipient [43]. Therefore if PHCWs have questions or are not clear about the information provided they must go beyond the information provider for help. In some cases this assistance is available from work colleagues, but in rural aid posts this option may not be immediately possible, if at all.

Written information has also been criticised for constraining the flexibility of language, which could in other circumstances be changed to meet the personal preferences and cultural contexts of the recipient. Tomasello [44] understood the need for this flexibility, believing that language and meaning is specific to a particular group. This goes far beyond Hofstede's [45] theory of a national culture, instead suggesting that communicators need to be aware that cultural differences can also occur at even a community level.

Any sort of interaction should also take into consideration the environment of the recipient. Research suggests that the pre existing context including factors such as lower literacy rates and lack of resources may effect the success of providing information to non western countries [46-48]. In addition the strong preference for oral communication in areas like PNG may need to be considered when transferring information in this way [49].

Another concern highlighted by the participants in this study is that not everyone has been provided with the latest version of the STMs, and therefore any decisions may be based on outdated information. How often information needs to be updated, and how this may in turn affect the perceptions of the manual's worth is difficult to judge particularly as most participants described the STMs in such glowing terms. However it is important to note that some PHCWs felt that they were unable to access current information.

At other facilities where they have no STMs the interaction does not of course, occur at all. One of the consequences of limiting dissemination to larger urban facilities may be to further apotheosize this resource or privilege some PHCWs above others. In general rural aid posts are the last to receive updates and in a lot of cases operate with old editions or nothing at all. While there may be very good reasons for this including budgetary restraints or the realisation that STMs written in English may be of little use to some CHWs, restricting their use may send a message which says that these are restricted to the "educated" or a certain "class".

The Decision

So when it comes to making a decision about what information to use, in some cases PHCWs are left with no choice. Either because of factors which make up the pre existing context such as a language barrier or unavailable resources, or the interaction itself which did not take place or resulted in misunderstandings, some of these participants are not able to utilise the information provided in the STMs. Thus their decisions are primarily based on what information and resources are available at any particular point in time, rather than the aim of the STMs which is evidence-based information.

Other studies have identified similar factors that impacted upon the health worker's decision to utilise standards, protocols and guidelines. Freed et al (op cit) for example identified two categories of influence. The first being environmental characteristics which corresponds with our pre existing conditions although they focus primary on facility resources. Secondly, they felt that information characteristics also contributed to guideline implementation. This area primarily centres on information content and dissemination processes. Apart from the degree of detail within each of these sections the difference between this paper and they one published by Freed et al (op cit) is the reference to a Information Transfer Conceptual Framework (refer Figure 1) which defines 4 distinct but interconnected domains.

The Outcomes

Resources such as standards, guidelines and protocols if used correctly, have shown to increase the use of the standardised evidence based practices [7,8]. This study to some extent reinforces this belief, with the data suggesting that some participants not only hold the STMs in high esteem but also provide examples of their use. However, there are also reports of lost opportunities where the participants either did not or could not utilise the information provided.

Conclusion

While the findings of one study can never be representative of a single geographical area, let alone the whole country, this article does suggest a conceptual framework (refer Figure 1) which rather than prescribing a generic procedure, can be used to create an information transfer process which meets the particular needs of the individuals, the organisation/s as well as the wider communities involved.

This of course leads to numerous possibilities for further research. Firstly the Information Transfer Conceptual Framework (refer Figure 1) needs to trialled in other settings to identify the differences and similarities that may occur. The conceptual framework will also benefit from additional research on each of the four domains individually and as interacting parts of the whole process. In addition the author suggests further research to identify the extent to which factors within each of the identified domains can both potentially enable as well as inhibit this type of information transfer.

One of the primary messages from this paper is however that the STMs are extremely well regarded by the participants in this study, which is a key factor in assisting with their implementation [9]. Despite the fact that they are held in such regard however, factors within each of the four domains of Pre Existing Context, Interaction, Decision and Outcome, appear to constrain the process of transferring information. Therefore to further exploit this willing audience, the Information Transfer Conceptual Framework (refer Figure 1) suggests that if factors within each domain should be identified and addressed.

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Complexity and its Implications for Health Systems Implementation

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Abstract. The National Programme for IT in England is an ambitious programme comprising a variety of systems from the tried and tested to the new based on new government policy that is being implemented at the same time. For such a large and complex programme, it is not surprising that there are a variety of outcomes emerging. While there are many successes, there are also delays and concerns. This paper looks at two very different systems in the programme (Choose and Book and PACS). It compares and contrasts their implementation within a health community and identifies implications, based on complexity theory, this has for the choice of approach to implementation of associated change.

Keywords. Complexity, complex adaptive system, implementation

Introduction

The English National Programme for IT (NPfIT) is briefly explained followed by descriptions of two elements of this programme, namely the Choose and Book and Picture Archiving and Communications (PACS) systems and their implementation. This is followed by an analysis of the comparative complexity and cultural impact of these systems.

Given limited implementation resources, these need to be deployed to ensure success but not wasted on activities that are unnecessary. This paper compares and contrasts the implementation of two of the systems within a local health community. It suggests that adopting implementation approaches that are tailored to the specific needs of the different projects can lead to improved success. An assessment of complexity can assist in the selection of appropriate approaches. Such tailoring can ensure greater acceptance by stakeholders and less error in revised processes used with the new systems.

Much published work in this area has focused on systems design or evaluation. This paper focuses on using the same principles to design the implementation.

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1. Context

This paper is based on the experience of implementing the National Programme for IT within the West Essex health community. This local health community comprises an acute hospital operating from one large and three smaller sites, three Primary Care Trusts responsible for the healthcare of different geographical areas, and about 40 general practices. Senior management was enthusiastic and provided support and resources for the successful implementation of the systems. Clinicians needed to understand the implications for themselves and for their patients before engaging fully in the programme. The governance arrangements for the programme comprised hierarchical structures and defined processes linking local organizations, through Strategic Health Authorities and Clusters, to the Department of Health.

1.1. National Programme for IT

The programme originated from the 1998 Department of Health strategy entitled 'Information for Health' [1]. A supporting document [2] outlined the information and IT system required for delivery of the NHS Plan [3] and to support patient centered services. 'Securing our Future Health' [4] concluded that to meet people's expectations and deliver high quality the UK needed to devote more resources to healthcare matched with reform. Information and communications technologies (ICT) were recognised as a major driver of this reform. NPfIT was formally established in October 2002 to procure, develop and implement modern, integrated IT infrastructure and systems for all NHS organisations in England by 2010.

NPfIT is a wide ranging programme covering national infrastructure and applications as well as applications to support local organisations. The systems and services of a Local Service Provider (LSP) were procured nationally. The implementations, which were the responsibility of local organizations, were performance managed to achieve dates set nationally.

NHS Connecting for Health is the agency of the Department of Health whose purpose is to deliver the National Programme for IT. The national contracts were for the technical implementation of systems with suppliers being paid once this had been achieved locally. Achieving the changes in working practice were the responsibility of local organisations even where process design across the NHS was required for successful operation of the systems as in the case of Choose and Book.

The local and national systems offered through the programme had a good fit with the strategy and business needs of the acute hospital although this was less so in primary care. Due to various changes in national strategy over recent years, the implementation of modern information systems had been delayed or deferred on a number of occasions and few systems met the current needs of the local organizations. Replacement of legacy systems was not an issue since both management and clinicians well appreciated that these no longer supported the provision of good patient care nor met business requirements.

1.2. Choose and Book

Choose and Book is a national service that requires General Practitioners to offer patients a choice of service provider for their first specialist outpatient appointment. It also enables choice of date and time. In the words of Connecting for Health "It revolutionizes our current booking system, with patients able to choose their initial hospital appointment and book it on the spot in the surgery, or later on the phone, or via the Internet, at a time that is more convenient for them."[5] A number of health communities had prior experience of electronic booking of first outpatient appointments using an e-booking system and many GPs already offered some choice of provider. The mandatory requirement to offer choice was new.

The information system to support this is called the Choose and Book system. It is a single national system that interfaces with a variety of General Practitioner systems and hospital patient administration systems (PAS) or hospital information systems (HIS). Hospitals publish their directory of services, with dates of sessions and available appointment times provided by PAS or HIS. The national system polls local PAS/HIS overnight to update available appointment slots. Primary Care Trusts enable those hospitals with whom they have a contract to be seen by GPs within their area. Once an appointment is booked on the Choose and Book system this is transferred to the hospital PAS/HIS system.

To work successfully, the process of booking would change fundamentally. The process required to ensure that patients successfully received the date and time of appointment needs to be understood by all those involved in it, including the patient. Providing an appointment at a place and time of the patients' choice, and with a consultant appropriate for their condition, involves process design across diverse organizations. This was to be achieved through the local (health community) implementation of a national system. Most GPs welcomed the direct booking although many had reservations about offering the choice. Direct booking was a substantial change to the way of working of hospital consultants with less flexibility to transfer to another clinic when a GP had referred inappropriately.

1.3. PACS

The Picture Archiving and Communications System (PACS) enables images such as x-rays and scans to be stored electronically and viewed on screens, so that doctors and other health professionals can access the information and compare it with previous images at the touch of a button [6]. Benefits include elimination of lost x-rays, staff safety (eliminates chemicals) and patient safety (fewer repeat images) and the potential reduction of the time between imaging and report and image availability.

While there is considerable advantage in sharing images across organisations, for example cancer networks, the initial implementations tended to focus on the hospitals within a single Trust. The systems being implemented as part of the national programme had previously been implemented in other hospitals and were tried and tested. Clinicians were demanding PACS to improve clinical practice rather than being required primarily to support government policy, although there is little doubt that PACS and other systems were required to support the government's new referral to treatment time of 18 weeks [7].

2. Complex System

2.1. Definition

Many experts now view the NHS as a complex adaptive system [8,9]. A complex system as Allen defines it is “Any system that has within itself a capacity to respond to its environment in more than one way.”[10] A complex system encompasses notions of predictability and unpredictability, of order and disorder, of regularity and chaos and of self organizing systems with emergent properties. The interaction between different components of the system can produce unpredictable behaviour. Another important feature is that complex systems have a history and are sensitive to initial conditions.

A complex adaptive system is self organizing in that it changes as a result of changing circumstances and learns to adapt to changes in circumstances, actively seeking to benefit from the changes. Lewin and Regine suggest that by understanding the characteristics of complex adaptive systems in general, we can find a way to understand and work with the deep nature of organizations [11]. The NHS as a whole has these characteristics as do the individual semi-autonomous organizations that make up the NHS, for example individual healthcare providers in primary, secondary and tertiary care.

As indicated by Aardt, we might consider both the business information system and the organizational environment as interacting complex adaptive systems [12]. Theory suggests that the systems will be used in ways that were never intended and, by implication, ways for which they were not designed. In particular, it is suggested that the historical nature of designing systems to support sequential processes can cause particular difficulties. McMillan further suggests that “the linear, simplistic approach leads to an assumption that the same methods and approaches will work with everyone more of less effectively – that a successful model of organizational change may be used in a number of organizations with similar results.” She goes on to point out that understanding of the sensitive dependence on initial conditions suggests that this is most unlikely [13]. The healthcare programme in the UK entitled “Do Once and Share” relies on the principle of using the same model across many organisations [14]. Teams of clinicians share their experience once at a national level to identify best clinical practice. At the same time they review the specification for new IT systems and service. It is intended that this standard approach to care, which aims to make optimal use of IT systems, is then shared and implemented across the NHS. While this process can offer a framework, without sensitive adaptation locally, the implementation of complex IT systems in this manner can at best only expect to achieve limited success.

2.2. Assessing complexity

The method used here for assessing complexity is an adaptation of that proposed by Weidong and Gwanhoo for grasping the complexity of information systems development projects [15]. They developed a measurement along two dimensions: organizational versus technological and structural versus dynamic. The measure is used here in a qualitative manner for the comparison of the relative complexity of the PACS and the Choose & Book systems. Table 1 describes the categories of complexity.

Table 1. Categories of complexity

Category	**Description**
Structural Organisational Complexity	Nature and strength of relationships between the project elements and the organizational supporting environment: top management support, clinical engagement, capacity and competence of project staff
Structural IT Complexity	Coordinative complexity among the IT elements: diversity of user units, variety of technology platform, level of interoperability, diversity of external vendors
Dynamic Organisational Complexity	Rate of change in organizational environment: changes in user requirements, information needs, business processes and organizational structures, impact of the IT on the organizational environment
Dynamic IT Complexity	Rate of change in the IT environment: changes in IT infrastructure, architecture and development tools

Using the schema in Table 1 the PACS and Choose & Book systems, and the organizational environments in which they are being implemented, are compared.

Table 2. PACS and Choose & Book compared

Category	**PACS**	**Choose & Book**
Structural Organisational Complexity	The project derives from an expressed need of clinical radiologists and is supported by top management because of the potential financial savings and improved quality of care. Stakeholders are limited to a single organisation (radiologists, radiographers and main specialty consultants) and its immediate partners providing diagnostic imaging. Local governance structure incorporates all stakeholder groups. Financial structure for project encourages local organisation to meet nationally imposed implementation targets. Project staff competency limited in area of business and process change.	This project is derived from central government policy to offer choice of healthcare provider for patients. While the direct booking of outpatient appointments has the support of GPs, neither booking nor choice has the support of the majority of consultants: clinical engagement is low. The number of organizations and stakeholder groups involved in system use is high: including GP practices, PCTs, acute hospitals (clinicians and administrators), Clinical Assessment Centres, NHS Direct (appointments line) and patients. Local governance structure excludes stakeholder groups. Structure of nationally imposed targets for implementation provides little incentive for individual local providers to meet them. Project staff competency limited in area of business process change.
Structural IT Complexity	Tried and tested systems, implemented and operated locally. Interoperability with single instance of small range of radiology systems from single supplier.	New systems operated via a national network. System designed for sequential process when operation can be non-sequential. Interoperability with multiple instances of large range of PAS and GP systems from multiple vendors.

Category	PACS	Choose & Book
Dynamic Organisational Complexity	Introduction of independent diagnostic and treatment centres. Changes the way in which radiologists report and the way main specialty clinicians assess images. Eliminates chemical processing and film handling. Introduction of 18 week referral to treatment target. Main stakeholder community relatively stable (acute clinical care).	Changing structures and main business processes of PCTs and GPs, including practice based commissioning. Changes the process by which the GP refers patients, patients organise appointments and hospitals process referrals, bookings and outpatient sessions. Implementation of several government policy initiatives that will impact on processes and behaviours in ways that are difficult to predict. It also impacts on the power and status of senior clinical staff.
Dynamic IT Complexity	Very large images, increasing in size with capability of new modalities.	GP systems and PAS systems are being replaced and/or progressively developed. The IT system is undergoing incremental change as issues emerge from early user community.

Both systems are complex in their own way and both are being implemented in the complex adaptive systems of the organizations that comprise the NHS. However the level of uncertainty, impact on the organizations and configuration of organisation into which they are being implemented are very different.

The PACS system is relatively straightforward. It has an impact on the way of working of clinical staff and the project requires an element of business change. This business change is mainly contained within a single organisation and requires minimal development of the capability of project staff. While emergent use of the system must be anticipated, the areas where this is likely to happen can be envisaged.

Choose and Book is a new and complex information system without the engagement of the clinicians who are required to change the ways in which they work in order to ensure that patients receive quality outpatient consultations.

3. Discussion and conclusion

The local approach to implementation of the two systems is similar. The local organizations are working in partnership with their Local Service Providers on the installation of the systems but it is the NHS organizations that have responsibility for the organizational success of the systems and the delivery of benefits. Contracts vary in different parts of the country in the level of support for business change that the supplier is required to provide.

The need for engagement of stakeholder groups and the need to change working practices in order to achieve success are well understood by the organizations implementing the National Programme. The interpretation of this is to seek common structures and processes for the implementation of the various IT systems irrespective of their relative complexity. A simple ‘transactional’ approach tends to be adopted. This redesigns individual functions within a process with the investigation of “as is” process and converting it to a "to be" process. Complexity theory would suggest that this approach puts the success of the Choose & Book system at greater risk than it does the PACS system.

Both Choose & Book and PACS systems are currently being implemented as part of the English national programme for IT in the NHS and will be subject to formal evaluation in due course. However indications of degrees of success are beginning to emerge. By February 2007, 50% of the planned deployments had been achieved with 65 PACS systems installed across the NHS within 2 years. In the eastern region of the country, 100% of Trust business cases had been approved and funding agreed. Clinicians welcomed the systems and were optimistic about success. The main target for Choose and Book was to achieve 90% of referrals electronically using the system by March 2007. In October 2006 many organisations were booking less than 10% and few were optimistic about reaching the target.

If the approach were to be at the 'transformational' level, then it could be argued that success would be achieved for all levels of complexity but that resources would be wasted in relation to the simpler IT systems.

As a result of this investigation, it is suggested that the approach to implementation of systems in the national programme needs modification:

- Facilitate the adoption of appropriate approaches to the change in working practices by local organizations: taking account of the varying complexity of the systems and the initial condition. This would equip the organisation with the ability to expect and manage unpredictable consequences and emergent properties.
- Implement governance arrangements that take account of the complexity generated by multiple organisations and stakeholder groups.

This use of complexity theory can improve the successful implementation of IT systems by highlighting the characteristics of local environment into which the systems are being implemented.

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Structuration and Sensemaking: Frameworks for understanding the management of Health Information Systems in the ICU

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Abstract. This paper will describe two alternate conceptual frameworks (i.e. Structuration and Sensemaking) that will help to describe and provide insight into how best to implement health information systems in ICUs throughout the globe. Structuration and sensemaking are two competing ways to view the social world within hospitals. To examine the impact of information technology in health care organizations, it is important to explore the dynamic interplay between clinical decisionmaking, outcomes of HIT implementation, and individual characteristics of the organizational setting. The adaptation of information technology within health care organizations is by its very nature quite complex. The recursive pattern of social interactions that shape the implementation of technologies within that setting is key. Structuration theory provides an understanding of human work as social interaction within that organizational culture, mediated by artifacts such as tools, language, rules and procedures, and open to change. The ICU provides multiple opportunities for sensemaking. It involves caring for multiple patients simultaneously; is subject to high levels of uncertainty and is provided under significant time constraints. It is highly interdependent work, necessitating shared sensemaking as well as individual sensemaking. Sensemaking is made partially visible in this context as clinicians communicate to each other what they think is the cause of the patient's symptoms and how to treat them in the form of discussions about patient care, consultation requests, ancillary testing, and the electronic medical record. The collaborative nature of work in the ICU lends itself to the application of sensemaking and structuration theories.

Keywords. Structuration, sensemaking, Health Information systems, Workflow.

Introduction

The development of health information technology (HIT) is actually socially shaped. (Coiera, 1999).

"The biggest information repository in healthcare lies in the people working in it, and the biggest information system is the web of conversations that link the action of these individuals" (Coiera, 2000).

This paper will describe two alternate conceptual frameworks (i.e. Structuration and Sensemaking) that will help to describe and provide insight into how best to implement health information systems in ICUs throughout the globe. Sir Anthony Giddens' Structuration theory is a useful framework for examining social and organizational changes associated with health information systems implementation. The structurationist perspective focuses on looking beneath the surface of technology's role in organizational change to uncover layers of meaning brought to technology by an organization's social systems. Conventional methodologies rely on linear, staged models that do not take into account the dynamic interplay and reciprocal interaction between technology and the social processes involving its use. Organizational change is seen as: "inertial, linear, progressive, goal seeking, motivated by disequilibrium and requiring outside intervention" and the change manager's role revolves around creating and influencing change – finding points of leverage and communicating alternate frameworks (Weick & Quinn, 1999).

Health information systems implementation is an interpretive process – one that is socially shaped and context specific giving rise to an alternate set of assumptions regarding the content, context and process of change. Health information systems and its context are also mutually constitutive – institutional properties of the setting are drawn on in the appropriation and enactment of technology, and at the same time technology appropriation also reinforces or modifies these social structures. This process is viewed as one of reciprocal causation and interaction between human actors, technology and the specific organizational context. The mode of organizational change is best described as emergent, improvisational, ongoing – "one of translation where ideas have impact through a combination of fit with purposes at hand, institutional salience and chance" (Weick & Quinn, 1999).

Empirical evidence shows that 80% of failure that occurs in implementation efforts of health care information technology is due to social and organizational factors (Gardner, 1998). Understanding the environment of clinical work will therefore facilitate the efficient implementation of a health care information system (Aarts & Peel, 1999).

Structuration and sensemaking are two competing ways to view the social world within hospitals. To examine the impact of information technology in health care organizations, it is important to explore the dynamic interplay between clinical decisionmaking, outcomes of HIT implementation, and individual characteristics of the organizational setting. Each theory has strengths and limitations. Their combination reinforces their strengths to make them applicable in the health care context.

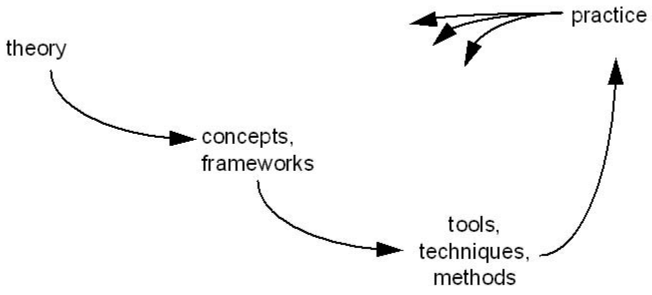

Figure 1. From Theory to Practice

In order to have a better understanding of a broader phenomenon such as the implementation of health information technology, we start with theory and then translate that into actual practice. (Figure 1) Models are neither arbitrary nor do they signify an absolute truth about the way things are. They are social constructions. Their usefulness derives from the fact that many people use them to make sense of the world. Their validity is based on social convention.

Giddens Structuration Theory – Basic Tenets

Agency

Anthony Giddens in 'The Constitution of Society' (Giddens, 1984) elaborated on the nature of structuration theory. Structuration theory attempts to recast structure and agency as a mutually dependent duality. Human agency is the capacity to make a difference (also known as 'transformative capacity') (Giddens 1984 p 14). In practice, human agents retain some transformational capacity. Resources (focused by signification and legitimation) are structured properties of social systems, drawn on and reproduced by knowledgeable agents in the course of interaction' (Giddens 1984 pp 15). Resources are of two kinds: authoritative resources, which derive from the coordination of the activity of human agents, and allocative resources, which stem from control of material products or aspects of the natural world (Giddens 1984). Actions have intended and unintended consequences.

Structure

Giddens defines structure as "rules and resources recursively implicated in social reproduction; institutionalized features of social systems have structural properties in the sense that relationships are stabilized across time and space". Structure can be "conceptualized abstractly as two aspects of rules - normative elements and codes of signification. (Giddens 1984) Structure "exist only as memory traces, the organic basis of human knowledgeability, and is instanciated in action' (Giddens 1984). Structure refers, in social analysis to the structuring properties allowing the binding of time space in social systems, the properties which make it possible for discernibly similar social practices to exist across varying spans of time and space and which lend them a systemic form. Giddens regards structure not merely as constraining, but also as enabling, a rather important distinction.

The duality of structure

Giddens recasts the two independent sets of phenomena (dualism) of structure and agency as a 'duality' - two concepts which are dependent upon each other and recursively related. 'The structural properties of social systems are both medium and outcome of the practices they recursively organize' (Giddens 1984 pp 25). Thus, as human actors communicate, they draw on interpretative schemes to help make sense of interactions; at the same time those interactions reproduce and modify those interpretative schemes that are embedded in social structure as meaning or signification. Similarly the facility to allocate resources is enacted in the wielding of power, and produces and reproduces social structures of domination, and moral codes (norms) help determine what can be sanctioned in human interaction, which iteratively produce structures of legitimation.

Human agents in their actions constantly produce and reproduce and develop the social structures, which both constrain and enable them. “All structural properties of social system are the medium and outcome of the contingently accomplished activities of situated actors. The reflexive monitoring of action in situations of co-presence is the main anchoring feature of social integration” (Giddens 1984 pp 191).

Structuration is dynamic; social practices evolve over time and space and must replicate even to stay the same (Figure 2). More commonly they evolve as they are reproduced.

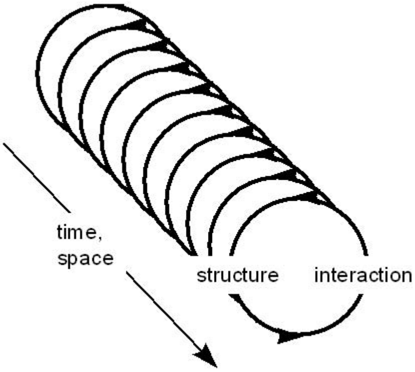

Figure 2. Structuration over time and space

The further social practices extend through space and time, the better established they are, and the more likely to be thought of as institutionalized features of social life.

Orlikowski’s adaptation of Giddens Structuation Theory

Wanda Orlikowski at MIT has adapted Giddens’ Strucuration theory to help explain the use of information technology in organizations. Orlikowski articulated the structurational model of technology which is the concept of the duality of technology (analogous to the duality of structure in Giddens’ original theory) which states: “Technology is physically constructed by actors working in a given social context, and technology is socially constructed by actors through the different meaning they attach to it and the various features they emphasize and use” (Orlikowski, 1992). Thus, technology reflects both subjective and objective qualities.

The adaptation and enactment of technology by organizational actors are viewed as a key factor in organizational change. While technology incorporates interpretive schemes, norms and resources (Orlikowski, 1992), it is only through the activation or appropriation of information systems that it comes to be utilized, and therefore play a meaningful role in organizational processes. The structurationist framework views the mutual adaptation of technology and organization as one involving reciprocal causation – it is a relationship where the specific institutional context and human actions are both mediators in the ongoing interaction (Orlikowski, 1992).

An underlying premise of Orlikowki's structuration model of technology is the concept of interpretive flexibility: " Interpretive flexibility is an attribute of the relationship between humans and technology and is a function of the material artifact, characteristics of the human agents, and the institutional context in which technology is developed and used" (1992:409). According to Orlikowski and Gash, the interpretive flexibility of technology allows it to be open to different interpretations by multiple groups who construct different technological frames or assumptions and meanings used to understand the nature and role of technology (Orlikowski & Gash, 1994). Since technological frames strongly influence the views held about the function, value and role and hence the choices made regarding technology, information systems-enabled change can therefore be understood in terms of shifts in technological frames over time.

One of the issues raised by the concept of technological frames is the relationship between intended and unintended change outcomes. In an extension of her structurationist model of technology, Orlikowski conducted a study which examined the enactment of groupware across different contexts (Orlikowski, 2000). The sites studied varied based on three kinds of conditions: interpretive ("understandings and shared meanings that members of the community constructed for sense-making"), technological ("tool and data properties available to users"), and institutional ("social structures constituting part of the larger social system within which users work"). She found that people's interactions with the technology enacted other social structures such as changes in work practices.

Her research study highlighted the conditions under which people use technology to do something really different. The study attempted to identify the conditions and triggers that allow people to really change the way they work. Orlikowski asserts that an understanding of organizational change is increasingly critical as emergent global forces demand greater flexibility and adaptability (Orlikowski, 1996). Orlikowski (1996) delineates the ways in which significant organizational change can occur in stages or "metamorphoses" within the everyday practice of a specific functional unit. She uses the observations from this firm to advance a situated change perspective, within which change emerges not as a result of deliberate planning and execution but as a result of incremental changes within the situated practice of a firm.

Application to health care

Structuration theory has explanatory power in the adaptation of health information technology. Hospitals are organizations where a number of actions are occurring. These actions are guided by a set of rules and resources available to the knowledgeable human agents, nurses and physicians. These rules set the general pattern in which nurses and physicians take care of patients. Inherent to the health care profession are the autonomy of action and the uniqueness of patient cases. In organizations where there is such variability, rules are subject to modification and change according to the judgment of individual clinicians.

Structuration theory points out the dynamic relationship between human actions and organizational structure. Current thinking in healthcare informatics have examined the impact of information technology in a rigid, structured format where such technology is introduced to organizations to facilitate already existing practices. The complex and collaboratve nature of clinical practice among highly trained physicians and nurses has not been extensively appreciated. Viewing structure and agency as a dynamic two-way relationship diverts the emphasis from static categories and structures at equilibrium to continuously changing realities (Kaplan, 2001). The structuration process depends on the individuality of each organizational setting: the environment of the organization, the human agents that operate within it, and their interactions within that embedded social reality. Health care providers such as nurses and physicians are human agents that through their interactions and actions sustain those embedded social practices that exist in hospitals throughout the globe. Those embedded social practices impact patient care in all of its expressions: nurse and physician workflow, rules that govern their interactions and storing of electronic patient data. As a result of the explicit characteristics of each unique healthcare organization, the introduction of information technology advances in a nonlinear fashion.

The adaptation of information technology within health care organizations is by its very nature quite complex. The recursive pattern of social interactions that shape the implementation of technologies within that setting is key. In order to maximize the value of healthcare information technology investment, it needs to be embedded into the overall organizational culture of that healthcare organization. Structuration theory provides an understanding of human work as social interaction within that organizational culture, mediated by artifacts such as tools, language, rules and procedures, and open to change. When people act in organizations, they recursively create dimensions of social interaction.

The introduction and use of new technologies require nurses and physicians to adapt to new communication patterns and social interactions. Current work patterns may be disrupted in order for clinicians to learn how to use and interact with the new technology. They may have to learn new hardware or software. This disruption to clinical workflow is one of the key challenges of the implementation of new information systems. Nurses have been trained to view their work tasks through a certain training mindset that has to be adapted to any new technology.

"Enthusiastic application of new technologies does not always have the consequences expected of them. This is not least because they are always introduced into a social environment, and this often acts strongly to modify the ways in which their capabilities are harnessed" (Parker & Coiera, 2000).

Barley's (1986) study directly examined the dynamic interactions between structure and action, and supports Giddens' structuration theories. Barley's direct observation of action and structure gives face validity to some of his conclusions. Barley observed the impact of CT scanner technology on the social reality of two radiology departments. Through participant observation and interviews at both sites for almost a year, Barley witnessed the evolution of work relationships between radiologists and technicians caused by the interpretive challenges of the new equipment. Barley codified the interaction between radiologist and technician into scripts and used statistical analysis of script frequency to demonstrate that social relationships significantly changed as CT scanner technology was incorporated into the workflow of the hospital (Barley, 1986). Barley developed a "script" methodology to translate his observations into quantifiable data.

This allowed him to use statistics of script frequency rather than verbal arguments to support his arguments. Barley followed with another quantitative look at the same study, focusing on the change in informal network structure resulting from the new technology (Barley, 1990).

Sensemaking as a Conceptual Framework

Karl Weick, a leading social theorist from the University of Michigan has devised a theory of sensemaking. Sensemaking is the transformation of raw experience into intelligible worldviews. It is what mapmakers do when they try to make sense of an unfamiliar place by capturing it on paper. The key point is that there is no best map of that particular terrain. Sensemaking lends itself to multiple, conflicting interpretations, all of which are plausible. Weick identified seven properties that could be used to analyze organizations and human actors. (Weick, 1995) Sensemaking is a tool for inquiry with the first two properties being “sensing” aspects with the last five being “making” activities.

- Grounded in Construction of Self- Weick defines construction of self as a sense of self in a given setting. The process of sensemaking is driven by our need as individuals to have an identity and an identity tnat is consistent and positive. People are coninually redefining their identity as a result of experiences and contact with others.
- Conducted Retrospectively- This sensing aspect is on retrospection or looking back. This is about thinking of experiences that have passed and trying to make sense and derive meaning from those set of experiences. The perceived world is a past world in the sense that things are visualized and seen before they are conceptualized.
- Enactments of Reality - As people enact their environment, Weick states that we create our own reality. Individuals are actively and continually constructing their own reality through their actions. This includes creating new elements of the environments they inhabit. Once such elements are created they become tangible, unique and visible as well serve as potential constraints. People enact rather than react to the environment that they are a part of. “People act as if they have environments, create the appearance of environments, or simulate environments for the sake of getting on with their business. These organizing acts are acts of invention rather than discovery, they involve a superimposed order rather than an underlying order…” (Weick, 2001). Even though sensemaking is an ongoing interpretive process, it is enacted through an occurrence or need for action, which call for people to make sense of action. As individuals enact environments, they are involved in the process of improvisation.
- Improvisation- Improvisation can aptly deal with the unexpected but prior understandings are needed. “While improvisation is affected by an individual’s associations, past experiences, and current setting, it is also determined by the kernel that provides the pretext for assembling these elements in the first place.

These pretexts are not neutral. They encourage some lines of development and exclude other ones" (Weick, 2001).

- Social- The process of sensemaking is inherently a social process with our ability to make sense involves other people. Weick states: " sensible meanings tend to be those for which there is social support, consensual validation, and shared relevance."
- Ongoing - The process of sensemaking has no beginning or no end. The process nevers stop. Sensemaking flows are constant but they can be interrupted by events that focus and crystallize meanings.
- Focused on and by Extracted cues - this highlights the fact that we very naturally focus on some things and ignore others. We simply cannot notice everything and analyze it to the same degree. Our brains cannot possibly cope with all that activity.

Sensemaking involves actively giving meaning to the world. In dealing with organizational issues, sensemaking allows us to look for explanations in terms of how people see things rather than rather than structures or systems. Sensemaking is a way of understanding the interaction among people, instead of describing things going on out there. It also places people in the role of participants and actors, whose own perspectives impact on what is happening, rather than as observers who are detached from the issues and problems of the organization.

Sensemaking is working with people's ways of seeing things: dealing with the consequences of different perspectives; encouraging the emergence of shared models or metaphor while recognizing the richness and inevitability of different ways of being and understanding. Sensemaking, which is the active process of assigning meaning to ambiguous data, can only occur through human reflection. Reflection is the process by which individuals can summon from the realm of their inner experience. This process of reflection can bring up new insights and ways of seeing the social reality around us. Reflection serves two ends: (1) it develops a more accurate picture of the data and of the system in which the data are embedded and (2) it allows those who can act on the meaning constructed to more fully comprehend the outcomes they intend to enact.

Karl Weick views organizations as networks of subjective meanings or shared frames of references. Weick conceives of as socially embedded enterprises where thought and action or conceptualized as interpretation systems where shared cognitive maps amongst management formulate the organization's interpretation (its process of translating events, developing models for understanding, bringing out meaning and assembling conceptual frameworks) (Daft & Weick, 1984).

Other scholars such as Dougherty, Boland, and Tenkasi have viewed organizational sense-making as a process of distributed intelligence whereby multiple communities of knowing with specialized knowledge interact to create holistic patterns of meaning and action (Boland & Tenkasi, 1995; Dougherty, 1992). According to Boland and Tenkasi, distinct communities develop unique socially embedded knowledge repertoires, which guide their interpretations of the world. Dougherty (1992) in fact, found that different functional groups within the same organization have differing departmental "thought worlds". These differing systems of meaning through which members interpret issues were found to inhibit the development of new knowledge and new social forms as ideas that did not fit existing funds of knowledge were rejected. Dougherty's findings can be viewed as a failure in sensemaking by these departmental thought worlds (Boland & Tenkasi, 1995). The ability to surface, access and examine each other's differing interpretive schemes – to take each other's perspective into account in a self-reflexive way represents the core of the sensemaking process. Issues arise in sensemaking because knowledge and meaning systems are often taken for granted and because there is a tendency to assume others worldviews are similar to one's own (Tenkasi & Mohrman, 1999). These perspectives are especially in hospitals where departmental organizational cultures are very strongly imprinted and can impede effective knowledge sharing necessary for optimal quality of care and organizational performance.

The very human ability to retrospectively find patterns in the continual flow of events that individuals experience daily and hourly in order to give those events meaning. The patterns they construct are strongly influenced by their knowledge base and their past experience. People do not make sense of events only once, but rather engage in a continual revision of their understanding based on subsequent events (historical revision) and based on the interpretation of others (social influence). Thus, sensemaking is not to find the "right" or "correct" answer, but to find a pattern, albeit temporary, that gives meaning to the individual or group doing the reflection--that makes what has occurred sensible. Taylor (2005) points out that sensemaking is a way station on the road to a consensually constructed, coordinated system of action.

Application to healthcare

Sensemaking is critical in an environment such as the intensive care unit (ICU) of any hospital. ICUs are often unpredictable, with different patients responding differently to treatments and processes. Planning and anticipation provide only a limited sense of understanding, and "important actions, adjustments, and decisions must be undertaken in real time" (Schulman, 2004). Nurses in ICUs work in environments of great uncertainty and must respond to many emerging, non-routine events (Vogus, 2004). In any given situation, nurses sense the best way to respond, adapting to the unique characteristics of the patient and context. Nursing work is also interdependent. Nurses rely on information from other nurses and also rely on each other for second opinions, problem solving advice, equipment expertise. Response to crises in the ICU often requires group effort.

In ICU's there are unplanned for contingencies or events for which not standard protocols exist. This creates the need for clinicians to develop and implement new procedures in real time. These contingencies are multi-faceted requiring clinicians to combine interventions in unexpected ways. This is the way that improvisation plays a role in the process of sensemaking. This improvisation requires creativity under tight time constraints in order to save the lives of patients. Implementation of new techniques in the ICU requires mental precision and situation awareness. This is where sensemaking and clinical judgment play a large role.

The process of sensemaking can captured by two questions: "What is the story?" and "Now what should I do?" (Weick & Sutcliffe, 2005). The ICU provides multiple opportunities for sensemaking. It involves caring for multiple patients simultaneously; is subject to high levels of uncertainty and is provided under significant time constraints. It is highly interdependent work, necessitating shared sensemaking as well as individual sensemaking. Sensemaking is made partially visible in this context as clinicians communicate to each other what they think is the cause of the patient's symptoms and how to treat them in the form of discussions about patient care, consultation requests, ancillary testing, and the electronic medical record. The collaborative nature of work in the ICU lends itself to the application of sensemaking and structuration theories.

Application of both frameworks to the ICU

As a number of societies throughout the globe ages, a larger number of elderly patients will require ICU care, thereby sharply increasing the demand for ICU services (Angus, et.al. 2000). A well-coordinated ICU team promotes standardized care, more timely intervention, and appropriate use of resources (Pronovost, 1999).

The intensive care unit (ICU) can serve as an exemplary case for studying the impact of health information systems. ICU's have a complex work environment with high technology, high intensity and high reliability. Work practices in the ICU are under a number of constraints such as time, intensity of work effort, complexity of care process and highly specialized medical techniques.

Clinical practices in the ICU require rapid acquisition and organization of clinical information. Information systems have transformed the delivery of care by integrating real-time physiologic, laboratory, and imaging results with current medications and interventions. With such tools, adverse trends are identified and management of patients by an interdiscipllinary team is more effective (Morris, 2002).

Information systems can provide effective decision support to nurses and physicians by combining benchmark data and evidence-based management algorithms with individual patient data. Effective implementation of information systems may potentially reduce adverse events, avoid drug interactions, and improve accurate drug selection (Evans, 1998). These systems can also set workflow priorities to increase efficiency. Such improvements to current care processes through effective implementation of information systems may allow clinicians to treat a larger number of critically ill patients with improved patient safety.

Information systems can provide for synthesizing clinical data, identifying trends, and organizing workflow. These changes can only be made visible for nurses and physicians if socially embedded knowledge is used to redesign patient care rather than perpetuating current outmoded work processes (Dimick, 2001).

The ICU is an area where patients with complicated conditions are cared for by multidisciplinary teams and receive complex and interactive treatment. Sensemaking can work more effectively in an organizational culture that promotes trust. In the complex milieu of the ICU, understanding the underlying social reality is critical to improving clinical performance and promoting adoption of evidence based clinical practices.

Overall, the ICU is a very sophisticated and growing complex work environment. Human vigilance and sensemaking and direct patient interaction are the most important in the prevention of adverse events. Even with the newest models of monitoring or drug administering devices, a human may be easily confused and the patient's care jeopardized. Spending more time at the bedside and obtaining a more detailed history are often the most essential factors that will help prevent an error or recognize it in time. In the ICU, patient data presentation usually consists of handwritten often-illegible notations on a single sheet of paper, the location of which is not always known. There is a great need to “make sense” of conflicting clinical information. Most communication in the ICU is verbal. These social interactions are the key to clinical decisionmaking and judgment.

The understanding of patient data is an area where the theories of structuration and sensemaking can be applied and made visible. Current information systems do not always present patient data in a legible, consistent format. Data needs to be grouped by organ system, using color-coded charts and graphs to flag abnormalities. This can help identify what is happening with the patient in a rapid, easily understood fashion. An effective alert system at the bedside for nurses to use would be very helpful for management of patients. The capabilities of such a system would include flagging drug allergies, interactions between medications, and appropriateness of dosage range.

Conclusion

This paper has outlined two separate conceptual frameworks in our understanding of the implementation of information systems in the ICU in hospitals. Reframing implementation of health information systems as an interpretive process calls for a shift towards an alternate set of assumptions. This is where health information systems are viewed as interpretively flexible and socially constructed, is inextricably linked to its context. This is where organizational actors and institutional context interact in a process of reciprocal causation. A deeper understanding and attentiveness to the dynamics of the interpretive process of implementation holds timely and important implications for further investments in HIT. Both structuration and sensemaking share certain attributes. Social reality whether in a small group or an entire organization is a dynamic occurrence. People create reality as they experience it. To do so, people fall back into existing patterns or in other circumstances they improvise.

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Whose Work Practice? Situating an Electronic Triage System Within a Complex System

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Abstract. An electronic triaging system was introduced into a busy children's hospital emergency department. Within 18 months of its introduction, amidst complaints from staff about patient safety related to work slow downs, a decision was made to stop using the system. In this paper we examine issues that arose with the introduction of the electronic triaging system, and discuss these in relation to decision making in complex systems. We suggest that difficulties with the triage system resulted partly because data resulting from the triage encounter are used in several domains including the care domain, the access domain, the federal equity and accountability domain, the local accounting and quality domain and the research domain, each of which has different primary stakeholders, with varying needs. Greater attention to identification of data requirements for each of these domains and acknowledgement of varied stakeholder interests prior to software selection and implementation may improve future implementations.

Keywords. Electronic triage, work practice, decision making, domains of use.

Introduction

In 2002, a decision was made to acquire an electronic triaging system (e-triage) for use in a children's hospital emergency department (ED). The initial decision was largely conceptual. Subsequent consultation with colleagues in the Canadian Association of Emergency Physicians (CAEP) resulted in a decision to purchase the system described here. From the doctors' standpoint, there was discussion with the nurses, however, nurses felt that they had not been consulted. An e-triage system was introduced in 2004, and used by nurses to triage patients for 18 months. Although e-triage offered several benefits, a decision was made to discontinue use of the system amidst complaints from staff that the system slowed work and placed patients at risk.

Here we provide a brief overview of the e-triaging system, and outline some of the work practice issues that triage nurses experienced while using the system. These are discussed in relation to the complexity of the health care environment into which the e-triaging system was introduced, which included older computer systems, plans to acquire enterprise-wide computer solutions, and ambiguities about whose work practice the e-triage system was meant to support. This case points to the need to clearly identify the goals that computer based tools are intended to meet, as well as the need to identify the multiplicity of stakeholders whose work practice may be altered with the introduction of new health information systems. The history of the electronic triaging system in this hospital is followed by an overview of the functionalities of the system, which are discussed in relation to varied stakeholder needs (e.g., management needs, quality assurance needs, triage nursing needs and patient needs) and the organizational computing environment, which posed some constraints.

1. Early history of E-Triaging

Triage is a critical component of emergency care [1]. Usually performed by a registered nurse, triage occurs when a patient presents at an emergency department (ED). "The goal of triage is to identify the patients who need to be seen first and those who can safely wait" [2: 422]. Nursing staff at the triage desk perform a quick assessment of the patient which consists of a visual assessment, recording vital signs, and recording the patient's chief complaints. This information is used to generate a triage score to reflect a patient's acuity, and the urgency of care required. The triage score determines in which order patients are seen in the ED—the higher the level of acuity, the more quickly a patient is seen. Triaging is based on patient signs and symptoms rather than diagnosis.

Although the triage function seems relatively straightforward (nursing staff ask patients questions and assign a score based on patient responses), differences have been observed in how experienced nurses and inexperienced nurses triage [3]. In pediatrics, observation of a patient's appearance is important as patients are often unable to speak. Historically there has been considerable variation in triage scales used throughout the world [4], which has made it difficult to conduct research about the effectiveness of interventions. Among the drivers for standardized triage scores are the desire for higher quality intervention and outcome data. At the same time that there have been extensive efforts throughout the world to standardize triage scales. For example, a national 5 level triage acuity scale was developed in Australia, and in 1997 a collaboration between the Canadian Association of Emergency Physicians and the National Emergency Nurses Affiliation resulted in a 5-level Canadian Triage Acuity Scale (CTAS), which has become mandatory in most of Canada [4][1]. Nurses who have learned to use CTAS "believed that their patient assessments were more thorough, accurate, and consistent throughout the department." [5:436], and with use of CTAS, triage accuracy was high. Some dissatisfaction with CTAS exists. For example, rural ED physicians have indicated that since the implementation of CTAS, "a number of adverse effects from its implementation have been encountered in rural EDs" [6:271].

Studies undertaken elsewhere have demonstrated poor agreement between nurses applying adult triage scores to pediatric populations [7]. Limitations related to the use of CTAS by pediatric emergency department (PED) staff have contributed to the development of a pediatric CTAS, derived from the adult CTAS [4]. Prior to the development of the Pediatric CTAS (P-CTAS) which was undertaken as a vehicle for measuring case

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[1] Electronic triage is a component of the HAS system which is an electronic information system that has been developed in Australia.

mix and to ensure timely access to interventions, there was no widely accepted tool for triaging pediatric patients. Although the P-CTAS is increasingly used in Canada's PEDs, many regions of Canada do not have children's hospitals, and even in those areas that do have children's hospitals, children are frequently seen (and triaged) in general EDs, where CTAS (rather than P- CTAS) is used.

By 2003, a company whose triage software might be appropriate for use in the Children's Hospital was identified. At the time the decision was being made, CTAS was very positively viewed, and most Canadian EDs had adopted CTAS, which was a model for other national efforts. The level of computerization at the hospital at the time was minimal, and consisted mostly of administrative computer systems (such as an admissions and discharge system), and computer based record systems maintained by individual clinical areas (but not accessible to staff outside those areas). Because plans were underway to introduce a hospital wide information system, funds for computerization of individual units were limited, and any systems acquired were viewed as temporary systems that would be superseded by a hospital wide system to be introduced a few years later. A physician member of CAEP- Michael Bullard created an electronic triage system which then was available. There was a push to standardize pediatric triage so it could be used at both pediatric and general EDs if it was successful. If other PEDs used the same system, patient acuity and patient load could be compared across facilities.

The ED is considered an outpatient department in the hospital, so the extensive administrative data that is routinely collected on inpatients is not available, (e.g. all inpatients are categorized with an International Statistical Classification of Disease Related Health Problems (ICD) 9 code, but ED patients are not). In order to do research about patients, data are required, and it appeared that the system chosen would produce more than a triage score and could be tapped to collect patient data. A computerized admitting system that captured some data from the triage process and subsequent ED visit had some limitations: the discharge diagnosis in the PED was captured as a free text entry and could be written a myriad of ways, so finding, for example, all the limb trauma required a manual search. Finally, staffing levels are based on numbers and acuity, and so a "standardized score" was seen to be more reliable than a nurse's gestalt that could have inter-operator variability, and a computer based standardized score had more credence with doctors than a nurse generated score, even if generated on the basis of clear parameters from the CTAS.

Although the activity of triaging is primarily intended to identify those patients who need to be seen first and those who can safely wait, in an environment of resource constraints, data resulting from triage activities serves multiple purposes. For example, the triage score may be used to determine in which area of an ED a patient should be seen, and to facilitate patient flow through both the ED and larger hospital [8]. In addition, triage scores may assist staff in communicating with patients or their families about expected care and wait times. Triage scores may be used to help predict resource utilization in hospitals [9]. Obtaining triage scores does not require an e-triage system, however, e-triage offers the possibility of standardizing assignment of those scores.

Because CTAS was launched across Canada in 1999, and the P-CTAS was introduced in 2003 as a national standard, at the time the decision was made to obtain an electronic tool to support triage, there was a clear preference to obtain an electronic triage tool which was based on CTAS, and, ideally, P-CTAS. The program chosen for use was the only one available at the time which assigned a triage score based on CTAS. The program chosen for implementation described here "presents the triage nurse with a selection of complaint types (e.g., chest pain, limb complaint – trauma), and then the CTAS discriminators within each complaint type" [10: 2]. The program used language for presenting complaints which sometimes reflected diagnostics, rather than presenting complaints (e.g., asthma could be selected but there was no entry for wheeze), and although the hospital had purchased a pediatric version of the software, some nurses felt that the language inscribed in the program was more appropriate for adults than for children (e.g., no entry for "crying baby" required use of "altered level of consciousness").

The e-triage software chosen was designed to meet a number of needs. With the paper based system, data for accurate management decisions including staffing levels was not available for the ED managers or other potential stakeholders, such as regional health authorities, and it was hoped that the electronic triage software would improve this situation. Additionally, the program supported standardized application of triage scoring by nurses, based on the P-CTAS. Using the e-triage system, the triage nurse used the computer based template to assist in triaging patients, which generated a CTAS score which nurses could override in the event that their assessment of the patient's level of acuity differed from the level of acuity the program assigned. The tool also captured data about the number of patients seen each day and their level of acuity, which could be used as a basis for requests for additional resources for the ED. In an environment where ED wait times were a topic frequently covered in the press, data that could be generated from the e- triage system assumed a level of importance in the context of national and provincial debates about appropriate levels of care, and ED waiting times.[2] Finally, data captured by the triage software could be used by doctors and nurses as research data. Some of the data which the triage software captured had been available through the hospital's admission and discharge system. In contrast to that system, the triage software incorporated the CTAS standard, and allowed ED staff to view data in real time, rather than the next day (as had been the case with the admissions and discharge data). It was the ability to categorize patients diagnostically (although it was supposed to be presenting complaints) that would to be helpful, as e-triage overcame the limitations associated with free text diagnostic entries that were available through the admitting and discharge system. Challenges that arose during use compromised data quality and data were not ever used as intended.

2. Work practice issues and the decision to halt use

Although the e-triage software chosen had been used and evaluated elsewhere, and previous implementations had shown acceptance by RNs and no increase in time required to triage [11], in the implementation described here nursing staff found it increased the time required to triage patients. During a busy period in the ED, time required to triage patients using e-triage became unacceptably long, and a difficult decision was made to stop using the e-triage system after 18 months. Numerous challenges

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[2] In spite of the significance that ED wait times have had in health policy debates, there is no accepted standard for the measurement of ED wait times in Canada. See footnote 7, in the section titled The Federal Equity and Accountability Domain.

had arisen with the introduction of the e-triage system. An informal survey[3] was undertaken by nursing staff in an effort to gain further insights about triage nurses' views of the software. The survey consisted of 6 open-ended questions, which sought nurses' views about strengths of the paper and e-triage systems, challenges associated with both the paper and e-triage systems, willingness to try another computer based triage system, and suggestions about what the unit leadership team could do to make use of the current e-triage system easier. Survey results suggested that challenges related to the introduction of the e-triage system could be grouped around 5 themes:

1. **design / work practice issues:** (e.g., the order of entries required by the e-triage system interrupted the logic of the triage interview; the need to navigate through multiple menus lengthened the time required to complete a triage interview);
2. **classification / standardization issues:** (e.g., the presenting symptom list was inadequate; it was not possible to list more than one presenting complaint; rather, one had to list associated symptoms separately, which required several steps; the relationship between symptoms in the pull down lists was not obvious to all triage nurses, and the presenting complaints and level of urgency (LOU) did not always present a good reflection of the patient);
3. **technical issues** (e.g., print problems including printing backwards; loss of data after it was entered);
4. **technical support issues** (lack of responsiveness of technical support);
5. **ergonomic issues** (switching between mouse and keyboard driven input; area / equipment setup interrupted nurses' visual and verbal interaction with patient).

A severe flu season, long overall waits, a nursing shortage, and a change in nursing leadership which resulted in an increased focus on recruitment (which impacted triage because new nurses do not triage for 9-18 months) all contributed to a decision to stop using the triage software. The electronic triage system required a 2 hour training, followed by "buddy" time when experienced triage nurses spent time with new triage nurses at the triage desk. Nurses who could triage had to triage for longer periods due to shortages and were assigned to triage more often. The level of comfort with keyboards and speed varied amongst nurses. When technical problems such as upside down printing occurred, or during busy periods when the length of time required to electronically triage contributed to longer waiting periods, nurses returned to paper triage. The data resulting from use of the e-triage system were reviewed by the nurse educator and staff in the quality assurance department, both of whom determined independently that data quality issues made the data unreliable for research purposes. Some nurses liked using the e-triage system and saw the benefits associated with its use (e.g., increased legibility and standardization of LOU assignment), but long pre-triage waits and concern about

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[3] The survey was undertaken as a quality improvement initiative rather than as a research project, and hence did not meet normal research standards. 23 surveys were returned, however it is not known what percentage of the total distributed this represents.

patient safety resulted in a decision to temporarily halt use.[4] The ED went into "emergency mode"- nurses did not feel e-triage added to efficiency.

3. Looking forward, looking back: Decision making in complex organizations

Reflecting on the challenges which occurred in implementing the e-triage system described here, two connected themes emerge: (1) issues related to implementation of the classification system in a manner which slowed work down, and (2) issues related to the underlying classification system inscribed in the software. Challenges associated with the classification system around which the software was built (discussed at length below) were compounded by the manner in which the classification was implemented in the program. Nurses were required to go through multiple nested pull-down menus to indicate their selection, which slowed the triage process down placing patients at risk. It is possible that implementation of the classification system in another manner (e.g., instead of multiple nested pull down menus, through use of a well executed auto-completion system, where typing a few letters generates word suggestions which can be overridden with additional typing) might have lessened the time burden associated with entering chief complaints into the e-triage system.

While there were several challenging aspects of the triage software use such as the time burden associated with multiple nested menus, one of the more challenging issues related to the classification system inscribed in the software. Although the classification system reflected the CTAS standard, and the ED had purchased a pediatric module of the software (which some would argue was not well executed), there were, nonetheless, challenges related to the terminology used in the list of chief complaints. The terminology at times reflected terminology used by nurses, and in other instances reflected terminology used predominantly by doctors, as well as by administrators who use ICD 9 or 10 codes to classify patients. Ambiguities about language inscribed in the program are perhaps indicative of the contested terrain or multiple roles that triage data—and hence triage software- must fill—a point we return to in greater depth below.

3.1. Triage as a classification system

The main role of triage is to assign priority to patients who need urgent care, and to predict the nature and scope of care which patients will likely require [4]. The triage process results in the assignment of a score, or, put another way, the triaging process is one which has as its end goal the classification of an emergent patient's acuity. Implicit in the definition above is the notion that triaging systems are classification systems, and the process of triaging is a process through which classification system(s) are applied. Classification systems are sets of boxes (either metaphorical or literal) into which things can be placed, and which do some kind of work, such as knowledge production work (e.g., they serve as one component of an indicator system that allows us to understand how

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[4] Initially the plan was to halt use for 3 months. The system has not been used for 1 year, and plans underway to develop an electronic triaging system in house are stalled.

well EDs function), or bureaucratic work (e.g., in the case of triage scores, they serve as an ordering system which determines who is seen when) [12].

The tension between knowledge production work and bureaucratic work is evident in documents describing how to implement the Canadian Emergency Department Triage & Acuity Scale (CTAS), which "attempts to more accurately define patients [sic] needs for timely care and to allow EDs to evaluate their acuity level, resource needs and performance against certain operating "objectives" [13:2]. Use of triaging scores is both oriented towards caring for patients (efficient management of an ED requires a team of providers capable of correctly identifying patients needs, setting priorities and implementing appropriate treatment, investigation and disposition [13], and at the same time has been developed to "allow ED's to evaluate their acuity level, resource needs and performance against certain operating objectives" [13:2].[5] Hence triage not only serves as a guide for patient treatment, but also plays a role in the production of knowledge used for management purposes. Often data elements (such as patient acuity data) also play an important role in the production of research knowledge, for example, about the impact of ED wait times on patient outcomes. The triage score sits at the centre of several domains of knowledge (described further in Section 3.2 below), as illustrated in Figure 1.

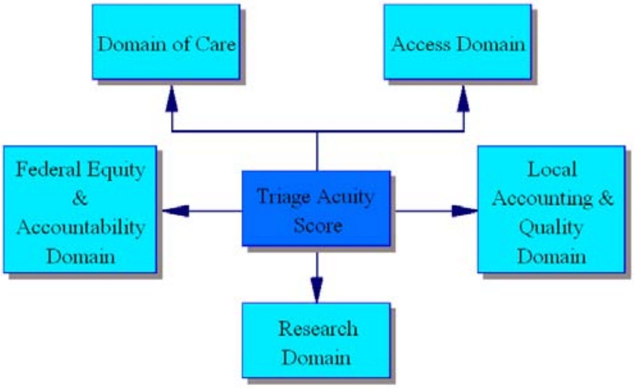

Figure 1. Relationship of Triage Scores to Domains of Knowledge

3.1.1. Classification systems and infrastructure

Infrastructure is relational [15]. Something "becomes infrastructure in relation to organized practices," and "infrastructure occurs when the tension between the local and the global is resolved," and when local practices are accommodated by a larger scale technology, which can be used in a natural, ready-at-hand fashion [15:113-114]. The recent interest in development of triage acuity scales reflects what [16] has called a quest for accountability, which would remain unimaginable at the scale currently being pursued, were it not for the existence of computer systems, which offer the possibility of extending both the reach and uniformity (at least in theory) of data collection activities over multiple locations. "Classification systems are integral to any working infrastructure,"

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[5] See CTAS Implementation Guidelines[14] for more information about CTAS use.

[12:16] and [15] have argued that infrastructure emerges in relation to organized practices. The paper triage forms that the software replaced can be thought of as a form of infrastructure, which reflected practices that had evolved in the PED over a number of years. While the paper forms may have borne a resemblance to forms in use in other EDs, they differed from other forms in ways that reflect differences in work routines from one ED to another. The paper triage forms used prior to the introduction of the triage software could be used in a natural, ready-at-hand fashion, while the software failed to achieve that status in the PED (although published accounts suggest that the software may have achieved infrastructural status in other settings). One nurse commented "the way data was collected was not linear or logical compared to the nursing approach to patient assessment which triage nurses are taught."

Information infrastructures can be difficult to analyze [12] because they disappear—or fade into the background—when they work well. Additionally, the complexity of computerized information infrastructures often lack easily recognizable material expressions (one can't see data as it moves through a computer, and the underlying information system architecture is often invisible to all but information system departments and system designers) —hence the logic of the triage software may have been completely apparent to those who designed it, but remained cumbersome to many of the nurses who had to use it. In this case it can be argued that it was the visibility of the classification system—and, more specifically, the poor fit between the embedded classification system based on ICD 9 codes, and nurses' usual practice—which was a key failure of the triage software in the PED. Also, at the same time, the needs of varied stakeholders were in evidence: nurses had to complete several fields during the triage interview which did not directly assist them in providing patient care. Many of the work practice issues that arose with the implementation of the triage system in the pediatric setting were expressed as issues related to the length of time required to triage with the software. However, the additional time required to electronically triage may well have been the symptom of a classification system problem (compounded by system architecture and usability issues). The electronic triage system included a classification system whose organization was illogical to the nurses whose work depended upon its use which rendered the failure of the program to achieve infrastructural status for the nurses—the logic of the program did not follow the logic of the triage interview. The invisibility of the logic of the underlying classification system upon which the software rests contributed to a masking of the multiple domains or arenas in which data resulting from triaging activities are used, and the multiple sets of demands that triage data must meet for different stakeholders.

3.2. Situating triage data within larger organizational contexts: The multiple domains of triage data

"Infrastructures are never transparent for everyone, and their workability as they scale up becomes increasingly complex" [12: 33]. In our work in varied hospital settings, we have noted many instances where infrastructure becomes visible, and in its visibility, signals a sort of infrastructural failure. This seems to occur when information systems that are implemented with the intention that they will become boundary objects (malleable enough to work for varied communities of practice, and to meet the needs of multiple domains) fail to satisfy the informational requirements of all of the social worlds or domains which they inhabit. One way of viewing the challenges associated with implementation of the triage software in the pediatric setting is that the combination of an inappropriate classification system and system design that slowed work practice for nurses (e.g., multiple nested pull down menus) resulted in a situation where the triage system failed to function as a boundary object—it was not malleable enough to support the informational needs of nurses and doctors, both of whom required the intervention of information services staff to fulfill their informational needs. When boundary objects do not effectively bridge between social worlds, communities of practice and domains of use, like broken bridges, they delineate borders, rendering visible the different communities that exist in their midst.

Data collected during the triage encounter crosses into several domains, which [17] has identified as the access domain, the federal accountability domain, the local accounting and quality domain, and the research domain, all of which interact with the care domain, in which patients' needs are met. Within each domain, triage data serves different (though related) purposes, and is essential to the work of varied stakeholder groups. Each of the domains outlined below may be comprised of multiple professional groups, many or all of which may have their own legacy computer system, or at the very least, preferences about the classification system which gives coherence to their portion of the care domain. Each of these domains is described briefly below.[6]

3.2.1. The domain of care

Within the domain of care, the focus is on direct patient care. In the domain of care, the triage acuity score signals to care providers the urgency with which a patient should be seen. The primary stakeholders who use the triage score in the domain of care are triage nurses (who generate the score, ideally, according to P- CTAS standards), and other nurses and doctors in the ED who use the triage score in varied ways in relation to delivering care. Patients benefit from a assignment of a triage score as they are more likely to receive appropriate care in a timely manner, and they can anticipate how long they may have to wait.

3.2.2. The access domain

The accessibility of EDs in Canada's hospitals has become a "hot button" issue, with the public, the medical community, health policy makers and the press all engaged in public debates about how long people must wait before being seen in an ED. Waiting times are of great concern to Canadians. This measure is being used as an indicator of the health of the health care system [18]. Reports of long wait times cause panic in communities [19, 20, 21, 22], and calls for action from health system managers. ED wait times play a significant role in resource allocation decisions in hospitals [23, 24, 25, 26]. Hospitals with long ED wait times come under scrutiny, and senior management of hospitals issue directives to middle management to shorten patient waiting times in the ED. Emergency wait times are also invoked in discussions about poor service, and hospitals that post long wait times come under scrutiny. Publicity of long wait times often results in inter-

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[6] For a more extensive treatment of each of these domains, see [17].

ventions aimed at reducing wait times. Recent examples of effects of such publicity include opening additional beds [27], providing improved care outside of hospitals, quicker access to specialists within EDs as well as access to liaison nurses charged with improving communication related to care within EDs, setting up discharge lounges, purchasing new equipment, and improving information systems within EDs [28] and allowing ED triage nurses to order diagnostic tests [25]. While there are a range of possible responses to ED waiting time data, it is easy to demonstrate that these data are the lynchpin for a number of decisions. The domain in which these decisions take place is the access domain, which is populated by varied health practitioners (both inside and outside of EDs), policy makers, human resource departments, and the computer systems used by those groups to develop an understanding of issues related to the accessibility of Canada's EDs.

In the access domain, data from the triage process (the level of a patient's acuity, and often the patient's arrival time at the ED and information about when a patient receives care[7]) is combined with patient registration data to produce information about how long patients wait for care, in relation to the acuity score they are assigned through the triage process. Data about the level of patient acuity and wait times are also used to generate a picture of an ED's case mix and volumes. This is very important as each CTAS score has a "time to be seen by a physician" guideline which the CAEPs maintain EDs should meet and which lay people think are reasonable, but are times which none of the EDs meet. Data about patient acuity and volumes is also used to determine appropriate staffing levels for EDs, or to develop programs aimed at diverting less acute patients away from EDs. In these contexts, triage data ideally would be compatible with data from other computer systems such as the patient registration system because debates within the access domain—the domain where local health systems attempt to address issues of ED and broader health system access-- may depend upon triage data as an important input into decision making that occurs in the access domain. For those operating in the access domain, triage data is essential in determining whether ED wait times expose patients to increased health risks, and are essential in gaining insight about upstream interventions that could reduce ED demand.

3.2.3. The Federal Equity and Accountability Domain

The Federal Equity and Accountability Domain is the domain in which the distribution of health resources is monitored by the federal government, as an element of insuring accountability to Canada's federal health act. Canada's health act sets out several principles for the Canadian health system, which include equitable, accessible and universal care. Although the underlying principles upon which the health act is built have been specified at a federal level, responsibility for delivery of care in a manner consistent with the federal health act falls to the provinces in Canada, with costs for health care delivery shared by the federal government and provincial governments. In practical terms this means that in order for the federal government to ensure that health services are being delivered in a manner that is consistent with the federal health act, some form of monitoring must take place. Provincial governments are responsible for the day to day management of health within provinces, but must demonstrate to the federal government

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[7] The specific information collected about times from one facility to another is extremely variable.

that they are complying with the Canada Health Act in delivery of care. Within this context, provincial governments may collect data about health service delivery within their province, and the federal government may require the provinces to report data about health service delivery in order to determine whether the provinces are meeting their obligations. Although data about ED wait times has become an actor in health policy debates in Canada and elsewhere, "there is no established standard or definition for measuring ED wait times."[8] While limitations of the ED wait time data set are significant, the data are used and do play a significant role in health care debates. Often unbeknownst to staff who enter data that are used to derive wait times, the data they generate as they interact with triage, patient registration and medical record systems trickle from the care domain into both the access domain and the federal and accountability domain, where they play a role in significant policy debates.

3.2.4. Local Accounting and Quality Domain

Hospitals are typically large institutions characterized by a high degree of hierarchy, and, due to their size, a certain amount of decentralized control. In many hospitals, the first areas that were computerized related to finances. One consequence is that often, data related to finances are the most complete data that exist, and data about costs of providing services are frequently used as a proxy for service delivery and/or health outcomes. Another consequence of the early computerization of finance departments is that the processes used by finance departments are often well entrenched in established practices, which in turn are often reified by legacy computer systems. Although many of the administrative functions at a hospital (such as costs) may be monitored through a central finance office, budgets are typically decentralized, with each area (e.g., the ED) or groups of areas (e.g., out patient services) sharing a single budget. Triage data that are collected may be combined with cost data at some point in order to determine (for example) what costs are associated with patients of various acuity levels, once those patients enter the system. The ability to combine ED data with existing financial data as well as data about what additional services a patient may have used while in a hospital may play a pivotal role in whether or not an ED is allocated additional resources for staffing. This domain may be the most important domain to the extent that it may have the greatest direct impact on the resources available to an ED. The primary stakeholders in this domain are those directly responsible for management of the ED.

3.2.5. The Research Domain

Each of the domains outlined above can be thought of as a context in which triage data may be used, and each of the contexts may, to varying degrees, exert influence over what data look like (e.g., because data collected in one domain must be compatible with data collected in another domain), and which data are collected. Many factors come to bear ultimately on which data are collected, including the relative strength of parties involved in decision making about information systems, the data architecture built into existing and available computer systems, local, provincial and federal reporting requirements, and so on. In spite of the existence of lots of data, the data that exist may or may not be

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[8] From personal communication [29].

helpful to researchers in understanding, for example, whether or not the interventions carried out in an ED have a positive impact on patients. Existing data may be missing information that is central to the question researchers are seeking to answer (e.g., it may be difficult to determine what the staff mix was who treated a patient), or may exist in a format that is not ideal. Researchers typically want to collect much more extensive data than what is required for treating a patient, and must typically make do with far less detail then what is considered desirable by researchers. Although ample data exists in hospitals, it is often insufficient to serve as a basis for evidence based medicine, which seeks to improve the evidentiary basis for medical practice through the application of scientific method to medical practice.

Recent advances in networked computers and the ability to combine data from multiple sources have left open the possibility for engaging in more ambitious—and theoretically more robust—research that can (for example) link treatment options to health outcomes, and is an important aspect of evidence based medicine. In order for researchers to have data, someone must collect data, and the collection of data for research purposes—or even to create circumstances that will support merging of data from two computer systems— will alter someone's work practices. For example, in order for triage data to be linked to admitting and discharge data, there must be a "common identifier" (such as a personal health number) entered into both computer systems. The manual triage process does not require triage nurses to ask for or record that number. If triage nurses were required to ask for and record a personal identifier it would increase the length of time required for the triage encounter, which would represent a change in triage nursing work practice, which would not benefit triage nurses directly. Although not implemented, it was hoped that the triage software, by means of standardizing presenting complaints, would support the capture of certain population level parameters which in turn could signal a rise in certain rare conditions. Such data may not be required to provide direct patient care, but rather, would be of primary interest to researchers.

The research domain is another domain in which health information systems are discussed, and where output from information systems is used. Researchers are the primary stakeholders in the research domain. A range of other stakeholders such as managers and policy makers may be secondary stakeholders within the research domain. At times, research endeavors can have a significant influence on the architecture of information systems used in health care settings, however, more often than not researchers' needs are poorly met with in-house data collection systems, and researchers often set up parallel data collection systems to meet their needs.

4. Delivery of care, data and decision making in complex organizations

The domains in which triage data are used that are outlined above provide a framework for thinking about the multiple ways that triage data are used, the varied stakeholders who use triage data, and the varied purposes that triage data serve. Clearly, all of the stakeholder groups in each of the domains outlined have an interest in the production of high quality triage data, as activities in each of the domains will have an impact on the delivery of care—some more immediately than others. For the triage nurses and front line ED medical staff, the validity of the acuity score is likely to be of greatest concern.

For an ED manager, the ability to use triage data as an input for staffing or resource decisions may be the primary concern. For researchers, the ability to obtain accurate data about presenting complaints and level of acuity may be the highest priority.

Computerization of complex healthcare organizations occurs in varied ways, ranging from the development of software within specific units, to hospital wide enterprise systems designed to meet many and varied needs. Any new information system will alter the work practices within an organization, and typically, the introduction of new computer systems alters work practice at both a local level (e.g., for triage nursing staff), and for other groups as well (e.g., the information systems department, which must maintain the new system). There is overlap in the data needs that exist within varied domains, but there are also some data requirements in some domains that are domain specific. Although the uses of data related to healthcare information systems typically extend beyond domains of care, and health data typically are used in multiple domains, often decision making about information systems is undertaken from within a single domain or with reference to limited domains. To the extent that information systems incorporate classification systems which may reflect the data needs of some domains better than others, some stakeholder needs will be better met than others with the introduction of new information systems, and work practices of some groups may be more adversely altered than others.

In a perfect world, new information systems would be able to meet all stakeholders' needs. However, to the extent that varied stakeholder groups inhabit different communities of practice and function within different domains, and use varied practices that are reflected in often unique classification systems, information systems often fail to meet the needs of diverse stakeholders. As the PED has begun to look forward in relation to its informational needs, and we have reflected on past events described here, one of the questions that has emerged in relation to the past effort to provide computer support for triage work has been "whose work practice was the focal point of computerization?" Was the primary goal to standardize the assignment of CTAS scores, to provide real time data to support daily staffing and resource allocation decisions, or to generate research data? Looking back at the implementation described here, there was a desire to standardize assignment of triage scoring to meet the needs of all of these domains. The decision to use the software was undertaken with an awareness that use of e-triage might increase the time required to triage. Despite this awareness, the consequences for the people doing the work were greater than anticipated, and the people doing the work were not all aware of all of the domains in which the data they were collecting might be used. In order to create buy- in for use of a new program, the benefits of the program needed to be sold to multiple stakeholders. For many groups the benefits were clear, however, for nurses, the benefits were less obvious, and use of the system was more akin to doing a good dead (e.g., it would allow the Children's Hospital to compare it's patient load and wait times to a nearby large adult hospital which triages close to the same number of children each year).

Reflecting on the information system implementation described here suggests that in planning for new information systems, it may be prudent to describe the varied domains in which any given information system is intended to function, to identify the primary and secondary stakeholders in each of those domains, to describe their informational needs, and to outline any known classification systems that are in common use in communities of practice that will interact with a new information system. Tradeoffs are inevitable in information system development, however, the process of triaging informational needs can be made more explicit, which in turn ought to lead to systems which meet more clearly defined needs.

It is tempting to view the outcome of health information technology implementations as either successes or failures, and although use of the e-triage software in this setting was discontinued, the project yielded many insights and benefits. A project manager overseeing implementation could have been an asset in overseeing challenges with ergonomics, equipment, reporting, IT problems (the little pieces). An ergonomic assessment may have prevented problems that developed with individual nurses such as neck pain.. From an education perspective nurses were not resistant to using an electronic system; they were open to change and understood the usefulness of data collection. Nurses easily transitioned to use of the e-triage system because the training and practice time along with buddy time and the 24 hour educator support for the first 2 weeks of implementation supported their new practice. Reflecting on program functionality, there were problems with such things as pull down menus which caused frustration, and it seemed obvious that a pediatric triage nurse was not involved in the design because it lacked many common pediatric presenting complaints in pediatric terms (such as wheeze, crying baby). When the department was busy and nurses were frustrated because patient safety was compromised from waiting too long the nurses needed a lot of support and the opportunity to vent their frustrations. The need to interact with the computer during the triage encounter interrupted the nurses' human connection with the patient, and made it more difficult to pick up the frustration and concern of parents. For the novice nurse who began to triage while the electronic system was in place there was a tendency to rely on the program to generate the LOU, rather than thinking critically about the special consideration pediatric patients require.

Management and nursing staff could see that increasing use of computers in the ED would occur within a framework of increasing electronic accountability. The e-triage system appeared to be a good introduction into the computerization of emergency documentation, in an environment where it was not possible at that time to fully computerize the ED. Nursing staff now know more about electronic triage than they did prior to this project. ED managers now know more about what kind of data they require, and what the costs of collecting those data will be. The ED is more knowledgeable about the expertise required to implement such a system, and the costs of learning these lessons have been comparatively smaller than they might have been had a more costly computer system been implemented.

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Evaluating the Implementation and Use of a Computerized Physician Order Entry System: a Case Study

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Abstract. *A study at the urology clinic, Frederiksberg Hospital Denmark, the clinicians working procedures, when prescribing, dispensing and administrating drugs using a computerized physician order entry system (CPOE) showed an overwhelming majority of the clinicians who believed it does support the patient safety and quality of treatment despite the CPOE was not used to the expected degree.*

Keywords. CPOE (Computerized Physician Order Entry), evaluation, use of system, outcome, prescription, working procedures, documentation.

Introduction

Copenhagen Hospital Corporation (H:S)[2] purchased in 2001 a physician order-entry system (CPOE) to be implemented in 2006. The main purpose for implementing the CPOE was to increase the documentation quality of drug prescription, dose dispensing and drug administration, to ensure that the correct patient gets the correct drug and dosage at the correct time.

The outcome of CPOE systems is an issue being discussed not only in Denmark but also worldwide. Clinicians are often questioning whether a CPOE system can fulfil the purpose, will it introduce new types of errors and will it make clinicians dependent on computers instead of taking care of the patients [1], [2], [3], [4].

This paper concerns selected results from Frederiksberg Hospital (FH), part of H:S. The study shows that the use of the CPOE system in several areas is not as intentional as it was expected.

1. Study context

The CPOE system has been fully implemented in five out of six hospitals in H:S by the end of 2006. The mental hospital (Skt. Hans Hospital) uses another system, and is not expected to migrate. All together more than 9000 clinicians are registered as users.

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[2] From January 1st 2007 a part of the Capital Region in Denmark.

The H:S covers secondary health care only. The hospitals are organized in outpatient clinics, acute and stationary wards. FH is a minor hospital with a total medical staff of: 207 physicians and 587 nurses. The presented results are from the urology clinic at FH. The urology clinic covers urological diseases – e.g. kidney stones, impotence, sterilization and incontinence, which may need elective surgical treatment. The CPOE system is the first system to be used directly by both the medical and nursing staff without any written support from medical clerks.

The CPOE system was developed for H:S by Acure an IBM division. It has been tested in specifically chosen wards for about two years, before implementation was initiated. The system is implemented in version 1.1, and is currently running on a version 1.1.31. New updates are planned in the light of experiences made during the implementation, and a version 2.0 is being tested.

All users have been offered a three hours training course prior to implementation, and so called "super users", have been singled out on every ward to assist during the implementation period and were offered extra training. The CPOE system was implemented at the urology clinic mid-March 2006. The day set for implementation ended all paper-based registration of drug prescriptions and dispensing/administrating.

Through process analyses the exact need for hardware, PCs in the drug storage room, PCs in the nurses and physicians offices etc., was identified and provided prior to implementation e.g. a number of portable PCs to ensure the physician is always able to bring the PC – and thereby the patients drug record – bedside.

2. Methods

A case study was chosen to detect the outcome of using the CPOE and as a consequence of the constraints in resources and time it was chosen to use a holistic single-case design well aware of difficulties in generalization from one case to another [5]. Furthermore the evaluation model from the Business School of Aarhus in Denmark developed on basis of a previous evaluation was followed [6]. The model is a simple approach to evaluate the outcome by documenting a baseline before using the CPOE and an after-study of the CPOE system in use. The model provides proposals for different kinds of outcome of a CPOE compared to manually working processes. It was chosen to use the indicators stated by the model, which could give data of the use of certain functionalities in the system and some working processes when documenting prescriptions, dose dispensing and administration of drugs.

A questionnaire is the main method of collecting data, but in a smaller approach interviews and data drawn from the system itself to discuss the results further is planned. The questionnaire comprised of three main sections in the baseline covering questions of general interest e.g. age, education and profession, questions of different work processes when e.g. prescribing, followed by expectations to the CPOE. In the after-study the questionnaire was supplemented with questions of how the respondents experienced the implementation process. To compare the baseline with the after-study the questions were made as comparable as possible by using the same sentence focusing on either the manual procedure or the procedure using CPOE.

The questionnaire was tested by clinicians to evaluate the understanding of the questions and the use of scale. The study is mainly formative and will be used to modify the implementation process when implementing CPOE and other clinical IT-systems in the future. The results will also be used summative to analyse in what degree the expectations are met for using the CPOE.

Baseline was collected during spring 2006 and after-study data was collected autumn/winter 2006/2007. The after-study was planned to be done after three months use of the system due to other organizational changes[3] which could influence the use of the system. The baseline is now documented [7], [8] and the after-study data collection is completed and being documented.

3. Results

The baseline questionnaire was sent to 34 clinicians, both medical and nursing staff having a part in the drug working processes. 71% responded of which 42% were medical staff. The after-study questionnaire was sent to 33 clinicians and 64% responded, of which 38% were medical staff. 12% of the respondents answered positively that they participated in the baseline questionnaire and 11% did not remember. Only 3% answered with certainty not to have participated.

The ages of the respondents ranged from 20-59 (average 43 and 38 in baseline and after-study respectively). In the baseline 54% of the respondents have worked less than 5 years in the current job compared to 68% in the after-study. The baseline showed 12% have worked more than 10 years in the current job compared to 9% in the after-study. 96% stated that the CPOE system is a part of their daily work. Only 5% of the respondents were not favourably disposed towards working with the new system and the new work procedures. 77% of the respondents claim to have participated in the offered 3 hours of training, and 88% out of these claim to find it adequate. 75% of all respondents claim the implementation has had a positive influence on the security related to "correct drug and dose to the correct patient at the correct time". 85% agree that the CPOE system has in fact increased the level of professional care provided. Only 5% felt that access to data has decreased and 57% find access to the patients' drug record improved or radically improved. 12% find access reduced. When asked to the overall satisfaction with the CPOE, 76% were satisfied or very satisfied. Only 9% were not satisfied.

3.1. Registering adverse reactions

Adverse reactions have to be documented for each patient and it is important for the safety of the patient that the clinicians can find an updated and valid documentation of adverse reaction at all times. A valid way to register is described in the Danish National Guideline for drug working procedures [9]. The medical staff was asked how often they experienced lack of data related to a valid documentation of adverse reaction using paper, the base line, and using CPOE, the after-study data.

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[3] January 1st 2007 H:S became a part of the Capital Region of Denmark and new organizational structures for clinical specializations in hospitals are expected as a consequence.

When prescribing surprisingly 63% of the medical staff experienced frequently or always absence of updated adverse reaction documentation in CPOE. None of the respondents had the same experience when using the paper system. It is mandatory to register adverse reactions in the CPOE system, mainly in order to decrease the number of prescription errors known to occur, when prescribing without having direct access to the patient's medical journal and adverse reactions information.

3.2. Prescriptions sent directly by the CPOE system to pharmacy

The CPOE system provides an easy way of transferring patients' prescriptions from the hospital to a local pharmacy, where the drugs can be purchased by the patients when discharged. The medical staff was asked if they used the functionality offered by the CPOE. Only 13% of the physicians frequently used the function. The remaining respondents mostly prescribed drugs on paper, which means an increased risk of transcription errors, transferring data from the CPOE system to paper.

3.3. Use of the drug catalogue when prescribing drugs

The CPOE system provides an easy online access to the drug catalogue, allowing the physician to look up any drug information whenever needed. Using the paper system, the physician was dependent on large drug catalogues often carried around in their white coat pocket to be sure to find it when needed. When introducing an online access it was expected that more physicians would use it whenever any drug questions would appear when prescribing.

The results indicate that although using the link in CPOE is much easier, it is not being used additionally. Despite the small number of respondents the results seam to show, that they rarely use the online drug catalogue at all. It is rather surprising since the medical staff outlined it as functionality, they would find very useful and important before the CPOE implementation.

3.4. Documenting prescriptions when the decision is made.

When adjusting the workflow in the clinic prior to implementation, there was a specific point made of the documentation needed to ensure patient safety. The medical staff is therefore obliged to document the prescribed drug immediately after consulting the patient. It is not approved practice to wait until after consulting further patients or firstly to note the prescription on paper, and then gather the prescriptions of the day and enter them later in the CPOE. A time interval of 5 minutes is chosen as an indicator of following the correct working procedures for real-time data input and therefore the medical staff was asked how often they document the prescription less than 5 minutes after consulting the patient. Before implementing the CPOE 70% of the medical staff claim to document less than 5 minutes compared to only 35% using the CPOE.

4. Discussion

The results showed that the medical staff was not using the CPOE as intended. Data collection approximately three months after implementation might have influenced the lack of expected outcome, since new working processes and procedures were not fully adapted, furthermore the study only gives superficial information of the use given by the users themselves. Nothing in the small sample indicates that the implementation process itself has had a negative influence on the use of the system, since a majority of the respondents claimed satisfaction. Directly asked, the respondents found that the quality of treatment had improved. But it is an important fact that the results indicate inadequate use of the system which must be detected as soon as possible to avoid unwanted routines.

The point is made particularly clear when looking at the registration of adverse reactions which is less correctly documented using the CPOE. Registering the prescriptions in real-time has decreased severely and may lead to prescription errors e.g. wrong prescription to wrong patient, unreadable prescriptions or prescriptions simply forgotten to be made. It is less severe, that the medical staff does not use the extra functionality provided to make their work easier, e.g. online access to the drug catalogue. However it is surprising since this functionality was a very big desire prior to implementation.

5. Conclusion

Three months after implementation it is clear, that the CPOE is not used as expected or intended. Looking at the results it must be realized that the actual use of the system decreases patient safety, and there is a great potential for drug related errors which might have severe consequences for patients.

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Telemedical teamwork between home and hospital: A synergetic triangle emerges

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Abstract. The aim of this paper is to describe the effect on the clinical cooperation when introducing video consultations in the home of the patient. The study was conducted as a Participatory Design process containing workshops, field studies, clinical experiments and pilot tests involving participants from the Danish primary and secondary care sectors as well as patients and relatives. The video consultation set-up constitutes a new organisational way of working, described as "a new triangle", based on immediate inter-individual cooperation and team-work. In the triangle, competences were combined which led to a more holistic treatment and a more active role of the patient. Furthermore, a spreading of knowledge between all participants was seen, resulting in an upgrading of the competences of especially the visiting nurse. The introduction of a real-time, on-line link between hospital and home constitutes the basis for simultaneous communication between all participants, resulting in a "witnessing" situation potentially securing or even enhancing quality of treatment.

Keywords. Home care, telemedicine, team work, diabetic foot ulcers

Introduction

Researchers in telemedicine provide strong arguments for telemedicine as a means of increasing access to specialized care and obtaining substantial cost reductions [1,2]. Related research in technological areas has offered the view that information technology is the key to solving some challenges in the future when health care providers will have to handle an increasing number of elderly people with an increasing prevalence of chronic disease [3,4]. One example is the aging population where technology may enable the citizen to stay independent longer [5]. In applying information technology some hospital functions could possibly be moved to a more cost-efficient setting in the homes of the patients, while increasing the patient's quality of life [6-8].

We report from a study investigating an alternate way of treating people with diabetic foot ulcers by the use of a telemedical setting in the home. The study ran over three years and formed the basis for two individual doctoral theses – one in health science and one in computer science. The overall method for the activities has been an approach adopted from computer science, named Participatory Design [9] (PD) and is elaborated on in detail in an earlier article [10].

In other earlier reports from the study, we have described the technical setup for the telemedical intervention which enabled the movement of the treatment from the hospital to the home of the patient and the feasibility of the technology used [11]. Furthermore, in an article under review elsewhere we conclude that the telemedical consultations are viable alternatives to the traditional in-hospital treatment of a patient with diabetic foot ulcers: The doctor and expert nurses were able to evaluate the ulcers and prescribe treatment at a distance, while closely cooperating with the visiting nurse and the patient. The visiting nurses experienced increased confidence in treating foot ulcers and they characterized the consultations as a learning situation, which improved their competence. The patients expressed satisfaction and confidence being treated by this new team, which included all relevant staff and involved active participation from the patient.

Apart from these clinical and technological conclusions, our findings point towards several other conclusions. In particular, we have identified a new pattern of cooperation. In this article, we describe our findings regarding the telemedical cooperation as observed around the treatment performed in the home: How does telemedicine change the work involved in conducting the treatment? How does technology affect the human relations, and what impact does it have on treatment?

1. Methods

As mentioned, the study consisted of a three year process of Participatory Design (PD) detailed described in an earlier article [10]. A multidisciplinary team of two patients, one relative, five visiting nurses, five expert nurses from the hospital, one expert doctor, and one general practitioner took part in a design process along with researchers from both health science and computer science. Data was collected in a series of experimental workshops and experiments in our laboratories. In the beginning of the study, we carried out field studies at the out-patient clinic and by following visiting nurses. During the workshops problems and potential solutions were discussed and various technological setups were prototyped and evaluated. Finally, we included a pilot test in the study. Five (n=5) patients who were all following a course of diabetic foot ulcer treatment in the out-patient clinic were selected for inclusion by the experts. The patients were offered three consecutive video consultations in their own home replacing three visits to the outpatient clinic. We also included one visiting nurse for each patient in the study by contacting the local centre in the residential area of the patient. All patients gave informed consent, and the project was approved by the Aarhus regional ethics committee. Each consultation was video filmed both in the home of the patient and at the hospital and transcribed afterwards. Patients, visiting nurses, the doctor and the expert nurse all answered a questionnaire after each consultation. After completion of the telemedical experiments, we conducted interviews with each of the visiting nurses and with the patients (which in three out of the five cases also involved a relative). Finally, we conducted a focus group interview with the three expert nurses and one individual interview with the doctor.

The technical setup for the pilot test intervention consisted of a web-based online ulcer record enabling hospital clinicians and visiting nurses to share documentation (text and digital images) concerning their common client. The record also contained contact information for everybody involved. Furthermore, the participants were able to conduct video consultations using 3G (third generation) videophones. Thus, the setup consisted of mechanisms for both synchronous and asynchronous communication.

A telemedical course of treatment was initiated with an intensive consultation in the outpatient clinic, where the experts created the patient file in the online ulcer record and uploaded high resolution images of the ulcer as well as obtaining measures such as peripheral blood pressure, blood sugar, etc. Furthermore, the first of the three telemedical consultations was scheduled with the visiting nurse.

Prior to the consultations, the visiting nurse used the video telephone to take pictures of the ulcer and transmit them to the ulcer record. At the agreed time of consultation, the visiting nurse made a video-call from the patient's home to the doctor and an expert nurse at the hospital. The experts used (1) the still images and the video stream from the 3G telephones, (2) images from the previous consultation and (3) the cooperation of the visiting nurse in order to evaluate the ulcer and to prescribe further treatment. After the consultation, the experts wrote their summary of the consultation in the online web-based record.

The combined empirical material consisted of transcriptions of all field studies, workshops and pilot test consultations as well as interviews and questionnaires. Both researchers went through the material and collected quotes and sentences by writing them on post-it notes. The notes were then placed on large sheets of paper until all notes were sorted into categories.

2. Results

We found this new way of treatment to require organisational change, as the new course of treatment requires interactions between separate organisations that were only loosely connected today. The cooperation between actors from different organisations alters the coordination of the course of treatment and introduces a shared responsibility, hitherto unaddressed by the caregivers. Further, the direct and simultaneous dialogue between all stakeholders gives rise to changes in the co-operational patterns.

2.1. Synergetic teamwork

The telemedical consultation radically changes the cooperative patterns between the involved parties in the courses of treatment of patients with diabetic foot ulcers. The major changes are shown in the figure below. The first triangle depicts the traditional hierarchical pattern signified by unilateral communication pathways. The expert doctor/nurse (ED and EN) sees the patient (PT) in the out-patient clinic, evaluates the condition, and prescribes further treatment to the visiting nurse (VN) by means of a written letter. Accordingly the visiting nurse interprets this information and carries out the prescribed treatment. The visiting nurse, however, often finds the given information incomplete and at times difficult to fully comprehend with no opportunity to directly address problem areas. The result is that visiting nurses are left to make their own decisions often regarding difficult clinical matters.

Our initial field studies and workshops provided many different examples of this issue. For instance, one of the visiting nurses that we followed said: "I have now treated this patient for a year, every time I leave I wonder: is this the right treatment, I do not know who to ask and therefore I continue". The lack of access to specialised knowledge may result in a higher frequency of referrals to hospital than necessary, and in many cases perhaps prolonged periods of treatment. Furthermore, the lack of direct communication between the hospital and the visiting nurses means that the patient becomes the coordinator between the hospital and the visiting nurses, and this is a role that several of the patients we talked to during the study characterised as burdening. The communication paths of the present situation are shown in the first triangle in figure 1.

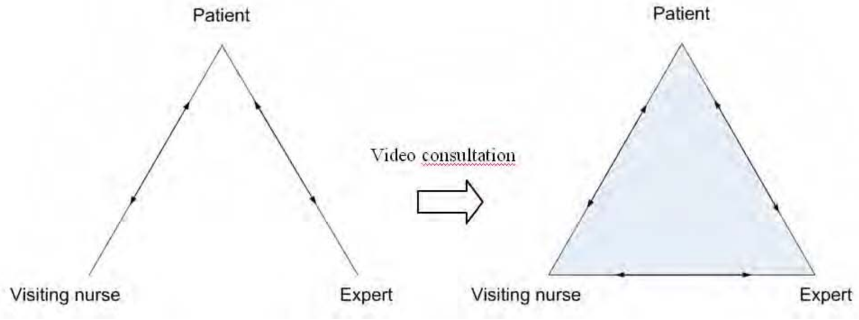

Figure 1. Traditional cooperation (left) and telemedical team cooperation (right)

The telemedical consultation changes the cooperative work patterns between clinicians and patients as illustrated by the second triangle. The common goal for this situation is full communication (direct and indirect) and equality between all involved parties, resulting in a synergetic teamwork approach.

The direct dialogue between all parties (including the patient) allows for a treatment plan commonly agreed to, thereby overcoming the physical separation. This led to a great degree of professional satisfaction for staff and the patients, who participate equally. Overall these highly active individual and mostly simultaneous contributions resulted in a clearly perceived experience of working as a team. "There is a profound cooperation in carrying out the treatment; it is increasingly a dialogue between visiting nurse, patient and expert, where the visiting nurse gets insights into the experts reasoning and thoughts (ED)". Additional specific tasks can be delegated to a higher extent to the individual visiting nurse because instructions can be delivered directly. "I think I have a better understanding and a much better help in what is right and what is wrong to do (VN)". Even a transformation in terms of self esteem arose by due to the recognition as a full fledged member of a professional team. One visiting nurse went as far as to exclaim: "Of course I am responsible for what I do – cutting the ulcer for example, but I had backup, so I wasn't just the amateur that did something that I, in fact, shouldn't have done".

From the patients' perspectives a number of viewpoints have been highlighted. One most interesting of these is captured in the quote of one patient during the interview: "It was interesting and good that the doctor was able to see me in my living room, see my ulcer directly and explain to me what he intended to do, I was more a part of the situation, it became more personal, thereby a triangle is created, notably a triangle you need not run after (PT)". This impression was also substantiated by the clinicians' experience that a higher number of questions were put forward from the patients at home as compared to patients in hospital. The patients and the relatives participated by giving input to and opinions to the consultation, thereby becoming an active part of the new triangle. They also expressed the feeling that a deeper insight was gained when being treated on home ground, and they felt that the doctor, somehow, "saw me as a whole person", and they were taken seriously. Or, as expressed by a VN: "I think that the video consultation moves the concerns from the ulcer to the patient as a person. When he returns from the hospital, I carry out the prescribed treatment, when I'm here [i.e. in a video consultation] I participate in the consultation and in that way the patient is more in focus." Another VN put it this way: "The patient's role is different, there is more focus on the patient, he could tell things as well and so did his wife." Other researchers call this empowerment of the patients and argue that empowerment will naturally lead to a better outcome of treatment, followed by higher quality of life and satisfaction for both provider and patient [12]. Empowerment may be an elusive goal due to reluctance among the clinicians [13], but we did not find any evidence for this conclusion in our study.

The visiting nurse played a very important role as a link between experts and and the patients at home. Her detailed personal knowledge of each individual patient assisted in the success of the telemedical consultation. The input of the visiting nurse thereby becomes an important supplement to an ordinary hospital consultation. In the traditional out-patient course of treatment, competences of the respective parties (hospital experts, visiting nurse and indirectly the patient) remain separated to a larger extent. The telemedical setup facilitates "a new sharing of competences" based on real-time, on-line dialogues between the above mentioned parties.

We observed that the visiting nurse (especially when possessing little knowledge about ulcer treatment beforehand) improved her professional skills during the first to the third consultations, and thereby she became more satisfied and confident in treating the patient. One expressed it this way: "The next patient I see will benefit from my new knowledge (VN)".

The doctor confirmed this by pointing out that individual competences grew rapidly as a result of the combining of competences with other team members. He explained it this way: "The sum of competences grows much faster than the competence of any individual person can (ED)". These findings are in line with Gardner et al. [14] and Ameen et al. [15], who reported that the competence of the visiting nurse may increase during this telemedical consultation, facilitating the spread of knowledge from expert to the community.

2.2. Witnessing

An interesting finding was that the different stakeholders became witnesses of the different situations. When communicating in "the new triangle" using video phones, all parties were automatically, synchronously and actively involved in the consultation. When two of the parties (for example a doctor and a visiting nurse) are in dialogue, others (for example patient, relative, expert nurse) hear this dialogue and can participate in the consultation.

The visiting nurse witnesses the expert talking to the patient. This solves the problematic issue of the patient having to act as messenger between hospital and primary care instances. It may still be necessary for the patient to draw the clinicians' attention to facts such as earlier incidents of side effects with medication as was the case in one of the consultations. Here the patient checked his records to see the name of the antibiotic he was allergic to. He was able to provide this new information, thereby playing an active role in his own treatment.

There may also be situations in which the direct contact between the hospital and the home take away the patient's ability to veto the clinicians: e.g. – as in another case from the study – if the patient will not hear of any wheelchair. The visiting nurse sometimes acts as an interpreter between the doctor and the patient, at times because the patient may be hard of hearing and at times due to suboptimal technology.

The patient witnesses his/her visiting nurse getting instructions from the expert. In this way the visiting nurse and patient get a common reference in their subsequent discussions. Furthermore, the patient can use the simultaneous access to both expert and visiting nurse to bring forth other health issues, e.g. sleeping problems or diet, where the patient can ask the doctor about the concern while ensuring that the visiting nurse hears the answer as well.

The expert witnesses the dialogue between visiting nurse and patient, which reveals important information. Since the visiting nurse usually has a more personal relation to the patient, the expert can benefit from the details in their conversation to convey important issues pointing at a specific problem, for instance in regard to patient compliance.

The witnessing aspect in this new cooperation triangle differs from the old triangle, because the new way of conducting a consultation in itself contains an assurance of quality by adding more perspectives to the same situation. Making formal decisions (e.g. prescribing medicine) and informal decisions (advice for patient, e.g. regarding his feet) may enhance patient understanding of the issues and matters of compliance. In this way the visiting nurse understands the reflections behind the decisions and the seriousness of actions taken and can now act responsibly on the basis of direct knowledge. It is also a learning situation for patients and relatives, because patients get a first-hand experience of the dialogue between the health care professionals. Another positive side effect is that the patient no longer has to be the messenger between experts and visiting nurses as is the case today.

2.3. Verbal and non-verbal communication

Cooperating over distance requires a combination of the two separate physical spheres. The channel between these spheres may not allow for participants to get a full picture of what is going on in the other end. For example, it may be difficult to perceive facial expressions precisely, and thereby being able to read between the lines of more complicated issues.

At the same time the engaged parties may be in a situation where it is difficult to get a glimpse of the context the other party is working in. For instance, after one consultation the patient at home said: "The doctor seemed busy today". The fact was that the doctor ran into problems with the nurses at the hospital, which caused delays in the rest of the day's program. Thus the patient's perception of "business" was correct, but the underlying causes naturally could not be understood at a distance with a "limited window".

Likewise, experts at the hospital may not experience the full context of the patient's home. For example, at one consultation the expert nurse suddenly was in doubt about whether the patient was in a wheelchair, and she was a little embarrassed to ask about it. Yet another example occurred during a clinical experiment undertaken in the early phases of the project at a time when we were identifying the importance of showing the larger picture first before zooming to a close-up of the ulcer. On one occasion, the clinicians were almost able to conduct a complete consultation before realising that the expert had mistaken the actual location of the ulcer (i.e., on the foot and not under the heel).

The above examples demonstrate the importance of being aware of potential technological and organisational obstacles to optimal treatment. Not having the patient physically in front of you requires close attention to these issues. For instance, before zooming in to the ulcer and discussing specific problems, it is recommended to ensure the overview over the general situation.

Conducting a video consultation requires consideration of the verbal expressions used. At one particular consultation, a conversation between EN and VN with both relatives and patient listening resulted in the following: (EN): "I would like to get a knife into that [ulcer], do you have one?" If this same sentence was said face-to-face probably nobody would have worried. But when presented over a video phone between the two nurses, the patient and relative may be offended as they have no eye contact or impression of the atmosphere in which the comment was made. The words may be perceived in a much worse way than intended, and therefore may create anxiety and nervousness for the patient in question.

3. Discussion

Telemedical studies may remain at the level of clinical trials due to organisational issues, which arise when attempting clinical implementation [16,17]. Unfortunately, issues of implementation are often not dealt with when undertaking these studies. The organisational consequences of using video consultations in daily clinical practice must be understood and described simultaneously with the development of the new ways of providing treatment. In his article [18], Aas identifies a number of such organisational consequences, representing both enhancements and deficits to the quality of treatment and care.

We mainly perceive our "new triangle" as an improvement of the cooperation that takes place. The synergy and cooperation between all the participants, which replace the one-way information based on written instructions from the expert to the visiting nurse, benefits all the participants, particularly in terms of teamwork and inter-individual cooperation. which is important in optimising clinical treatment and patient satisfaction. This is in line with a study published in 2003 [19] in which the authors concluded that home telecare supported by dedicated multidisciplinary care teams can promote partnerships between patients and caregivers.

This, however, does not mean that there will not be obstacles on the way towards implementation in daily practice. For instance, telemedicine often gives rise to shifts in the balance of power [20]. In our case the doctor may become more dependent on the visiting nurse acting as a proxy in the treatment. Not everybody may be willing to accept this in the future.

The present group of patients still belongs to the older generation, which is brought up with the attitude that the clinicians (especially the doctor) are in charge and have the power of decision. Will this group of patients prefer the traditional visit in the out-patient clinic, and if implemented, will telemedicine be an alternative the patient can refuse? One study concluded that there are still patients who prefer the face-to-face consultation [21].

We did not experience substantial resistance towards the technology in our study. On the contrary, our study consisted of participants who took part ownership of the concept and could see the advantages. In our pilot test the hospital personnel was already experienced since they had been participating throughout the research process. Consequently, they were able to act with drive, engagement and leadership. This meant that the experts were ready to accommodate the visiting nurses making the video consultations smooth by creating energy and engagement. We therefore recommend, when implementing video consultations, that the experts are already familiar with the use of the technology.

This study did not consider the numerous economical issues related to the introduction of telemedicine. In particular, advocates of asynchronous telemedicine point to the fact that synchrony in the collaboration is costly in terms of reduced efficiency [22]. Indeed, on a couple of occasions we experienced how a small delay of the visiting nurse caused waiting time for the hospital clinicians, but this time was to perform other tasks relating to other patients in the hospital. The benefits of multidisciplinary cooperation for treatment are indisputable. The main challenge is to schedule and coordinate without depriving participants of their existing flexibility and without constraining workflow unnecessarily.

When video consultations are implemented on a larger scale, new ways of working will automatically ensue. For instance, the doctor could commence the consultation and the expert nurse finish it while the doctor starts a new consultation, thereby utilising staff efficiently. Of course, this will in turn reduce the benefit of witnessing. The share of responsibility might also be challenged, and a discussion involving the trade unions might be needed before implementing in larger scales.

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ICT & OTs: A model of information and communications technology acceptance and utilisation by occupational therapists (part 2[1])

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Abstract. The research reported in this paper describes the development, empirical validation and analysis of a model of technology acceptance by Australian occupational therapists. The study described involved the collection of quantitative data through a national survey. The theoretical significance of this work is that it uses a thoroughly constructed research model, with one of the largest sample sizes ever tested (n=1605), to extend technology acceptance research into the health sector. Results provide strong support for the model. This work reveals the complexity of the constructs and relationships that influence technology acceptance and highlights the need to include sociotechnical and system issues in studies of technology acceptance in healthcare to improve information system implementation success in this arena. The results of this study have practical and theoretical implications for health informaticians and researchers in the field of health informatics and information systems, tertiary educators, Commonwealth and State Governments and the allied health professions.

Keywords. Technology acceptance, Unified Theory of Acceptance and Utilization of Technology (UTAUT), health IT, allied health, structural equation modelling

Introduction

Information system (IS) implementations are fraught with difficulties and the health sector is not immune to experiencing their share of 'difficulties' and outright implementation failures [1, 2]. The cost of these failures – both directly and indirectly, and in economic and non-economic terms can be devastating and failed implementation efforts in the past have no doubt contributed to the lag in technology use within the health sector. The unacceptable rate of failures continues to warrant research and investigation into how and why IS implementations fail, what is needed for them to succeed, and for the outcomes of these investigations to be incorporated into the design and implementation process by all stakeholders to improve the success of IS implementa-

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[1] Part 1 of this paper was presented at ITHC2004

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tions in this arena. One such area of investigation is the technology acceptance decisions made by individual healthcare practitioners.

The field of technology acceptance research within the discipline of Information Systems has a history spanning 30^+ years. In that period various theoretical models have been devised to investigate individual acceptance of technology. These models continue to be frequently applied and tested within samples of university students or within business environments and typically explain ~40% of the variance in individual intention to use technology [3].

In the three years that have past since 'part 1' of this paper was presented at the 2nd ITHC Conference [4], research on implementation, acceptance, adoption and diffusion of IS in health care has grown substantially. However, there is still much work to be done to develop and gain empirical support for models of technology acceptance within health and to examine acceptance and utilisation issues amongst health professionals.

A review of the literature shows that a common factor in this field of study is the inherent complexities involved in IS implementation in health [2], as well as a resistance by health professionals to accept and utilise information and communication technologies (ICT). This is a view supported by researchers, practitioners and health informaticians alike and although the gap has decreased, the traditional lag in technology adoption in health which has been widely reported for over a decade still holds true today - despite advances in technology, the increasingly high profile attributed to health ICT [5] and the potential benefits of adoption [6].

While the technologies studied in acceptance studies have been diverse, the application of a sociotechnical approach to this work is scarce. In his 2004 seminal article '*Four rules for the reinvention of health care*', Coiera [7] makes the case for sociotechnical approaches to the design of health services and health information system design and implementations to ensure the sustainability of healthcare. It thus follows that sociotechnical approaches are necessary to mitigate and improve IS implementation success in health. Despite this and other acknowledgements of the importance of a sociotechnical approach [8], many of the technology acceptance studies continue to use overly simplistic models to explain what is essentially a very complex and diverse phenomenon in a very complex and diverse system. Only by examining the social, technical and system issues can we hope to understand technology acceptance within health.

Another key limitation of technology acceptance research is its almost exclusive focus on the acute care sector and the physicians who work within it [9]. Outside of the acute care sector, medical practitioners and their local practices are again the focus [10]. The need for technology acceptance studies to incorporate a more holistic and inclusive view of those who work in healthcare is vital, as we can not presume to understand technology acceptance within health unless we study all the players in the system to ensure that a more complete view of technology acceptance within health and thus improve the success of information system implementation in this arena [11].

The research reported in this paper attempts to address these issues through development of a sociotechnical model of technology acceptance and use by Australian occupational therapists. Occupational therapists (OTs) are allied health professionals who provide support to a wide range of people with physical, psychological or developmental injuries or disabilities. They work in a wide variety of settings including private practice, hospitals, nursing homes, community centres and private industry and work with clients across the lifespan, from infancy to old age [12].

1. Research model

The research model developed in this study (Figure 1) draws on findings from relevant prior research and is primarily based on the UTAUT model [3] and on the generic framework for technology acceptance proposed by Chau & Hu [13]. For a full discussion of the development of the research model see Schaper & Pervan [14].

The research model theorises that technology acceptance has three dimensions: 1) characteristics of the individual; 2) characteristics of the technology; and, 3) characteristics of the implementation context. The characteristics of individual users are grouped within the individual context. The technological context refers to the characteristics of the technology itself and is made up of two determinants – performance expectancy and effort expectancy. The implementation context refers to the specific professional environment of the user and includes the determinants of social influence, organisational facilitating conditions and compatibility. It is the implementation context which is theorised to have the predominant influence on user acceptance, as it is within this dimension that organisational and social issues are examined and, importantly, the compatibility of the technology with the clinical priorities of delivering positive outcomes for clients.

In this research model, compatibility is defined as the degree to which an innovation is perceived as being consistent with the existing practices, values, needs and experiences of the health care professional. In a health care context, compatibility of a technology with the work practices, values, needs and experiences of the user becomes a crucial determinant in acceptance decision-making. The high value placed on the therapeutic relationship between a client and therapist can not be underestimated as it is a crucial tool in the therapeutic process. An innovation which is perceived to be incompatible with this process or incompatible with the ultimate aim of improved patient outcome, will ultimately lead to rejection of the innovation by health care professionals. This is emphasised by research conducted into telepsychiatry innovation in clinical practice [15]. In this instance, health care professionals who were initially championing the virtues of telepsychiatry, eventually found that the technology threatened deeply embedded professional constructs about the nature and practice of therapeutic relationships and was eventually rejected in a determined way [15].

1.1. Moderators

The role of moderating influences on technology acceptance has recently received increased prominence in studies of technology acceptance. In their recent paper, Sun and Zhang [16] state the potential of moderating variables to overcome the limitations of explanatory power that plagues many technology acceptance studies and models.

As this study was the first time technology acceptance research had been performed within this unique population, hypotheses were not formulated for the influence of moderating variables. Moderating variables were included in the research model and methodology to explore their affects on technology acceptance by Australian occupational therapists.

The moderating influence of 7 variables were tested in this research. Specifically, the influence of age, computer experience, computer skill level, job position, work sector, work setting and geographical area. While some of these potential moderators have been included in other technology acceptance studies, all are important characteristics which define Australia's occupational therapy population.

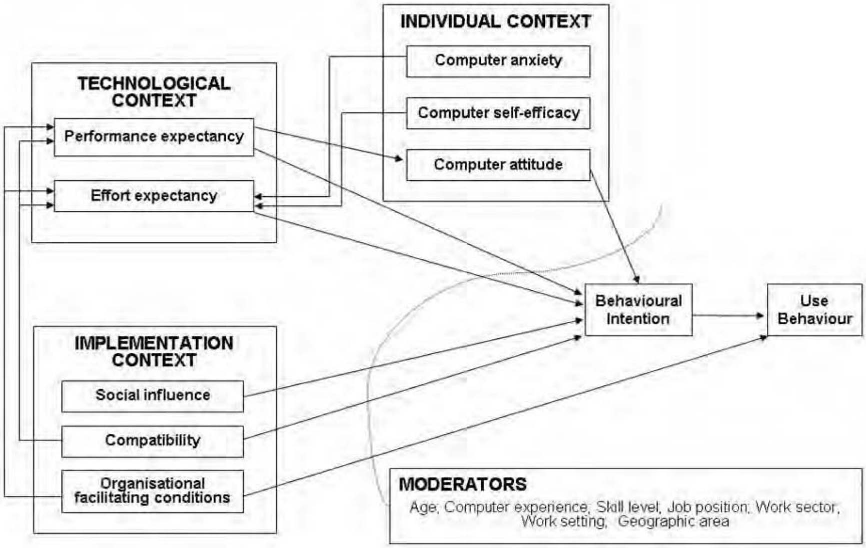

Figure 1. Research Model

2. Methodology

The proposed model was tested through a three-phase study design, using mixed-mode methodology to collect substantial quantitative, qualitative and longitudinal data on technology acceptance and use amongst occupational therapists across Australia. Phase I consisted of the development of the preliminary research model, questionnaire development and pre-testing and conducting focus groups to obtain qualitative data. Phase III involved a longitudinal case study analysis of technology acceptance. A survey research design was utilised in phase II, involving a national survey sent to 6453 Australian occupational therapists to provide cross-sectional data on behavioural intention and acceptance of ICT and other issues surrounding utilisation of ICT. The results of phase II are reported in this paper. Description of the methods used in this study can be found in Schaper & Pervan [14].

3. Results

3.1. Study respondents

Thirty two (32%) percent of the 6453 questionnaires distributed were returned. Of the 2044 responses received, 439 had incomplete responses that pertained to the measurement model. This analysis pertains to the remaining 1605 complete responses.

Characteristics of the study respondents are found in Table 1. The average age of respondents was 37 years and 95% were female. Based on the gender and age distributions of the data, the sample appears highly representative of the occupational therapist population within Australia [17]. OTs in management or senior roles made up 32.6% of the respondents and 13.7% were self-employed. The number of years of computer/ICT experience ranged from 1-30 years, with an average of 11.7 years. The majority (66.5%) of respondents rated their computer skills as 'medium' and almost a quarter of the respondents believed they have low levels of computer skills.

Table 1. Characteristics of respondents (*n*=1605)

		Frequency	**Percent (%)**	**Mean**	**SD**	**Range**
Gender *n*=1605	Female	1524	95.0			
	Male	81	5.0			
Age *n*=1565	21-30	573	36.6	36 years	9.9	21-73 years
	31-40	493	31.5			
	41-49	328	21.0			
	Over 50	171	10.9			
Job Position *n*=1584	Self-employed	217	13.7			
	Manager/Senior	516	32.6			
	Therapist/Other	851	53.7			
Computer experience (yrs) *n*=1577	1-9	372	23.6	11.7 years	4.4	1-30 years
	10-19	1107	70.2			
	20-30	98	6.2			
Computer/ICT Skills *n*=1583	Low	377	23.8			
	Medium	1053	66.5			
	High	153	9.7			

1. Note that the *n* for each variable is not equal to the total *n*=1605 because of missing values.

3.2. Test of the research model

3.2.1. Data analysis methodology

The partial least squares (PLS) approach of structural equation modelling was used in this test of the model [18]. The analysis of the research model was conducted using PLS Graph v03.00 [19]. Model estimation involved two stages: firstly, the reliability and validity of the measurement model was assessed; and secondly the structural model was assessed. This ensures that measures of the constructs are reliable and valid before assessing the relationships among the constructs [18].

3.2.2. Assessment of measurement model

To ensure the research model has acceptable measurement properties, reliability, internal consistency and discriminant validity were assessed. Individual item reliability was tested by using PLS to produce individual item loadings. Of the 35 items SI4, SE1, SE3 and SE4 had loadings of less than the acceptable level of 0.3 [20] and were removed from further analyses. As a result, computer self-efficacy (SE) has only the one item included in the analysis of the model. While this is statistically correct, using only one item to measure a construct limits the model's ability to adequately capture the entire concept and raises the potential for respondent error. It is recommended that future studies revise the indicators for SE.

The revised model with 31 indicators was again tested using PLS. All individual item reliabilities were above 0.662 and thus deemed reliable.

All internal composite reliabilities were greater than the acceptable level of 0.70 [21]. The square roots of the shared variance between the constructs and their measures (AVE) were higher than the correlation of latent variables, with the exception of 2 values (COM/PE and COM/ATT). Thus while convergent and discriminant validity is good, it is not fully supported.

3.3. Assessment of structural model and hypothesis testing

Table 2 (section a) shows model test results with direct effects only. The results of the PLS analysis with bootstrapping reveal that all of the 12 direct path are statistically significant. The model explains 63% of the variance in behavioural intention.

While not discounting the relevance and importance of these statistical significance figures, the high statistical power is to be expected due to the large number of cases (*n*=1605) which will produce small standard errors and make the statistical tests overly sensitive [22]. Measures of practical significance can be applied to this data to provide a further level of analysis to assess the substantive and theoretical implications of the relationships between the variables [22].

The path coefficients for COM PE and PE ATT are both at 0.75. Thus for every unit change in COM there is almost a one unit change in PE; the same applies to the effects of changes in PE on ATT. The relationship between these variable is thus more substantive than the relationship between OFC PE, in which 9 unit changes in OFC would need to occur before there is a 1 unit change in PE.

So while tests of statistical significance show that all 12 direct paths are significant, tests of practical significance demonstrate that PE, ATT and COM have a more substantive influence on behavioural intention (BI) than does EE or SI.

3.4. Assessment of influence on moderating variables on the structural model

Due to space restrictions the moderating variables of age, job position, computer experience and computer skills will be discussed here. PLS was used to generate path coefficients for each separate data set. The results are shown in Table 2 (section b-e). The R^2 values and hence the explanatory power of the model did not change significantly in each subset (ranged from 56.9% - 67.8%), despite significant changes in *n* and the existence of differing moderating variables. This consistency across subpopulations is a sign of representative reliability and implies the model is robust as the R^2 is high across subpopulations.

a) Moderating variable - age
To examine the effect of age on the various paths/relationships in the model, the complete data set of 1605 cases was split into 4 aged-related categories (Age 21-30, Age 31-40, Age 41-49 and Age 50^+). The effect of EE on BI decreased with age and the relationship was not statistically significant with those who were aged over 50 years. The influence of COM on PE increased with age, suggesting that older users are more likely to consider compatibility of the technology to their roles as therapists as important in their ICT intentions. Given the increasing age of the workforce, the influence of age on technology acceptance needs to be considered in future studies.

b) Moderating variable - job position
Respondents were asked to indicate if they held senior or management roles, or were self-employed. The influence of SI on BI for managers was not statistically or practically significant. This is to be expected as managers are less likely to use ICT just because others in their workplace think they should. The attitude of self-employed OTs was shown to have no significant effect on their intention decisions.

c) Moderating variable - computer experience
Survey respondents were asked to quantify the number of years they had been using computers/ICT for work or personal use. Their responses were categorised into 1-9 years, 10-19 years or 20-30 years experience. The influence of PE on BI for those with the most computer experience was dramatically different from those who had been using ICT for under 10 years. Those with less experience were more likely to have their intention decisions moderated by the performance gains they expect to achieve from using ICT. Results also showed that the effect of ATT on BI increased with experience.

d) Moderating variable - skill level
Respondents were asked to rate their overall skill level/competency at using ICT as either 'low', 'medium' or 'high'. The R^2 values showed the most degree of change within these subsets, ranging from $R^2=0.578$ for low skilled respondents and $R^2=0.678$ for high-skilled respondents. For those with high levels of computer skills, COM was shown to have the largest direct influence over BI, while EE and SI had no statistical and little practical significance over their intention decisions. These results indicate that self-perceived computer skills is an potentially an important moderating influence and should be included in future studies on technology acceptance.

4. Discussion

This paper presents an overview of the development and testing of a sociotechnical model of technology acceptance by Australian occupational therapists. The analysis performed to date and presented in this paper demonstrates that all 12 direct path hypotheses are statistically significant, and that compatibility (COM), attitude (ATT) and self-efficacy (SE) exhibit a higher practical significance on intention to use ICT than effort expectancy (EE) or social influence (SI). The direct-effects only model explained 63% of the variance in behavioural intention to use ICT.

The explanatory power of the model did not change significantly amongst subsets when the potential moderating variables of age, job position, computer experience and computer skills were taken into account. This provides further evidence of the robustness of the model which was able to explain 56.9% - 67.8% of the technology intention decisions of participants. This analysis also demonstrates the value of including moderating factors to help explain and describe the phenomenon of technology acceptance.

Table 2. Significance of Path Coefficients

a) Complete			**b) Moderating Variable: Age**			
Path	**t-value for path**	**Complete** *n=1605*	**Age 21-30** *n=573*	**Age 31-40** *n=493*	**Age 41-49** *n=328*	**Age 50^{+}** *n=171*
COM → PE	59.7216****	0.755****	0.707****	0.748****	0.758****	0.828****
PE → ATT	58.7182****	0.747****	0.690****	0.760****	0.730****	0.829****
ANX → EE	21.7849****	-0.435****	-0.458****	-0.391****	-0.394****	-0.539****
OFC → EE	12.3296****	0.243****	0.218****	0.267****	0.299****	0.196***
SE → EE	11.5194****	0.226****	0.264****	0.227****	0.199****	0.105*
PE → BI	7.8554****	0.258****	0.289****	0.292****	0.125*	0.280**
ATT → BI	7.7468****	0.231****	0.315****	0.163***	0.179**	0.327***
COM → BI	7.3779****	0.240****	0.173****	0.197****	0.441****	0.162
COM → EE	6.7638****	0.140****	0.080*	0.172****	0.156****	0.183***
OFC → PE	6.6169****	0.112****	0.094***	0.153****	0.092*	0.090*
EE → BI	5.9503****	0.140****	0.114***	0.205****	0.106*	0.067
SI → BI	4.4865****	0.082****	0.070**	0.081***	0.099***	0.092
	R^{2}	**0.634**	**0.637**	**0.609**	**0.647**	**0.672**

c) Moderating Variable: Job Position				**d) Moderating Variable: Computer Experience**		
Path	**Therapist/ Other** ***n=851***	**Self-employed** ***n=217***	**Manager/ Senior** ***n=516***	**Exp 1-9 years** ***n=372***	**Exp 10-19 years** ***n=1107***	**Exp 20-30 years** ***n=98***
COM → PE	0.758****	0.689****	0.775****	0.791****	0.742****	0.705****
PE → ATT	0.764****	0.692****	0.757****	0.742****	0.734****	0.770****
ANX → EE	-0.441****	-0.407****	-0.437****	-0.483****	-0.409****	-0.407****
OFC → EE	0.182****	0.297****	0.303****	0.220****	0.263****	0.243***
SE → EE	0.241****	0.216****	0.195****	0.135****	0.257****	0.234****
PE → BI	0.224****	0.324****	0.252****	0.347****	0.262****	-0.042***
ATT → BI	0.276****	0.016	0.310****	0.158**	0.229****	0.380***

	c) Moderating Variable: Job Position			**d) Moderating Variable: Computer Experience**		
Path	**Therapist/ Other** ***n=851***	**Self-employed** ***n=217***	**Manager/ Senior** ***n=516***	**Exp 1-9 years** ***n=372***	**Exp 10-19 years** ***n=1107***	**Exp 20-30 years** ***n=98***
COM → BI	0.222^{****}	0.371^{****}	0.194^{***}	0.242^{***}	0.225^{****}	0.361^{**}
COM → EE	0.171^{****}	0.120^{***}	0.110^{***}	0.148^{****}	0.127^{****}	0.239^{***}
OFC → PE	0.098^{****}	0.217^{****}	0.093^{***}	0.130^{****}	0.092^{****}	0.156^{*}
EE → BI	0.149^{****}	0.115^{*}	0.110^{***}	0.099^{*}	0.167^{****}	0.105
SI → BI	0.097^{****}	0.115^{*}	0.052	0.088^{**}	0.074^{****}	0.158
R^2	**0.653**	**0.635**	**0.619**	**0.618**	**0.632**	**0.645**

e) Moderating Variable: Skill Level							
Path	**Low** ***n=377***	**Medium** ***n=1053***	**High** ***n=153***	**Path**	**Low** ***n=377***	**Medium** ***n=1053***	**High** ***n=153***
COM → PE	0.760^{****}	0.729^{****}	0.797^{****}	ATT → BI	0.229^{****}	0.247^{****}	0.178^{*}
PE → ATT	0.739^{****}	0.696^{****}	0.691^{****}	COM → BI	0.264^{****}	0.219^{****}	0.407^{****}
ANX → EE	-0.464^{****}	-0.401^{****}	-0.495^{****}	COM → EE	0.116^{***}	0.158^{****}	0.179^{*}
OFC → EE	0.195^{****}	0.226^{****}	0.153^{*}	OFC → PE	0.096^{***}	0.093^{****}	0.017
SE → EE	0.297^{****}	0.160^{****}	0.172^{*}	EE → BI	0.082^{*}	0.136^{****}	0.063
PE → BI	0.268^{****}	0.237^{****}	0.254^{***}	SI → BI	0.103^{***}	0.098^{****}	0.077
				R^2	**0.578**	**0.569**	**0.678**

Notes

1. Figures were calculated by performing a bootstrapping resampling technique within PLS Graph, which uses randomly selected subsamples to generate t-statistics to indicate significance of model paths.
2. *p-value <0.05 (significant t-values);
3. **p-value <0.01 (significant t-values)
4. ***p-value <0.005 (significant t-values);
5. ****p-value <0.0001 (significant t-values)
6. Coefficients in grey font are statistically non-significant.
7. Note that the combined *n* for each variable is not equal to the total *n=1605* due to missing values.

A full interaction analysis of all potential moderating variables, including potential interaction between the variables had not been performed at the time of writing this paper. Further confirmatory and exploratory analysis will be performed and revisions to the model will be examined during this process.

The results of this study show that the constructs and relationships of factors that influence technology acceptance in healthcare are complex and do clearly require a sociotechnical approach. Researchers and academics studying technology acceptance amongst healthcare professionals need to be mindful of this and to direct their research efforts to identifying and addressing this complexity. The significance of factors that make up the technical and implementation contexts of the model have practical implications for employers, managers, policy makers, information system professionals and IS vendors – as attention to these factors during the design and implementation phases should enhance the success of IS implementations. Finally, this research has both theoretical and practical implications for occupational therapists - as armed with the knowledge and evidence of their needs will empower them to request and make changes in their workplaces to ensure their ability to access and use ICT is not constricted by organisational (system), social or technical factors.

Although this study provides valuable insights into the factors affecting the intention to use ICT amongst Australian occupational therapists, there are some limitations. These include: this phase of the research was a cross-sectional quantitative look at technology intention and did not study technology acceptance over time. Phase III of this study did examine technology acceptance over time, however due to the small number of subjects in the case study, statistical significance of the direct paths and moderating variables was unable to be determined (see [23] for further information on this phase of study). Additionally, the target group of this research was Australian occupational therapists and thus generalisations of the results to other groups of healthcare professionals is limited. However, it is likely that the model will apply to other allied health professionals due to the many similarities between allied health therapists and their role and position within the health sector. It is anticipated that future research will investigate the generalisability of the model.

5. Conclusion

This paper has presented a brief overview of the theoretical basis behind the development of a model of technology acceptance by Australian occupational therapists, a full structural equation modeling analysis of the direct effects model and preliminary analysis of the influence of four moderating variables on intentions towards technology acceptance. The research described forms part of a three-phase PhD study, the objective of which was to understand the factors contributing to occupational therapists' acceptance of ICT and to develop and empirically validate a model of ICT acceptance amongst this group of health professionals.

The theoretical significance of this work is that it proposes a thoroughly constructed research model, with one of the largest sample sizes ever tested, to extend technology acceptance research into the health sector and specifically to occupational therapists. This work reveals the complexity of the constructs and relationships that influence technology acceptance and highlights the need to include sociotechnical and system issues in studies of technology acceptance in healthcare to improve information system implementation success in this arena. The results of this study have practical and theoretical implications for health informaticians and researchers in the field of health informatics and information systems, tertiary educators, Commonwealth and State Governments and the allied health professions.

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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 pre-selected 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 in from initiating an interruption	**Indirect Recipient** – the incidental recipient of an interruption; i.e., talking with another and 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

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.

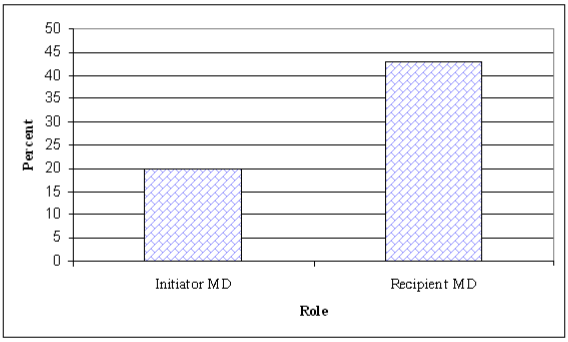

Figure 1. Role for MDs in the interruption event

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

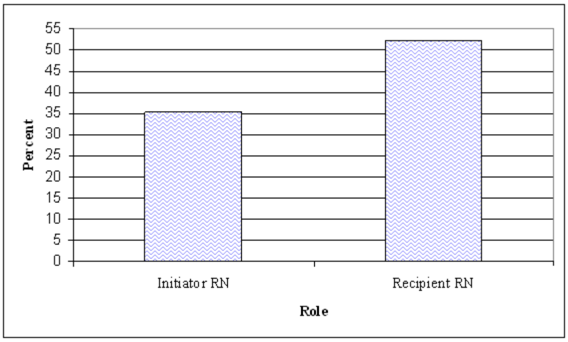

Figure 2. Role for RNs the interruption event

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 clinical 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.

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Analysis of Communicative Behaviour: Profiling Roles and Activities

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Abstract. In this paper, we discuss how profiles of communicative behaviour can be used to present and analyse information about role activity recorded through structured observation of specific situations. The role activities are encoded as distinctive speech acts. Example profiles resulting from the analysis of three clinicians' communicative behaviour during pre-rounds meetings and ward rounds are given. The examples are based on an observational study performed at a Norwegian university hospital. 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. The data has been post-processed by associating each event with one communicative act. The approach is an efficient and useful means for studying clinicians' information and communication patterns in hospital wards, which can serve as an important tool in the design of new clinical information systems.

Keywords. Structured Observation, Communicative Acts Profiling, Requirements Elicitation, Software Design, Point of Care Clinical Information Systems

Introduction

Healthcare is a communication- and information-intensive sector with a history of mixed success with introduction and use of information systems. Some of the problems can be ascribed to simplistic design processes and methods unsuitable for the complexity of healthcare. In our research on mobile, electronic patient records, we have identified that the primary system requirements are determined by the situation in which the system is used. Important properties of the situations can be captured trough observation of actors, processes, systems, their interaction and context.

Observational methods give rich and detailed domain knowledge that is highly relevant for a software designer [1]. The more "objective" the observation is, the higher reusability of the information gathered. From a system designer's point of view, video recording and protocol analysis lie at one extreme end of a spectrum of methods providing high detail but no systematic or simple way of abstracting the knowledge. Traditional methods for requirements engineering lie at the other end of the spectrum, providing only abstractions of user behaviour or needs; possibly unfounded, but directly applicable in the design process.

Our overall objective has been to make structured observation, the planned watching and recording of behaviour and/or events as they occur within a well-known/ predefined environment, into a practical tool for elicitation of domain knowledge in the software design process. Towards that objective we need to codify the observations, namely attributes of context, role and communicative behaviour. In particular, it is interesting to characterize the communicative behaviour of an actor in terms of whom or what takes part in the communication, what the subject of communication is and to what purpose the communication takes place. Once this characterization has been done for a particular set of observations, it is possible to make quantitative profiles of situations and actors according to the needs in specific design problems. The power of keeping observation and interpretation separate is that the same observational data may be analysed in different ways according to the current need and perspective of design.

The rest of this paper describes some of the related work on speech act profiling, our instance of a structured observation framework, data from a set of observations in two hospital wards, an outline of how activities are categorised as communicative acts, and finally some example activity profiles and a discussion of how the profiles can be used to analyse roles behaviour in different situations.

1. Background and related work

There is a growing attention to the importance of supporting effective communication in health care [2]. Several studies have addressed communication patterns in clinical settings, mainly focusing on documenting variations in communication loads and communication interruption rates between different clinical roles [3, 4]. In contrast, our main contribution is a *technique* for transforming observational field data to visualizations of communicative profiles of roles, which provide the opportunity to elucidate variations among *individual* clinicians, as well as between different clinical roles and activities in various hospital wards.

Our approach is based on a previously developed framework for structured observation of clinical activities that allows selective characterisation of situations, actors, and processes, and corresponding methods for aggregation and analysis towards system requirements [5]. The method is related to the Communication Observation Method (COM) [6], but our framework requires structured observation as means of data collection, and is bent towards producing system requirements.. The information recorded focus on type of information, information source, actor-, and situation attributes. However, when designing information systems, the *intention* of the communicative activity is important. Analysis of the observations should make it possible to answer questions like: Who is asked for information about patient status at the pre-round meeting? What is the difference in information needs for nurses at ward X and Y during the morning round? We have used the narratives in the observations, background knowledge, and the codified information to classify communicative activities according to a limited set of communicative acts. Our view of speech act theory, and the accompanying philosophy [7], is purely utilitarian: At this stage, we want to characterize simple intentions that can make sense both for a system interface designer and a potential system user.

Speech act theory has an old, albeit somewhat tainted, tradition in software design [8]. More recently, Schoop [9], has used speech acts to describe behaviour in the ward. Similar, descriptive studies has been performed by Stolcke [10]. Twitchell et al. [11, 12] have used speech act profiling to enhance detection and retrieval of specific computer mediated communication.

Activity	Rule/trigger	Location	Main actor	Role	Co-actor(s)	Role(s)	Patient-ID	Reason for admission (RfA)	Time	Informaiton Source	Direction I/O	Information	Purpose	Patient category
Pre-rounds	Continue after interruption	OFF4	R9	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	R9	PR	CP13 on phone (Nur9GR)	Ex	P67		11:10				The physician is paged from the ultrasound lab. Both the patient and the ultrasound machine are ready	
Suppl. work	Quest. arose after pre-rounds. Asks before ward round in order to be able to give the answer to the patient during round	LAB2	R9	PR	CP13	Ex	P67		11:45				Perform US examination	New patient for the physician. Particular examination
		LAB3	R9	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.	
Rounds	After pre-rounds	PR16	R9	PR	Nur8	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. Except from observational data (Department of Cardiology), translated from Norwegian.

2. Methods

2.1. Data collection: Structured observations in hospital wards

The data presented in this paper was collected in an observational study (also described in [13], [14] and [5]) that 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 spent 11 days at Division of Gastroenterology and 9 days at Department of Cardiology. She followed one physician at a time, observing the physicians' daily patient-centered work. A total of 7 physicians were followed; among them 1 chief physician with many years of experience in the ward, 5 medium experienced senior residents and assistant residents, and 1 intern. Both male and female physicians were among the participants. The co-actors of the situations consisted of other physicians, nurses, patients, and relatives. Approximately 70 patients were involved in the study.

The data was collected by means of an observation form based on and further developed from previous, similar studies [5]. 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-rounds meetings, ward rounds, and discharge). A 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, rule, location, main actor and role, co-actors, patient ID, illness history, reason for admission, situation start and end time, information sources, information types, purpose, results, and previous knowledge. 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.

Figure 1 shows an example extract of the observation form with observational data recorded at the Department of Cardiology. The activities in the example include one pre-rounds situation, examination, supplementary work, and ward rounds. The location is Office 4 (OFF4), Labs 2 and 3, and Patient Room 10 (PR10). The main actor is *Resident9 (R9)*, (role: PatientResponsible (PR)), while *Nurse9* (Nur9) (role: TeamLeader) is the main co-actor. *ChiefPhysician12* and *13 (CP12 and CP13)* are other co-actors. The information sources used during the situations are the patient list (PATLIST), the nurse (NUR), the patient (PAT), the patient chart (PC), and the electronic patient record (EPR). The content of the 'Information' column is elaborated in the 'Purpose' column. In the example figure, the free-text columns 'Illness history', 'Result', and 'Previous knowledge' have been removed in order to make the figure more readable.

One hundred and thirty five situations consisting of a total of 525 acts were recorded from Division of Gastroenterology, while 190 situations of 1032 acts were recorded at Department of Cardiology. In this paper, we present the result of three main actors; *Resident9* and *ChiefPhysician9* from Dept. of Cardiology and *Resident1* from Div. of Gastroenterology. Results from pre-rounds and ward rounds situations are presented.

2.2. Communicative acts

We want to profile roles and their interaction according to communicative behaviour, as a supplement to describing context, mode and quality of communication. We extend Searle´s theory of speech acts to also include observable actions involving forms and systems (e.g. signing a paper form, clicking "sign" on a screen, using a search interface, placing an order and such). Speech-act theory, or the "Language/Action Perspective" (LAP), has been formative in design and analysis of information systems. Methodologies and tools like DEMO [15] and Coordinator [16] use the theory as a basis for system design. Schoop used a LAP approach [17] to describe requirements for cooperative documentation systems. She used ethnographic methods to uncover failures and weaknesses in situations, but did not describe the observations in a LAP-terminology.

Table 1. Communicative Acts and example data. Information sources are Nurse (NUR), Patient (PAT), Patient chart (PC), X-ray presentation system Wiseweb (WISEW), the Electronic patient record (EPR), and personal note (NOTE). 'I/O' indicates the direction of the information exchange (In (I)/ Out (O)), and the information types are Changes (NEW), Family and social cond. (FAMSOC), Medications (MED), Blood tests (BLOOD), Findings and examination results (FINDEX), and Previous illness history (PREVILL).

Category	**Communicative Act**	**Example observational data (main actor CP9, Dept. of Cardiology)**			
		Purpose	**Source**	**I/O**	**Info.**
Asser-tives	Navigate into common understanding (NCU)	Changes since yesterday	NUR	I	NEW
	Assess	Review medications	PC	I	MED
	Answer inquiry	Inquire about the examination. (The patient wants to be explained what is going to happen)	PAT	I	FINDEX
	Inform	Info about changed dosage	PAT	O	MED
Commissives	Evaluate	Compare x-ray thorax from yesterday to admission x-ray	WISEW	I	FINDEX
Directives	Request information	Ask about home situation	PAT	O	FAMSOC
	Prescribe	Change blood pressure drug	PC	O	MED
	Order	Order blood tests	NUR	O	BLOOD
	Refer	Refer to neurological supervision	EPR	O	FINDEX
	Delegate responsibility	Instructs nurse to contact physician on-call to switch drug if problems occur during the night.	NUR	O	MED
	Remind	Remember to check previous numbness (task for later)	NOTE	O	PREVILL
Declaratives	Sign	Sign	PC	O	MED

Searle´s speech act is atomic, and has a propositional content (what the utterance is about), and an illocutionary force (the way the act is performed). One important aspect of the force is how the utterance interacts with reality. Searle uses five categories: **Assertives**, which state facts about the world (assess, diagnose, observe, record), **commissives**, which state that the speaker will perform a task (evaluate, review, confirm), **directives**, which aim to make the listener perform tasks (order, refer, request), **expressives**, which refer to states of mind or to expressions (suspect, query), and **declaratives**, which change the world by statement (admit, sign, discharge). We have manually categorised observations into 12 different communicative acts. Table 1 shows the acts, their category and examples of corresponding observational data. The categorisation was quite straightforward, but the actual choice of relevant acts and the repeatability of categorisation is of course an issue for further discussion and analysis.

3. Example analysis

The observational data have been processed in Microsoft Excel and radar graphs have been created in SigmaPlot. The graphs show the 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, and the radial axes indicate the number of each act found in the various selected observational data sets. The following sections present some example graphs.

3.1. Profiling individual physicians in one hospital ward

One interesting question that could be answered by applying communicative acts profiling is: "What are the differences between the communicative behaviour of individual healthcare workers in one hospital ward? "

Figure 2a and 2b show the communicative acts profiles for two different physicians at Dept. of Cardiology. Figure 2a shows the profile of *Resident9* during 22 pre-rounds situations (total number of comm. acts: 214), while Figure 2b shows the corresponding profile for *ChiefPhysician9* during 24 pre-rounds situations (total number of comm. acts: 220).

When comparing the profiles of *Resident9* and *ChiefPhysician9*, we find that the patterns are almost identical. They use the same sources of information, and perform the same communicative acts. The most noticeable difference is that *Resident9* uses electronic sources in addition to paper-based and human (the nurse) in order to "navigate into common understanding" during the pre-rounds conference. Other differences are that the chief physician spends more time *informing* the nurse, while the resident gives more *orders* (to the nurse). When looking into the field data, one possible reason for this is found: *"[ChiefPhysician9] must order INR for tomorrow to follow up; however, the nurse often takes care of this without any further notice from the physician".* This indicates that the communication between the nurse and the chief physician is based on confidence and long experience, while the resident/nurse communication is more explicit.

3.2. Profiling activities in different wards: Dept. of Cardiology vs. Div. of Gastroenterology

Another interesting question is to look into the difference between the behaviour of corresponding roles/activities in different departments/wards.

Fig. 2a: Communicative Acts Profile for *Resident9* (Pre Rounds situations, Dept. of Cardiology)

Comm. Acts: 214 (22 Pre Rounds situations)

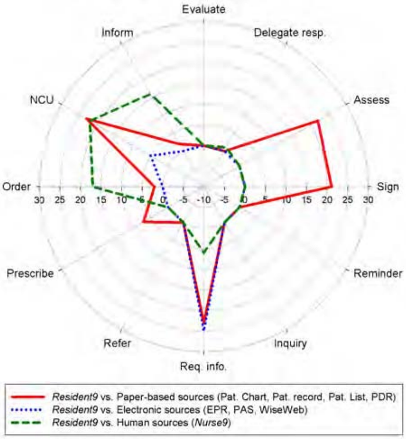


Fig. 2b: Communicative Acts Profile for *ChiefPhysician9* (Pre Rounds situations, Dept. of Cardiology)

Comm. Acts: 220 (24 Pre Rounds situations)

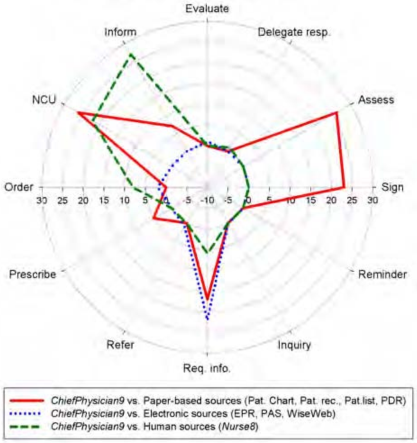


Fig. 2c: Communicative Acts Profile for *Resident1* (Pre Rounds situations, Div. of Gastroenterology)

Comm. Acts: 226 (39 Pre Rounds situations)

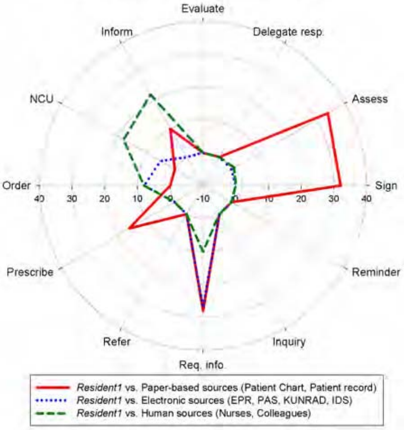
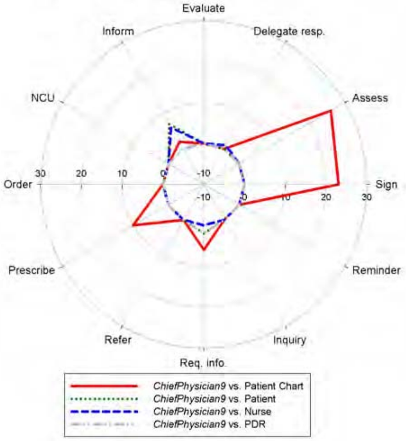


Fig. 2 d: Communicative Acts Profile for *ChiefPhysician9* Pre Rounds and Ward Rounds (Dept. of Cardiology)

Comm. Acts: 108 (Drug related events)



Figures 2a and 2c show the communicative acts profiles for two residents working at Department of Cardiology (*Resident9*) and Div. of Gastroenterology (*Resident1*).

Like in the previous section, we find that the patterns of *Resident9* and *Resident1* are to a great extent similar. However, Figure 2c show that *Resident1* at Div. of Gastroenterology uses electronic sources (in particular the EHR) more often both to find patient information and to order tests and examinations than the resident at Dept. of Cardiology. The resident at Div. of Gastroenterology also uses fewer paper-based sources of information (only the Patient Chart and Patient Record), and he does not use the paper-based sources for "Navigating into common understanding", but updates the patient chart with new test and examination results (comm. act. "Inform"):

"Register blood test results in the patient chart. Retrieves data from the EPR"

"Updates the patient chart about requested ulcer examination [...] to inform the physician at the next shift."

Resident1 also orders tests and examinations during the pre-rounds situations via electronic systems more often than his colleague at the Dept. of Cardiology, who orders via the nurse. Whether the differences found in these profiles are caused by individual differences in working patterns, different traditions in different wards, or other reasons can be more thoroughly investigated by studying the field data

3.3. Profiling specific activities: Drug related events

Figure 2d shows the communicative acts profile for *ChiefPhysician9* (Department of Cardiology) during 108 drug related events (extracted from 24 pre-rounds and 24 ward rounds situations). The reason why both situation types are merged is that this gives a more complete picture of the physician's actions with respect to medication. The figure shows that the most frequently used acts are "Assess" and "Sign", which are mainly performed during pre-rounds situations and with the patient chart as information source. The physician prescribes some medications, occasionally looks up in the Physician's Desk Reference (PDR), and informs both patient and the nurse about changes in medications. He is asked some questions by the patient, and delegates responsibility of follow-up to his successor via the nurse:

"[Patient] asks about the reason of the nausea. [...] The physician checks the patient chart. He knows that nausea has been a problem for the patient since he started using new drugs after the cardiac infarction."

"Instructs nurse to contact physician on-call to switch drug if problems occur during the night."

4. Discussion

Section 3 of this paper gives some examples of how profiling communicative acts can be used to ask and answer several important questions related to the design of new systems. As an example, the profile of Section 3.3 (*Drug related events*) could be extended to comprise all actors/systems involved in medication situations. Thorough analysis of the resulting profile(s) could provide quite detailed functional requirements for an information system for drug related events (i.e. an important part of a mobile, electronic patient chart). We find communicative acts of the categories 'Delegate responsibility', 'Inform', and 'Remind' particularly interesting as they could be direct input to the task lists of individual healthcare workers or roles/functions (e.g. message from *ChiefPhysician9* to the leader of Team A at night shift: “Remember to check *Patient43* for drug response at 0200 hours.”).

Similarly, if a system is to replace actors A and B, creating profiles of their communication patterns would provide valuable input to the functional requirements of the system. Other interesting questions that can be addressed are “What are the differences between situation A and B (e.g. pre-rounds conference vs. ward rounds)?”, “What is the range of variation in situation X?”, and “Does category Y activities change with the introduction/use of a mobile EHR?”.

In most of the example figures presented in Section 3, several sources are merged into one commmunicative acts pattern (e.g. 'electronic sources' or 'paper-based sources'). However, it is possible to profile each individual information source, providing a good insight into how the various sources are used by the clinicians.

The example observational data presented in this paper only included physicians, but the methods can also be used for other actors/roles and activities. The radar graphs are based on data collected by one observer. When used in the design of information systems, more observers should be used in order to ensure validity of the field data.

5. Conclusions and future work

The communicative act profiles shown in this paper are based on manual analysis and coding of the observational data, and hence the resulting figures are mainly illustrative. However, the examples demonstrate that the method is interesting as it gives a good visual presentation of the communicative behaviour of individual clinicians, roles, or larger groups of healthcare workers during various clinical activities. Comparison and further analysis of the resulting profiles can be carried out since the recorded observational data includes detailed contextual information of each situation. This analysis makes it possible to identify similarities, redundancy and perhaps common missing information situations and other details that can provide useful input to the design of new clinical information systems.

5.1. Future work

The analysis presented in this paper is preliminary and the results show the total number of communicative acts of a few example situations and actors. One natural next step is to perform statistical analysis of roles and activities showing variance and explicit use of various sources of information in different situations.

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. Also, explicit coding rules of each particular communicative act will be defined.

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Pathology's front line – a comparison of the experiences of electronic ordering in the Clinical Chemistry and Haematology departments

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Abstract. Socio-technical approaches to health information systems evaluation are particularly relevant to the study of Computerised Provider Order Entry (CPOE) systems. Pathology services are made up of a number of departments each with unique and complex tasks and requirements. These different components of pathology have received very little research attention. This study used qualitative methods to identify key organisational and work process along with repercussions of the implementation of CPOE through a comparison of the Haematology and Clinical Chemistry departments of a hospital pathology service. The results focus attention on areas where the departments face similar challenges along with those areas where work practices diverged. This underlined the key importance of understanding the context and setting of pathology laboratories. The study also draws attention to the importance of cross departmental and multi-disciplinary negotiation in the implementation process and highlights the potential for technology to affect and be affected by the organisational context in which it is placed.

Keywords. Biochemistry, Evaluation studies, Haematology, Laboratories, Hospital information systems, Pathology, Qualitative research

1. Introduction

Over the last five years there has been a significant rise in the interest shown in socio-technical approaches to health informatics research and evaluation. This development has meant a shift away from one-sided technology-centred approaches to health informatics [1] and helped to establish social aspects (culture, values and politics) and technical aspects (equipment, procedures and technology) as interdependent and interrelated [2]. A number of landmark studies have questioned some of the underlying

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assumptions involved in the implementation of Information and Communication Technology (ICT) systems [3, 4] and focused attention on the nature of hospital work processes and environment [5, 6], as well as the relationship between departments and professions [7].

The adoption of socio-technical approaches has been particularly salient to the implementation and design of Computerised Provider Order Entry (CPOE) systems. These systems are currently a high priority for health systems across many parts of the world [8-11]. CPOE systems enable clinicians to enter orders electronically. In doing so they provide the potential to improve the quality of health care, particularly through the use of decision support mechanisms [12] and the interlinkage of information sources [13]. However, CPOE systems can have a variable (even detrimental) impact on hospital settings, with major impacts on performance, hospital culture and departmental relationships [14-16]. These experiences have led many to assert the point (often associated with socio-technical approaches to research and evaluation) that the technology artefact has the potential *to affect* and *be affected* by the organisation in which it becomes embedded [1, 17-19].

The introduction of CPOE systems into hospitals have a very major affect on ancillary departments such as pathology and medical imaging laboratories. Although a significant number of hospital orders involve one or other of those departments, there has been relatively little attention given to them within the research literature [20]. Existing laboratory studies have tended to concentrate on measuring the effect of CPOE on indicators of pathology and clinical performance such as test volumes [21], turnaround times from order to result [22, 23] and test costs [24]. And although there are some important pioneering studies [25, 26], there remains a paucity of research aimed at addressing questions of how users experience the new system, and of the organisational and social context in which it operates. Moreover, the attention to pathology services often fails to compare and account for the different sections and departments of the pathology service, their unique functions and requirements. Failure to adequately address the complex web of interactions that make up a pathology service can produce findings that lack granularity [27] and are not able to be easily transferred to other settings and locations. This study used qualitative methods with the aim of identifying key organisational and work process implications of the introduction of CPOE based upon a comparative analysis of the Haematology and Clinical Chemistry Departments of a pathology service.

2. Material and methods

2.1. Research setting

This study was carried out in the Haematology and Clinical Chemistry departments of a pathology service based at a major Sydney metropolitan tertiary referral and teaching hospital. Both departments employ approximately 35 staff (including scientific, technical and ancillary staff). Clinical Chemistry would normally process between 1200 – 1400 specimens per day. Haematology processes approximately 1200 specimens per day. The departments are part of a pathology service made up of over 300 staff serving an area health service comprising a number of hospitals. The Cerner Millenium Pathnet was introduced in November 2005, followed by Power Chart (version 2004.01) across the hospital in January 2006. This integrated system allowed doctors and other authorised clinicians to electronically place orders for a range of items including pathology and radiology tests. The system replaced the existing Laboratory Information Service (Hoslab) that had been moulded to suit the needs of its users.

2.2. Design

The study adopted a formative design [28] with the objective of investigating the introduction of the new system in the course of its preparation and implementation between August 2005 and July 2006. This allowed the research team to examine issues and their impact during the course of implementation. The study used qualitative methods based on focus groups, interviews and participant observation as a means of understanding the influence of social and organisational factors and how users perceive and experience the system [29].

2.3. Participants

2.3.1. Focus group and interviews

The study included one focus group consisting of five Haematology hospital scientists and a series of individual interviews involving nine senior laboratory scientists and managers from the Haematology (6) and Clinical Chemistry departments (3). There was a total of 25 interview sessions all carried out by the lead researcher (AG). The initial focus group and interview sessions began before the introduction of CPOE and used a set of semi-structured questions about the nature of laboratory work processes. Participants were asked to describe characteristics of their current work (including problems) and discuss the likely effect of the new system. The themes that emerged from these initial sessions were developed in the course of the formative implementation experience. Interviews were carried out systematically over the course of the study and were often repeated for clarification purposes. This process also provided the research team with the ability to investigate the relevance and validity of emerging themes. The study employed chain referral sampling techniques using the recommendations of informants to extend the sample base [30]. Six of the interview sessions were taped and transcribed by a person experienced in the task. This resulted in 117 single spaced A4 pages. Research notes of all interviews and the focus group were recorded in a log with memos reflecting on the data and the research process. This log represented an audit trail of the progress and development of the research study [31].

2.3.2. Observations

There were four formal observation sessions lasting between 30 minutes to an hour and totalling nearly two hours, carried out across the two departments. These were supplemented by observations that were embedded into the interview process [32]. This usually involved demonstrations and visualisations of issues discussed. Notes from all the observation sessions were recorded in the researcher's log.

The research was approved by the University of New South Wales Human Research Ethics Committee and the relevant Area Health Service Research Ethics Committee. Participants were provided with a letter outlining the study, its voluntary nature and the confidentiality of all findings and participants.

2.4. Data analysis

A grounded theory approach [33] was adopted to provide procedural guidance to the task of analysis. Emergent themes were identified using participants' own words. These themes then formed part of the enquiry strategy, taken up for discussion with senior laboratory scientists and across both pathology departments. This process provided the study with an important means of feedback and respondent validation [34]. NVivo 2.0 [35] software was used to assist in the analysis of the data. Data source triangulation occurred with data collected from hospital scientists from both departments, and from managers to gain varied perspectives of laboratory work processes and their implications for CPOE implementation.

3. Results

Our analysis of the results of this study identified three recurring themes that we have described under the subheadings below. We have included quotations from interviews to represent these themes.

3.1. The contextual setting - Clinical chemistry and haematology

Participants described Haematology as the study of blood along with its cellular elements, and the diseases of the blood and blood forming tissues. Clinical chemistry was described as the analysis of blood and other body fluids for chemical components. These two departments could be said to be the general-type laboratories most often associated with pathology departments. They could also be described as the "front line" of pathology:

> I suppose a lot of haematology tests and a lot of chemistry tests become more front-line tests, so when the patient first presents they'll do those tests as a baseline. UECs, [Urea, Electrolytes, Creatinine] your full blood counts and maybe some coags [coagulation testing]. When they think – what's going on, some ask for some more specialised tests – drug levels, serology, some microbiology if they think the infection is a concern. I suppose it's the bread and butter of pathology tests, but also maybe kind of more front line tests as a lot of generalised information can be gathered by the clinician on the patient's status. Then they start specialising and get into the esoteric things if required. (Clinical Chemistry participant)

Both departments have a large proportion of urgent (STAT) testing that they are required to perform. A huge bulk of urgent tests emanate from critical care units and emergency departments where the treatment of a patient may often be reliant on laboratory results. This makes issues like the turnaround time (the time it takes for a test request to be processed and a result issued) important to how the laboratories undertake their work processes.

3.2. Middleware' communication

While there are similarities in the bulk of tests received, the nature of the laboratory work implies significant differences in how the two laboratories undertake their tasks. In Haematology it was described in the following way:

> Most of our work is ordered as a standard group of say, 20 tests. But from the initial results of those 20 tests, we have rules in place that decide what else we might do, and that's why we're different from [Clinical Chemistry] – they again have the huge volume that we do, but whatever is requested is done and that's where it stops. We've got other systems in place that need to make decisions, based on the initial result as to what to do next. The example being – you've asked for a full blood count. For 30% of those patients we'd look at a blood film, 70% you might not, so we need systems in place to identify that, and then systems in place to allow us to process that. So that's what makes us very different. (Haematology participant)

This difference is highlighted by the divergent information requirements of the two laboratories. Clinical Chemistry reported less reliance on clinical notes. These notes are provided by doctors on the test order and supply information that can be relevant to the patient's condition along with the choice and interpretation of the laboratory test. Generally, clinical notes do not impact on the Clinical Chemistry's analysis, except in some situations which may be relevant in explaining an abnormal result. However within Haematology, a clinical note supplied by a doctor about a patient (eg, their present or past condition) will often impact on the decision about the test required.

Both Haematology and Clinical Chemistry utilise 'middleware' which sits in between the departments' analysers and the Laboratory Information System (LIS). For Clinical Chemistry it was described as a communication interface between their department analysers and the LIS for result interpretation and handling. The Haematology department's 'middleware' has a different emphasis related to the task of validating test results:

> Eighty-five per cent of our work gets validated by [pre-defined software] rules so there's no lab intervention. It goes through the machine, the rules in place look at the instrument errors, the previous patient's results and then makes the results available to the clinicians at the other end. 15% of that, we have to have an intervention in before they're available to the clinician. It's identifying that 15% and processing them that the middleware helps us with. (Haematology participant)

The issue of 'middleware' and how the new electronic ordering system replaced or handled the existing 'middleware' was therefore an important one for both departments with major work flow implications on the ordering of tests and the upload of results from analysers to the LIS patient files.

3.3. The development of the Specimen Orderable Status (SOS) system

With a vast amount of specimens to process, across different automated laboratory processors, the efficient and safe monitoring and tracking of specimens is a vital component of laboratory functioning. This figured prominently in both departments' planning and preparation for the new system.

> We identified this issue on probably day one of the whole Cerner project back in 2002. Tracking is a fundamental thing for chemistry. We have so many specimens and aliquots [daughter tubes], and urines – all different specimen types, which we just *need* to know where they are… We just can't line things up and put them in numerical order. So tracking and knowing where things are for retrieval and for safe storage is critical. (Clinical Chemistry participant)

The previous sample tracking system within the lab was a home grown system that complemented Hoslab. It allowed laboratory staff to scan the laboratory number and then provided them with information about what processes the specimen had been through, what further processes and remaining tests needed to be undertaken and where the specimen had to be stacked at the appropriate analysing resource or stored (final storage). As one participant explained:

> Cerner had nothing like that. They had a tracking system but you had to select the rack, and follow the next empty hole, and say – OK – I'm putting this tube into this spot, which works well at the final storage process, but we have requirements in between." (Clinical Chemistry participant)

The pathology department was forced to negotiate the addition of a new program, "Specimen Orderable Status" to compensate for the loss of previous system functionalities. Participants explained that with their previous system the task of changing aspects of the software was relatively straightforward. This is because they had a much greater level of control and dealt with personnel that were familiar with their needs. Under the new Cerner system it involved a lot of negotiation and effort.

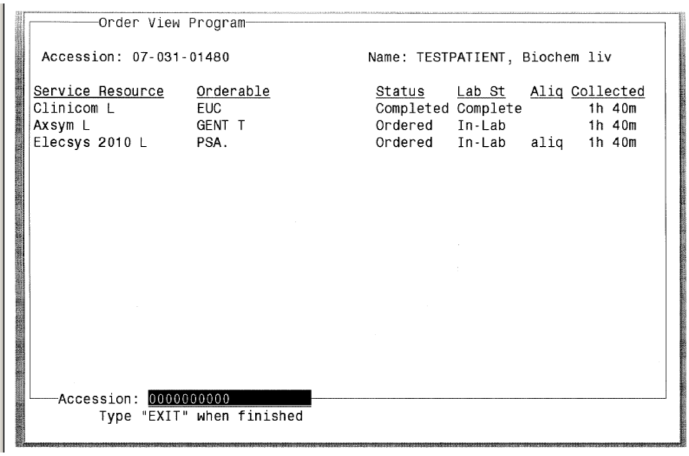
> It was a complicated thing to get this SOS program written because the Cerner tracking solutions weren't going to be the entire answer for us. Their final way of storing things, and their way of reading tests off labels in order to know where they go in the lab weren't going to work for us, and coming from a computerised system, which did work for us, we weren't going to go backwards. (Clinical Chemistry participant)

Within Haematology the experience of the new system was expressed in a different way:

- **Senior Laboratory Scientist**: We had middleware previously and we've lost that functionality. We do not have middleware at this point. We still have those manual processes we discussed prior to even going online.

- **Researcher:** So you actually have to go through it all yourself?
- **Senior Laboratory Scientist.** That 15% we have to find, identify, and process.
- **Researcher.** So how do you find 15%?
- **Senior Laboratory Scientist.** With the SOS program. So every time a specimen comes off a machine, any automated piece of equipment we have, as it comes off, we need to have the barcode read through the SOS program and it indicates to us whether the results have been validated or not. So when they haven't been validated, which is that 15%, we then need to go into Cerner and see why not, and then perform the manual validations. We then go back into SOS to see that it has actually happened. (Haematology participant)

Figure 1 provides a screen shot view of the SOS that is currently in use in Pathnet. The screen differentiates between the "Service Resources" (laboratory instruments and work areas) that each specimen is designated to travel in order of priority. It also provides a report of the specimen's "Status" (completed or not) and "Laboratory status" (physical location in the laboratory). "Aliq" indicates if an aliquot (daughter tube) was required. And "Collected" to the time the specimen was scanned into SOS, an important feature for Haematology which needs to complete its testing procedures within certain time frames. SOS took the place of two previous Hoslab applications, Hoslab Specimen Reception (SPR) (Figure 2) and Hoslab Specimen Tracking (SPT) (Figure 3). SPR was used by Clinical Chemistry to direct specimens to appropriate analysers in order of priority. SPT was used after each specimen was finished at each analyser/work area. It determined the next rank/location of the specimen according to priority along with a rack position for easy location.

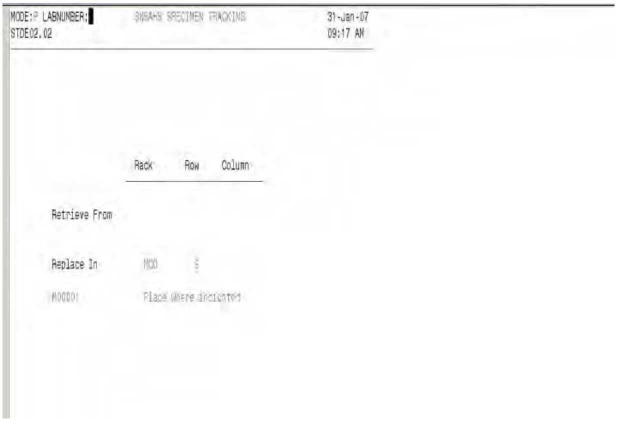


```
Order View Program

 Accession: 07-031-01480                    Name: TESTPATIENT, Biochem liv

Service Resource    Orderable               Status    Lab St   Aliq Collected
Clinicom L          EUC                     Completed Complete        1h 40m
Axsym L             GENT T                  Ordered   In-Lab          1h 40m
Elecsys 2010 L      PSA.                    Ordered   In-Lab   aliq   1h 40m

    Accession: 0000000000
         Type "EXIT" when finished
```

Figure 1. Screen shot view of Specimen Orderable Status developed in Cerner Pathnet

```
BIO_DATA>SPR

SPR (Version 1.49)
Enter the Lab number <EXIT>: M00001

FE,                    967654/LIV


MODULAR + AXSYM + SEPARATED, PLEASE ADD STRIPE TO TUBE

Enter the Lab number <EXIT>:
```

Figure 2. Screen shot view of the previous Hoslab Specimen Reception system



```
MODE:P LABNUMBER:      SWSAHS SPECIMEN TRACKING          31-Jan-07
STDE02.02                                                09:17 AM

                           Rack     Row    Column

          Retrieve From

          Replace In       MOD       5

          M00001           Place where indicated
```

Figure 3. Screen shot view of the previous Hoslab Specimen Tracking system

4. Discussion

This comparative study has brought to light a number of features of pathology laboratory organisation that can impact (directly and indirectly) on the implementation of electronic ordering systems. We draw attention to three areas that featured in this study, and offer the following guides to assist the task of implementation.

4.1. One size does not fit all - the importance of context and setting in pathology laboratories

The results of this study illustrate some of the organisational similarities of the Haematology and Clinical Chemistry departments. They are large departments with heavy workloads with a large proportion of urgent tests which require immediate attention. It appears apt to describe them as pathology's frontline where clinicians often turn first for important initial information relevant to the patient's condition and treatment.

The study showed that there are important organisational differences between the departments that impact on what decisions need to be made about the test process. For instance, our results showed that the test processing stage within Clinical Chemistry is mostly geared to providing results on tests, at which point the process usually ends. In cases where further investigative tests are indicated the laboratory will issue comments that accompany the initial results as a recommendation to the doctor. In the Haematology department the test process does not necessarily end with the provision of an initial set of results. The department is often required to investigate further. These decisions can be based on the initial test results or on patient information provided by the clinician, or incorporated into the system. This is an example of where clinical information contributes to the effectiveness of the laboratory's contribution [36, 37] to patient care.

These contextual variations point to important existing differences between pathology departments [38]. The impact of a new system can vary considerably on different departments [4] and often represent a major challenge for system designers and implementation teams who are often required to engineer different solutions to suit different situations, sometimes in locations that can even be adjacent to each other. It also underscores the value of undertaking comparative studies across sites and departments as a way of adding to our understanding about the impact of contextual and organisational features on electronic ordering systems [27]. A literature review of clinical decision support systems undertaken by Kaplan, draws attention to the need for a greater diversity of approaches to investigate the actual processes involved in using these systems. These include the pervasive impact of social, cultural, political and work life factors [39].

Accordingly, there are circumstances where traditional research and evaluation techniques like randomized controlled trials will not be ideal for assessing the interactive effects of multiple factors on systems implemented in complex environments consisting of many confounders [40]. Hence the need for multi-method approaches that can incorporate quantitative and qualitative methods to address the interdependent and interrelated social and technical aspects of health information systems [2, 41].

4.2. The capacity for technology to affect and be affected

One of the frequent criticisms of evaluations of information systems in health is that there has been an over emphasis on the technological artefact (ie, the software and/or hardware) [42] and its affect on organisations, to the detriment of the interpretive, collaborative and reactive components of the clinical and laboratory process. Whilst it is apparent that a new CPOE system in a hospital will involve new ways of planning and organising the laboratory test order process, it should not be forgotten that new technology needs to be implemented in the context of existing systems and social practices [43] many of which may be the legacy of previously existing technology.

In this study we identified the role of two existing systems each with their own set of unique practices. Firstly we saw the role of 'middleware' in the laboratory processes of both departments. 'Middleware' plays an important intermediary role in the laboratories helping to bridge any shortfalls between the information system and the processing and output of results. The 'middleware' in Clinical Chemistry remained operational with the introduction of CPOE, but not so in Haematology where it failed. The second system involved a home grown specimen reception and tracking system (operated in conjunction with LIS) which was used by both departments in different ways and for different purposes. The new Cerner Pathnet system did not replicate this role. This situation required the laboratories to undertake a complex set of negotiations with the software vendor (Cerner) to build an addition to Pathnet, Specimen Orderable Status (SOS) to compensate for this lack of functionality.

4.3. The usability of a system is a dynamic and negotiated process

One of the key factors that makes the introduction of new electronic ordering systems so complex is that their impact is spread out over many facets of the hospital and across disciplines [44]. In the past cooperation and collaboration of different departments in the implementation process has not always been present. This has often been cited as a reason for lack of user acceptance [45]. Building such collaboration requires a move away from silo-based implementation strategies which view each department as a separate implementation task, toward integrated strategies that cross departmental and disciplinary divides [46]. In this study we drew attention to some aspects of the effort taken to ensure the establishment of new software. The success or otherwise of a new system does not lie in the technology itself but in a complex web of social and technical factors, including how the department adjusts and adapts to change [43].

4.4. Limitations

This study focused on the circumstances, dynamics and complexity of two departments in one hospital. The advantage of such comparisons is the richness and granularity the research findings provide. However, the generalisability of the findings may be offset by factors unique to the study site that may not be replicated in other settings. Nevertheless, the findings provide valuable evidence of the type of effects new systems can have with lessons that can be transferable to other settings. The formative design of this study enabled the research team to identify major issues as they arose, and to witness how each department responded. The potential disadvantage with this approach is that it lacks the benefit of hindsight and overview that the passage of time often grants participants and researchers.

5. Conclusion

This study has drawn on the initial experiences of two pathology laboratories confronted with the impact of CPOE implementation, to highlight a number of socio-technical consequences of new technology each with their own design and implementation implications. Such comparative studies can play an important role in uncovering and drawing attention to the complex and challenging tasks involved with new electronic ordering systems in healthcare.

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Towards Automated Observational Analysis of Leadership in Clinical Networks

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Abstract. Clinical networks are being increasingly employed to drive innovation in health services by encouraging multi-disciplinary clinical engagement in management processes. The effectiveness of a network, however, depends critically on the ability of its leader to coordinate group interactions. This paper discusses leadership of clinical networks, and in this context reviews technologies for analyzing the way team members interact in group conversations. This review will form the foundation for ongoing research to develop the profile of an effective clinical network leader, along with techniques and tools for evaluation and professional development.

1. Introduction

Clinical networks are linked groups of health professionals and organisations working in a co-ordinated manner, unconstrained by professional and organisational boundaries, to ensure equitable provision of high quality, effective services [1]. A clinical network is a new organisational entity aiming to enhance coordination between services, facilitate better access to services, increase the uptake of evidence-based practice, result in more efficient use of resources and, most importantly, improve health outcomes and the patient experience [2,3].

Effective leadership is necessary if clinical networks are to succeed in achieving these aims. This intuition has been confirmed by experience in the United Kingdom's National Health Service (NHS), which has identified leadership quality as a critical factor in a network's success. Effective network leaders are characterised by innovative problem solving skills, the ability to manage group decision making and a readiness to engage in reciprocal rather than manipulative behaviours [4,5,6]. This presents a different emphasis than the profile of a traditional technical leader. Coupled with the recognised shortage of clinical leaders [7,8], this implies a need to identify and train a new kind of clinical leader.

The need to develop an evidence-based profile for such leaders, as well as methods for their evaluation and professional development, motivates structured observational studies of clinical network teams. Structured observation is an approach in social psychology that defines coding systems to categorise group behaviour. Examples include

Interaction Process Analysis [9], the McGrath Task Circumplex [10], and SYMLOG (System of Multiple Level Observation of Groups) [11]. While these coding systems allow empirical testing of hypotheses, which in turn yield insightful analyses of group behaviour, the labour-intensive coding process generally restricts their application to smallscale studies.

Recent technological progress in the field of human-centered computing, however, has the potential to alleviate this limitation. A range of technologies has been developed to facilitate information extraction and interaction analysis of group meetings [12,13,14,15]. By applying signal processing and pattern recognition methods to recorded microphone and video signals, verbal and non-verbal interactions can be automatically captured and transcribed. Examples include speaker turn segmentation [16,17], automatic speech recognition [18,19], dialog act coding [20,21], and emotion recognition [22,23,24]. In automating the coding of group interactions, these technologies may facilitate larger scale empirical studies and allow structured observational approaches to be embedded in ongoing programmes for network development and evaluation.

This discussion paper presents research directions for the study of clinical network leadership based on a review of the social and technological literature. The proposed research directions aim to profile the interaction attributes of an effective clinical network leader, and to develop techniques and tools for their training and evaluation. The focus throughout is on behaviours during clinical team meetings. While leadership and effectiveness within clinical networks clearly involve more complex issues and interactions than those found in meetings, such group discussions provide a constrained context in which inter-personal interactions may be observed in a structured manner. The remainder of this paper is organised as follows. Section 2 gives an overview of the emergence of clinical networks and the leadership need that this implies. Section 3 reviews the state-of-the-art in technologies for analysing group interactions in meetings. Promising directions for research are proposed in Section 4, followed by concluding remarks.

2. Leadership in clinical networks

Clinical networks are being increasingly employed to allow health service management to benefit from the expertise of clinicians. Clinical networks have been established in Queensland by the recent Forster Review to address health service safety and quality [25]. They will adopt functions such as service planning, resource allocation and monitoring of outcomes, and will be characterised by evidence-based decision making, cross-institutional and inter-disciplinary collaboration, a commitment to service improvement, and a focus on the continuum of care [26]. A key implication is the need for networks to innovate in order to find new solutions to age-old problems. Networks will be expected to overcome the human, financial and systems barriers which have persisted in health services for many years. Two key factors in achieving this innovation are open and dynamic group interactions [27], and effective leadership [28].

A key source of innovation in a clinical network is found in its dynamic social nature [27]. Studies of network-based organizations in the United Kingdom, including the NHS, provide a useful description of their key attributes [4,5]. Networks are underpinned by social relationships, rather than formal hierarchical structures. Networks should encourage new members to participate by creating a sense of belonging and understanding, and an honest environment conducive to the formation of lasting alliances. The characteristics of high performing business teams identified by Losada [29] are similar to the attributes we require clinical networks to demonstrate: mutual influence between member institutions and disciplines; positivity during team interactions and problem solving; a genuine desire to understand the concerns of other health care providers and consumers; the ability to learn from the external environment and recognize the strengths and weaknesses of the network; and an enthusiastic environment in which new ideas towards improving patient outcomes are embraced.

In order to ensure effective innovation, however, these dynamic group interactions must be coordinated by a clear leadership role. Facilitating inclusive and effective group decision making is an important skill at which clinical network leaders must be competent if they are to achieve their goals. Complicating this, networks may in practice contain several members who are traditional leaders within their discipline or institution, bringing a risk for conflict. In such an environment, there is a need to define a clear leadership role which relies on on communicative skills, rather than formal authority, to ensure the clinical network achieves its desired outcomes and minimises unproductive conflicts [28]. The ideal clinical network leader is therefore someone with recognised clinical expertise who is committed to developing their skills as a negotiator, collaborator, relationship builder and innovative problem solver [4,7].

Current thinking in Queensland on clinical leadership describes two types of clinical leaders [25, Appendix 6.1]. The first is a technical expert who is representative of a professional group. The second is a health systems leader: a clinician who is enthusiastic about health systems improvement, who effectively participates in the management of healthcare, and who has both population and individual patient perspectives. In the case of the former technical leader, evaluation criteria are clear and well established: referral volumes from peers, membership of professional associations, peer reviewed publications and academic positions. Given the emphasis on social rather than technical skills, it is less certain how to objectively recognise or evaluate an effective health systems leader, and yet it is apparent that the effectiveness of the clinical networks will hinge on their emergence.

A need exists, therefore, to clearly define the profile of an effective clinical network leader. This profile should be based on empirical research of effective clinical teams, undertaken within the relevant organisational context. As a principled means for analysing social interactions, structured observational analysis offers a methodology for to develop and evaluate this profile [9,10,11]. While useful in isolated small-scale studies, however, the human observation and coding of team interactions has limited practicality for multiple, or larger-scale, studies, and as the basis for evaluation in an ongoing programme.

3. Technology review

Emerging technologies in human-centred computing hold promise for automating the observation of group interactions. The following review summarises the state-of-the-art in automatic methods for analysing both verbal and non-verbal content of group conversations.

These methods assume the availability of audio and visual recordings of meetings as input. In practice these may be acquired using standard tele/video-conferencing systems, other consumer devices, or purpose-built facilities.

3.1. Verbal content analysis

Speech recognition

Verbal content analysis depends on first transcribing the spoken words. This can be achieved using *Automatic Speech Recognition* (ASR) systems. Compared to other application domains, such as dictation or broadcast news transcription, meetings pose a number of challenging problems for speech recognition. Speech in meetings is conversational in nature and so does not follow standard grammatical constraints. There are also difficulties due to multiple people talking in the same room - it can be difficult to separate speaking turns as people often talk over the top of each other. A further challenge is that while current ASR systems rely on headset microphones, there is a need to move towards less constraining hands-free microphones to encourage more natural interactions. Research towards resolving these issues is being coordinated through evaluation on common meeting recordings in the NIST (National Institute of Standards and Technology, USA) Rich Transcription Meeting Recognition Evaluations, held annually since 2002 [30,18]. The state-of-the-art performance achieved in the 2006 evaluation was 24% word error rate (WER) using headset microphones, and 34% using table-top microphones [19]. While room for improvement clearly remains, this level of accuracy has been shown to be sufficient for a range of practical information processing tasks [31].

Dialogue act coding

Words provide the lowest level of granularity for analysing verbal content of a conversation: analysis can be enriched by examining higher-level information. For instance, is the leader effective at both eliciting different opinions through questions, as well as concluding debates with decisive statements? *Dialogue act coding* provides a categorisation of spoken utterances according to their function. Automatic tagging of speech transcripts according to dialogue acts is an active field of research [32,20,21]. To give an indication of state-of-the-art, a system for automatic segmentation and classification of meeting dialogue acts from ASR transcripts was evaluated in [32] for a set of five acts: statements, questions, back-channels, fillers and disruptions. Their system achieved a (word-level) error rate of 19% using hand-segmented transcripts, and 25% using fully automatic segmentation.

Topic segmentation

A further question we might ask is whether the group leader is effective in progressing through different topics of discussion in the meeting. Do they tend to linger too long on a particular topic, or skip past it too quickly? Are they proactive in bringing about topic shifts, or reactive to other group members? These questions may be answered with the support of *topic segmentation* techniques [12,33,34,35]. Automatically classifying the topic of a given text document is a well studied problem, whether it be a typed document or a spoken one converted to text by ASR. Conversational speech, however, poses a more challenging task, as it must first, or concurrently, be segmented into coherent units for classification. State-of-the-art approaches to conversational topic segmentation employ a combination of verbal and non-verbal information. As an indication, an error rate of 23% was achieved for segmentation of recorded meetings using a selection of verbal and non-verbal features [34].

3.2. Non-verbal content analysis

There is a growing literature on automatic analysis of non-verbal content of conversations [36]. The following presents an overview of this research as it relates to attributes of leadership.

Turn-taking patterns

It is known that analysis of the group *turn-taking patterns* can give insight into dominance and influence [37,38]. It has been shown that turn-taking patterns in meetings can be predicted [39] or simulated [40] using simple probabilistic models. *Speaker turn detection* and *speaker clustering* are fundamental tasks in automatic speech processing systems. State-of-the-art systems can successfully segment and group speaker turns to a high degree of accuracy by observing significant changes in the distribution of auditory features [16,17], or the speech source location [41]. Analysis of higher-level structure to the speaker turns may be built upon this segmentation. This can be done to segment the conversation into discussion phases, or to model the tendency of each individual to contribute to, or dominate, the discussion [15,42,14,43,44].

Addressing

To what extent does the leader coordinate the conversation by influencing speaker turns? *Addressing* behaviour is the act of directing speech at a particular person, or group of people [45]. While addressing may be accomplished verbally, in general it occurs through different communication channels, including speech, gaze, and gesture [46,39,40,47,37]. Although there is an increasing body of work on automatic analysis of head pose and visual focus of attention in multiparty interaction [48,49], there are few studies on automatic identification of addressees and so this is considered an emerging topic of research [50,51].

Emotion recognition

Complete understanding of human communication cannot be achieved without an indication of emotion. Is a leader aggressive or conciliatory in their manner? Are group members interested and engaged in the conversation? Automatic *emotion recognition* has attracted significant research attention in recent years [52]. Research has investigated the use of audio and visual cues, and a combination of these [22,53,23,24,54,55]. While significant progress has been made in categorising an individual's emotions in an acted monologue or a one-on-one interview, emotion recognition in the context of professional group conversations remains an emerging research topic.

4. Research directions

The previous sections have discussed issues related to clinical network leadership, and reviewed technological advances in analysing the content of group meetings. From this review, we identify promising avenues for short-, medium- and longer-term research towards automated observational analysis of leadership in clinical network meetings. Each of the proposed directions focusses on observing behaviours during team meetings as a constrained context that facilitates structured observational approaches. It is acknowledged, however, that clinical network leadership involves more complex issues and interactions than those found in such meetings.

Automatic speaker turn segmentation and speaker clustering are mature technologies with reliable performance and simple hardware requirements. In addition, it is known from social psychology that turn-taking patterns can provide insight into issues of group dominance and influence. Analysis of turn-taking patterns therefore presents a promising short-term research focus. For instance, recent work has applied social network theory to analyse turn-taking patterns in radio broadcasts [56]. Based on properties of the resulting social network, each speaker was successfully categorised according to their role in the broadcast. Such techniques may be adapted to develop models of the leadership role in clinical network discussions.

In the medium-term, by also incorporating the output of speech recognition, dialogue act coding, and emotion recognition technologies, the above turn-taking analysis could subsequently be extended to more closely resemble traditional structured observation coding systems, such as Interaction Process Analysis [9], the McGrath Task Circumplex [10], or SYMLOG (System of Multiple Level Observation of Groups) [11]. For instance, cues based on the words, speaking turn duration and utterance type may be used to assign codes related to dominance and influence [57,58].

While we have focussed on leadership as a major contributing factor, the ultimate goal of the research discussed in this article is to understand the likely effectiveness of a given clinical network in successfully achieving outcomes. For instance, work has shown that business teams can be broadly categorised as high, medium or low performance by analysing their interactions over three dimensions: inquiry-advocacy, other-self and positivity-negativity [29]. In determining the validity of such findings for clinical networks, these dimensions could be measured using automatic speech recognition, dialog coding, addressee detection and emotion classification. Beyond this, there is also potential to analyse the relationship of other interaction behaviours to outcome effectiveness through statistical analyses over series of meetings [59].

5. Conclusion

This paper has proposed research directions for the study of clinical network leadership-based on a review of the social and technological literature. The discussion has been focussed towards defining and measuring attributes of effective clinical network leaders using structured observational methods. The review has shown that emerging technologies in the domain of human-centered computing have potential to facilitate large-scale empirical studies and to form the basis of tools for ongoing professional development and evaluation. Ongoing work will follow these research directions in defined clinical network studies within Queensland Health. While the current paper has focussed on issues related to group leadership, the reviewed technologies have broader application to clinical network meetings. As an example, such technology may be used to study differences in interaction behaviours between remote and face-to-face multidisciplinary teams in order to evaluate the use of telemedicine [60] or, in a real-time application, to support more effective remote communication.

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Constructing Technology-in-use Practices: EPR-adaptation in Canada and Norway

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Abstract. Investigating two longitudinal ethnographic studies of managing gradual adaptation of electronic patient records in Canada and Norway, we conduct a cross-case analysis of the enabling factors that support a continuous transformation of technology and health care practices. In line with previous research, our study shows that large-scale information systems adaptation in health care should be managed by a project-group including not only IT-developers, but also representatives of future users and management. While we also argue for the importance of these meetings, we complement and expand the notion of project meetings by providing a conceptualization of the essential aspects of these meetings. Our conceptualization is composed of continuous reflection-on-practice activities to construct technology-in-use practices. Reflection-on-action activities are internally initiated, and comprise critical reflections by the participants, who continuously evaluate and question work practices in relation to technology.

Keywords. Electronic patient record (EPR), technology-in-use, reflection-on-practice, adaptation.

1. Introduction

The idea of computerized patient data that contain clinical information as recorded in the paper charts was introduced in the 1960s and 1970s [1]. For the last couple of decades, the implementation of Electronic Patient Records (EPRs) has been viewed as a highly challenging task. Among prevailing visions of what EPRs should be, are goals to make them into management tools that will be able to support managed care logistics, redesign of work processes, and improved quality of care [2]. Electronic patient records are expected to improve efficiency, coordination, and planning, and consequently, decrease costs and waiting times for patients. However, the transition to EPRs turned out to be an unexpectedly long and complex process where many goals have not been met yet. “Despite a series of heavily funded national and international initiatives, there is only very modest success in establishing working EPRs in large hospitals” [3]. Some of the existing myths about information systems implementation within health care are that an implementation is a technical realization of a planned system in an organization, that the implementation process can be left to the IT department, and that the implementation is merely a technical realization of a planned system in an organization [4]. There are many examples of technology implementations that have fallen victim to these myths. Mean-

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while, the governments of countries such as Canada, the Netherlands, Norway, and the United Kingdom use extensive amounts of resources on implementation of information systems. Thus, we as researchers believe that it is highly important to conduct more research that is grounded in real cases studies, because these studies can assess the construction of alternative approaches for managing the complexities of information systems in the health care sector. It has been argued that EPR can deliver benefits only if there is an effective integration of the technology with localized work practices, while allowing space for ongoing adaptation and redesign [5]. We would therefore like to extend this argument and include the importance of having space for ongoing reflection-on-practice.

To construct alternative approaches, we must first consider our conceptualization of information system implementation. Adaptation, adoption, integration, implementation, appropriation, or acceptance, are all concepts which reflect on the process in which a technology is introduced and interlinked to the work practices in a particular setting. However the various concepts have different connotations. ‘Adaptation’ reflects on introducing, facilitating, and integrating technology into the work practices in a particular context. It refers to a process that changes both the technology and practice. Whereas the concepts of ‘integration’ and ‘implementation’ might indicate a primary focus of the technical aspects, ‘adoption’ or ‘acceptance’ might suggest that technology adaptation is simply a human choice and not a transformation process [6]. In this paper we view the interlinking process of technology and practice as adaptation emphasizing the transformation aspect. Thus, we follow a socio-technical approach and view the adaptation of information systems as a continuous process in which work practices and technology are influencing and are influenced by each other throughout a transformation and aligning process [e.g. 7, 8, 9].

In this paper we investigate two concrete cases of adaptation of information systems in the health care sector, and we propose an alternative strategy for managing the ill-structured and messy transformation process. Having access to rich empirical material from two longitudinal ethnographic field studies of managing gradual adaptation of electronic patient records (EPR), one in Canada and one in Norway, we have the unique opportunity to conduct a cross-case analysis of the enabling factors that support a continuous transformation of technology and health care practices. We explore the data material from these two cases by applying the concept of technology-in-use [10] to capture and represent the transformation process at different stages during the adaptation. We argue that one core challenge in the process of adaptation is to construct spaces for critical reflections and continuous evaluations of the work practices related to technology-in-use. We frame this alternative strategy as continuous reflection-on-practice activities constructing technology-in-use practices.

The paper is structured as follows. In section 2 we present the theoretical framework applied within the analysis, followed by a presentation of the empirical cases in section 3, and data material and research methods in sections 4. In section 5 we conduct cross-cases analysis and in section 6 we discuss our empirical observations and offer final remarks.

2. Adaptation, technology-in-use & reflection

To understand the adaptation of complex technologies, we need to investigate the realities of introducing technology in specific organizational settings [11]. Technology adaptation is a transformation process in which existing work practices influence and are influenced by the technology. Such a process produces new situations that did not exist prior to the system, which in turn result in new transformed practices [7, 12]. Adaptation is an ongoing process of aligning practice and technology and is lead by disruptive events where the result is altered organizational structures [8]. We know that adaptation of collaborative technologies, such as EPR, requires more effort and commitment from the users than single-user systems [13]. Still, we know little about which factors or activities foster such commitment. However, success of adaptation has been found to depend on the malleability of the existing organizational work practices [8] and on how well the technology becomes embedded within the local context [14, 15].

Embedding technology in the context requires knowledge and understanding of the situated work practices [16]. Plans and situated actions are highly interlinked; however, when identifying structures of organizations in the process of embedding technology, one should assume that organizational structures are located in the situated actions rather than in the formal plans [17]. Making situated action visible in the process of adapting technology is thus an essential activity within technology adaptation. Initial planning of the adaptation process is important; however, one must recognize that it is impossible to predict and fully plan the socio-technical changes and the overall effect of the technology [2, 4, 18]. This unpredictability is due to the emergence of new possibilities and unanticipated patterns of use, that are brought along by the new technology [12, 19]. Thus, the impact of a new technology becomes emergent only in use [10, 18, 20]. Hence, the extent to which the system is used can potentially be much wider than initially designed for [22, 23]. This confirms the need for continuous reflection and re-negotiation of organizational work practices [24].

Adaptation of technology is highly influenced by people's perception of it [20]. Technology-in-use practice comprise peoples' understanding of how to use the technology on a daily basis and the consequences of such use [10]. Through the use of the technology, people have to reconsider their knowledge, which is based on experience, and their context-dependent practice of use. This is a dynamic and reflexive process where the technology is locally shaped and re-invented through the situated use, and an ongoing learning process where people try to configure ways of utilizing the technology [25]. This means that the fundamental purpose of technology adaptations in the health care sector is for the health care personnel to create and continuously re-negotiate technology-in-use practices while taking into consideration the situated actions. Re-negotiating technology-in-use practices requires spaces comprising reflection-on-action activities. Reflection-on-action refers to the activity in which health care personnel reflect on the experienced problems and articulate the strategies for actions which were implicit in the practice [26]. Thus, the purpose of spaces is for health care personnel to step back from their situated practices on different occasions during the adaptation process to critically evaluate and reflect upon their technology-in-use practices and, on this basis, construct new technology-in-use practices for further development.

Previous research states that large information system adaptation projects should be managed by a project group, including but not limited to the IT department, which meets periodically to and negotiate system specifications and implementation plans [4]. Both of the empirical EPR-adaptation cases presented in this paper had meetings during the adaptation process; however, there were great differences between how these meetings were executed and how they were a part of the overall adaptation project. Thus, in this paper we complement and expand previous research by providing rich empirical data of the role and impact of essential meetings and conceptualize an alternative strategy for adaptation that encompasses continuous reflection-on-practice activities to construct technology-in-use practices.

3. Empirical cases

Both in Norway and in Canada, implementation of EPRs has been on the political agenda for a long time, as these are viewed as 'magic silver bullets' that can be applied to solve the various financial problems faced in the health care sector. EPR implementations are affected by the health reform and are funded through national or provincial initiatives. The amount of money that is spent on such technologies is rather high, and so are the expectations.

The EPRs in our empirical cases were 'brought to life' to encourage a meticulous organizational transformation, which essentially focuses on achieving benefits that are measurable in financial terms. Hence, the initiative to develop an EPR was, to a large extent, formed by external pressure. Case A takes place in a large hospital in Norway where an EPR system was adapted to establish a common platform among the university hospitals. Case B takes place in a community health centre in Canada where the EPR was part of the renewal initiatives supported by the health authority. In both case studies, the infrastructure that existed before the EPR was highly complex and fragmented, characterized by loosely coupled systems existing on top of hybrid paper charts. Moreover, paper charts were distributed in fragments, were place dependent, and contained redundant information. These complexities provided poor and limited support for data integration and transfer across various health care organizations. Paper charts were also supported by various notebooks, binders, folders, and so forth. There were many different artefacts and various routines established to support the existing medical work practice. Fragmentation was also found in the technical infrastructure, which included in both cases several information systems (e.g., patient administrative systems, systems for laboratory results, patient registries in Excel sheets).

Even though there are many similarities between the two cases, there were also differences in some aspects, such as institutional structures, organizational size, and technical architecture of the EPR system. While we acknowledge these differences, we believe that by comparing the organization of the meetings guiding the adaptation process in these two different settings, we have the opportunity to provide important insights into the role and impact meetings have on the development of technology-in-use practices.

4. Method and data material

The data collection method applied to both research projects was longitudinal ethnography. Ethnographic research seeks to place the phenomena studied in a wider social context [5]. The primary focus is on acquiring rich insight and in-depth understanding of human, social and organisational aspects of the phenomena [27, p. 4], as well as understanding how these aspects influence, and are influenced by, the context [21]. Such a method is particularly good for generating interpretive knowledge because social phenomena and actors are studied in their natural settings. Conducting ethnographic interpretive research implies that reality is viewed as constructed rather than given and that there can be numerous interpretations of reality [28]. The overall aim in both studies was to gain a deeper socio-technical understanding of the situated work practices and the actual use of the EPR.

The fieldwork in Case A was initiated in October 2002 and lasted for one year, while the fieldwork in Case B began in October 2004 and is still in progress[2]. In both cases, the implementation of the EPR was followed from the initial phase of installation until the adaptation process had reached stability, but for our analysis, we will mainly focus on the first year of the adaptation process.

Similar techniques were employed for collection of the empirical data in the two cases. These included interviews and observations of activities. Open-ended, semi-structured interviews were conducted in different languages with various health care personnel (doctors, nurses, and secretaries) and IT staff (IT vendor and IT department) as well as with decision and policy makers. In Case A, these interviews were conducted in Norwegian and Arabic, while in Case B, interviews were conducted in English. All interviews were audio-recorded, fully transcribed, and carefully translated into English. To gain deeper knowledge about heterogeneous medical practices and to capture interactions that are inaccessible during interviews, they were supplemented with participant observations in various places, such as reception desks, charting rooms, and meeting rooms. The first author participated in several formal and informal meetings, such as medical team meetings for all the staff and clinical meetings for physicians, EPR meetings, and meetings with the IT department (or vendor). Various documents were collected, such as minutes from all the meetings, reports, memos, emails, and project plans. To become familiar with the two types of technologies adapted, the first author attended training sessions with health care personnel in each respective case, which included basic and advanced training sessions organized separately for each professional group.

Cross-case analysis was used for both cases [29, 30]. This included comparison of data material concerning the types of meetings held during the adaptation process in order to identify diversities and similarities between the management, execution, and impact of the reflective spaces. We primarily focused on the meetings held by the project managing group in each case. To identify how the technology-in-use practices evolved over time, we carefully re-investigated all the data material by applying the theoretical concept of technology-in-use. Having identified the technology-in-use practices within

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[2] This research is part of a large on going project called ACTION for Health, which studies the role of technology in the production, consumption, and use of health information.

the two cases, it became clear that the meetings had different degrees of impact on the adaptation process in the two cases. Thus we re-examined the data material available from the two cases concerning the meetings and this lead to our conceptualization of continuous reflection-on-action activities.

5. Analysis: Identifying technology-in-use practices

We will now describe the adaptation process as it proceeded in Case A and Case B, providing in-depth descriptions from our empirical material as to how the technology-in-use patterns developed over time. It is not our intention to determine which case was more successful, after all, the EPR is still in use in both cases. Our intention, rather, is to identify which activities were supporting and driving the development of technology-in-use practices.

5.1. Technology-in-use patterns in Case A

During the first few months, the health care personnel in Case A acquired elementary and basic knowledge about the EPR after attending a one-day training session. The adaptation process was lead by the IT-department, and both secretaries and physicians were supposed to start using the system on the same day. During this initial stage of adaptation, the IT-department conducted several introductory meetings with the various staff members.

Identifying the initial technology-in-use practices in Case A, the work practices, by and large, remained unchanged as physicians continued to dictate medical notes and hand them over to the secretaries for transcription. Upon completion, the secretaries printed out the notes and handed them back to the physicians who proofread the notes by marking corrections on the paper. They then handed the notes back to the secretaries who corrected the electronic version. Finally, the physicians would validate and sign the medical notes using the EPR. The work practice related to retrieval of information remained the same as before the EPR, and staff continued to use paper charts alongside with various books and folders.

After a period of time, new technology-in-use practices slowly emerged in some departments, and brought along organizational changes. Accordingly, physicians in these departments were now responsible both for transcribing and for correcting their own medical notes. However, there were no other major changes in the technology-in-use practice. Additional functions embedded within the EPR, e.g., electronic prescriptions and doctors' notes, were only used to a very small extent. In an attempt to encourage physicians to use these additional functions, some of the secretaries attended a training session and learned how to build templates for the physicians. However, the extent to which these additional functions were used remained minor. There were no radical changes, especially since the health care personnel were requested to keep both the paper charts and the electronic records updated. The secretaries therefore spent a considerable amount of time grooming and updating the charts by re-printing the recent versions of notes and by shredding the redundant ones.

The technology-in-use practices continued slowly to evolve, and after some time, the EPR was used not only for validating and signing notes, but also for retrieving patient data. Moreover, physicians gradually started using internal electronic referrals. The degree of use, however, varied between the different departments. Some physicians used it extensively on a daily basis, while others did not use it at all. In addition, there were different work practices in each department, and while some physicians dictated the referrals, others typed the referrals by themselves.

After using the EPR for an extended period of time, the amount of print-outs grew dramatically and rapidly. Subsequently, there were crises in the hospital archive, both in terms of the lack of physical space and the increasing workload [31]. This led to discussions concerning the urgent need to start scanning paper charts, which, at that time, was viewed as a temporary ad-hoc solution for the existing hybrid information system. Several scanning strategies were discussed and piloted, but, due to various challenges, the implementation was postponed.

5.2. Technology-in-use patterns in Case B

As in the previous case, the adaptation process in Case B began with one-day training sessions for the health care personnel. However, Case B, established a special EPR committee which was responsible for following the adaptation process, including the organizational changes needed during the process. The committee consisted of representatives from each professional group, and they conducted meetings on a weekly basis. Their aim was to discuss the various challenges and complexities that were faced, to evaluate the transition process, and to define new goals.

The initial technology-in-use practices in Case B comprised the secretaries' usage of the EPR for scheduling and billing activities. Physicians were slower in developing technology-in-use patterns and initially they used the EPR primarily for entering various medical summaries. They followed, however, a gradual adaptation process, beginning to use the EPR for one patient and then later increased the number of patients. Then not long after, some physicians began using the EPR for additional functions, such as writing prescriptions and using the search function (e.g., to retrieve the names of all diabetes patients).

The increased use of the system also triggered a discussion concerning the need to scan old paper charts (those belonging to inactive patients), thus making these records accessible electronically. Therefore, physicians became responsible for going through their charts and carefully selecting the most pertinent documents which they wanted to have accessible through the EPR. The secretaries then began scanning the documents and linking them to the corresponding chart. This meant that over time the physicians' technology-in-use practices were progressively changing. Their use of the EPR was gradually extended to include advanced functions, such as electronic billing and referrals. Moreover, there was an increasing interest in using additional templates, which led to more requests for designing new templates.

Paper charts were barely visible in the clinic anymore, and the health care personnel were increasingly motivated to "go paperless". Having this aim, the committee outlined a strategy for updating and integrating all the information into the EPR. This greatly affected the practices of cleaning up the patient charts. Thus, in contrast to Case A, where secretaries groomed the *paper charts*, in Case B, secretaries groomed the *EPR*. Since the physicians' workload gradually increased, the special EPR committee decided to redefine some of the existing roles and responsibilities. Accordingly, the secretaries were now responsible for updating the EPR. This implied going through each patient record and updating the narcotic agreement, and the allergy record, as well as information related to height, weight, and blood pressure. Since the secretaries had been scanning old paper charts for a period of time, there was an increase in the amount of information available through the EPR. This led the EPR committee to implement a new policy whereby physicians were expected to stop asking secretaries to pull paper charts. They were now expected to retrieve most of the information from the EPR. In addition, the committee decided that there was no need for physicians to sign off on charts, since this was done through the EPR. In sum, the decisions and work practices related to the EPR changed so rapidly that our attempt to create a summary document that could capture these changes seemed profoundly challenging as it had to be repeatedly updated.

At this point, the number of challenges began to decrease and there was a sense of stabilization in the adaptation process. Secretaries were now responsible for shredding papers that were printed out from the EPR for faxing or mailing purposes. Some physicians started to use the advance function for writing quick referrals, which allows reuse of previously entered information. Graph and diagram-generating functions were also adopted by some physicians. The EPR committee developed a strict protocol for what the secretaries would be required to scan. The requests that were not approved by the protocol would be scanned by the physicians who were now provided training sessions.

5.3. Technology-in-use practice across cases

We have now presented how the technology-in-use practices developed over time in the two cases. While we see that the practices around technology changed and evolved in both cases, we also observed that the extent to which the work practices changed was different. In Case A, the health care personnel did manage to adapt the EPR into their work practices and therefore develop technology-in-use practices over time. It is evident, however, that in Case B, the amount of changes were considerably greater, thus increasing the use of the EPR. In Case B, the health care personnel managed to develop highly complex technology-in-use practices over time. The below table summarizes the development in both cases.

Table 1. Technology-in-use practices in the two cases.

	Initial technology-in-use practices		**Emergent technology-in-use practices**	
	Physicians	Secretaries	Physicians	Secretaries
Case A	Validating and signing notes	Transcribing and correcting notes	Transcribing and correcting notes Retrieving information Partial use of prescriptions Partial use of doctor's notes Internal referrals	Piloting scanning Creating templates
Case B	Entering medical notes Prescriptions Search function	Scheduling Billing Scanning	Entering medical notes Retrieving information Prescriptions Search function Referrals Scanning Creating templates Partial use of visual graphs and diagrams	Grooming and updating the EPR Scanning

6. Discussion

We have now illustrated how the technology-in-use practices developed rapidly into more complex work patterns in Case B compared to Case A. In this section, we will investigate the factors promoting the adaptation process. Examining our empirical observations, we found that one of the major driving forces in Case B was the establishment of the EPR committee and their meetings. It was during these meetings that the health care personnel evaluated the adaptation process and continuously developed new and more advanced technology-in-use practices.

There were also meetings in Case A; however, these meetings took a different form and were organized by the IT department. Introductory meetings were mainly intended to introduce the various functions in the EPR. Follow-up meetings were conducted with contact personnel and 'super-users'[3], who were representatives from each professional group. Reaching consensus in these meetings was profoundly challenging because every time a new function was introduced, each group claimed their workload was already so high that they could not adopt these additional tasks. The staff from the IT department would often turn to the department head to ask for support.

In Case B, reaching decisions was radically different. Here, continuous discussions and negotiations took place with all committee members. Typically, when a new function was put into use, the committee members would request comments from the individuals specifically impacted by the change. This was often followed by a testing period where the new work practice was piloted. The committee would then request

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[3] 'Super-users' refers to a group of individuals that were expected to acquire more advanced knowledge and were assigned additional responsibilities (e.g. providing daily support to the staff, downloading updates, and informing the staff of any changes).

feedback on the pilot testing, thus evaluating whether the changes were feasible and/or beneficial. For example, when the committee discussed the need to fully update the EPR, they decided that it was not feasible to ask the health care personnel to enter all the information, as this demanded a considerable amount of time. Instead, the committee decided to prioritize which parts of the information should be entered. Hence, decisions were reached through a mutual and dynamic process of negotiation and re-negotiation of technology use [9, 24]. These meetings encouraged increased collaboration across professional groups, especially between physicians and secretaries. The committee meetings in Case B accumulated a process of continuous alignments, adaptations, and fine-tuning of local work practices to the technology (and vice versa). In situations where the workload evolved, new decisions were made based on new evaluations. Scanning, for instance, was initially conducted by the secretaries; however, as the number of requests increased, new strategies were established to distribute the workload between the secretaries and the physicians. The meetings in Case B enforced systematic evaluation mechanisms through iterative feedback loops. In Case A, when the IT department managed to reach a consensus and a final decision, the changes in the work practice were not always followed by the health care personnel. While the changes in Case A came from 'the-outside' ('the top level')- from the IT department who struggled with forcing changes the changes in Case B were initiated internally by the health care personnel. This can be viewed as a 'bottom-up approach'.

The meetings in Case B were very different in nature compared to Case A. The participants in these meetings did not constitute individuals that were randomly chosen to represent their professional group. Rather, the committee in Case B consisted of individuals who freely volunteered to participate in weekly meetings and dedicate some of their time to testing the EPR. It was therefore a group of committed and enthusiastic individuals who took responsibility for dealing with various challenges and actively defined new goals for further development. Since there were rapid changes applied to the technology-in-use practices, the committee acknowledged the importance of disseminating knowledge to all the health care personnel.

In contrast to Case A, where most of the meetings were held at the beginning of the adaptation process, the meetings in Case B were held on a weekly basis for half a year. It was only when there was a sense of stabilization and the number of challenges decreased that the committee changed their schedule to biweekly meetings, which were later reduced to monthly meetings. This allowed the health care personnel to deal with unexpected challenges as they emerged along the adaptation process. Such challenges and unanticipated uses could not be predicted in advance [22]. For example, usages of the messaging feature brought along challenges regarding how to deal with urgent messages in situations when the computer was turned off.

Thus, the weekly meetings in Case B constituted continuous reflection-on-action activities [26], which were essential for dealing with concrete, local, and situated complexities related to both the technical implementation and the necessary adaptation activities. Because of these meetings, technology-in-use practices were gradually emerging from situated actions [16]. Furthermore, the meetings in Case B provided space to engage in critical debates and question existing rigid and duplicated routines. An illustration of this questioning was when the secretaries at one point asked the physicians why they continued the routine of signing paper charts when this function was now conducted through the EPR. In other words, secretaries were questioning patterns of work that were a result of old habits.

In Case B, each new function was always discussed in relation to other existing functions. Hence, if a new function increased the workload for one professional group, it was always evaluated in relation to the overall context of changes. Decisions concerning changes in the distribution of practices were based upon the existing workload at a certain point in time. When the health care personnel discussed the need for updating the EPR, for example, the physicians suggested that the secretaries do this task since their workload decreased dramatically when they stopped grooming paper charts. Hence, the committee acknowledge the continuous changes in the amount of work and strived to balance the distribution of the workload among the staff. On the contrary, in Case A, each development of a new function was discussed in isolation from the overall context of changes. Hence, as mentioned earlier, when a new function was introduced, it was more easily rejected by the staff, who often saw the additional work tasks that were brought along with the new function.

The process of reflection was essential for enabling and assessing the management of the adaptation process and for cultivating technology-in-use practices. While, in Case A, the technology was viewed as something that took the practitioners' time and disrupted the medical practice, in Case B, new technical knowledge was articulated through use and influenced peoples' perceptions and understanding of the technology and its use [10]. Gradually, technology-in-use practices became embedded in the medical practice and were viewed as an important aspect for enhancing quality of care.

7. Concluding remarks

Previous research found that large scale information systems adaptation in health care should be managed by a project-group including not only IT-developers, but also representatives of future users and management. They also found that negotiations of system specifications, as well as organizational changes, should be discussed frequently at project-group meetings [4]. While we also argue for the importance of these meetings, we additionally complement and expand the notion of project meetings by providing a conceptualization of the essential aspects of these meetings. Our conceptualization is composed of continuous reflection-on-practice activities constructing technology-in-use practices. Reflection-on-practice activities are internally initiated and involve critical reflections by the participants, who continuously evaluate and question work practices in relation to technology. Finally, it is evident that what distinguishes other meetings from reflection-on-action activities is that the participants take on the responsibility of bringing awareness of the new and revised technology-in-use practices to the professional groups. Our empirical observations suggest that participants' capabilities to provide awareness of new technology-in-use practices is dependent upon how well they are embedded within the local context of the work practices, which again is influenced by the engagement and commitment of the health care personnel. We found that our conceptualization of reflection-on-action activities was useful in explaining the differences between our two cases of EPR adaptation. Moreover, we hope this work will inform health care personnel as well as provide an analytical perspective enriching the existing research in the area of technology adaptation.

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Measuring Nurses' Time in Medication Related Tasks Prior to the Implementation of an Electronic Medication Management System

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Abstract. A substantial proportion of nurses' work consists of medication related tasks undertaken in a current environment of high medication error rates. Electronic medication management systems (EMMS) are anticipated to address many of the factors which contribute to errors. These factors, for example illegible hand-written drug orders, reputedly require nurses to spend additional time in clarification and discussion. We report an observational modified time and motion study of 44 registered nurses (215 hours of observation) in a major academic hospital to quantify the time nurses spend in medication related tasks prior to EMMS introduction. On average nurses spent seven minutes in an 8.75 hour shift clarifying or discussing medication issues. The majority of this time (5.4mins) was spent talking with other nurses. Only 1.6 minutes was spent clarifying or discussing medication with doctors. Our results call into question some of the predicted efficiency benefits to nurses' work following EMMS introduction.

Keywords. Nursing informatics, medication errors, time and motion studies, interdisciplinary communication, health care quality access and evaluation, nursing administration research, medical order entry systems.

Introduction

Preparation and administration of medication is a core element of nursing work and is reported as consuming a significant proportion of nurses' time [1]. Since the release of the IOM report "To Err Is Human" [2], there has been recognition of the problem of medication administration errors. Rates of error vary considerably depending on the method of investigation, with errors typically under-reported by clinicians as fear of blame and repercussion persists [3-5]. Not only do researchers use different definitions of medication errors as well as differing methodologies (from retrospective audits to observational methods) [6], but also clinicians have different interpretations of what constitutes an error when self-reporting [7-9]. Observational studies have reported medication administration error rates as high as nearly one in every five administered doses [10].

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Attention has been paid within the nursing literature to factors contributing to medication administration errors. Two of the most recent literature reviews in this area reported a range of factors contributing to medication administration error [11, 12]. These have been supplemented by results from further studies [13-17]. While much of this literature remains under-empiricised, the identified factors include:

- Illegibility of prescribing orders with poor handwriting and improper use of abbreviations leading to confusion in drug identification as well as uncertainty of dose;
- Distractions and interruptions, with Hicks et al reporting distraction as the single most frequent contributory factor leading to errors in an anaesthetic recovery unit [18];
- Poor mathematical skills of some nurses, with deficiencies in conceptualization as well as in calculation;
- Nurse fatigue and stress with high workloads plus poor staff mix with a high proportion of junior staff; and
- Insufficient knowledge of, or access to, information about medications.

These factors cover both those within and outside the control of nurses, but all factors are likely to result in an increase in the time taken to prepare and administer medications. Examples include time taken to decipher or clarify an illegible order, re-calculate drug doses to compensate for skill deficiencies or physically search for a drug manual to find information. The opportunity cost is the lost time available for other work tasks.

Several studies have demonstrated the strategic role that nurses play in detecting medication errors prior to administration. For example, Rothschild et al, investigating the clarification role of nurses, studied medical error by direct observation and incident reports in an acute care setting. They reported that nurses provided a significant role in error prevention, with 73% of recovered errors relating to medication. Examples of such clinical practice included querying questionable orders [19].

Electronic medication management systems (EMMS) target several of these central factors thought to contribute to medication administration errors, and thus expectations regarding the benefits for these systems to reduce error rates are high [20]. EMMS allow for the direct ordering of a drug (usually chosen from a drop down menu list) from a computer database by a licensed prescriber. Varying levels of decision support tools can be provided, for example alerts to notify of patient allergies or drug to drug interactions. The system may also include an electronic medication administration record (e-mar), which allows for documentation once the drug has been given. The combination of the electronic ordering and e-mar can thus replace paper medication charts in hospital ward settings.

The potential impact of EMMS on nurses' work is also considerable. By potentially reducing the amount of time currently spent finding medication charts and deciphering illegible scripts etc, it is anticipated this work time may be re-distributed to other tasks. However two studies which examined nurses' perceptions of time savings following EMMS introduction reported conflicting findings [21, 22], with a more recent study demonstrating that drug administration rounds took nearly twice as long after introduction of an electronic system [23]. Emerging evidence also suggests that face-to-face communication between doctors and nurses about medication-related tasks may be reduced following EMMS introduction, and that this may have a negative impact upon care delivery [24].

In order to evaluate these systems and thus inform decisions about the ways in which these systems should be integrated into nursing practice to support safe and efficient work practices, further data are needed. A fundamental problem is the lack of quantitative data about the extent to which each of these factors identified as influencing medication administration error impact upon nursing practice in the current environment. There are extremely limited data internationally regarding the amount of time nurses spend in specific medication related tasks, and about the burden placed on nurses in terms of spending time undertaking tasks related to ensuring the accuracy and safety of medications. One study by Ridge and While sub-divided nursing tasks around medication activities and employed a work sampling technique in the highly specialised area of a neonatal unit, but our searching revealed no similar studies in general adult wards [25], nor any recent research in this area. Such data are necessary if we are to measure and understand any changes in work practices following the introduction of EMMS. In addition, these data are important in informing the debate about the importance of specific factors in contributing to errors and negatively impacting upon nurse's time. For example, there are currently no data available about the proportion of time nurses spend clarifying medication orders or searching for drug information in general wards.

We undertook a large-scale observational study to quantify the amount of time nurses spend in routine activities, with particular emphasis and detail on medication tasks, as the first stage in a research project to evaluate changes in work task activities following the introduction of an EMMS.

Methods, setting and participants

The study took place across four wards (two geriatric, one respiratory and one combined renal/vascular) of a teaching hospital in Sydney between July 2005 and February 2006. These wards are expected to implement an EMMS during 2007. Fifty-two nurses were observed undertaking their routine activities Monday to Friday from 7am to 7pm. A total of 250 hours of observation was undertaken, with each observation period averaging one hour.

A multi-dimensional work classification system was used which enabled collection of data regarding which activity the nurse was performing, who the nurse was with, and the method of task execution. This multi-dimensional work classification system had been used previously in a paper-based work-sampling study of nurses [1], which exhibited high face validity and inter-rater reliability. Categories and definitions of nursing activities were further refined to incorporate details about specific medication tasks (Table 1).

Data were collected using a personal digital assistant (PDA),which enabled time stamping of each task, as well as recording of multi-tasking and interruption data. At the end of each observation session, the data were synchronised with a central database on a personal computer.

Table 1. Definitions of Nursing Activities

Nursing Activity	**Definition**
All Medication Tasks	All tasks associated with medication, includes preparation, administration, documentation, discussion & clarification)
Medication sub-tasks	
find order	Looking for medication charts/medical records with drug order
prep drug	Activity around drug preparation & clean-up
clarify	Confirmation by the nurse of any part of the drug order (with person or other info source)
check drug	Checking with & co-signing of another nurse's or doctor's medication
admin	Giving medication to a patient
chart	Recording drug administration details
order	Ordering stock or non stock items including S4 and S8s for a particular patient
discuss	Talking about a drug with another health professional &/or patient/relative
review	Looking over drug orders as part of planning care
Direct Care	All tasks directly involved with patient care, includes direct communication with patient &/or family
Indirect Care	All tasks indirectly related to patient care (eg reviewing results, planning care)
Documentation	Documentation (paper and electronic), excludes medication documentation
Professional Communication	All non-medication related communication with another health professional, includes ward & patient hand overs
Ward Related Activities	Ward activities, including coordinating beds and staffing
In transit	Time between tasks and between patients
Supervision	Supervising others, including supervising students
Social (incl break)	All non work communication, as well as tea & meal breaks
Other	Any other task not included above

Following approval by the relevant hospital and university Human Research Ethics Committees, nurses were recruited during information sessions. Participants signed a consent form, and details regarding their classification, age and experience were collected. During observation sessions, patients were introduced to the observer and permission was sought.

As the purpose of the study was to detect differences between nurses' activities pre and post EMMS implementation, sample sizes were calculated using previous work-sampling studies [1]. We determined that at alpha=0.05 and with power of 80%, 226 hours of observation were required to detect a three minute difference in the proportion of time spent in combined medication-related tasks pre and post system introduction using a two-tailed t-test.

Data collectors, all clinically experienced registered nurses, undertook approximately fifteen hours of training in the observation method using the PDA. Inter-rater reliability tests at the end of training and throughout the study demonstrated that agreement was maintained in the range 85%-98%.

The results for this paper focus on the work activities of registered nurses (RNs), of which 215 hours of observation were carried out. Analysis was undertaken using SPSS version 14.0. Descriptive statistics were used to present the average proportions of nurses' time spent in categories of work tasks, as well the average time per shift spent undertaking specific work tasks. As task categories were not mutually exclusive, two or more could be occurring at the same time. For example, there were times when nurses were engaged in direct care as well as in a medication task (ie multi-tasking). Medication related tasks were further analysed by subtasks, and the percentage of time spent in each subtask as a proportion of total medication-related time calculated. The drug route was not part of the analysis, nor was the type of medication. Thus there was no difference in analysis between an injectable drug of addiction and an oral medication freely available over the counter.

Results

We found the nursing activity occupying the most time was professional communication, comprising 20.6% of registered nurses' (RNs') time, which equated to 108 minutes over a normal shift (Table 2). This task category describes all communication of a non-medication nature with other staff including doctors, other nurses, pharmacists, allied health and ward clerks. Direct care was the second largest work category, consuming 18.5% of total work time.

Combined medication tasks consumed 16.9% of RNs' time, which corresponded to 89 minutes per shift. A range of sub-tasks are included within this category, for example preparation, administration, documentation and any discussion or clarification about medications.

Analysis of the medication subtasks show that RNs spent the greatest proportion of total medication-related task time in medication preparation (35.0%), followed by medication administration (20.2%) (Table 3). Preparation involves all activity around preparing a drug and the clean-up afterwards.

Table 2. Overall Percentages of Time in Different Activities

Nursing Activity	Percentage of Overall Time Registered Nurses (RNs) Are Involved in Activity	Number of Minutes per 8 ¾ Hour Shift
Professional communication	20.6%	108.1
Direct care	18.5%	97.1
Combined medication tasks	16.9%	88.6
Indirect care	11.1%	58.1
Social	10.7%	56.0
In Transit	7.8%	40.9
Documentation	7.2%	37.7
Supervision	3.3%	17.5
Ward-related	3.1%	16.3
Other	0.9%	4.8
Total	100%	525.0

Table 3. Percentages of Time in Medication-Related Tasks

Medication Tasks	Percentage of Medication Time Registered Nurses (RNs) Are Involved in Task	Percentage of Overall Time Registered Nurses (RNs) Are Involved in Task	Number of Minutes per 8 ¾ Hour Shift
Prepare medication	35.0%	5.9%	31.0
Administer medication	20.2%	3.4%	17.9
Chart medication	12.7%	2.2%	11.3
Review medication	11.1%	1.9%	9.9
Discuss medication	10.5%	1.8%	9.3
Check medication	6.5%	1.1%	5.8
Clarify medication	1.6%	0.3%	1.4
Find medication	1.5%	0.3%	1.4
Order medication	0.8%	0.1%	0.7

Thus for an injectable drug, this activity includes reading the medication order, obtaining the drug keys if necessary, finding the drug in the medication area, obtaining and organizing the equipment, confirming the medication with another health professional and drawing up the medication. The task category "check medication" specifically relates to checking with, and co-signing of, another nurse's or doctor's medication preparation. Administering the medication to the patient describes actually giving the medication, as well as patient identification checks, patient preparation (eg repositioning the patient so they could swallow medication), reviewing or taking vital signs prior to giving the medication if necessary, and checking and/or adjusting equipment throughout the process such as IV tubing. Any discussion with the patient about their medications was separately recorded under the task "discuss medication". The combination of medication preparation and administration corresponded to approximately 49 minutes of a normal shift, exceeding general documentation time by more than ten minutes.

Registered nurses were engaged in medication discussion 10.5% of the total medication task time, corresponding to 1.8% of total shift time or 9.3 minutes per shift. By definition, this time includes instances of conversation with a staff member, patient or relative about choice of drug and/or dosage, side effects, efficacy, discharge instructions or administration protocols. Clarification occupying 1.6% of total medication time, (which equated to 0.3% of total shift time or an average of 1.4 minutes), specifically relates to confirmation by the nurse of any part of the drug order once it had been written. Thus queries with other people regarding legibility issues and apparent orders outside normal regimes are included in this category, as are instances

of looking up drug information in written sources in order to check the appropriateness of a prescribed drug.

To understand who nurses were talking to in general and about medication tasks we further analysed the work tasks (Table 4). Professional communication about non medication issues with other nurses occupied on average 75.6 minutes over a normal shift, but occupied only 8.4 minutes with doctors.

Table 4. Percentages of Time with Other Nurses, Doctors & Pharmacists for Professional Communication, Medication Discussion & Clarification

		Professional Communication	**Medication Discussion**	**Medication Clarification**
With Nurses	Percentage of Overall Time	14.4%	0.9%	<0.1%
	Minutes per Shift	75.6	4.7	0.7
With Doctors	Percentage of Overall Time	1.6%	0.2%	<0.1%
	Minutes per Shift	8.4	1.0	0.6
With Pharmacists	Percentage of Overall Time	< 0.1%	< 0.1%	< 0.1%
	Minutes per Shift	0.4	<0.1	<0.1

Figure 1. Minutes Per Shift Spent in Professional Communication, Medication Discussion and Medication Clarification with other Nurses and with Doctors

Discussion with doctors about medication issues averaged one minute per shift, while discussion with other nurses about medications was higher at approximately four and a half minutes per shift. Within the medication-related sub-task of clarification, approximately 35% of clarification time was spent talking with doctors. Another 41% of clarification time was spent talking with another nurse. These percentages equated to less than one minute per shift with each of these professional groups. Clarification with a pharmacist was observed only once in the 250 hours of observation, while medication discussions with pharmacists occurred during four episodes over the entire data collection, totalling three minutes.

When the separate categories of professional communication, medication discussion and medication clarification were totalled, we found that RNs spent an average of ten minutes in active dialogue with doctors per shift. This contrasts with eighty-one minutes of active dialogue with other nurses (Figure 1).

Of this time, nurses were discussing and clarifying medications with doctors for a total of 1.6 minutes, and with other nurses for 5.4 minutes. This equates to a combined figure of seven minutes of medication related dialogue with another health professional per shift comprising 2.8% of total work time. This figure excludes standard medication checking procedures.

Discussion

Our results confirm earlier work [1] showing that medication-related tasks require a significant amount of nursing time, and consumed 17% of total work time. Thus interventions aimed at improving the efficiency and safety of these processes are worthy of attention. We examined time spent in two specific work tasks which may reflect nurses' role in preventing medication errors, namely clarification of medication orders and discussion about medications. Clarification refers specifically to seeking further information about a questionable order, for example seeking assistance in deciphering an illegible order or checking if an order appears out of a normal dosage regime. Medication discussion relates to more general communication about a patient's medication.

We demonstrated that RNs spent only 0.3% of total time (or 2% of total medication time) in the task of clarification, averaging less than two minutes across an eight and three quarter hour shift. Our results also revealed that RNs were clarifying with other nurses at the rate of approximately 30 seconds per shift, with a similar rate for clarification with doctors, and undertook virtually no clarification with pharmacists. It would appear from our data that nurses are spending minimal time in clarifying ambiguity in the current paper-based system.

RNs spent a small proportion (1.8%) of their total time in medication discussion with others, with only two tenths of this time with doctors equal to an average of one minute per shift. Medication discussion by RNs with pharmacists was also low, with only four episodes totalling three minutes observed during the entire 250 hours of observations.

The combination of medication discussion and medication clarification with doctors was less than two minutes per shift. By contrast, time in non medication discussion (professional communication) with doctors was 8.4 minutes, revealing that medication issues represent a small proportion of overall time of doctor-nurse discussion. Considering the emphasis on the importance of multidisciplinary communication and cooperation on safety and quality in the delivery of healthcare [26, 27], the low rate of face-to-face interactions between doctors and nurses is surprising and potentially alarming. No comparable figures from other studies could be identified.

The reasons for this limited time spent in communication are not clear from this study, but may be related to lack of opportunity in a fast-paced work environment. Prescribing orders may have been of a high quality which did not require any clarification, perhaps nurses were unable to recognize any orders which may have required clarification, or perhaps doctors discouraged clarification questions. It was unusual in these wards for nurses and doctors to undertake formal ward rounds together, thus limiting their time in potential interaction. A lack of formal ward rounds, for whatever reason, has previously been demonstrated to reduce the amount of doctor-nurse communication regarding medication management [28]. Beuscart-Zephir et al, in researching the implications on cooperation and communication in decision making for medication management when order entry systems are introduced, demonstrated that in sites where order entry systems were in place ward rounds no longer existed, and the opportunity for synchronous discussion consequently decreased [24]. Considering the small amount of time we found RNs engaged in nurse-doctor communication, it will be of interest to ascertain if this is even further reduced with the introduction of an EMMS.

It is predicted EMMS will introduce welcome changes around medication management. International literature [23, 29] reveals that what nurses liked about new electronic medication technologies included elimination of illegible scripts with less ambiguity and fewer errors. Given the small proportion of time currently consumed by clarifying orders in the paper-based system, it is unlikely that EMMS will provide a significant time saving in this area, though the benefits to error reduction are unclear. Other reported benefits by nurses included 'eliminating the problem of the missing chart' [23 p45]. Our data enabled us to quantify how much of nurses' current time is spent looking for medication charts, a task that is complained about in many discussions regarding problems with the current paper-based system. RNs spent approximately 0.3% of their time looking for medication charts, or on average approximately one minute per shift. Despite this being an obvious irritation to nurses, it is not supported empirically as a significant time factor.

The results from this study have demonstrated the value in investigating underlying assumptions about current problems in nurses' work which are identified as being improved following the introduction of EMMS. We investigated the assumptions that nurses currently spend significant time in clarification and discussion of medication issues and in searching for missing medication charts, all tasks which EMMS would be expected to significantly improve. We found that individually and together these tasks consume a small part of nurses' work. Thus evaluating the benefits of an EMMS on the basis that unnecessary time spent in these work categories will allow for a significant redistribution of nurses' time to other work tasks, is unlikely to produce a positive outcome. We did not investigate the large volume of indicators which could be used to measure the potential benefits of EMMS for nursing practice and health care delivery. However through the evaluation of only a small number of indicators we have shown that assumptions about the size of existing problems in practice may not be confirmed when measured. Evaluators need to be vigilant in quantify the assumed problems which IT solutions such as EMMS are promoted as targeting.

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Generation Y in Healthcare: The Need for New Socio-technical Consideration for Future Technology Design in Healthcare

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Abstract. While identifying reasons for the failure of information communication technology (ICT) to transform the healthcare system and constructing models of better designed technology with socio-technical integration is relatively straightforward, implementing these solutions into the rapidly changing medical world has proven considerably more difficult. From a technologist's perspective, the promise of technology remains powerful. New technologies, with high level of socio-technical integration have long been considered as one of the most important factors to transform the medical world in order to deliver better and safer care. From the socio-cultural perspective, however, there is an equally powerful force, which has largely been ignored by the greater community: the entry of generation Y into the healthcare system. Generation Y has generated significant changes in many other industries. This powerful socio-cultural change within the healthcare system needs to be more clearly investigated to guide the design and implementation of socio-technical integrated ICT solutions. This research-in -progress paper presents a methodological approach that both generates an in-depth understanding of generation Y and illuminates criteria that can be used to meaningfully identify the guiding principles for future socio-technical integrated ICT design and implementation. It aims to make a significant contribution to the field of socio-technical approach to ICT design by alluding the audience to this new generation Y phenomenon in healthcare. It provides some preliminary data to support the need to consider generation Y in future ICT design in healthcare.

Keywords. Socio-technical integration, generation Y, qualitative research.

Introduction

The healthcare system is at a cross-road. In the coming decades, the healthcare system will be undergoing the biggest transformation of any industry in history [1]. From the care delivery point of view, there will be significant increase in the demand for care. The ageing population, with more complicated medical problems [2], will demand greater services from limited medical resources. The rapid subspecialisation of medical care will exacerbate the shortages of healthcare professionals. Furthermore, the increasing utilisation of multidisciplinary care creates the need to improve communications and

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information exchanges among various healthcare professionals [3]. Therefore there are increasing supports for rapid automation of the medical care with technology. Furthermore, one could argue that the problem with information exchange and delivery within the healthcare system could be solved by the development and implementation of ICT [4]. The implementation of multi-billion dollars IT projects in the United Kingdom [5] is a living example of our confidence in the potential of ICT to solve the healthcare crisis. The simple statement presented at a recent medical informatics conference summarises the perception among information technologists [4]: "The solution to the problem of ageing population is to develop better and faster computers in order to deliver the right information to the right people at the right place at the right time."

Electronic healthcare implementation, however, has not so far delivered on its promise to improve efficiency and safety of healthcare delivery [6]. Significantly, many information technology projects in healthcare fail [7]. There are considerable problems associated with the electronic health projects in the United Kingdom [5]. More significantly, one of the most evidence-based electronic solutions to healthcare problems, the computerised physician order entry system, has suffered major setbacks during the implementation phase to the wider community [8]. The noteworthy increase in mortality after the implementation of a computerised physician order entry system in the United States serves as a reminder to all involved that the implementation of electronic systems in healthcare is not a risk-free activity [8].

When the failures of ICT are analysed in detail, it becomes clear that the problems are related to the ethos of "techno-centrism" and "info-centrism". The problem is not related to the technology itself, but the lack of socio-technical integration with the existing healthcare system [9]. There are significant intrinsic issues with the understanding of the medical workflow and hence the system designs for ICT in healthcare [10]. This often leads to a lack of socio-cultural consideration for technology implementation [9]. Significantly, the lack of socio-technical integration often leads to unwanted consequences which might adversely affect healthcare delivery [8]. Therefore, there has been a recent proliferation of various user-centred design techniques which claim to achieve socio-technical integration for electronic healthcare implementation [9] [11].

The understanding of the importance of socio-technical integration will likely lead to a change in future of technology designs. When we move towards the electronic future the emerging technology, armed with the principles of socio-technical integration, will take ergonomic design to the next level [12]. From the perspective of technologists, the application of user-centred design and socio-technical integration will likely lead to a renewed enthusiasm and interest in the electronic transformation of a future healthcare system [12]. There is, however, another very important aspect of socio-technical design which has been largely under-recognised in the health informatics literature: the heterogeneity of the socio-cultural factors within the health system, especially the increasing number generation Y clinicians. From the socio-cultural perspective, this new generation of workforce might be as powerful as ICT in transforming the healthcare system. Therefore, it is essential and timely we revisit the principles of socio-technical integration which governs future ICT design through the lens of generation Y.

This article firstly describes the characteristics of generation Y as experienced by other industries. It then explores the potential platform created by generation Y for ICT to flourish within the health system. The paper goes on to examine the potential problems associated with generation Y and ICT implementation. This emerging socio-cultural factor requires a holistic methodological approach to generate contextual insights into the integration of generation Y into the medical workforce. The generation of in-depth socio-cultural insights of this generation of healthcare workers provides an understanding of the systems requirements expected of the future ICT in the healthcare system. This research project aims to formulate guiding principles for future ICT design with generation Y healthcare workers in mind. This research-in-progress paper then provides some preliminary data to support our work in the field.

1. Generation Y and the healthcare system

Generation Y is commonly defined as those born after 1978 [13], although the exact cut off year is arguable [14]. This generation of young workers has created big impacts in the other industries [15]. As they are now getting into their 20's, their impact on the healthcare system is slowly being acknowledged. The distinctive characteristics of generation Y, and the generational gap challenge, have been described and reviewed elsewhere [13][14]. This section will focus on the characteristics which are relevant to the healthcare system. More importantly, this section focuses on the characteristics of generation Y, which might have important implications for ICT design and implementation in the healthcare system.

1.1. Life experience and challenges

Generation Y loves life experience and challenges [16]. They want to have fun during their routine work [16]. They thrive in stimulating and challenging conditions [16]. The industry revolution, and now the information age revolution, have seen the automation of most manufacturing jobs. Unfortunately, most of the routine day-to-day jobs in healthcare system are still carried out by human beings. There might be a significant generation disharmony as the healthcare system requires a combination of routine and challenges.

1.2. Technology savvy

Generation Y has grown up surrounded by technology [13]. They see the diffusion of computer from academic research centres into everyday life. They experience the impact of technology in many aspects of their lives. Technology has not only transformed their lives, but also provided limitless career and financial opportunities for generation Y from "Yahoo" to "YouTube". The healthcare system is unfortunately an industry that is slow to take up technology. When it does utilise technology, however, the story of failure is common [7]. Therefore, the enthusiasm of generation Y for technology might have to be managed with the resistance and experience of failure for technology within the healthcare system.

1.3. Fluidity of workforce

Generation Y loves variety [13]. They are likely to change jobs or institutions frequently [14]. Generation Y-ers feel bored when they need to remain in one job for a long time. This creates significant problems in the medical workplace as every hospital is slightly different. The maintenance of a workforce with essential tacit knowledge will become very important. This problem is made more difficult due to the traditional emphasis within the medical world on explicit knowledge representation, such as evidence-based practice. The representation and delivery of tacit knowledge have until now largely been ignored.

1.4. Information gathering and presentation

Generation Y-ers are street smart and they gather information fast [13]. The information gathering process often includes the utilisation of technology such as internet, but most likely they obtain essential information through social networking and mobile messaging [13][14]. Generation Y wants simple information presented in simple language. In generation Y terms: “U get info U wnt 2 ur mates only. :)”. Unfortunately, this culture might not fit into the formality and hierarchy of healthcare system.

1.5. Education and training

Education and training are part of generation Y’s life [13]. They are the most educated generation of all time. Generation Y, however, learns in a different way. Generation Y-ers want on-demand, ubiquitous and relevant education and training. These education and training needs are often supported by technology. The healthcare system, however, is based heavily on an apprenticeship model [17]. Education and training provided are often irrelevant to their perceived immediate needs.

2. Potential opportunities and pitfalls of ICT

There are potentially many opportunities for ICT to flourish with the increasing critical mass of generation Y in healthcare workforce. Most generation Y healthcare professionals are computer literate and love technology. This significantly reduces the adaptation problems with computer technology. There are also many potential pitfalls working with generation Y as their expectation of ICT might be difficult to achieve. This section explores these opportunities and pitfalls.

2.1. Potentials

The entry of generation Y clinicians brings an opportunity to reassess and improve the use of ICT within the healthcare system. Generation Y-ers have been swimming in technology since birth. They believe in technology! Generation Y finds it easy to adapt to new technology. Given the ageing population, the increased complexity of medical disease management and increased number of prescription medications, electronic health records are the only sustainable future [2][3]. The implementation of an electronic healthcare system will not require significant up-skilling with generation Y workers as most of them are familiar with computer technology.

The speed of technology roll out offers the necessary stimulation for generation Y to remain interested in the healthcare system and to participate in the redesigning of the healthcare system. While this might sound like a daunting task to many, generation Y-ers will find it challenging and they will want to be part of this evolution. Therefore, researchers and other information technologists might find the suggestions from generation Y through user-centred design process much more practical and useful due to their familiarity with technology.

The preference for rapid and on-demand access to education, training and decision support system by generation Y can only be fulfilled by well-designed new technologies. ICTs have the potential to deliver teaching and education at the right place at the right time. Furthermore, the availability of on-line, on-demand information search engines and decision support systems will be well received by generation Y.

Knowledge management and representation, especially tacit knowledge management, will become increasingly important, and technology can play a significant role. The tacit knowledge which enables individual healthcare professional to function in a specific institution has previously been transferred through the process of socialisation. With the increasing number of short-term employment, part-time and locum workforce [18], the representation of tacit knowledge will have to be delivered to workforce rapidly. This allows another dimension for ICT to flourish in the healthcare system.

2.2. Pitfalls

There are, however, potential pitfalls with the utilisation of ICT with generation Y. Firstly, generation Y has very high expectation of what technology should deliver. While the technologies, especially wireless mobile technologies, might be available, there are multiple issues to be considered such as ethics, security, data integrity, cultural factors, environmental factors and social factors [19].

Secondly, the workflow of healthcare professionals is not well understood [9]. While there are socio-technical integrated solutions, these are still more failures that successes [9]. The familiarity of generation Y with technology will create the expectation that technology can fix all problems. This is not likely to be the case in the complex healthcare system.

Technology implementation is very expensive as demonstrated by the recent experience in the United Kingdom [5]. The healthcare budget is limited. It is not possible to fund cutting edge technologies all the time. Some jobs have to be done and they have to be done with minimal technology.

While it is often possible to retrieve on-demand information and to receive on-demand education, one needs to have a certain level of knowledge and competency in the medical world. Furthermore, the hierarchical structure assumes certain functions for each individual within that organisation. The on-the-spot clinical decision support and knowledge representation for generation Y will challenge the basic fundamental assumption of the medical world. This has the potential to create significant conflict within the medical profession.

Finally, Generation Y will create a generation gap in leadership, clinical governance and work-life balance [20]. Their familiarity with technology and their desire to utilise technology, if not managed appropriately, will lead to widening generation gap and disharmony in the healthcare workplace.

3. Methodological approach

Given the new socio-cultural experience created by generation Y in other industries, it is imperative that the healthcare system takes generation Y seriously. Significantly, the future design and implementation of ICT within the healthcare system needs to take generation Y into account. More importantly, as generation Y slowly replaces the ageing healthcare workforce, the socio-cultural aspect of generation Y associated with ICT implementation needs to include that of generation Y as well as the generation gap. Furthermore, medical personnel may be a self-selected group of people for whom the characteristics of generation Y found in other industries do not apply.

Given the scanty literature available on this topic, the main aim of this pilot exploratory study is to generate in-depth socio-cultural understanding of generation Y doctors within the current healthcare setting. The conceptual socio-cultural understanding generated will allow us to develop guiding principles for future ICT design and implementation within the healthcare setting. We believe that a socio-technically integrated ICT system, taking generation Y into consideration, will provide a powerful force to transform the healthcare system. Therefore, the research objectives of this project include:

- To generate an understanding of the impact of generation Y on healthcare.
- To understand the perception of ICT in healthcare among generation Y-ers.
- To understand the generation Y's expectations of technology in healthcare.
- To generate a conceptual model to involve generation Y in the socio-cultural-technical integrated design and implementation of ICT in healthcare.
- To generate socio-cultural insights of generation Y and hence develop guiding principles for future ICT design and implementation.

Qualitative research is increasingly being used in health research due to the complexity of the phenomena being studied that include social and cultural norms and perceptions that impact on behaviour and medical practice [21]. This is particularly useful in the investigation of the realm of socio-cultural-technical interactions [22]. In order to obtain a holistic understanding regarding the socio-cultural issues of generation Y, we employ qualitative research methodology, applying interpretivist epistemology as the underlying research philosophy.

We use a three-stage approach in order to generate the complex socio-cultural contextual insights. This particular approach also aims to answer the call the improve quality and rigour of qualitative research in the field of information systems by fulfilling the well-regarded criteria for rigour in interpretivist research, namely credibility, transferability, dependability and confirmability [23].

Given the technological orientation of generation Y, the researchers take this opportunity to explore the possibility of undertaking technologically-supported qualitative research through the socio-technical lens. The data recorded are analysed using Giorgi's descriptive phenomenological method [24. It is deliberate that most of results are interpreted by the generation Y researchers in order to provide the rich-contextual insights, through the lens of generation Y.

3.1. First stage; Familiarisation phase

This phase of the research, carried out in 2006, involved the utilisation of both ethnography and semi-structured interviews techniques. The ethnographic techniques utilised in this phase of the study have been described in detail elsewhere [25] [26]. We adapted the view of Franke, who stated that "culture, the object of our description, resides within the native point of view." [26]. During this phase of research, it was assumed that people make inferences and the display of culture can be interpreted through their behaviours [26]. The researcher's role in this phase of the study was to immerse oneself in the generation Y world in order to document, interpret and understand the culture of generation Y. One of us had the privilege to work with 15 generation Y doctors during 2006 and especially had the privilege to work closely with five of these doctors at different period of time as a team to deliver healthcare services. These five doctors became the key informants and the other ten doctors became informants of this phase of study, at which social interactions and interviews were documented; especially when it was perceived that these generation Y doctors exhibit certain behaviours to display their cultural believes. The "thick description" method described by Clifford Geertz was utilised in the event-triggered documentation [26]. These field notes, taken over the 12 months period in 2006, were then analysed using Giorgi's descriptive phenomenological method [24].

The researcher also carried out ten semi-structured interviews with final year medical students who were about to enter the medical workplace. The interview method was guided by that described by Berg [27]. Five essential questions were asked in the interview process, which investigated the perception of generation Y regarding ICT implementation in healthcare, their familiarity with technology, their expectations of the potential benefits of ICT, their willingness to assist in the ICT design and their perception of potential risks and benefits of ICT implementation in healthcare. Additional questions and probing questions were asked depending on the responses from the doctors. Re-iterative methods were utilised in order to provide a clear understanding of the view of generation Y doctors. Field notes were taken during the interviews. The interviews were recorded if the interviewees agreed to the process. The transcript of the interviews were analysed using the Giorgi's descriptive phenomenology methodology [24]. The data were then organised into themes in order to guide ICT design and implementations.

3.2. Second stage: Longitudinal follow-up phase with semi-structured email interviews

After the first phase of the study, we believe that a longitudinal follow up study will generate more significant results to guide ICT design and implementation. We plan the second and third phase study, both of which will be carried out in 2007. In the second phase of the study, we aim to utilise technology to conduct the research. Generation Y interns working at Royal Hobart Hospital were given information at the beginning of 2007 to explain the voluntary nature of the study. All generation Y interns who are willing to participate in the study will be sent weekly emails for the first month and then monthly emails for 12 months. Each email will contain five open-ended questions as the essential questions. The first response to the email will be screened for the need for clarifications and probing. The analysis of the answers will be carried out within three days and clarifications will be sought from responders if needed.

These email interview questions will investigate the views of generation Y regarding ICT design and implementation as well as their utilisation of technology within the workplace. The questions will explore their perceptions of the current role of ICT in healthcare, their willingness to utilise technology, the benefits and problems that they face while using technology, their understanding of the impact of ICT in healthcare as well as their perceived capability to assist in ICT design and implementation. The data collected will be coded and analysed using Giorgi's descriptive phenomenological method, by generation Y doctors [24].

3.3. Third stage: Traditional interviews at two separate sites

Phase three of the study will be carried out at two separate sites late 2007. All generation Y interns at the Royal Hobart Hospital will be invited to participate in a face-to-face interview. The interview will consist of 7 questions. These interviews will be audio recorded and transcribed. This same process will be carried out at a different site to a different cohort of generation Y medical doctors by a separate generation Y researcher. The same research questions and techniques will be used. We aim to investigate the actual utilisation of ICT in healthcare by generation Y doctors, the perceptions and experience with ICT in healthcare, the perceived advantages and disadvantages of ICT in healthcare, and their suggestions for future ICT design and implementation in healthcare. The data will be coded, analysed and interpreted by the two researchers separately. We plan to cross interpret the data after the initial analysis by the two researchers independently.

This three phase research design aims to provide rich-contextual data about generation Y in healthcare system, especially the potential transformative role of ICT. Phase two study, in combination with phase one study will attempt to improve the credibility of the results. The transferability of the results will be improved through triangulation of multiple research techniques as well as research cohorts. The dependability is addressed in our study through triangulation of the email and face-to-face results, as well as the potential to repeat the same question in different emails. The final construct for determining rigour, confirmability, will be improved through cross-analysis and interpretation of the phase three data by the two generation Y researchers independently.

4. Results and discussion

We have completed the phase 1 study and in the process of carrying out phase 2 and phase 3 studies. This research in-progress paper will therefore report the phase 1 results and use it as a foundation to discuss and debate our phase 2 and phase 3 research approaches. Our phase 1 results confirm many characteristics of generation Y as described in the literature [13][14][15]. More importantly, from the perspective technologists, there are a few important characteristics of generation Y which might assist the implementation of ICT in healthcare. Generation Y doctors are technology savvy. They learn very quickly through experience. They are familiar with technology and believe in their ability to rapidly adapt to technology within the healthcare sector. Generation Y doctors look for information through various means, especially through electronic means.

Our preliminary results show that generation Y doctors love life experience and thrive in challenging environments. Generation Y doctors move from one institution to the other, in search for better education, training and life experiences. They, however, do not think that they need training to adapt to new ICT systems in new environment, as most systems should be "user-friendly". Our results also reveal that generation Y doctors, while familiar with technology, might not be as technologically driven as reported in the literature [13][14][15]. Furthermore, they might not be familiar with cutting edge technologies. In fact, many generation Y doctors choose to use technology that they are familiar with rather than cutting edge technologies.

While generation Y doctors love technology, they have high expectations of the benefits that ICT could deliver. Many of generation Y doctors plan to utilise mobile wireless technology, although they are unclear of the exact role of the technology will have in their routine work. They expect the organisations to provide adequate soft-ware support for clinical practice. Furthermore, generation Y doctors expect well-designed ICTs to be available for utilisation in their working environment; in their terms "user-friendliness just like google, you don't need to learn and yet you could find what you want." More importantly, our results show that generation Y doctors dissociate themselves from the design and implementation of ICT in healthcare. They do not believe that they could participate and assist in the socio-technical integrated design of ICT, neither do they see it as their role. There are significant difficulties for generation Y-ers to articulate the functionality of ICT which might assist them in their workflow.

Our preliminary data supports the need to further investigate and generate rich-contextual insights into the socio-cultural aspects of generation Y in healthcare, in order to achieve socio-technical integrated ICT design and implementation. The entry of generation Y doctors presents a golden opportunity for ICT to flourish within the healthcare sector. There are, however, many future challenges as this generation of doctors has very high expectations of ICT. Many different socio-cultural issues need to be considered for ICT design and implementation in future healthcare systems. More importantly, the guiding principles to achieve socio-technical integration might not be easily obtained unless a triangulation methodological approach using generation Y doctors as researchers is utilised. We believe that our Phase 1 study serves as an important platform for future studies to clarify the socio-cultural aspects of generation Y within the healthcare setting. Our approach of using generation Y researchers interested in socio-technical integrated design might be the key to derive these guiding principles. We believe that our research will assist health informatics professionals to conceptualise future socio-technical integrated ICT design and implementation.

5. Conclusion

In this research-in-progress paper, we presented our views of the changing socio-cultural factors in the healthcare system for future ICT design. We presented our methodological approach to investigate this socio-cultural change: the entry of generation Y into the healthcare system. We presented our Phase 1 research results on the potential socio-cultural impact of generation Y on ICT implementation in healthcare. This paper contributed significantly into the field of socio-technical design by alluding the audience to this new generation Y phenomenon. It provides some preliminary evident to support further work in this area. We believe that the final research results will contribute significantly to the field of socio-technical ICT design.

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A Longitudinal Study of Usability in Health Care – Does Time Heal?

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Abstract. We report from a longitudinal laboratory-based usability evaluation of a health care information system. A usability evaluation was conducted with novice users when an electronic patient record system was being deployed in a large hospital. After the nurses had used the system in their daily work for 15 months, we repeated the evaluation. Our aim was to inquire into the nature of usability problems experienced by novice and expert users, and to see to what extend usability problems of a health care information system may or may not disappear over time, as the nurses get more familiar with it – if time heals poor design. On the basis of our study, we present findings on the usability of the electronic patient system as experienced by the nurses at these two different points in time and discuss implications for evaluating usability in health care.

Keywords. Electronic Patient Records, usability, longitudinal study, experts and novice users

Introduction

Usability evaluations are increasingly applied to assess the quality of interactive software systems. Usability has been defined as consisting of three aspects: efficiency, effectiveness and satisfaction and is often also measured on the basis of identified of usability problems [10] [14] [15]. Most mainstream approaches to usability evaluation involve "prospective users" thinking aloud while using the system [6] [15] [17]. According to mainstream guidelines, there is a considerable difference between involving so-called novice or expert users because these users may have different levels of experience with the system being evaluated. However, the consequence of involving novice or expert users as test subjects when evaluating a system's usability is still being debated (see for example [16]) and several comparative studies are being reported (see for example [3] [8] [18] [16]).

Inspired by Nielsen [13], the purpose of the study reported in this paper is to inquire into nurses' experience of a health care information system over time as they develop system expertise. The key question is how the nurses' experience of the system's usability changes when they transform from being novices to being experts. Do usability problems disappear when users get more familiar with a system? Does time heal poor design? Addressing these overall questions, we report from an experiment comparing the experienced usability of an electronic patient record system when it was introduced into a large hospital to the experienced usability after one year of extensive use. The results of this experiment are presented in detail and discussed as a basis for advising evaluators on selection of test subjects and design of task assignments when preparing a usability evaluation within the health care domain.

1. Evaluating with novice and expert users

The Human-Computer Interaction (HCI) literature generally discusses the importance of using "appropriate test subjects" when carrying out a usability evaluation. Typically, it is pointed out, that it is vital to choose participants that are representative of the intended target user community with respect to parameters such as their demographic profile (sex, age, education, profession etc.), and their level of experience (for example if they are novices or experts) [6] [15] [17]. In relation to the level of user expertise, Nielsen [14] propose that there are (at least) three different dimensions to consider:

1. The user's knowledge about the domain (ignorant versus knowledgeable)
2. The user's experience with computers in general (minimal versus extensive)
3. The user's experience with the system being evaluated (novices versus experts)

In relation to system experience, the discussion of when and why to choose test subjects with high or low level of experience is still ongoing. Some systems are only intended to be used infrequently by first-time users, such as many web-based systems, installation programs, etc, and should thus support novices by being quick and easy to learn. Other systems, such as airline booking systems, advanced industrial control systems, and many systems within the health care domain are designed for more frequent use and for highly experienced users. These may take longer time to learn to use but should, in the long run, support expert users by being highly effective. When evaluating such systems it is often intended to have test subjects that reflect the expected profile of the end users. However, in reality it is often difficult and sometimes not even possible to make such a simplistic differentiation between novice and expert users [14]. In real life, users often don't acquire expert skills in all parts of a system regardless of how much they use it because most systems are often very complex and offer a wide range of features that are not frequently used. Thus even highly experienced users of a system may still be novices in respect to some parts of it. Likewise, novice users of a system may have a high enough level of expertise with, for example, the use domain or computers in general to be able to understand and operate even very complex new systems if they are designed properly. Also, it is commonly known that test subjects may feel under considerable pressure during a usability evaluation because they feel that they are being assessed and not the system [15] [17]. For novice users, this feeling of insecurity may be higher than for experts because they are not familiar with the system, and more efforts may consequently be required for making the test subject feel comfortable with the situation [17]. On the other hand, when testing with experts, some usability problems may not appear because these users have developed workarounds to compensate for poor design. A final issue is access to test subjects. While it is typically not a problem to find novice users, it can sometimes be difficult to gain access to a large number of system experts, especially if the system is still under development or has not yet been deployed in the target organization.

Several experiments have inquired into the difference between novices and experts. In information retrieval, it has been observed that novice users often perform poorly [1]. An empirical study of information retrieval through search in a database compared the performance of novices and experts. Though there were no significant differences in the accuracy with which tasks were solved, the expert users performed significantly faster than the novices [5]. In a usability evaluation of a nursing assessment system, novices experienced severe usability problems that were not experienced by the experts. The novice users could not complete the tasks without going back to the patient for more information, and had difficulties locating where information should be entered into the system. The experts, on the other hand, could complete the tasks and had learned to use the system as a checklist for collecting the necessary information [4].

The empirical studies mentioned above all share the characteristic that experiments with novices and experts are conducted at the same time. Thus these experiments rely on a classification of different people as experts and novices. Such a classification is not without problems [2]. Our aim with the study reported in this paper has been to examine the difference between novice and expert user performance within the health care domain but based on a longitudinal study involving the same users in both evaluations. We have focused on the following research questions:

- RQ1: To what extent is the effectiveness and efficiency of using an EPR system different from novices to experts and is this measure identical for different tasks?
- RQ2: Which usability problems of an EPR system are experienced by novices and by experts: which problems are the same, and is there a difference in the severity of the problems that are experienced by both novices and experts?

The first question reflects two of the fundamental aspects of usability. Although they may seem related, it has been shown empirically, that it is necessary to consider both, as they are not correlated [7]. The next question focuses on the usability problems experienced by novices and experts both in terms of the problems and their severity.

2. Electronic patient record usability

Between 2002 and 2003 we undertook a longitudinal empirical study of novice and expert users' experience of the usability of an electronic patient record (EPR) system for a large regional hospital in Denmark (IBM IPJ 2.3, figure 1). The basic design of the study was to conduct 2 usability evaluations of the same system with the same users. The first evaluation was conducted in May 2002 when the EPR system was being deployed at the hospital. The second evaluation was done in August 2003 when the users had used the system in their daily work for more than a year.

A key part of the system's use domain is the hospital wards. The nurses in each ward and the medical doctors use patient records to access and register information about their patients. They also use it to get an overview of the patients that are in a ward. Through the patient record, they can see the state, diagnosis, treatment, and medication of each individual patient. The nurses use the patient record in three different situations: 1) monitoring how the state of a patient develops, 2) daily treatment of a patient, and 3) emergency situations.

The monitoring typically involves measurement of values, for example blood pressure and temperature. These values are usually measured at the patient's bed and typed in later. The daily treatment of patients can be described as structured problem solving. A nurse will observe a problem with a patient, for example that the temperature is high. She will then make a note about this and propose an action to be taken. This action is subsequently evaluated after some time. All steps are documented in treatment notes. In addition, the patient record provides a basis for coordination between nurses. For example, a nurse coming on duty will look through the list of patients to get an overview of their status and to check the most recent treatment notes to see what treatment has been carried out and what treatment is pending.

Medical doctors and nurses have developed the traditional paper-based patient record as a manual document style over a long period of time. The aim of the electronic record is to computerize that manual document. An electronic patient record is confronted with all the classical problems of creating a database that is shared across a complex organization and designing an interface that is both easy and effective to use. In addition, a hospital has many different groups of employees who may record and interpret data differently. The advantages of electronic patient records are also classical. The primary one is that data will be accessible to all personnel at all times whereas paper-based patient records usually follow the patient physically and is only accessible at one physical location at a time. Electronic patient records also potentially make overall processing of information about large groups of patients much easier.

Figure 1. The status window of the EPR system

3. Method

The first usability evaluation involved 7 trained nurses from the same hospital. Prior to this evaluation, they had all attended a course on the IPJ system, and they were just starting to use the system in their daily work. All 7 nurses were women, aged between 31 and

54 years, their experience as nurses varied between 2 and 31 years. Before the first evaluation they had received between 14 and 30 hours of training in the EPR system. They characterized themselves as novices in relation to the EPR system and IT in general. The purpose of the second evaluation was to facilitate a longitudinal study of the usability of the system after one year of use. In order to avoid the source of error that originates from individual differences between randomly selected test subjects we used the same 7 participants in both evaluations. Before the second evaluation, all the nurses had used the system in their daily work for about 15 months. They indicated that they on average used the system 10 to 20 times a day, amounting to a total time of use of about 2 hours per day. Therefore, we now characterized them as experts.

In preparation for the evaluations, we visited the hospital and had a number of meetings and discussions with the two nurses who trained the personnel in the EPR system and dealt with the deployment of it. The purpose was to understand the work at the hospital wards related to patient record use and to get an overview of the system. Based on this we made a number of scenarios of the use of the system in collaboration with the nurses who were responsible for the deployment of the system.

The purpose of the usability evaluations was to inquire into the usability of the EPR system for supporting nurses in solving typical work tasks. Based on our scenarios, we designed 7 tasks, including a number of subtasks, centered on the core purpose of the system such as retrieving information about patients, registering information about treatments, making notes, and entering measurements. The tasks were developed in collaboration with the two nurses dealing with the implementation of the EPR system at the hospital. The exact same tasks were used in both evaluations.

The test sessions were based on the “think-aloud” protocol as described by Rubin [16] and Nielsen [13] where the test subjects solve a series of tasks while thinking-out loud, describing their actions, how they perceive the system etc. In both evaluations, the 7 test sessions were conducted over two days. The order of the nurses was random. Each nurse used the system to solve the 7 tasks. This lasted approximately 45 minutes. If a test subject had problems with a task and could not continue on her own, the test monitor provided her with help to find a solution. If a test subject was completely unable to solve a task, the test monitor asked her to go on to the next one. One of the authors acted as test monitor throughout all 14 test sessions. All test sessions were conducted in a dedicated state-of-the-art usability laboratory at Aalborg University, Denmark with a desktop PC setup matching the hardware used at the hospital.

All 14 test sessions were recorded on digital video. The video recording contained the PC screen with a small image of the test subject and test monitor inserted in the corner. The time spent on solving each task was measured from the video recordings. This measure is relevant for addressing RQ1.

The data analysis reported in this paper was conducted in August 2004, one year after the second evaluation. The 2 authors who did not serve as test monitor analysed all 14 videos. Each video was given a code that prevented the evaluator from identifying the year and test subject. The videos were assigned to the evaluators in a random and different order. The evaluators produced two individual lists of usability problems with a precise description. A usability problem was defined as a specific characteristic of the system that prevents task solving, frustrates the user, or is not understood by the user, as defined by Molich [12] and Nielsen [14]. Each evaluator also made a severity assessment for instance of a usability problem. The typical practice with severity is to make one general severity assessment for each problem expressed on a three-point scale, e.g. cosmetic, serious, and critical [12]. Yet this general severity assessment introduces a fundamental data analysis problem. Two users may experience the same problem very differently, and it is rarely clear how individual differences influence the general assessment. Moreover, we wanted to understand to what extent the severity changed from novices to experts. Therefore, we rated severity based on the extent to which it impacted the work process of each individual user. The severity ratings were necessary for addressing RQ2.

The individual problem lists from the 2 evaluators were merged into one overall list of usability problems. This was done in a negotiation process where the problems were considered one at a time until consensus had been reached. Out of the total number of 103 usability problems, 64 were identified by both evaluators, 17 only by evaluator 1, and 22 only by evaluator 2. The overlap between problems identified by the 2 evaluators suggests a low presence of the evaluator effect [9] and thus a high reliability of the merged list of problems. The resulting problem list was the basis for addressing RQ2. The evaluators also produced a 2-4 page log file for each of the 14 test sessions containing the exact times and descriptions of the users' interactions with the EPR system. The log file also describes whether the user solves each task, and to what extent the test monitor provides assistance. The extent to which each task was solved and the test monitor interference was necessary for addressing RQ1.

4. Findings

4.1. Effectiveness and efficiency (RQ 1)

Effectiveness reflects the accuracy and completeness of the subjects achieving certain goals and this includes indicators of quality of solution and error rates. In this experiment, we distinguish between completely and partially solved tasks. The mean numbers of solved tasks for the expert subjects were 6.29 (SD=1.11) tasks and for the novice subjects 3.57 (SD=1.27) tasks and a Wilcoxon signed rank test shows significant difference z=2.116, p=0.034. Thus, we found that the test subjects solved significantly more tasks as expert subjects than as novice subjects. The calculated standard deviations indicate high variance for the novice subjects; in fact the novice subjects on numbers of solved tasks ranged from 3 to 6 whereas the expert subjects ranged from 5 to 7. All expert subjects solved all 7 tasks either completely or partially while only two novice subjects solved all tasks and this difference is strong significant according to a Chi-square test $^{2}[1]=6.667$, p=0.0098. Considering only completely solved tasks, four expert subjects failed to solve all 7 tasks within the given time frame while all 7 novice subjects failed to solve all tasks completely, but this difference is not significant $^{2}[1]=3.000$, p=0.0833.

In conclusion, the expert users were more effective than the novices. The experts solved significantly more tasks and there was less variation than among the novices.

Efficiency reflects to the relation between the accuracy and completeness of the subjects achieving certain goals and resources spent in achieving them. Indicators often include task completion time, which we use in this experiment. Despite the significant higher number of solved tasks, we found no significant differences in mean values for the total task completion times z=1.402, p=0.161. The assignments enfold important variances and the two simple data entry tasks were solved faster by the experts, but we found no significant differences for any of the individual tasks.

In conclusion, the experts were faster for simple data entry tasks, though not significantly faster, and on more complex tasks there were no major differences.

4.2. Usability problems and severity (RQ 2)

We identified a total number of 103 usability problems. These top most of these were related to the three overall themes of 1) complexity of information, 2) poor relation to work activities, and 3) lack of support for mobility [11]. The novices experienced 83 of these 103 usability problems whereas the expert subjects experienced 63 of the 103 usability problems (this is shown in table 1). Attributing severity to the identified usability problems, the highest experienced severity for each problem is used. We found that the novices experienced 93% of the critical problems (25 of 27 problems) while the experts experienced 70% (19 of 27 problems). Similar distributions were identified for the serious problems where the novices experienced 80% of the identified problems compared 61% for the experts. Finally, minor differences were found for cosmetic problems: 65% for novices against 50% for experts.

Table 1. Total numbers of identified usability problems for the novices and experts.

	Novice (N=7)	Expert (N=7)	Total (N=14)
Critical	25	19	27
Serious	45	34	56
Cosmetic	13	10	20
All	83	63	103

Table 2 outlines key results on mean numbers of identified problems for the novices and experts. We found that the novice subjects experienced significantly more problems than the experts according to a Wilcoxon signed rank test z=2.159, p=0.031. However, this difference is mainly a result of more serious problems z=2.159, p=0.031, whereas we found no significant differences for the critical problems z=1.420, p=0.156 or the cosmetic problems z=1.876, p=0.061.

Table 2. Mean numbers of identified usability problems for the two setups.

	Novice (N=7)	Expert (N=7)	z	p
Critical	5.29 (1.50)	3.29 (1.98)	1.420	0.156
Serious	17.29 (3.09)	9.14 (2.97)	2.159	0.031
Cosmetic	8.86 (2.41)	11.43 (2.76)	-1.876	0.061
All	31.43 (4.93)	23.86 (4.49)	2.159	0.031

Figure 2 outlines problems unique to the novice subjects, problems unique to the expert subjects, and problems experienced by both novices and experts. 40 of the 103 identified problems were experienced by the novice subjects only and most of these problems concerned simple data entry tasks such as typing in values for patients. 43 of the 103 identified problems were experienced by both novice and expert subjects and they typically concerned advanced data entry or solving judgment questions. 20 problems were identified for experts only. These mainly concern functionality and services that the novices did not use for solving the same tasks, for example work task lists, because they were not familiar with those parts of the system.

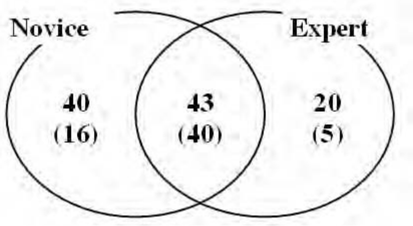

Figure 2. Distribution of the identified problems for the novices and experts. Numbers in parentheses show total numbers of problems subtracted unique problems.

Discarding problems from the distribution only experienced by 1 test subject, we see that most of the usability problems (40 of the 61) were identified in both the novice sessions and expert sessions. Further, the experts experienced 5 non-unique problems not experienced by any novice subjects and none of these 5 problems were critical. Accordingly, all critical non-unique problems were identified in the novice sessions.

The distribution of usability problems experienced by more than one test subject is illustrated in figure 3 below.

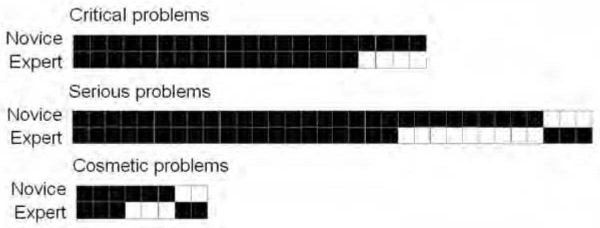

Figure 3. Distribution of usability problems identified by novices and experts in the two studies. Each column represents a usability problem. A black square indicates that the respective user group identified a problem. A white square indicates that a problem was not identified by that user group.

As illustrated in figure 3, 17 critical problems experienced by the novices were still experienced after one year of use. Both novices and experts experienced more than half of the serious problems, while nine serious problems were only experienced by the novices. The expert users, on the other hand, only experienced 3 serious problems not also experienced by the novices. In relation to the cosmetic problems, less than half were experienced by both novices and experts. 3 cosmetic problems were experienced only by novices and 2 only by experts.

In conclusion, there was a huge overlap of both critical and serious usability problems experience by novices and experts. Some problems disappeared over time, but far from all of them. At the same time, new serious and cosmetic problems appeared because more parts of the system were being explored.

Based on our instrumentation for problem identification and categorization, we classified problems according to how the individual test subjects experienced the problems. Thus, the same problem could be critical to one subject while cosmetic to another. 43 of the 103 usability problems were experienced by both the novices and the experts. Attributing the severities values between 1 and 3 where 3=critical, 2=serious, and 1=cosmetic problems, we can count the severity for each of the 43 problems. Considering the number of subjects experiencing the problems, each of the 43 problems was experienced on average by 3.61 (SD=2.19) novice subjects and on average by 3.39 (SD=2.01) expert subjects. But this difference is not significant according to a Wilcoxon signed rank test z=0.722, p=0.470. We further calculated the mean value for each of the 43 problems for the novices and experts. The mean value for novices was 1.91 (SD=0.51) and the mean value for the experts was 1.55 (SD=0.57) and this difference is significant z=3.963, p=0.001. Finally, we analysed the problems experienced in both the first and second evaluation on worst-case for each year. Here we found that the problems on average had a value of 2.19 (SD=0.59) whereas the experts on average experienced the problems to a mean value of 1.84 (0.75). This is significant according to a Wilcoxon signed rank test z=2.690, p=0.007.

In conclusion, a remarkably high number of problems were experienced both by novices and expert users. These problems were experienced significantly more severe for the novices, so the problems that remained became less severe after one year of use.

5. Implications for usability evaluations in health care

The implications for the choice of novice or expert users as test subjects are several. In relation to effectiveness, we found that the expert users completed significantly more tasks and had lower variance in task completion than the novices. This indicates that in situations where it is important for the software development process that every planned aspect of an expert system (such as en electronic patient record) is evaluated, one should consider using experts rather than novices in order for the evaluation sessions not to be held up. As discussed in relation to efficiency, this does not necessarily influence task completion time.

In relation to the identification of usability problems, we found a significant difference between the number of problems experienced by novices and experts. The implications of this finding are debatable. On one hand it can be stated that one should use novices because they enabled more problems to be identified. On the other hand, it could be argued that the use of experts supported the elimination of noise from “false” usability problems (typically rated as cosmetic). Regardless, however, our results show that when evaluating a system designed for highly specialized domain, such as health care, including users who are novices with the system but highly experienced with the use domain as test subjects can support the identification of as many critical and serious usability problems as when using system experts. This finding is important in situations where expert users may be a scarce resource for usability studies.

In relation to problem severity, we found a significant difference between the mean severity ratings for novices and experts, with the latter generally experiencing the usability problems of the system as less severe. The implications of this finding is primarily that when analyzing the data from a usability evaluation with novice users and making suggestions for subsequent response, designers should remember that even though time may not heal a system's usability problems, returning users will get familiar with the system, and that the cost associated with this learning may in some cases outweigh the costs of a redesign that may or may not be significantly better. This is especially important in relation to when responding to cosmetic usability problems.

6. Conclusions

This paper has reported from a longitudinal study in health care where we have compared the usability of an electronic patient record system as experienced by novice and expert users. The usability of the system was measured in different ways. The first measure was effectiveness and efficiency. The expert users were more effective than the novices; they solved significantly more tasks and there was less variation than among the novices. However, we found no significant differences on task completion times for the individual tasks. The second measure was the number and severity of usability problems experienced. The novice subjects experienced significantly more critical and serious problems, whereas the experts experienced significantly more cosmetic problems. Thus there was a huge overlap of both critical and serious usability problems experience by novices and experts.

Some of the overall results confirm the outcome of other studies. The most striking results are that the expert users are not more efficient on complex tasks and that a remarkable number of serious and critical problems with the electronic patient record system still remained after one year of extensive use. Thus we conclude that time does not heal usability problems. Even though time allows people to learn strategies for overcoming a system's specific peculiarities, poor design remains poor.

On the basis of our findings, we propose the following five take away points for usability evaluations in health care:

1. Time does not heal. Although some problems were not experiences as severe, they still remained after one year of extensive use. Poor design remains poor.
2. Expertise reduces experienced severity of usability problems. When testing with novice users, evaluators must take into consideration that some problems may not be as severe as it seems.
3. Solve usability problems early. If usability problems do not disappear over time, we should get rid of them as soon as possible. There will always be novice users – new employees, temporary staff, etc.

4. Evaluate with both novice and expert users and use their different experience of the system as a lens to get a more complete picture of a system's usability. They both represent a prospective user group.
5. All experienced problems are relevant regardless of user expertise – but problems for expert users should be given priority in re-design. Problems mostly severe to novice users might be given priority through teaching (if applicable).

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Using blogging tools to help individuals record their experiences: an exploration and review of two commercial web applications in the Netherlands

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Abstract. Blogs, short for "web logs," together with podcasts and wikis are currently important foci of general internet research. These three applications are part of the larger body of next-generation communication applications that comprises "Web 2.0." Within the specific 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 emergent findings from a new project that looks at blogging interfaces as potential tools for disease prevention and health promotion. I use a literature review combined with "front stage" web analyses of two cases and interviews with the supporting institutions for these sites to discuss the relevant informatics questions that arise with respect to these applications. I further introduce the idea of "goal-oriented" blogging that is found in the first case study. Because this research project is still in preliminary phases, this should be viewed as an exploration into the topic and work in progress. In addition to raising questions, I will outline the important subsequent research steps.

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 are one part of a larger body of communication applications that are collectively dubbed "Web 2.0" and are considered to give credence to well-known claims about the democratizing nature of internet technologies. These applications give users easy avenues to produce/publish and exchange 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 Sym-

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posium 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, for example, blogs, bloggers and practices of blogging more generally, the literature on blogs specifically 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] Although little attention has been given to how patients use these specific applications with respect to their health, the topic is closely related to work currently being done that focuses on Personal Health Information Management (PHIM) and Health Information Management in the Home (HIMH). Patients are increasingly expected to play a more active role as managers in their own care. The central role afforded to individuals implies that they have an essential responsibility to retrieve, manage, maintain and store many different kinds of information from different sources using different media. [4-5] Pratt et al [4] suggest that patients need tools that address current 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. Moen and Brennan [5] contribute to this that individually-oriented resources might be more effective when informed by the contexts in which they are intended to be used.

Although health-related applications such as web logs do not completely facilitate integration or resolve other problems addressed in the articles mentioned above, they do allow individuals to utilize public web spaces to actively manage their own care information and experiences. Said individuals 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 public applications 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), such applications are incredibly easy for individuals in the general public to use, thereby further lowering the barriers to publication/distribution of various types of information.

In this article, I will begin with a short literature review that distinguishes blog applications from other web formats. Then, I will discuss two different cases where blog applications explicitly directed toward health care have been introduced by commercial organizations in the Netherlands. The cases share a similar approach and technology, but differ with respect to user group and purpose. After describing the features of the site (based on web analyses and interviews with the host companies as outlined in Section 1 below), I will use the discussion to raise important questions that are relevant for future Consumer Health Informatics (CHI) research.

1. Materials and methods

1.1. Literature review

Literature on this topic was gathered during October and November 2006. The terms “web 2.0,” “web log” and blog were used singularly and in combination with the terms patient, health and medicine to search in Scopus, an Elsevier abstract and citation index which, in addition to covering Medline, also returns results from social science publications and the web. It includes access to Open Access Journals, Conference Proceedings, Trade Publications and Book Series. [6] As a secondary measure the same terms were also entered into both Medline and the advanced search form of Google Scholar. [7] In February 2007, this search was repeated and included an additional search term, “health 2.0,” which has been coined in reference to second generation applications and changing health care roles. [8] This additional term in combination with terms mentioned above returned, in addition to the standard publishing types listed here, five different web logs devoted to health topics. All articles, conference papers, editorials and books (or book chapters) that discussed blogging applications or practices with respect to health care were considered relevant to the study and were included in the review. The web logs were bookmarked as references, but were not further reviewed for purposes of this paper.

1.2. Web analyses and interviews

In November 2006, an analysis was made of the website that forms the first case study discussed below. The layout, content and functions of the website were analyzed from a user’s perspective. The review focused on tools for information provision, communication possibilities and topics addressed both formally by the site designers and informally in discussion groups. After the analysis was made, a semi-structured interview was conducted with the two of the health educators that review content and supervise users of the site.[2] The second case study is being conducted similarly. Information about the site was first gathered through email contact with the organization and publicly available information pamphlets. Because the site is password protected, the semi-structured interview preceded the web analysis. In this case, the site was reviewed for content, layout and functions after an informal, telephone interview was conducted.[3]

2. Distinguishing blogs from other applications

Blogs are generally defined as personal web sites with content displayed in reverse-chronological order. [9] They can deal with personal or private issues or aim to situate themselves within the public discourse on a given topic. [10] New posts are placed at the

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[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.

[3] This case study is newer than the first one. Because of its nature set-up as explained below, the first interviews to be conducted will be with representatives from patient organizations, rather than directly with users. In this phase of the research, these are only being planned, but not yet conducted.

top of the page instead of the bottom, making changes easily identifiable. They generally have an identifiable author and include personal 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". [9] Blogs are often thought of as analogous to online diaries, but this is a misconception. [11] 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 combinations of links, text, photographs and other web materials. The format and tools used to produce the blog are more defining than the content itself. [11-12]

Information about an individual's health care in existing personal web spaces can be implicit, explicit or a combination of the two. 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 [13], 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. An example of a hybrid of these two types of health representation is the blog maintained by sociologist and internet researcher Eszter Hargittai. [14] Hargittai posts links of interest, 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 archive explicitly tagged for "health and fitness" refers to posts about her goal to run a 5K marathon, while other current posts and archives reveal more implicit references to her health.

Bridging different genres has been argued as one of the important defining elements of blogs. [15] The different features offered by the websites (most especially the first case) discussed below 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). I approach both cases as examples of blogs, rather than just personal home pages or just discussion boards, because of the fact that they both combine broadcast and communication tools in one.

3. Case 1: Promoting weight loss

The Valtaf ("is losing weight") 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 [16], 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, employees or other business relations. The websites, which were created in 2004 and further developed over the next two years, provide "personal web pages" to individual users and include diverse automatic content and social support functions that support participants in the weight loss process.

These commercialized spaces allow individuals to keep an online journal, collect and/or register information and utilize a variety of educational tools and resources. They also allow registered users to communicate with others through discussion boards, chat groups, or instant messaging relays on the parent site and through a function that allows readers to post responses to individual journal posts on personal sites. This site enables users to use their individual spaces to document the process of achieving a specific health goal. In other words, individuals engage in practices of "health goal-oriented" blogging in public, commercialized spaces.

3.1. The parent website

The parent page for valtaf.nl 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."

The personal web pages mentioned above 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. Most of the content is provided by volunteers and articles are posted by both Sofit employees and selected site subscribers. All content is screened by the health care consultants that work full-time for the site.[4] 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. Registration on the site is free, but for a fee, users can receive more intensive, personalized supervision with one of the health care consultants that works with the site. As much of the site as possible is kept open so that individuals first have the opportunity to experience it before they register. At any given time there is a constant of approximately 75 registered (but not necessarily paying) users and 75 visitors on the site. Current site records reveal that the average user is between 20-45 years old and 90% are women.

3.2. The personal web spaces

Through their links to the parent website, the personal web pages contain more content options than are expected from online journals, but the individual pages are 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. This content distinction is due in part to the fact that the site has developed through con-

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[4] The history of the site reveals that it was started by a non-professional who has gained much knowledge through experience. The health care consultants are a trained dietician and a trained nutrition specialist.

stant communication with its users, such that all of the content types and active functions have been added and adjusted (and sometimes even removed) in response to user requests. 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[5]. 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.

One important 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. 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 easily 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. The discussion boards also include resources for offline meetings and information or item (such as used clothing exchange) exchange. Thus, in these public spaces, individual practices of documenting experiences with an otherwise private and personal health issue become part of larger public processes and social activities. [17]

4. Case 2: The digital personal experiences record

In the earliest phases of establishing websites with a national reach, one way to ensure that the content available on a given site aligned with the information that users expected to find was to study log files of user search terms. While this approach was important and even recommended, it also had a disadvantage in that it contributed to an already existing information divide. [18] When the official or recommended sites all direct their attention to the most popular health topics, the same topics continue to receive attention, while rare diseases and less sought after terms remained unaddressed. For groups where

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[5] The term emoticon refers to a graphic image that is used to indicate emotions and attitudes that would otherwise be conveyed by body language or facial expressions in face-to-face communications. The best-known emoticon is the common yellow smiley-face, which may be winking, crying, red in the cheeks with anger, etc. The animated emoticons on the web page in question carry out actions related to the topic of weight loss; for example, a smiley with arms and legs may be wearing exercise gear and lifting weights.

information was already scarce, official sites often contributed little. What emerged in the Netherlands and other European countries was that the communication aspects of web applications became more important than unidirectional information provision. The web offers opportunities for these groups of patients to contact one another and exchange information, often with certain individuals collecting, repackaging and even translating information to share with others. [19]

Recognizing the need for Dutch patients with rare diseases to be able to share their experiences and communicate with one another, a Dutch Research and Development organization partnered with 11 patient associations and health-related non-profit organizations in 2004 and created the Digital Personal Experiences Record. The website has a digital-identifier protected area that contains the individual's actual record. Additionally it contains a section on published experiences (available to all website visitors) and the possibility for a forum once 500 individuals are registered to use the site. At the moment the use statistics published on the site indicate that there are 248 dossiers and 170 published experiences. Although use is fairly evenly divided among the genders, there are more women than men. User ages range from under 10 years to between 71 and 90 years old, with the majority of users being between 21-70 years old.

The public experiences section is based on the simple format afforded to blogging technologies and includes both an outlet for publishing and an opportunity for others to post replies. The archive is a simple table structure, with five category headings and two symbolic icons per entry. The headings, which are all clickable, include the alias of the author, the topic, the member organization, a rubric tag (eg: quality of care, communication) and the article (eg: the name and dosage of an individual prescription for entries about medicines). The first icon is one of several simple emoticons that indicate the user's opinion of the experience. Rolling over the icons gives a reading of poor, average, great, etc. Rolling over the second icon indicates whether it is about an experience with a physician or with a given medication/treatment.

The information pamphlet about this interface states that individuals are easily able to record and oversee their medical information and experiences. This enables them to have more insight into their own situation and also reveals certain trends among the target populations. It further enables the organization to respond to specific information needs. As in the first case discussed above, the users have control over how much information they reveal about themselves and provide feedback about how the organization can better adjust the site to user needs. However, whereas the first site is set-up to be a public, social process that links specific experiences and trends over time to the individual, this is much less the case in the form of the Digital Personal Experiences Record. Due to the sensitive nature of the information, the experiences and trends are at least more anonymous, if not completely decoupled from the individual. Tracking changes and trends over time still occurs; however, in this case, it occurs on a population level. The website even suggests that the feedback that is gathered from individual contributions to the site can be used to as input in the policy-making process to improve the quality of medicines for the entire target population.

In this particular case, there has been much less user involvement in the design. The R&D organization that runs the site is interested to launch a second version that incorporates more direct input from the patients that use it. The next steps will be to implement more point-and-click technologies to facilitate the ease of use and the overview that is promised.

5. Discussion

Although medical informatics recognizes the potential importance of the applications collectively known as web 2.0, these applications (especially web logs) are currently understudied. [20] The purpose of this paper has been to take a first look at health-related blog development in the Netherlands and to raise questions about new trends in health information management that are emerging with the further development of point-and-click tools. This section will raise relevant research questions in the following areas: individual experiences with blogging, blogging and the medical encounter and use of blogs for health policy purposes.

5.1. Questions regarding individual experiences with blogging

Herring et al [15] 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 autobiographies, or other forms of support, such as online and offline discussion groups.

Because public blogging sites, such as the first case, 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. In both cases it is important to use such research to gather more information from individuals about how they use a given site or its individual components and how they consider these to function. This informs not only the design and maintenance of the site, but also our understandings of how these types of sites fit into health care/information management processes.

In the first case presented here, 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? What work is involved in managing information and keeping up these personal spaces? [5] 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? Which identifiable groups are most benefited by such applications? Another interesting and important approach in this regard is to examine health explicit blogs not designed by a company for a specific group, but created by individuals of their own initiatives using popular blogging sites. How are these different from, or similar to, those sites created specifically for health goals and why do individuals choose one type over another?

5.2. Questions regarding blogging and the medical encounter

A second 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? An especially interesting line of research would investigate whether patients wish to receive a similar service from their own health care provider organizations 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 or specific target groups for promotion and prevention purposes.

5.3. Questions regarding blogging as feedback for policy

One final area of interest that can be especially important is the idea that blogs can be used to garner input for health policy and improvement of services, as is suggested in the second case. In this respect, information "management" becomes a broader concept. Existing research approaches the patient's managerial role as an issue of individual information management, with (top-down) practical projects set up to address information sharing challenges and integration of different interfaces. [4, 21] Where blogs are used for purposes of quality control or input for policy change, the application users (target groups of patients) become *information producers*, changing their current roles and creating room for new *information users* to emerge. Patient peers and health care providers are the expected information users, but blogs provide opportunities for policy makers, health-related businesses and other actors to gather unmediated information about experiences. The expectation is that this information can be placed alongside other forms of information as part of a body of evidence that is used for different aspects of healthcare decision-making. Patients' managerial roles, thus, extend far beyond managing their own health. Blogs also transform in this regard to something more than a personal space – they follow changing trends in business practice and become (bottom-up) tools for customer relations. [9] However, this is not unproblematic and leads to questions of whether personal experience information can feasibly be transferred to a different context [22] and whether lay expertise will be regarded on equal footing with expertise coming from other stakeholders. [23-24]

6. Conclusion

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. Nonetheless, new and emergent tools and applications that are available via the still very much changing internet are of special importance. 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. They are further unique in that they break through common assertions that the internet and its processes are largely anonymous. In this paper I have used two case studies 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.

What can we learn from the fact that patients are taking it upon themselves to utilize these and other publicly available and/or 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 foster healthy practices and how health care providers can capitalize on these easy-to-use applications for patient education, disease prevention and health promotion, or for changing policy and improving services.

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Heuristic Evaluation Performed by Usability-educated Clinicians: Education and Attitudes

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Abstract. Heuristic evaluation is a usability testing method aiming to improve the user interface design. Traditionally, a panel of experts in usability and human factor issues evaluate and judge the compliance of computer software according to recognized usability principles, the heuristics. In this paper, we investigate clinicians' attitudes towards learning and performing a heuristic evaluation and present the procedure of educating the healthcare staff and their accomplishment of the evaluation. 18 clinicians were recruited for a 2-hours education and filled in a post-education questionnaire regarding their opinions of the evaluation method when applied by clinicians. Six of the clinicians participated later in a heuristic evaluation of a web-based virtual health record,Their time spent for evaluation and analysis of results was approximately four hours each. Opinions from the six "clinical evaluators" were gathered in an post-evaluation form and compared to the post-education questionnaire. The results of 18 clinicians indicate that there is an interest in learning and participating in such evaluations. Our interpretation is that it is feasible to educate healthcare staff to perform rapid usability inspections to locate usability defects and additionally emphasize the domain specific problems residing in health information systems.

Keywords. Evaluation, Educational activities, Questionnaire, Usability Inspection Method, Design Heuristics.

Introduction

There are today numerous methods to assess ICT in healthcare [1], *constructive* to improve ICT systems during development or *summative assessments* of the ones already implemented. It is evident that use of modern ICT offers remarkable opportunities to improve healthcare work situations and quality of patient care [2].

However, many authors report problems during evaluation [2] and although several studies assert the value of usability and knowledge of human factors in development and evaluation of health information systems, (e.g. work of Ammenwerth et al [3], Berg et al [4, 5], Beuscart-Zéphir et al [6], Brender [7], Kaplan [8], Koch [9], Patel et al [10], and

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Timpka [11]) many systems fail in supporting healthcare professionals in their work [2, 12-14].

In order to improve ICT systems, it is necessary for designers to understand any deficiencies and to correct design flaws. This can be done assessing systems either together with users, or as e.g. Kushniruk & Patel [10] and Allen et al [15] propose; using approaches where usability experts formally assesses an interface design with respect to a set of heuristics, or design principles. A typical evaluation involves three to five evaluators who are experts in usability principles or the domain of interest, or both ("double experts") [16].

A problem associated with the technique is that usability experts seldom manage to identify domain specific problems. In addition heuristic evaluation (HE) *per se* does not generate solutions to the potential usability problems discovered. To cover these shortcomings, in a previous heuristic evaluation we added a "potential user analysis", applied double experts to facilitate encountering domain specific problems in the software and proposed design sketches of possible solutions [17].

It is normally quite simple to gather experts to solve a problem or to categorize potential usability problems. The difficulty lies in finding experts who are both professionals in the problem area and who also have an understanding of the area of application [1].

Although the literature states that users normally do not take part in this inspection method, our hypothesis is that users can act as double experts, on condition that education of the evaluation method and usability principles, as well as guidance, are provided.

Opposite to the conventional heuristic evaluation where usability experts gain an understanding of the application domain, we assume that these "reverse double experts", deriving from the domain of interest, e.g. healthcare, likewise will find potential usability problems in the user interface (UI), present recommendations for how to improve the UI and in addition identify domain specific usability problems and solutions to improve the system's functionality in practice.

In this paper, we investigate clinicians' attitudes towards learning and performing a heuristic evaluation, i.e. acting as clinical heuristic evaluators, and describe the procedure for educating healthcare professionals to evaluate according to this method.

1. Conventional heuristic evaluation combined with a potential user analysis

Heuristic evaluation, an established evaluation method in the field of Human-Computer Interaction, was originally proposed by Jakob Nielsen [16]. It is considered to be a time- and cost-effective technique to identify major usability problems. The method is particularly well suited to aiding the development of medical devices [18, 19] or telemedicine systems [20, 21]. A usability inspection can be conducted at any stage of the development and can be used repeatedly in a process of iterative refinement of an implemented system [1].

Heuristic evaluation, as suggested by Nielsen [16], typically has five phases:

1. Selection of appropriate heuristics,

2. An individual and independent inspection of the design using heuristics to identify features that conflict with some aspect of best practice,
3. Editing the joint material to identify and resolve duplicates and related findings,
4. Prioritization to identify severities
5. Analysis and report writing.

The evaluation is normally performed using validated heuristics originating from Nielsen's work [22]. Table 1 provides a list of the ten heuristics used in our previous evaluation [17], including evaluation criteria by Graham et al [19].

Table 1. Description and evaluation criteria for Nielsen's usability heuristics

Type of Usability Heuristic and Description [22]	Examples of Heuristic Evaluation Criteria [19]
H1) Visibility of system status The system should always keep users informed about what is going on, through display of information and appropriate feedback within reasonable time.	What is current state of the system? What can be done at current state? Where can users go? What change is made after an action? Does the task have clear feedback to indicate when goals are achieved?
H2) Match between system and the real world The system should speak the users' language, with words, phrases and concepts familiar to the user, rather than system-oriented terms. Follow real-world conventions, making information appear in a natural and logical order.	Does the user model match the system image: Do actions provided by the system match actions performed by users? Do objects on the system match objects of the task? Does the system use standard meanings of words or does it use specialized language for a specialized group?
H3) User control and freedom Do not give users the impression that they are controlled by the system. Users often choose functions by mistake and need a clearly marked "emergency exit" to leave the unwanted state.	Does the system avoid surprising actions, unexpected outcomes and tedious sequences of actions? Is it easy to leave an unwanted state? Does the system support *undo* and *redo*?
H4) Consistency and standards *Consistency*: users should not have to wonder whether different words, situations or actions mean the same thing. *Standards*: Follow platform conventions.	Do colour categorizations make sense? Is there spatial consistency? Do the levels of text organization make sense? Are operating commands clear? Are words, phrases appropriate?
H5) Aesthetic and minimalist design Dialogues should not contain information which is irrelevant or rarely needed.	Are principles such as "Less is more", "Simple is efficient" and "Progressive levels of detail" followed?
H6) Recognition rather than recall Minimize the user's memory load by making objects, actions, and options visible. The user should not have to remember information from one part of the dialogue to another. Instructions for use of the system should be visible or easily retrievable whenever appropriate.	"Information in the head or in the world"? Menus versus commands? Is information externalized through visualization, hierarchical structures, perceptual procedures, concrete examples (DD/MM/YY), generic rules and actions (e.g. drag & drop)?
H7) Flexibility and efficiency of use Accelerators may often speed up the interaction for the expert user such that the system can cater to both inexperienced and experienced users. Allow users to tailor frequent actions.	Shortcuts for experienced users? Shortcuts or macros for frequently used operations? Skill acquisition through chunking (e.g. abbreviations, function keys, aliases, templates, type-ahead, bookmarks, hot links history, default values)?

Type of Usability Heuristic and Description [22]	Examples of Heuristic Evaluation Criteria [19]
H8) Error prevention Either eliminate error-prone conditions or check for them and present users with a confirmation option before they commit to the action.	Does the system have controls to prevent serious errors? Are interfaces designed to make errors impossible, give informative feedback (e.g. different sounds)?
H9) Help users recognize, diagnose and recover from errors Error messages should be expressed in plain language (no codes), precisely indicate the problem, and constructively suggest a solution.	Does the system allow for reversible actions? Is the user allowed to recover from errors? Is the error message precise and not vague or general; coded in clear language; constructive and polite?
H10) Help and documentation Any such information should be easy to search, focused on the user's task, list concrete steps to be carried out, and not be too large.	Any context-sensitive help? Is there help arranged in Task-orientation, alphabetically ordered, semantically organized and/or by search? Is there help embedded in various contexts of the system?

1.1. "Potential user analysis" as basis when creating and walking through tasks

Having the potential users of the system in mind when performing HE should provide a richer assessment and consequently increase the quality of the entire evaluation. We therefore added a *potential user analysis* to the conventional evaluation. Together with the usability-educated clinicians designated to perform the evaluation, we defined specific characteristics of the potential future users, e.g. expertise, skills, knowledge, educational background, cognitive capacities and limitations, job characteristics, user role, frequency of system use and time for training.

Tasks based on probable behaviour of the defined *potential users* direct the evaluators to focus on particular aspects, e.g. how experienced ICT users would perceive certain design solutions compared to novices, or how experienced staff would understand certain domain specific information compared to substitutes. Each evaluator is furthermore instructed to consider three components deriving from the *potential user analysis*:

1. The kind of user, who will experience the violation,
2. The consequences that the impact of this violation will have on their experience with the system
3. The frequency that the usability problem occurs or affects functions that are frequently used in the system.

When the evaluators inspect the system individually, they follow the tasks, and walk through the system with the *potential user* specific considerations in mind. Additionally they rate the severity of the defects according to the following scale: (1) Cosmetic problem only, (2) Minor usability problem, (3) Major usability problem and (4) Usability catastrophe. Recurrent problem that affects most users will get higher severity rating than the defect alone. The severity rating provides a rough estimate of the need for additional development efforts and facilitates allocation of resources to handle the problems.

2. Participants in the study

To analyze clinicians' attitudes towards heuristic evaluations performed by healthcare staff, two groups of in total 18 clinicians were recruited. The first educational occasion took part at the Research School for Public Health at the Karolinska Institute in Stockholm, Sweden, with 12 participants, between 32 and 58 years of age; six of them were physicians, other professions represented were nurses, a psychologist, a pharmacist and medical informaticians. Seven of the participants had extensive clinical experience, 15 to 28 years. The other five had between three and eight years of experience in their work.

A second group consisted of six clinicians; two general practitioners (GP), two district nurses (DN) and two assistant nurses (AN) were recruited, geographically located in Hudiksvall, a town in northern Sweden. They were between 31 and 58 years of age, all with extensive clinical experience, between 15 and 38 years. Those participants were educated and performed the HE of a web-based virtual health record (VHR) [23]. They also had previously taken part in the development of the VHR, thus they had a high level of familiarity with the application.

3. Clinicians' education to perform the heuristic evaluation

In a one hour-seminar participants at both occasions were briefly trained in usability issues, cognitive matters and reviewing approaches. Detailed explanations of the evaluation criteria and the evaluation phases took another hour including time for questions. Instructions on how to perform the *potential user analysis* were provided in *Context of use* documents [24].

In the second group, clinicians selected to perform the evaluation, the educational part turned into practice after two hours of education and hands-on preparations for the evaluation were initiated.., The authors guided the clinicians through the *potential user analysis* since consistency with a previous evaluation was demanded. Considering the extensive knowledge of both their work practices and the VHR (the latter gained through participatory design seminars), the clinicians easily provided realistic tasks covering the system's strengths and pitfalls. After two hours of education, the domain-sensitive task producing and potential user analysis, the individuals were prepared to carry through the inspection without any influence by other evaluators or researchers. For each evaluator the inspection lasted approximately an hour, including documentation according to a template (Table 2).

Table 2. Documentation template of the heuristic evaluation.

Place of occurrence	**Problem description**	**Heuristics violated**	**Specific user considerations**			**Severity rating**
			User	**Impact**	**Frequency**	
Log in/ choose patient	When choosing a patient …	- Consistency and standards - Flexibility and efficiency of use	Both novice & experienced user	Irritating in the long run	Every time you choose a patient	3 Major usability problem

After conducting the individual evaluation, the participants gathered to edit their individual documentation to a joint material. The authors were present and guided the session, without interfering discussions of how to prioritize. This session took three hours and the material was later handed over to the researchers for report-writing. Total time spent for the clinicians was six hours, including education, domain-sensitive task development and potential user analysis, inspection, analysis and hand-over to the report-writers.

4. Questionnaires to analyze clinicians' attitudes towards heuristic evaluation

A forced-choice Likert-scale questionnaire designed to measure attitudes by quantifying subjective information [25] was distributed shortly after the two hour HE education (Table 3a, to the left). The participants were asked to indicate where along a four-grade rating scale their attitude regarding heuristic evaluations resided, from strongly agree to strongly disagree. In the questionnaire, there was also an opportunity to write comments.

The 12 questions were answered also by the 6 clinicians selected to perform the evaluation. A post-evaluation questionnaire containing 13 items (Table 3b, to the right) captured the attitudes of the clinical evaluators after performing the evaluation.

Table 3. Likert items of post-education (3a) and post-evaluation questionnaires (3b).

Post-education questionnaire (3a)		**Post-evaluation questionnaire (3b)**	
1	I find the method easy to learn	1	The method was easy to learn
2	I find the method easy to use	2	The method was easy to use
3	I find the method worth learning (to me)	3	The method was worth learning (to me)
4	I find the method worth using by clinicians	4	The method was worth using by clinicians
5	It is interesting to evaluate according to this method	5	Performing an evaluation was interesting
6	I feel prepared to evaluate a system according to the design heuristics	6	I was prepared to evaluate a system according to the design heuristics
7	I find usability issues and HE interesting	7	I would like to use this evaluation method again
8	After this lecture/education, I feel inspired to evaluate according this method	8	The education was sufficient to be able to perform the evaluation
9	To me, this lecture/education was sufficient to be able to perform the evaluation	9	Performing the potential user analysis was easy
10	My computer skills are superior to those needed at my work place.	10	Constructing the tasks was easy
11	I want to take part in the ICT development at my work place.	11	The individual inspection was easy
12	Management at my work support me while trying to improve the work practice	12	Editing the joint material was easy
-	-	13	Prioritizing the defects was easy

5. Results

Results from each occasion are grouped in three diagrams in each figure (figure 1, 2 and 3). The post-education questionnaire, answered by both participating groups, contains: Opinions regarding learnability and useworthiness of heuristic evaluations, (item 1-4), Personal interest in performing heuristic evaluations (item 5-9), and Opinions to ICT development at the own work place (item 10-12). Items of the post-evaluation questionnaire, answered only by the 6 clinical evaluators regard: Opinions about learnability and useworthiness (item 1-4) of HE, Personal interest in performing HE (item 5-8) and Accomplishment of the HE phases (item 9-13). The Likert items are listed in Table 3.

5.1. Results of post-education questionnaire – clinicians' opinions towards HE

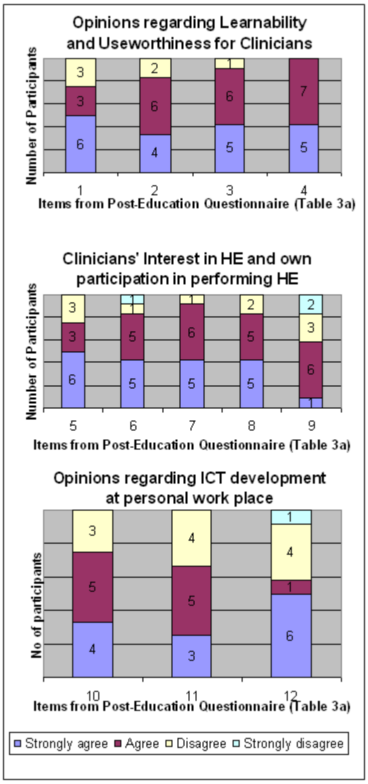

Figure 1. At the first occasion twelve participants completed the post-education questionnaire**.**

The first part of the study took place at the Research School for Public Health (Figure 1). The majority of 12 clinicians found the HE method easy to learn (strongly agree: n=6 and agree: n=3) and easy to use (strongly agree; n=4 and agree: n=6). Item 3 and 4 gave the participants the possibility to answer whether they found the method worth learning by themselves and whether they thought the method was worth to be used by clinicians.

Not everyone (11/12) found the method attractive for themselves, but everyone (12/12) thought HE is worth to use by (other) clinicians.

In the second diagram, participants own interest in usability issues and HE (item 7 and 5) are answered: 11/12 were positive (strongly agree: n= 5 and agree: n=7), and 9/12 (strongly agree: n=6 and agree: n=3) found it interesting to evaluate according to this method. 3/12 disagreed on item 5. To 6/12 participants, the lecture was sufficient to be able to perform the evaluation, whereas 5 thought it was insufficient (Item 9: disagree n=3 and strongly disagree: n=2). However, according to item 8, 10/12 (strongly agree: n=5 and agree: n=5) were *inspired* to evaluate according to HE, and the same amount of participants, 10/12, felt *prepared* to perform an evaluation (item 6).

The third diagram reflect opinions about own participation in ICT and work practice development at the personal work place, here the answers differ a lot. Item 10 reveals that 9/12 (strongly agree: n= 4 and agree: n=5), consider themselves having computer skills superior to what is needed at their work place. This is not remarkable, as the participants are not only clinicians, but research students, and thus in need of computer competence. Three participants disagree on that. Of the 12 participants, eight want to take part in the ICT development at their work place (strongly agree: n= 3 and agree: n=4), whereas four do not want to. Seven feel support from the management when trying to improve the work practice (strongly agree: n= 6 and agree: n=1), Five do not have the same opinion (disagree: n= 4 and strongly disagree: n=1).

The answers of the second study group consisting of six clinical evaluators were concordant (Figure 2). In this group, participating clinicians were already familiar with user centred system development, and they were very positive all across the questionnaire, apart from item 12. We note a remarkable difference compared to the participants in the first group; here 6/6 disagreed on the statement that management at their work supported them when trying to improve the work practice. This could be due the strong feeling of these clinicians to improve their own work place by ICT (item 11, 6/6 strongly agree) in combination with e.g. experiences where "project results have not been taken care of within the organization", or that "current ICT systems do not correspond to clinical needs".

5.2. Comparison of clinical evaluators' opinions – prior to and after the HE

When comparing opinions of the clinical evaluators prior to and after the evaluation, few differences are noted. In the figure 2 and 3, items 1-6 are directly comparable. Post-education items 7 and 8 corresponds to post-evaluation item 7: after the evaluation they were still positive and would like to perform more heuristic evaluations in the future. Item 9 corresponds to item 8 in the post-evaluation questionnaire where 1 person afterwards *agreed* on that education was sufficient, compared to the post-education, where all 6 *strongly* agreed to that statement. Item 9 in the post-education form also relates to items 9-13 in the post-evaluation questionnaire, where each phase of the evaluation is described. Finding potential users and constructing the tasks was easy, as they had experiences from previous similar work. The inspection and the cooperative parts were considered less easy (11: 1/6 disagreed and 1/6 agreed, item 12 and 13 rendered 1/6 disagreed, 2/6 agreed and 3/6 strongly agreed).

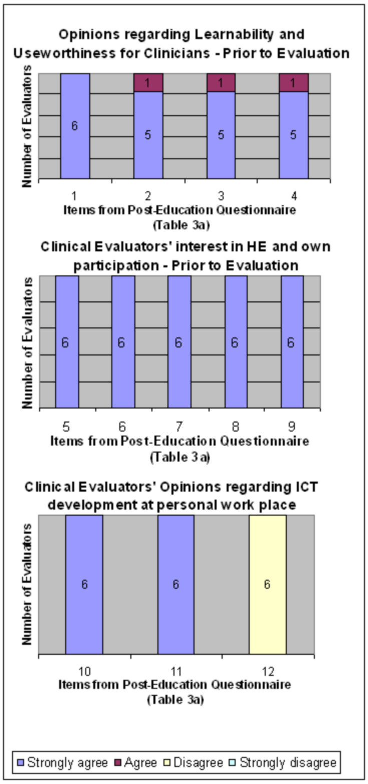

Figure 2. Six "Clinical Evaluators" completed the post-education questionnaire

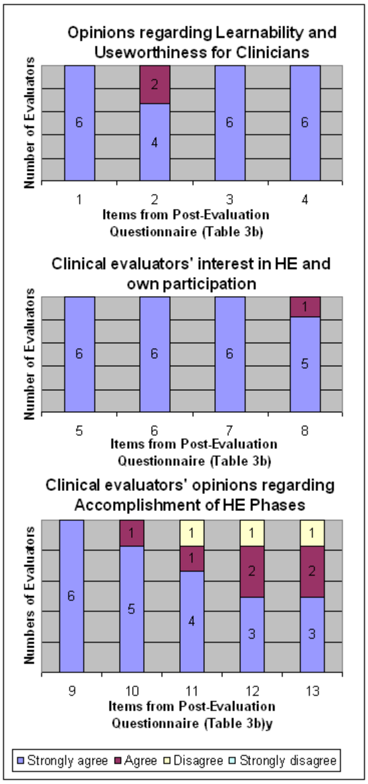

Figure 3. Six "Clinical Evaluators" also completed a post-evaluation questionnaire

The questionnaires reveal an *interest* by selected clinicians to perform rapid usability inspections, which is, or seems to be, worth learning and using by healthcare personnel. However, possibilities of participating in ICT development at their own work place differ, even though most participants feel their computer skills are higher than their work place demands. Lack of stimulation may attract clinicians to participate in evaluations, to make their voice heard and consequently propose improvements in their own health information systems.

6. Discussion

Almost all heuristic evaluations report a disadvantage in evaluators, or usability experts, not covering domain specific problems. Double experts are used to reduce the shortcomings, however, they are often ICT experts with an *understanding* of how clinical work is performed; they do not *work* in healthcare in practice. Our hypothesis is that it is feasible to educate clinicians in usability matters to strengthen the usability inspection with professional skills to emphasize the domain specific problems residing in the application at stake and consequently improve the entire evaluation. Some studies already demonstrate that for certain types of ICT systems users can participate in an heuristic evaluation, provided that there are suitable guidance and supervision [19, 26].

The objective of this study is not to conclude that heuristic evaluations with clinicians as double experts surpass the conventional heuristic evaluations; on the contrary, we consider a combination of different evaluation methods where both usability experts and users participate preferable.

Our intention was to bring out clinicians' attitudes towards involving users in HE, originally designed for usability experts. Results from the questionnaires show that participating clinicians were eager to learn new techniques, ready to provide new solutions to improve quality of healthcare applications and consequently enhance ICT based work situations.

We are however aware of that selected clinicians for this study may differ from ordinary clinicians; the first 12 clinicians were also students in a research school, consequently highly educated and with an interest in improving healthcare, although not only by means of ICT. The other six clinicians were already influenced by user centred methods; they have been clinical partners in the development of the VHR, the application they later assessed. A high level of familiarity with the application could facilitate the evaluation and consequently influence the answers. They personally know the authors and although we pointed out the importance of being honest while completing the questionnaire, the results can be confounded if the participants provided "socially desirable" answers. Bias often appears unintentionally, however, a study with less biased clinicians and a higher number of respondents of the questionnaires would increase the validity of these results.

6.1. Future work

The evaluation performed in this study is consistent with a previously performed heuristic evaluation and future work is to compare results of this evaluation to the evaluation performed by six usability experts (on the same application) [17]. Future work will investigate use of "reverse double experts", e.g. clinicians, as potential evaluators in heuristic assessments.

The two methodologically consistent evaluations are not yet analyzed, nevertheless we assume, influenced by findings of Laxmisan et al [27], that the evaluation results will show differences as a function of professional expertise; clinicians probably focus on clinical and human aspects of errors while usability experts find device- and interface-related defects. Experts investigate functionality on a level that users are not even aware of, e.g. cognitive support during information foraging or bread crumbs as navigational aid. On the other hand, users' understanding of consequences in daily work related to performance of the application is difficult to realize for the expert, consequently clinicians' severity rating might differ from experts'. If so, users' influence on which defects that are crucial to correct will probably be based on *useworthiness* for healthcare professionals rather than interface design flaws and might therefore decrease costs in development, user support and education.

7. Conclusion

In this paper we investigated 18 clinicians' attitudes towards performing usability assessments using heuristics. Results indicate that there is an interest in learning usability issues and participating in such evaluations. Furthermore, we outlined the method for educating healthcare professionals to actually perform heuristic evaluations and six clinical evaluators completed an evaluation. After the evaluation they were still positive and would like to perform more evaluations in the future.

Considering the few hours needed to train users and to actually assess an application, at this point in the study we recommend to educate healthcare staff to perform rapid usability inspections to locate usability problems in health information systems. Provided that results from validation of this "reverse double experts-method" are favourable, clinicians should start performing heuristic evaluations, and provide not only recommendations for how to improve the user interface, domain specific problems would be identified and solutions to improve the system's functionality in practice would be provided at a relatively low cost.

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The medication advice-seeking network of staff in an Australian hospital renal ward

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Abstract. Electronic medication systems may impact communication in hospital wards. To identify the ways in which communication patterns may be altered it is necessary to compare processes both before and after system introduction. This paper reports the use of a social network approach to examine the medication advice-seeking network of an Australian hospital renal ward before the introduction of an electronic medication management system. A social network questionnaire was completed by 96% of staff members (doctors, nurses, allied health professionals and administrative staff) on the ward (n=45). Survey data were analysed to produce a sociogram to display the medication advice-seeking network of the staff in the ward. The results showed that there was a relatively low level of advice-seeking about medication-related decisions and tasks. Most communication occurred within professional groups. Several key individuals were pivotal in providing advice both within and across professional groups.

Keywords. Social network analysis, electronic prescribing, evaluation, information system, advice-seeking, doctors, nurses, pharmacist.

Introduction

It is vital to evaluate information and communication technologies introduced into health care settings in order to determine whether they produce the outcomes desired. There are plans to introduce electronic medication management systems in hospitals in New South Wales, Australia. These systems allow medication to be prescribed electronically and for administration of medication to be recorded electronically. They are designed to improve the safety of medication management by, for example, reducing errors due to illegible handwritten prescriptions, providing decision-support at the point of prescribing and allowing ready access to patients' medication charts from anywhere within the hospital or even from doctors' homes. As such, the frequency, topic and context of discussions about medication between health professionals, particularly between doctors and nurses is likely to change, yet we have relatively little empirical data about how these changes manifest themselves and further what the outcomes of such changes may have for patient care. Beuscart-Zephir et al[1] found that when an electronic medi-

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cation system was introduced in a hospital in France, doctors and nurses had less chance to communicate, particularly regarding prescribing decisions[1]. In hospitals, people regularly rely on information from their peers in the course of their work[2]. Since these relationships are so important in the diffusion of innovation[3, 4] and in the provision of high quality patient care[5, 6], any disruption to them could have negative consequences.

Social network analysis is an approach that allows the detailed study of complex communication and interaction patterns, like those in a hospital setting. It is used to study people and organizations and the structure of the links between them. Data for social network analysis of individuals in organizations are traditionally collected through questionnaires. They can also be obtained by mining databases of electronic communications, for example email servers. Social network data are usually presented in a sociogram (see Figure 1), with the shapes representing individuals and the lines representing the relational ties between individuals.

Studies of communication in health care organizations using social network analysis revealed hierarchical structures in the clinical settings under study[7, 8]. Cott's[7] study of multidisciplinary long-term care teams found a hierarchical structure in the ward, with doctors, senior nurses and allied health professionals working together to make decisions, and with junior nurses carrying out most of the day-to-day work. Social network analysis has been previously used to study the impact of information technology (IT) on relationships and communication patterns, and to study how existing relationships and communication patterns affect the use of IT systems. These studies have been carried out in health care organizations[9-18] and in other settings[19, 20]. Some of the studies in health care organizations showed that the use of new computer systems increased interaction between staff, particularly in order to communicate about a new system[9, 16, 17]. In another social network study in a health setting, key network members were found to increase use of a computerized system by influencing those around them to use the system[18].

In order to evaluate the impact of a new system, work, communication and interaction patterns need to be studied both before and after system introduction. The study reported here is the first stage of research aimed at examining how interaction networks on hospital wards change following the introduction of an electronic medication management system. The paper reports pre-system implementation results from one ward. This stage of the research answered the following questions about the network of seeking advice regarding medication decisions and tasks in a hospital ward:

1. What are the key features in the appearance of the network?
2. Who are the key members of the network?
3. Are the medication advice-seeking relationships reciprocated?
4. What is the density of interactions?

5. How frequently on average is advice regarding medication decisions and tasks sought?
6. Is advice sought from those of the same profession or from other professions?

1. Method

The study was conducted using social network analysis. As most communication in a hospital setting is carried out using face-to-face communication, and not all health professionals use or even have access to email at work, the data in this study were collected using a questionnaire administered to each staff member in the ward.

1.1. Setting & sample

The study was conducted in the renal ward of an Australian metropolitan teaching hospital. At the time of the study, the ward consisted of 47 staff who regularly worked there, including doctors, nurses, allied health professionals and administrative staff. A profile of the hospital ward staff by their professions is presented in Table 1.

Table 1. Profile of ward staff by profession.

Profession	Number of staff
Medical	10
Nursing	30
Allied health	6
Administration	1
Total	47

1.2. Social network questionnaire

A social network questionnaire was designed using a roster format. This involves listing the names and positions (e.g. Person X, Registered Nurse) of all staff members on the ward. Respondents were required to answer five social network questions about each person named on the list. In this paper, results are presented for the responses to one of the questions, namely “How often do you seek advice from [each] person about medication decisions and tasks?”. Response categories provided were in terms of frequency of medication advice-seeking, ranging from 0 to 7, as shown in Table 2. The questionnaire was completed by 45 of the 47 staff, giving a response rate of 95.7%. One junior doctor and one senior Registered Nurse failed to complete the questionnaire.

Table 2. Response categories.

Response categories	Frequency of medication advice-seeking
0	Not once in the last year
1	A couple of times a year
2	Once a month or so
3	Several times a month
4	Every week
5	Several times a week
6	Every day
7	Several times a day

1.3. Analysis

Data were analysed using social network analysis software, UCINET[21]. Netdraw[22] was used to produce the sociogram in Figure 1. The medication advice-seeking network was examined in three dimensions:

1. Visually
2. Individual measures
3. Whole network measures

1.3.1. Visual analysis

A sociogram was produced in Netdraw. Key features of the network were elicited from the appearance of the structure of this sociogram.

1.3.2. Individual measures

Key people in the network were identified as those individuals who were sought out for advice regarding medication decisions and tasks by the greatest number of other members of the ward. The number of people seeking advice from each individual was measured using in-degree. *In-degree* is a measure of the number of people seeking advice from each individual. It is calculated using *degree centrality* which measures the number of ties directed towards an individual in the network[23]. The number of people each individual was seeking advice from was measured using out-degree. *Out-degree* measures the number of ties directed away from an individual in the network[23].

1.3.3. Whole network measures

Structural features of the whole network were measured. The overall structure of relationships and the patterns of relationships within and between professional groups were examined.

Whether those who were the source of advice also received advice from the individuals concerned was determined by examining the reciprocal nature of relationships. This was measured by *reciprocity*, a measure of the rate of reciprocation of relationships[23].

The structure of the medication advice-seeking network was measured by examining the number of ties between the members of the ward. The total number of ties was divided by the total number of possible ties, giving a measure of the *density* of the relations in the network[24]. This was calculated using data converted using the binary system into zeros and ones. The strength of the relations was ignored, and the data were analysed using just the presence (indicated by 1) and absence (indicates by 0) of relations. The density of the relations within and between professional groups was also calculated using these binary data.

The average frequency with which the members of the ward sought advice from each other regarding medication decisions and tasks was measured. This was calculated using the valued data, (ranging from 1 to 7 in terms of frequency of interaction, shown in Table 2) as the total value of all ties divided by the total number of possible ties. This measure of *density* calculates the *average strength of the ties*[23]. The average frequency with which the members of the ward sought advice from those within their own profession (and from members of other professions) were also measured by density calculated using these valued data.

In order to determine whether advice regarding medication decisions and tasks was sought from within individuals' own professional group or from members of other professions, the number of medication advice-seeking relations within and between groups was compared using the E-I Index. The *E-I Index* is a ratio of the number of ties linking group members with those outside a group to the number of ties within a group[25].

1.4. Ethics approval

The research was approved by the relevant university and hospital Human Research Ethics Committees.

2. Results

Results from the analysis of the network of advice-seeking about medication decisions and tasks of staff in a renal ward are presented in answer to the questions posed in Section 1.

2.1. Key features in the appearance of the network of medication advice-seeking in a hospital ward

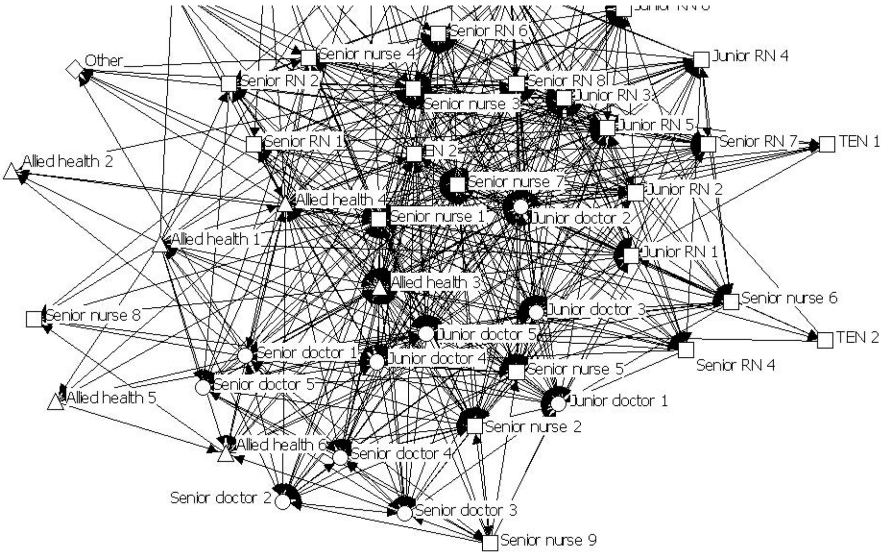

Figure 1. Network of hospital ward staff seeking advice about medication decisions and tasks

The network of advice-seeking about medication decisions and tasks is shown in Figure 1. Each member of the ward is represented by a shape (or node), with each line representing the relational tie of seeking advice about medication decisions and tasks. The doctors are circles, the nurses are squares, the allied health professionals are triangles and the ward clerk (the only administrative staff member) is a diamond.

The dense central section of the network in Figure 1 is made up mainly of nurses with some junior doctors and allied health professionals. The senior doctors are located in the lower left part of the network. Senior nurses 1 and 7, Junior doctor 2 and Allied health 3 appear to be very centrally located in the network, indicating that they seek out and/or are sought out by many other members of the ward for advice regarding medication decisions and tasks. Three of the allied health professionals are located on the periphery of the network. Several of the nurses are located on the periphery of the network, including the Trainee Enrolled Nurses (TENs), who are not involved in giving medication to patients, and Senior nurses 8 and 9 who are not regular ward nurses, and are not involved in direct patient care.

2.2. Key people in the medication advice-seeking network

Key people in the medication advice-seeking network are those with the largest number of people seeking advice from them. These people were identified by measuring the *in-degree centrality* of each member of the network. *In-degree* is the number of ties directed towards an individual. Table 3 shows the key people in the medication advice-seeking network. The people shown in the table are the five people with the greatest number of other ward members seeking advice from them about medication decisions and tasks.

Table 3. Five individuals with the greatest number of people seeking advice from them.

Rank according to number of people seeking advice from the individual	Individual being sought out for advice	Number of people seeking advice from this individual	Number of people this individual seeks advice from
1	Allied health 3	30	20
2	Senior nurse 1	25	45
3	Junior doctor 1	24	0
4	Senior nurse 7	24	34
5	Senior nurse 3	23	23

Allied health professional 3 (the ward pharmacist) has 30 people seeking advice from them about medication decisions and tasks. He/she has an in-degree of 30, with 30 relational ties directed towards them. Since a relational tie indicates that a person seeks advice from them at least a couple of times a year, 30 other members of the ward seek advice regarding medication decisions and tasks from the ward pharmacist at least a couple of times a year. Senior nurse 1 and Senior nurse 7 both seek and are sought out for advice about medication decisions and tasks by many other members in the ward. Senior nurse 1 reported that he/she seeks advice from 45 of the 46 other members of ward. This is measured by *out-degree*, the number of ties directed from a node. This is a measure of the number of people from which an individual seeks advice about medication decisions and tasks. Junior doctor 1 did not complete the questionnaire, which explains the out-degree of zero.

2.3. Reciprocation of medication advice-seeking relationships

In order to determine whether those who seek advice are also sought out for advice by the same people, the reciprocal or non-reciprocal nature of the relations was examined. The rate of reciprocation of the relationships was determined by a measure of *reciprocity.* The reciprocity of all ties was 0.3063. Of all the pairs of actors that have any connection, 30% of the pairs have a reciprocated connection. That is, 30% of those individuals who seek advice regarding medication decisions and tasks are sought out for advice by those same individuals. This is fairly low, indicating there may be a more hierarchical rather than horizontal structure in the medication advice-seeking network of the ward.

2.4. Density of medication advice-seeking relations in the network

The density of the network can be seen in Figure 1, where there are many lines between the nodes (or people) in the centre of the network. There is also a dense area in the lower left part of the sociogram, where there are a high number of interactions between the doctors.

The density of the whole network of seeking advice for medication decisions and tasks calculated using the binary data is 0.2979. *Density* is calculated by taking the number of relational ties in a network, and dividing it by the total number of possible relational ties in a network. A density of 0.2979 indicates that 30% of all the possible ties between people are present.

2.5. Average frequency of medication advice-seeking between ward staff members

The average frequency with which people approach others for advice regarding medication decisions and tasks can be measured using density calculated from the valued data (rather than density calculated using binary data in Section 2.4). This measure represents "the average strength of ties across all possible ties"[26] and is calculated by dividing the sum of the values of all ties by the number of possible ties[26]. The density of the network of seeking advice for medication decisions and tasks calculated using the valued data is 0.7937. This indicates that on average each member of the ward seeks advice regarding medication decisions and tasks from each other member of the ward less than a couple of times a year. This was interpolated using the frequency of interaction categories for the questionnaire, ranging from 0 to 7, shown in Table 2. A value of 0.7937 is less than 1 and response category 1 is "a couple of times a year".

2.6. Density and average frequency of medication advice-seeking according to professional group membership

The density of interaction between and within professional groups is shown in Table 3. *Density* was calculated using binary data to examine the density of the relations in the network and using the valued data to examine the average frequency of medication advice-seeking. The average frequency of medication advice-seeking was interpolated from the questionnaire response categories in Table 2.

Table 4. Density of interaction and average strength of ties for advice about medication decisions and tasks, by profession.

Professional group seeking advice	Professional group being sought out for advice	Density of ties (using binary data)		Average strength of ties (using valued data)		
		Density	**s.d.**	**Density**	**s.d.**	**Average frequency of medication advice-seeking**
Doctors	Doctors	0.6444	0.4787	1.3889	1.4275	> A couple of times a year
Doctors	Nurses	0.2033	0.4025	0.3200	0.7422	> Not once in the last year
Doctors	Allied health	0.3500	0.4770	0.9333	1.4126	< A couple of times a year
Doctors	Administrative	0.1000	0.3000	0.2000	0.6000	> Not once in the last year

Professional group seeking advice	**Professional group being sought out for advice**	**Density of ties (using binary data)**		**Average strength of ties (using valued data)**		
		Density	**s.d.**	**Density**	**s.d.**	**Average frequency of medication advice-seeking**
Nurses	Doctors	0.3300	0.4702	1.0600	1.8045	> A couple of times a year
Nurses	Nurses	0.3276	0.4693	0.9540	1.5772	< A couple of times a year
Nurses	Allied health	0.1556	0.3624	0.5389	1.3919	< A couple of times a year
Nurses	Administrative	0.1667	0.3727	0.8667	2.0934	< A couple of times a year
Allied health	Doctors	0.4667	0.4989	0.9667	1.2645	< A couple of times a year
Allied health	Nurses	0.2500	0.4330	0.4333	0.8439	< A couple of times a year
Allied health	Allied health	0.4000	0.4899	0.9000	1.3503	< A couple of times a year
Allied health	Administrative	0.1667	0.3727	0.5000	1.1180	< A couple of times a year
Administrative	Doctors	0.0000	0.0000	0.0000	0.0000	Not once in the last year
Administrative	Nurses	0.0000	0.0000	0.0000	0.0000	Not once in the last year
Administrative	Allied health	0.0000	0.0000	0.0000	0.0000	Not once in the last year
Administrative	Administrative	0.0000	0.0000	0.0000	0.0000	Not once in the last year

2.6.1. Density of medication advice-seeking within professional groups

Medication advice-seeking relations between doctors are dense, indicating that doctors tend to seek advice regarding medication decisions and tasks from other doctors. A density of 0.6444 of the relations between doctors (shown in Table 4) indicates that 64% of all possible medication advice-seeking ties between doctors are present in the network, whereas only 40% of possible ties between allied health professionals are present and only 33% of possible ties between nurses are present. There are no ties between administrative staff because there was only one administrative staff member in the ward.

2.6.2. Average frequency of medication advice-seeking within professional groups

The average frequency with which a doctor seeks advice from each other doctor about medication decisions and tasks is high in comparison with the other professional groups. The average strength of ties between doctors is 1.3889, which indicates that on average each doctor seeks advice about medication decisions and tasks from each other doctor more than a couple of times a year.

Nurses' average frequency of medication advice-seeking with each other nurse is 0.9540. This indicates that on average each nurse seeks advice about medication decisions and tasks from each other nurse less than a couple of times a year.

Allied health professionals' average frequency of medication advice-seeking of each other is 0.9000, similar to that between the nurses, also indicating that on average each allied health professional seeks advice about medication decisions and tasks from each other allied health professional less than a couple of times a year. Since most of the allied health professionals are not involved in prescribing or giving medication, this lack of advice-seeking between them makes sense.

2.6.3. Density of medication advice-seeking between professional groups

Results of the measurement of the density of the network of seeking advice about medication decisions and tasks across professional groups are shown in the density of ties column in Table 4. Allied health professionals tend to seek advice from doctors, with 47% of possible ties present from allied health professionals to doctors. Nurses tend to seek advice from the same proportion of doctors as they do nurses, with 33% of possible ties present between nurses and doctors. Doctors do not tend to seek advice from many nurses, however, with only 20% of possible ties present from doctors to nurses.

2.6.4. Average frequency of medication advice-seeking across professional groups

The average frequency of medication advice-seeking across professional groups is determined by the *average strength of ties* between each professional group. The greatest average strength of ties between groups is from nurses to doctors. An average strength of ties between nurses and doctors of 1.0600 indicates that on average each nurse seeks advice from each doctor just more than a couple of times a year.

The average frequency of medication advice-seeking is also relatively high from doctors to allied health professionals, from nurses to administrative staff and from allied health professionals to doctors. The average frequency of the interactions between individuals in these relationships is just less than a couple of times a year.

2.6.5. Medication advice-seeking within and between professional groups

The extent of the relational ties within and between groups in a network can be determined by comparing the number of relations between groups and the number of relations within groups. This can be calculated using the *E-I index*, a ratio of external to internal relations[25]. In this paper, we have used it to compare the number of relations outside professional groups to the number of relations within professional groups. Table 5 shows the densities of relations within and between professional groups.

Table 5. Density of medication advice-seeking relational ties within and between professional groups.

	Doctors	Nurses	Allied health	Administrative
Doctors	2.133	1.193	1.400	0.200
Nurses	1.193	1.531	0.867	0.867
Allied health	1.400	0.867	1.600	0.500
Administrative	0.200	0.867	0.500	

Densities in Table 5 are high as when using the E-I index measure, any relation (seeking or being sought out for advice) is counted as one relational tie. This is because the E-I index ignores the direction of ties, and just analyses the presence of ties. With the network partitioned by professional group, the densities of the within professional group relations of the clinical staff (doctors to doctors, nurses to nurses and allied health professionals to allied health professionals) are higher than the densities of their relations to those outside their respective professions. Table 6 shows the number of internal and external relations and the E-I Index. The total number of relations is 986.

Table 6. Relations within (internal) and between (external) professional groups and the E-I index.

	Frequency	Percentage	Possible	Density
Internal	530	0.538	990	0.535
External	456	0.462	1172	0.389
E-I Index	-74	-0.075	182	0.084

An E-I index of -0.075 indicates a very small tendency for the ward members to seek and give advice regarding medication decisions and tasks from other members of their own profession rather than those from other professions.

Group level E-I indices are shown in Table 7. The number of relations within professional groups and the number of relations to other professional groups are shown for each of the four professional groups.

Table 7. Each professional groups' number of relations within and to other professional groups and their E-I indices.

Professional group	Number of relations within the professional group (Internal)	Number of relations to other professional groups (External)	Total number of relations	E-I
Doctors	82	162	244	0.328
Nurses	426	191	617	-0.381
Allied health	22	96	118	0.627
Administrative	0	7	7	1.000

A moderate tendency for doctors to seek or give advice to those from other professional groups is suggested by the E-I of 0.328. The nurses' E-I of -0.381 suggests a moderate tendency for nurses to seek or give advice to other nurses rather than to or from other professions. Allied health professionals have an E-I of 0.627 indicating a strong tendency for seeking or being sought out for advice from members of other professional groups. The ward clerk with an E-I of 1.000 (the maximum possible), only interacts with other professions. As the only member of the administrative professional group, this makes sense. So medical, allied health and administrative staff in the ward tend to seek advice from and give advice to those outside their respective professions, whilst nurses tend to give advice to and receive advice from other nurses.

3. Discussion

Overall there is little interaction between ward staff members in order to seek advice about medication decisions and tasks, with only 30% of all possible medication advice-seeking ties present in the network, and with each ward staff member seeking medication advice from each other staff member less than a couple of times a year on average. When medication-related advice is sought, the results showed that health professionals tended to seek advice from within their own professional groups: especially nurses from nurses, and doctors from doctors. The results in Section 2.6 show that the average frequency with which each nurse seeks medication advice from each doctor is similar to the average frequency with which each nurse seeks advice from each other nurse (about a couple of times a year). However this means that the frequency with which nurses seek medication advice from doctors is overall very low, because there are only ten doctors compared to 26 other nurses from whom a nurse could seek medication advice. The tendency of the staff to seek medication advice from within their own professional group is represented clearly in the sociogram of the network with nurses located together on one side and doctors grouped together on the other side. This has serious implications for the quality of care provided, since good communication between health professionals is so important to them being able to provide high quality care to patients[5, 6].

Though there was little medication advice-seeking interaction overall, key ward staff members including Allied health 3 (the pharmacist), Senior nurses 1, 3 and 7, and Junior doctor 1 were identified through visual analysis of the sociogram and were confirmed to be sources of medication advice in the analysis (in Section 2.2) of the number of people seeking advice from each person. They were shown to play vital roles in the provision of advice regarding medication decisions and tasks to many other members of the ward staff. They interact with a large number of ward staff members from outside their own respective professions. The pharmacist (Allied health 3), in particular was sought out for medication related advice by 30 out of 44 others who returned the questionnaire. It is to be expected that a pharmacist would play a key role in providing medication advice in a ward. The pharmacist's role may change when the new system is introduced. If more information is provided and is easily accessible in the planned electronic medication management system, the importance of the pharmacist as a source of medication advice may lessen. Fewer doctors and nurses may need to ask the pharmacist questions. For example, access to specific drug information will be provided, saving clinicians from physically locating a drug manual or contacting a pharmacist. This is a key consideration for the collection and analysis of data after the introduction of the new system. The importance of particular individuals such as the pharmacist, and the role played by them in a network is in agreement with findings from previous studies using social network analysis in health care settings[16, 27-30].

Medication advice-seeking relationships were not reciprocated to a great extent, with only 30% of them being reciprocal (shown in Section 2.3). This indicates that there may be a hierarchical structure in the network of advice-seeking about medication decisions and tasks. Not hierarchy in a traditional organizational structural sense of senior staff down to junior staff, but hierarchical in that a large number of people seek medication advice from particular individuals. Other studies of social networks in clinical settings have also found evidence of hierarchical structure[7, 8]. The reasons for these particular individuals to be sought out by many others in the network could include factors such as their experience, expertise or availability. More in-depth study such as interviews would help elicit this. This could also be further investigated by analyzing the years of professional experience of each staff member to determine whether seniority is a factor which influences who is sought out for advice regarding medication decisions and tasks. Further social network analysis to determine whether the advice-giving is reciprocated in other ways, e.g. whether those who receive medication advice may give help solving work related problems to those from whom they receive medication advice.

Medical, allied health and administrative staff were found to have a tendency to seek and be sought for medication related advice from members of other professional groups, with more ties to those outside their respective professions than to those within. Nurses however tended to seek and be sought for advice mainly from other nurses. These findings correspond with that of a previous study of ward networks, where nurses were found to be excluded from the multi-disciplinary team[7]. Medical and allied health professionals also gave advice to and received advice from others from within their own profession, but to a lesser extent than did nurses.

The value of using a social network approach was demonstrated, particularly in being able to highlight that although on average each staff member sought advice from each other staff member very infrequently, key individuals could be identified by using the richness of the social network data display and analysis techniques. For example, the pharmacist was found to have the greatest number of people seeking advice from them, but when the frequency of interaction was averaged across professional groups, the allied health professionals in general (including the pharmacist) were on average rarely sought out for advice regarding medication decisions and tasks. Using social network analysis allowed a systematic way of studying specific interactions and relationships that exist within the complexity of communication that occurs between health care professionals in their work.

4. Conclusion

We have demonstrated the value of a social network approach for examining key features of medication advice-seeking interactions in a hospital ward. We were able to identify the key members of the ward in terms of the provision of medication advice and the patterns of interactions within and between professional groups in the network of medication advice-seeking, as well as the features of the overall pattern of interactions when ward staff seek advice about medication decisions and tasks from each other.

It will be informative to study the social networks again, after the introduction of the electronic medication management system. This will form part of an evaluation of the new system. By comparing the medication advice-seeking networks now with those after the introduction of the system, the impact of the system on communication and interaction will be able to be measured.

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Using Scenarios to Capture Work Processes in Shared Home Care

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Abstract. Shared home care is increasingly common, and in order to develop ICT that support such complex cooperative work it is crucial obtain an understanding of the work routines, information demands, and other central preconditions at the clinical level before the development is initiated. Scenarios are proposed as a technique that can be useful for capturing work processes in shared home care and experiences from the Old@Home project are presented. The scenarios are useful not only in the initial phases of the development project but throughout the development process, improving the accessibility of end user requirements and usability issues for the design team, and as a basis for use cases and further design.

Keywords. Scenarios, Shared Care, Home Care, Work Analysis, Cooperative work

Introduction

Home care is becoming an increasingly important part of health care, and the trend towards trying to shorten the time a patient spends in hospital care is likely to further increase the amount of care provided in the patient's home. The studies described in the final report of the national evaluation of the cost-effectiveness of home care [1], prepared for the Health Transition Fund, Health Canada, show that home care is a cost efficient alternative to residential care of elderly patients, and home care of elderly patients is bound to increase. In many western countries, home care of elderly is shared between different health care provider organizations [2], and several studies, e.g. [3-5], show that cooperation between different care providers in home care needs to be improved. In integrated healthcare professionals from different organizations have to work together in a team-oriented way to provide high quality care for a patient. This requires high quality of collaborative working relationships, the clarity and commonality of objectives, frequent communication among team members, a clear understanding and respect of individual roles and skills within the team, and the general flexibility of practitioners [6].

The electronic health record is one of the most important tools of health care professionals, both as a source of information regarding a patient's health, and as a documentation tool [7]. Despite the mobile nature of home care, mobile IT tools giving access to the electronic health record and supporting the work are rarely available. Gen-

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erally documentation is performed on the respective stationary system, or on paper, and the systems used in different organizations are autonomous and incompatible. In non-integrated organizational structures and information systems care providers risk spending time searching for misplaced information instead of taking care of their patients [3]. The lack of adequate mobile information access and communication tools hampers the care professionals' work; sharing information and coordinating work within the care providing team in particular.

In order to develop an IT-support that is easy to use and adapted to the work situation it is to be used in it is essential for developers and care providers involved to share an understanding of the work routines, information demands, and other central preconditions at the clinical level before the development is initiated [3]. The sociotechnical approaches emphasize that thorough insight into the work practices in which IT applications will be used should be the starting point for design and implementation [8].

The purpose of this paper is to describe how using scenarios as part of the work analysis process can be particularly useful in a shared care context, and to exemplify this by describing results from the Old@Home action research project [9].

1. Methods

A large number of health information systems developed actually fail in supporting the health care professionals in their work [10]. This is often due to lacking insight in the work processes to be supported, and therefore a method based on a general user centered system development approach [11] was followed in Old@Home. Emphasis was also put on cooperative work processes rather than discrete tasks for individuals, in contrast to most concrete attempts in health care informatics that focus on the individual health care professional, modeling his/her 'decision making process' [12].

An extensive user needs and work analysis was performed [13] and data was mainly collected: (1) from archives, (2) through interviews, (3) by participatory observation, such as the Master-Apprentice approach [14, 15], and (4) by iterative seminars with interdisciplinary working groups. The working groups consisted of experienced health domain specialists, medical informaticians (MI) and HCI specialists. The current study focuses on the care of elderly citizens staying at their private homes and involves three groups of care providers, or domain specialists; district nurses (DN), general practitioners (GP) and home help service personnel (HHS). The degree of IT usage differs between the different groups of health care personnel. At the start of the study, GP and DN documented either digitally on their respective medical and nursing record systems when working at the office, or they documented on paper. HHS used only paper-based documentation. None of the groups used digital, mobile documentation facilities, or had digital access to another group's documentation.

Here we will focus on one of the techniques used during the seminars, namely using scenarios to capture workflow and communication between different healthcare professionals.

1.1. The scenario concept

Nardi [16] defines a scenario as a description of a set of users, a work context, and a set of tasks that users perform or want to perform. She also stresses the futuristic quality of scenarios, claiming that the "purpose of a scenario is to provide an explicit concrete vision of how some human activity could be supported by technology"[16].

The concept of scenarios in system development is however broad, and many different ways of using scenarios have been proposed. Go and Carroll list typical scenario usage, i.e. within HCI for analyzing user tasks, envisioning future work, mock up and prototyping as well as evaluating the constructed system, and in requirements engineering for eliciting user requirements, deriving specifications and analyzing and describing the current system usage [17]. Benyon and Macauley also describe a range of scenario usage, from *'user stories'*; i.e. real or imagined experiences of people, through *abstract scenarios;* generating ideas and developing an understanding of the domain, to *concrete scenarios*; useful for prototyping and walking through design ideas, and finally to *use cases*; providing formal specification required by software engineers [18].

We used scenario building to concretize and illustrate the usage situation, the users' tasks, and goals. The aim was both to describe and analyze the different user groups current work situations, with or without ICT-tools, and to envision how these work situations could be supported by technology in the future. Both the current and future aspects of the work were analyzed with special focus on the cooperative aspects of workflow and communication within the care providing team.

1.2. Working with scenarios

Based on the results from observations and interviews the working groups identify the current mobile work situations the participating user groups have. During interdisciplinary seminars, these work situations are discussed and described, in what may be compared to the user stories mentioned earlier, and this form the basis for the work scenarios. The scenarios include general descriptions of information needs, communication flows, needs for documentation facilities and needs for planning support. Scenarios can become messy, so in order control the scenarios a structure is needed. We used the documentation template presented in Table 1 to document the different work scenarios the healthcare professionals identified.

Table 1. Documentation Template of the Work Scenarios

Scenario 1: Work situation **Short description of the context of the work situation.**			
Activity	Cooperation	Today.	Future
Activity 1 Short description .	Who do you cooperate with?	How do you cooperate? Communication, transfer of information etc	Could/should this change in the future
Activity 2…	…	…	…

Analysis of the work situations is based on observations and interviews, and is done together with the healthcare professionals in an iterative process. Each scenario describes one work situation, and the work situations are in turn broken down into different activities. A description of the context of each work situation is given, providing a background with information on when and why a certain work situation occurs. The activities are given short, but reasonably detailed descriptions in the template. While working on these descriptions questions may arise, that require further observations or interviews, and new information might lead to changes in the list of work situations so far.

In order to focus on the complex communication and cooperation taking place in shared home care, the analysis continues by focusing on the cooperative aspects of each activity. A list of the actors involved in the activity is created, as well as a list of the types of communication tools used today. The communication that takes place is analyzed by asking questions of the type; "when?", "where?", "with whom?", and "why?" communication occurs. Copies or descriptions of current documentation are also studied and categorized according to when it is needed, who needs it and why.

After having fully explored the current work situations focus is transferred to future work scenarios. Which are the prerequisites, boundaries, and limitations to concretize the personnel's expectations of future work? [21, 22] The aspects are evaluated with regard to which parts in the organization need change, and how difficult or complex a changing process to accomplish a specific goal would be. The working groups prioritize scenarios and detailed descriptions of selected work situations are documented and iteratively improved. Evaluation of future work scenarios are visualized through sketches and prototypes. While testing the prototypes participants reflect on present, and future, work practices and evaluate the expected effects in advance, e.g. in what way will an ICT tool make the work more efficient?

2. Results

In Old@Home we used scenarios to capture the mobile work situations of HHS, DNs and GPs. We worked in seminars, both intra-professional where only one healthcare profession participated, and inter-professional, where several healthcare professions worked together. The latter seminars focused primarily on cooperative aspects of the work, and were crucial to capture the entire work processes since the different professions had different views and lacked insight in each other's work. Table 2 gives an example of one of the HHS work scenarios, including the details of how communication is performed today, and what types of tools might be useful in the future.

Table 2. Example of Scenario from Old@Home

Scenario 3: Change in medication			
Activity	*Cooperation*	*Today.*	*Future*
Receive instructions A new medication has been assigned by the GP, or changes in the current medication, and the DN informs the HHS about this change and gives instructions.	DN, GP	Verbal 1. Direct 2. Telephone Written, paper; note left in home with instructions	Written, ICT; 3. Automatic message Verbal 4. Direct 5. Telephone
Document Changes and instructions are documented so that the entire HHS-team will be informed	HHS-team	Written, paper	Written, ICT; 6. Message saved

The future aspect of the work scenarios were further explored in so called goal scenarios, where the health care professionals outlined what they perceived as the best way to perform their work with the aid of different types of technology. Table 3 provides an example of a goal scenario from Old@Home.

Table 3. Example of Goal Scenario from Old@Home

Goal Scenario 3: Change in medication
1. When the GP changes the medication the HHS receive an instant message in their handheld devices.
2. If further information is required the DN sends a written message to the mobile devices, or inform the HHS in person. In that case the information needs to be documented, and will then reach the entire HHS team.
3. Sent messages reach the entire HHS team instantly and are saved so that they can be accessed at a later time.

One of the major benefits of the scenarios was that they formed a basis for discussion during the inter-professional work. Comparing the DN's scenario for a certain work situation with the HHS' scenario for the same situation in several cases showed that their views on the care process differed and that they had little insight into each others work.

3. Discussion and conclusion

Scenarios were used both to describe and create an understanding of the current work situations, and to analyze visions and requirements for future work scenarios. In the interdisciplinary seminars, the scenarios are iteratively transformed, from general narratives of current work scenarios to detailed descriptions of future work scenarios with special focus on cooperative work processes.

The scenarios improved the accessibility of end user requirements and usability issues for the design team, and were later transformed into use cases for further development. The scenarios, containing detailed information from every professional group, were easily understood by users and developers and can be used to verify the requirements in the development process.

In conclusion, by using simple scenarios to capture the health care professionals current work situations, as well as their expectations and hopes for the future, we were able to create a basis for our design that was fully understandable by both developers and users. Working with the scenarios in both intra- and inter-professional working groups created an improved insight into the cooperative work processes.

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Introducing an Innovative, Multidisciplinary Concept of Care – Communication Problems and Possible Solutions

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Abstract. Introducing an innovative, multidisciplinary concept of care means the change of existing structures both in work and communication flows which often involves problems. In this paper we describe exemplary the communication problems which arose during the introduction of the multidisciplinary concept of Family-Centred, Individualized Developmental Care of Premature Infants and Newborns at the Children's Hospital Heidelberg. We suggest workflow adaptations to achieve timeliness of information and present ideas to prevent communication problems e.g. caused by inadequate knowledge of staff. We used interviews, analyzed video-recordings and modified the Communication Observation Method [7] to analyze the present state of communication flows and structures.

Keywords. Communication, multidisciplinary care, NIDCAP, premature infant, newborn infant.

Introduction

Although most premature infants are healthy they often need intensive care because different vitals are not mature enough for a living outside the womb [1]. To optimize their care a new care concept was designed at the Children's University Hospital Heidelberg: "Developmental, Family-Centred, Individual Care of Premature Infants and Newborns" (German: '**E**ntwicklungsfördernde, **f**amilienzentrierte, **i**ndividuelle **B**etreuung Früh- und Neugeborener' – 'EfiB') involves the different professions (physicians, nurses, psychologists, physiotherapists,…) and the parents. EfiB is currently introduced in a stepwise approach.

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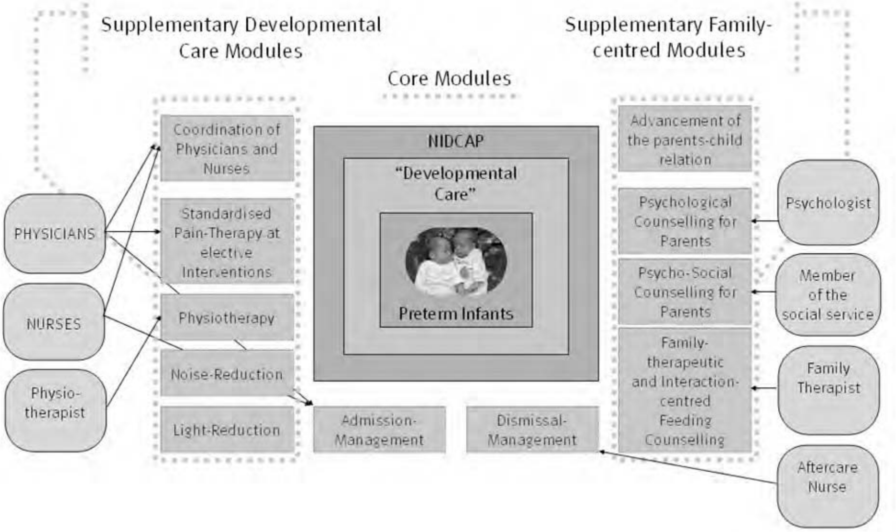

Figure 1. EfiB - Overview

EfiB is a modular concept of developmental care [2] (Fig 1) and based on the 'Newborn Individualized Developmental Care and Assessment Programme' (NIDCAP) [3,4]. All EfiB-modules aim to adapt treatment and environment to the needs and signals of the little patients, e.g.: newborns are only examined, when they are awake and light and noise are reduced to approximate the environmental conditions in the womb. Some modules are directed towards the well-being of the parents (e.g. the 'counsellings') because a stable parent-child-relationship also supports the development of the little patients.

When introducing EfiB in Heidelberg the communication processes were not optimal. But a well operating communication and exchange of information is essential for health care [5,6]. So we planned appropriate information logistics for EfiB at the preterm infant ward. Within this paper we summarise communication related problems which arose during the introduction of EfiB and present possible solutions.

1. Material and methods

Firstly, we analyzed the present state of communication structures and flows. Based on the observed strengths and weaknesses we designed a communication concept and developed implementation strategies.

Pilot observation: We accompanied all professional groups involved in newborn care for several days. These observations showed that communication can be divided into the classes: 'communication during individual workflows' and 'communication during team-conferences, ward rounds and handing-overs'. The latter is a permanent communication, typically between one sender and many receivers.

1.1. Modified COM

To analyze the ‘communication during individual workflows’, we used the Communication Observation Method (COM) according to [7]: For a complete shift every communication the observed person is involved in, is recorded, transcribed to a text file and merged with additional observations. Then communication events are marked up, coded and entered into a database. To accelerate data collection – in contrast to [7] – we coded and entered over 1000 communication events during observation directly into a database: We observed ward physicians, head nurses, staff nurses, supplying assistants and secretariat staff – three representatives of each group.

Interviews: Since the modified COM was not applicable to all groups of professionals (e.g.: some professionals work in the ward only for short times a day) we interviewed the head of the department, the psychologist, the member of the social service, a breast feeding advice assistant, the aftercare nurse and three parents about the communication they were involved in.

1.2. Video analysis

Team-conferences, ward rounds and handing-overs were video-recorded because of high density of communication events. For analyzing them we assembled ideas from different approaches: The COM [7], the ‘assessment instrument for evaluating the quality of communication processes in health care’ [8] and the ‘instrument to evaluate the communication process during multidisciplinary team conferences in rheumatology’ [9]. We observed three handing-overs of the nurses, five chart rounds and three social charts rounds (participants are a ward physician, the head nurse, the aftercare nurse and the ‘psycho-social-team’ consisting of the psychologist, the member of the social service and the family therapist).

1.3. Sample selection

Sample selection: To get a random selection we scheduled our observations without knowing the duty-rosters of the staff. We observed as many different persons as possible of each professional group. Furthermore, the staff got the opportunity to anonymously mention problems, make suggestions and express wishes using a ‘suggestions-box’.

2. Results

We observe nearly no communication which was necessary because of incorrect information. Some communication structures were well operating, e.g.: a common language in multidisciplinary team-conferences within EfiB was not missing like in [9]. But we also observed a couple of problems and weaknesses.

2.1. Identified problems and possible solutions

a) *Not transmitted information*: Sometimes not all necessary information (e.g. about arrangements with parents) was passed from one professional to another. That occurred especially between persons who are responsible for several wards such as the chief physician or the members of the psycho-social-team and the ward stuff. **Solution**: Guidelines should be established defining who has to be informed at which time about which arrangement or decision.

b) *Inadequate (physical) design of the patient record*: Patient data were recorded in multiple paper based and electronic systems which were hardly integrated. **Solution**: A comprehensive (electronic) patient record would adequately support the required communication structures for EfiB.

c) *Lack of knowledge*: Especially at the beginning of the introduction of EfiB some staff was not completely aware of the meaning and the scope of the modules. Thus, the necessary information could hardly be communicated to the right person, when a module is carried out by only one person. For instance the psychologist, the member of the social service and the family therapist have an overlapping scope of duties. Furthermore, different persons explained the meaning of an EfiB-module differently to the parents. **Solution**: A further training should be arranged where all EfiB-modules and established guidelines, their meaning, scope and responsible persons are presented to the staff.

d) *Inadequate workflows:* The aftercare nurse and the parents were sometimes informed too shortly about dismissal.. **Solution**: A 'dismissal-management' should be designed which firmly integrates the aftercare nurse and the parents into the workflows and defines time limits for informing.

e) *Inadequate environment*: Printed information for parents was spread over several places in the ward, sometimes in between pictures and other hints. **Solution**: A central blackboard should be established as 'information-point' for parents.

f) *Hindered communication*: Only a few staff members wore name tags. That hindered communication especially for new persons in the ward. **Solution**: Applicable name tags are necessary for all persons working in the ward.

3. Discussion

We used video analyses only for a small sample size of two up to three observations per session type. They were a supplement for more representative methods. Nevertheless, they proofed helpful to identify communication flows and structures.

3.1. Implementation

Deploying all proposed solutions will be a long process. However, small interventions can already improve the communication processes considerably. The following solutions are already implemented:

a) The claimed guidelines are initiated. Further efforts are necessary.

b) The development of a comprehensive electronic patient record is in preparation. It should also prevent inconsistency as there is a lot of redundant information in the various systems. This is definitely the most time-consuming and challenging part.

c) Staff information about EfiB took place. Additional activities are planned.

d) Dismissal-management was designed as an own EfiB-module and workflows are adopted.

e) A central information board for parents was introduced to communicate news and other information like consultation hours etc. from staff to parents.

f) In accordance with the staff well readable name tags were designed.

To support communication between staff and parents, boards were installed in the rooms, where nurses and parents can leave messages for each other like ‘mother wants to bath her child’ or ‘physician wants to be notified, when child is awake’.

Similar boards were installed outside each room for the names of the premature infants and the responsible nurses. That way, professionals who work in several wards are quickly able to locate their patients and the responsible nurses.

Conclusion

The current fast gain in medical knowledge and technology requires multidisciplinary care and treatment concepts to provide high quality care. However, their introduction is not plain sailing. We need to identify possible problems and initiate suitable solutions. Often a small leak will sink a great ship, but small interventions can also lead to serious improvements.

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Enhancing Immunization Coverage through Health Information Systems: A System Dynamics Approach

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Abstract. This paper demonstrates how qualitative System Dynamics methodology can be used to provide a better understanding of health systems thus facilitating better development and design of computer-based health information systems. In an earlier paper by the same authors, system dynamics modeling and field study research methods are used to capture the complex and dynamic nature of the immunization process, to enhance the understanding of the immunization health care problems and to generate insights that may increase the immunization coverage effectiveness. Through qualitative modeling, causal loop diagrams which are used to show the key issues that need to be addressed when developing health information systems are drawn with the aim of improving the immunization services. The paper shows the benefits of using System Dynamics to understand systems with complex interactions thus facilitating the development of information systems that meet the stakeholder requirements.

Keywords. Health information systems, immunization, System Dynamics

1. Introduction

The usefulness of health information systems has been well established in the more developed and industrialized parts of the world, however, the same is not true for developing countries in general. Developing countries lag behind in advances in information technologies over the internet, however, they are increasingly being used to increase the availability and quality of healthcare in remote areas, disseminate healthcare information to the public and provide knowledge to the healthcare professions [1]. In developing countries such as Uganda, Information Communication Technologies' (ICT) access is generally low in the healthcare environments, although most of the major hospitals and the medical schools use computers for administrative purposes such as wordprocessing and electronic mail for communication. Service delivery in the health sector is still a challenge in many developing countries. Some of the issues that are faced by the health services include deficiencies in service delivery, growing gaps in facility and equipment upkeep, inequity of access to basic health services by the communities, inefficient allocation of scarce resources and lack of coordination among key stakeholders [2].

Health care services like any other business involve a lot of transactions such as importation and delivery of medicines; construction of hospitals and clinics; hiring and deploying staff; processing and payments of staff salaries, purchase and delivery of food for patients; collecting and analyzing disease spread data, and educating the community [3]. The use of health information systems through web-based technologies can increase the quality of health service delivery by providing reliable information and effective communication thus enabling impoverished communities to access health care services. Previous experience has long since showed that healthcare software developed for the requirements of industrialized countries do not fit developing countries healthcare facilities' requirements, at least without major re-design [4]. In order to have well suited community-based health initiatives in developing countries, there is need to have community health monitoring information systems that have procedures that track individuals by recording events and needs as services are extended to communities. The success of a health information system depends on whether it meets the requirements of the stakeholders, which necessitates a deeper understanding of the organizational environment such as the one provided by qualitative System Dynamics.

1.1. Origins of the study

The authors initiated this study with aim of understanding the immunization health care problems and generate insights that may increase the immunization coverage effectiveness. Motivation of the study resulted from the fact that in Uganda, despite numerous immunization campaigns over the media, health visits and improved health services; the coverage rates are generally still low (less than 60%) [5]. There is a need to understand the challenges presented in the healthcare system and develop information systems that can support the management of healthcare.

1.2. Immunization coverage in developing countries

Due to low coverage, epidemics such as measles still occur in many countries in the world. The World Health organization has targeted measles for eradication in several regions of the world by the year 2010, but despite an effective vaccine there is still estimated to be 30-40 million measles cases and 800,000 deaths per year [6,7]. Various approaches have been applied to understand immunization coverage problems, however, there are acknowledged deficiencies in these approaches. This is clearly demonstrated in Uganda, where despite numerous immunization campaigns over media, health visits and improved health services, the coverage rate in Uganda is generally still low (less than 60%) [8].

Developing countries such as Uganda are faced with the challenge of solving problems that lead to the delivery of poor health services, inefficient use of resources and failure to meet the people's health needs. Governments, donor agencies and projects have made a lot of contributions towards an increase in immunization rates through improvements of health infrastructure, financing, supplies, staffing and management of national immunization programs. There is need to develop systems that fit the requirements of developing countries that are able to provide information that is critical for evaluation of services and policy design and analysis.

Figure 1, shows the immunization coverage rates in Uganda over time. BCG immunization rates are higher than those of Polio3, Measles and DTP3 due to the fact that it is administered at birth while the rest are administered after some weeks as scheduled. There is a general upward trend in immunization coverage rates which is sustained by continuous campaigns. As the immunization coverage rates decline, campaigns and different forms of advertising are used as a ”quick fix” to change the negative response towards immunization. This results in dependence on campaigns and advertising as a side effect whose effect wares off with time and the rates fall back as before.

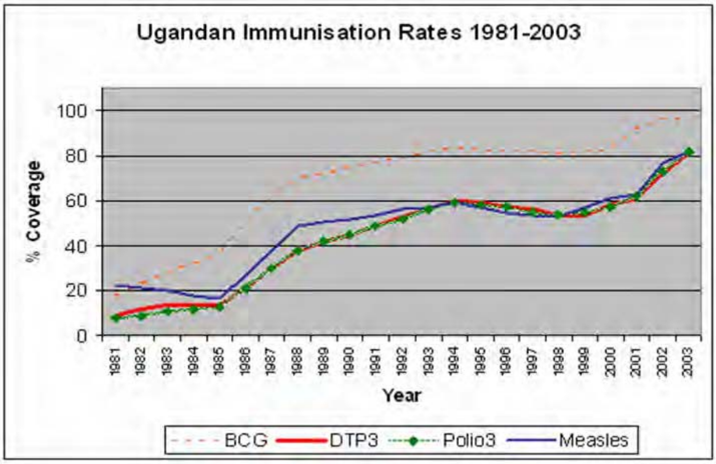

Figure 1. Ugandan Immunization Rates Graph 1981-2003

2. The current immunization system in Uganda

Health care services in Uganda including immunization services are provided through a decentralized system consisting of geographically spread health centres, regional hospitals which are categorized into health districts and health sub-districts. Policy design and review, strategic planning, establishment regulations, monitoring and evaluation and disease surveillance are carried out at the national level. The development of health plans and service delivery are channeled from the national level through the district, health sub-district and community-based health centres. The decentralized health care system makes the management and process of planning easier; however, this requires a lot of information feedback, monitoring and control of achieved goals.

Each health centre has its own immunization schedule and plan but it is desirable that the different health centres / hospitals offering immunization services work in a collaborative environment and be able to exchange data. It is vital that information is shared since it is a vital resource to the management of any organization. Effective sharing of information can be enhanced through the application of web-based communication technologies as well as health information systems.

In a scarce-resource based economy like Uganda, the responsibilities for planning, resource mobilization and allocation, management immunization services, storage and distribution of vaccines, supplies and equipment to the units under their supervision, maintenance of cold chain and training are done at the district and sub-district level. The district is responsible for support supervision, surveillance, management of outbreaks, development of training materials, social mobilization and advocacy. The health sub-districts are responsible for collecting, using and disseminating data, carrying out routine maintenance of cold chain, reporting and management of outbreaks.

Until 1993 Uganda had a centralized health information system (HIS) which focused on morbidity and mortality reporting, with data flowing only from individual health units to the district and national level. A health management information system (HMIS) that emphasizes use of information at the point of collection is currently in use [9]. The HMIS provides features that are useful for planning, management and review of health services, providing feedback to the individual health units and health policy makers and conducting health system research. At the health unit level, hard copies of registers and tally sheets are provided to staff to produce patients' information. The tally sheets are forwarded to the health district level for entry into HMIS. The reports from the districts are delivered to the headquarters either by hand, fax or by email.

Currently some of the challenges pertaining to immunization services are not addressed by the HMIS. There is need to develop computer-based information systems that are able to respond to the challenges of low immunization coverage by looking at the broad integrated view of the immunization system .

3. Contributions from System Dynamics Modeling

System Dynamics modeling employs both qualitative and quantitative analysis. This paper focuses on systems thinking (qualitative) methods that facilitate the understanding of systems by focusing on relationships that link the parts of the whole other than on the parts themselves. It is postulated that systems thinking is an excellent medium for exploring and identifying knowledge gaps [10]. In order to understand the systems interrelated parts, there is need to understand the cause - effect linkages to benefit managerial decision making through the provision of tools that enable them to comprehend complex systems, share the observations and experiences that provide a clear understanding of the dynamic behavior [11].

Causal loop diagrams can be considered as a representational system that allows us to view and describe reality, as well as provide theoretical knowledge by highlighting the relationships between variables, their polarity and direction of influence [12]. System dynamics provides qualitative description, exploration of complex systems in terms of their processes, information, organizational boundaries and strategies [13].

4. Factors that influence immunization coverage

Analysis of literature reveals a number of factors that influence immunization coverage. Some of the factors that have been suggested by other researchers are shown in Table 1, below:

Table 1. Key variables associated with immunization coverage

No.	Variable	Associated with	References
1.	Immunization coverage	• Cost of immunization • Religion /Caste • Number of Children in household • Mothers age (younger than 30yrs) • Use of public service providers, multiple vaccination providers • Availability and time of vaccination Service • Strength of social organization (community mobilization • Mother's level of literacy, awareness on vaccination issues (dosage), motivation, busy schedule, social stability (single/married), fear of side effects and family problems • Area of residence (urban /rural) • Country's level of poverty, healthcare system (organization of vaccines, supplies etc.)	[14], [15], [16],[17], [18],[19] [20],[21], [22],[23], [24],[25]
2.	Coverage of Child survival interventions	• Training of health workers which should include which includes clinical practice and sufficient facilitators • Use of materials relevant to local culture and language • Training of H/Workers in the management of common diseases • Tailored supervision in frequency and content to needs of the workers • Assessment of patients to determine • Regular monitoring activities such as supervision vis Relevant data at sub-national levels (collection & analysis) • Effective Interventions to be implemented at community & health facility levels • Assessment of alternative delivery strategies • Supplies must be tailored to meet demand and respond to the needs • Strengthening of national health systems which includes: Manpower, drug and vaccine management and supply, information systems, functional referral, child health programmes and simplified technologies.	[15],[18], [28],[27]
4	Low Immunization Coverage	• Inadequate financing for social mobilization • Inability to provide feedback to media queries • Belief in myths (HIV, anti-fertility drugs) • People tired of NIDS • Poor Sensitization • Superstitions and suspicions • Government is making it political • Lack of trained vaccinators (parents question their skill)	[28]

5. Field studies

Field studies were used to determine the full range of activities and challenges associated with immunization coverage and to examine the various acknowledged factors associated with the provision and utilization of immunization services were carried out. The study area Mukono District, lies in the Central region of Uganda comprises of four counties and has a good representation of both rural (83%) and urban population (17%). Secondly, the people of Mukono district reside both on the islands (1 county) and the mainland (3 counties) and the population consists of more than 18 tribes which would benefit the research by gathering cultural beliefs and opinions from the various tribes. Data was collected through interviews using semi-structured questionnaires from various stakeholders (national and district policy makers, health workers and mothers). The study was analytical; involving the various stakeholders who are important as far as the immunization system is concerned.

Mothers - In each county of the selected district, 200 mothers were interviewed. Multi-stage sampling method was used to select target sample size of 800 mothers. The sample size was determined as follows: Since many variables were being measured, a prevalence of 50 percent, which demands the largest sample size was used. At 95% confidence interval with the immunization coverage (p) of 70% and level of permissible error (e) as e 10% the sample size n was determined by the following equation :

$$n = \frac{z^2pq}{e^2} \qquad \text{Eq.(1)}$$

where p=0.7, q=(1-0.7)=0.3, z = 1.96 and e= 0.1

$$n = \frac{(1.96)^2(0.7)(0.3)}{(0.1)^2} = 80.67136 \qquad \text{Eq.(2)}$$

Considering a non-response rate of 20% results in 100 respondents. A design effect consideration resulted into 200 (100 x 2) respondents for each county thus making the number of respondents in the four counties equal to 800. In each county, the planned number of interviews was at least 200 mothers. The interviews of the mothers were carried out consecutively until the completed number of interviews which was 800. A structured questionnaire was used to interview the mothers.

Health Workers: Three (03) private and five government (05) health facilities selected by simple random sampling from the district. Those that were selected included one (01) government hospital and one (01) private hospital and the rest were health centers and dispensaries. At each sampled health unit, two people were interviewed, one vaccinator and one Officer-in-Charge of vaccines bring the total of those interviewed to sixteen (16).

Officials: At the district level, several meetings with various officials from health services, administrative officials were held. Local community leaders, national officials as well as consultants with UNICEF were interviewed.

6. Causal loop diagram

Figure 2, shows a causal loop diagram which represents the factors associated with demand for immunization as well as shows the key issues that need to be taken into consideration when designing information systems that can improve immunization services.

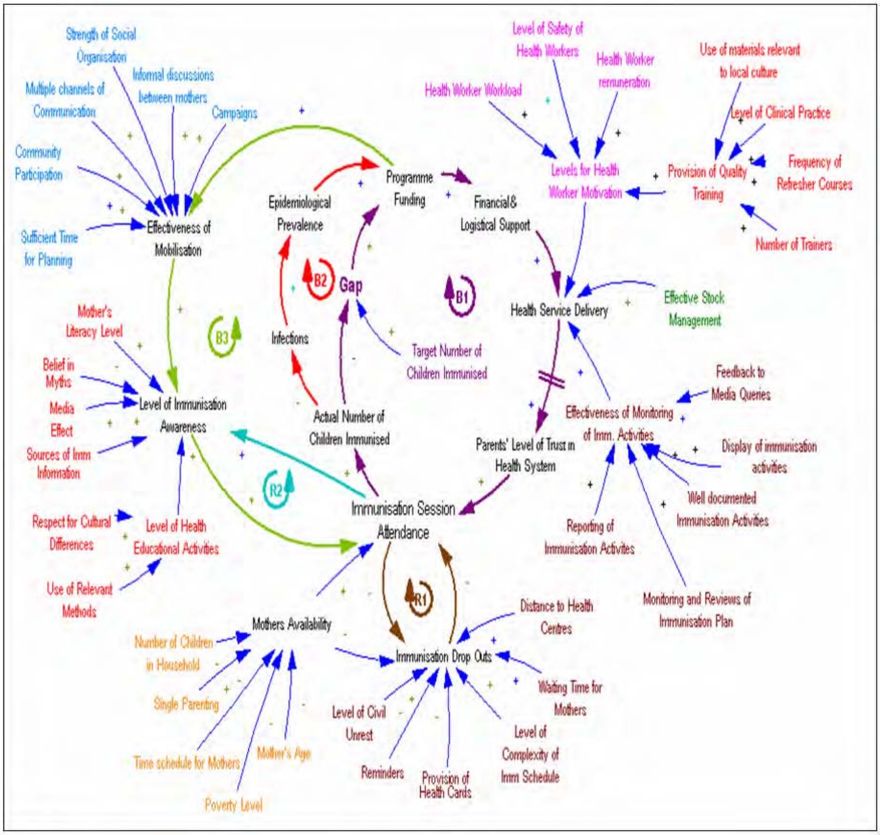

Figure 2. Causal Loop Diagram for Immunization Coverage

Figure 2, shows three balancing loops (B1, B2, B3) and two reinforcing loops (R1,R2). Balancing loops seek stability or aim for a specific target whereas reinforcing loops are positive feedback systems which represent growing or declining actions. *Loop B1* seeks to achieve the set immunization targets by focusing on the health service delivery. The difference between the targeted number of children and the actual number of children immunized creates a gap which triggers an increase in programme funding. An increase in programme funding results in increased financial and logistical support which when coupled with health worker motivation, effective stock management and effective immunization monitoring activities results in improved health service delivery. Improved health service delivery results in increased parents' trust in the health system which leads to an increase in immunization sessions and thus increasing the actual number of children immunized.

Loop B2 returns to control the occurrence of epidemics through health service provision and attendance of immunization sessions to reduce infections. An occurrence of epidemics, however, results in the need for more programme funding. *Loop B3* seeks to increase immunization awareness through effective mobilization which in turn results in increased attendance of immunization thus narrowing the gap between the target and actual number of children immunized. *Loop R1* represents immunization drop outs (these are children who get the initial doses of the vaccine but do not return for subsequent doses) who result from failure of the mothers to take the children for immunisation. *Loop R2* represents a growing action that arises as mothers attend immunization sessions. An increase in attendance results in increased immunization awareness which in turn contributes to increase in attendance.

6.1. Insights from the causal loop diagram

Studies indicate that in order to reduce the disease burden, eventually to the point of eradication, the intensity of immunization must be increased [25]. Figure 2, shows the following as key issues as far as immunization coverage is concerned:-

- Health service delivery - Proper management of financial and logistical support, stock management and effective monitoring of immunization activities should be addressed for improved health service delivery.
- Access to immunization information – There is need to use ICTs to have immunization information that is relevant to the community easily accessed by the health workers as well as the mothers in the communities.
- Mobilization and health education - There is a need to have continuous mobilization and health education to educate the communities on the importance of immunization, immunisable diseases, vaccines, side effects etc. Effective mobilization and education can be attained through well planned campaigns, multiple channels of communication, community participation, media and through the delivery of content that is relevant to the community.
- Availability of immunization services – It is important for easily accessible immunization services to be availed to the community within the in order to have increased participation.
- Health worker motivation. The provision of immunization services requires highly motivated health workers who are well trained, remunerated, facilitated and with acceptable workload.

From the causal loop diagram, a broad integrated view of the system is provided for the stakeholder to prioritize and set policies. The different information systems that need to be developed for the improvement of immunization coverage can then be generated from a clear understanding of the system.

7. Benefits

This section highlights some of the benefits that are gained through the use of qualitative SD in designing information systems for immunization coverage. SD provides qualitative description, exploration of complex systems in terms of their processes, information, organizational boundaries and strategies. SD is used to capture and analyze the complex interactions between behavioral, technical, policy, and cultural issues which provides a broad integrated view of the immunization system which facilitates communication and caters for the different stakeholder view points. The synthesis of the various theoretical concepts through use of causal loop diagrams facilitates the understanding of the immunization system which enables agreement on different policies and priorities. Causal loop diagrams foster communication among stakeholders by linking up the non-technical user view and the technical view of the designers and programmers of information systems thereby capturing the requisite information requirements for healthcare system.

8. Conclusion and future work

This paper demonstrates the benefits of using the systems thinking (qualitative) methods in facilitating the understanding of healthcare systems. It is through such understanding that effective health information systems that are suitable to communities such as those in developing countries can be designed. Developing countries, however, are still presented with challenges that might affect the adoption and diffusion of health information systems in remote areas. Some of the challenges include intermittent power supplies, unreliable phone lines and maintenance, high ICT installation and maintenance costs, lack of skilled ICT personnel, local content development, slow internet speed and capacity building and training.

Future work involves applying simulation modeling to test different healthcare policies using "what if" analysis with the aim of improving policy analysis in immunization coverage.

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Differences in Public and Private Sector Adoption of Telemedicine: Indian Case Study for Sectoral Adoption

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Abstract. Telemedicine is the use of communication networks to exchange medical information for providing healthcare services and medical education from one site to another. The application of telemedicine is more promising in economically developing countries with agrarian societies. The American Telemedicine Association (ATA) identifies three healthcare services: clinical medical services, health and medical education, and consumer health information. However, it is not clear how these services can be adopted by different sectors: public and private. This paper looks at four Indian case studies, two each in public and private sectors to understand two research questions: Are there differences in telemedicine adoption between public and private hospitals. If there are differences: What are the differences in telemedicine adoption between public and private sectors? Authors have used the extant literature in telemedicine and healthcare to frame theoretical background, describe the research setting, present the case studies, and provide discussion and conclusions about their findings. Authors believe that as India continues to develop its telemedicine infrastructures, especially with continued government support through subsidies to private telemedicine initiatives, its upward trend in healthcare will continue. This is expected to put India on the path to increase its life expectancy rates, especially for it rural community which constitute over 70% of its populace.

Keywords. Telemedicine, Sectoral Adoption, Developing Countries, India, Private Hospitals, Public Hospitals, Healthcare.

Introduction

Telemedicine is seen as a socio-technological system [1] and American Telemedicine Association defines it as “the use of medical information exchanged from one site to another via electronic communications to improve patients' health status” [1]. A U.S. survey by the Health Resources and Services Administration (HRSA) found that tele-

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medicine holds promises for expanded specialty health care for rural Americans [2]. The application of telemedicine is more promising in economically developing countries where most of the population lives in rural areas; this is illustrated by the following examples:

- Transmitting radiological images in Mozambique: In 1998, Mozambique, using existing terrestrial and satellite telecommunications systems, began transmitting images and radiographs between its hospitals in Beira and Maputo [3]. The project used standard low-cost tele-radiology equipment to transmit, exchange, and view radiology images.
- Videoconferencing for tele-consultation in Senegal: Senegal uses videoconferencing for tele-consultation between health professionals [4]. One of the key components of this project is in-service training for health professionals; in-service trainees from remote health centers are connected via videoconferencing.
- Linking healthcare professionals in Sub-Saharan Africa: Over 20 African countries have implemented HEALTHNET, a computer based telecommunications system that links health care professionals around the world [5]. This project links over 10,000 people in Sub-Saharan African countries using a low orbit satellite and phone lines; participants receive a low cost telemedicine service that allows them to share image files via email attachments.

To refer to information technology in the health sector, the literature uses Healthcare Information Systems (HIS) and Health Information Technology (HIT) interchangeably. In this paper we followed the American Telemedicine Association and used Health Information Technology (HIT).

Healthcare can be delivered as in-office service or as remote medical service [1]. The American Telemedicine Association (ATA) identifies three services: clinical medical services, health and medical education, and consumer health information. These services also highlight the socio-technical network of collaborative relationships in telemedicine. However, it is not clear how these services can be adopted by different sectors: public and private. This paper looks at four case studies, two each in public and private sectors to understand two research questions: Are there differences in telemedicine adoption between public and private hospitals. If there are differences: What are the differences in telemedicine adoption between public and private sectors?

This paper uses four case studies from Indian healthcare systems to understand the sectoral (public and private) differences in telemedicine adoption. In the following sections we use the extant literature in telemedicine and healthcare to frame our theoretical background, describe the research setting, present the case studies, and provide discussion and conclusions about our findings.

1. Theoretical background

“Telemedicine does not represent a separate medical specialty; rather it is a tool that can be used by health providers to extend the traditional practice of medicine outside the walls of the typical medical practice” [1]. Telemedicine, however, encourages greater involvement of the acceptor actor in making decisions. In this way telemedicine offers a means to transform healthcare. Telemedicine health services include specialist referral services, direct patient care, remote patient monitoring, medical education and mentoring, consumer medical and health information. A framework for the relationship between HIT and telemedicine is offered by the American Telemedicine Association [6]: this framework is shown in Figure 1.

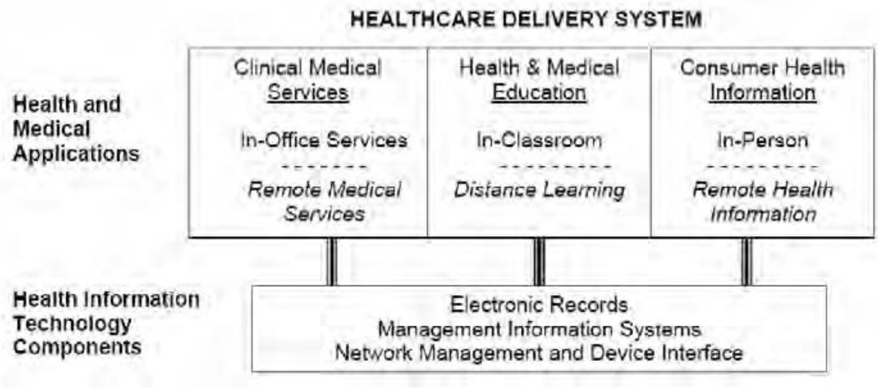

Figure 1. Framework for Relationship between HIT and Telemedicine

The framework shows that telemedicine can provide consumer health information, health and medical education, and clinical medical services.

2. Research setting

The case studies are conducted in India at public and private hospitals using telemedicine, see detail of cases in the next section. India, an economically developing country, has taken the lead in implementing numerous telemedicine projects. The lessons learned in India may easily be applicable in other economically developing countries. Prior to 1990s, India was perceived as analogous to bullock-carts, poverty, and heaps of garbage. While some of these still linger, India today is enjoying a booming software exports, major destination for business process outsourcing (BPO)and rising economy; it is at the crossroads of waiting to be transformed into an IT leader. India has 3% share in global software industry and is already dominating off-shoring market with 65% and 46% share in global IT and BPO, respectively. Entire spectrum of business within India, including healthcare, has opened up to information technology applications.

India's adoption of telemedicine is matched by growing positive change in public policy on infrastructure and sponsorship [7]; its advancements in information technology are fueling the introduction of telemedicine in the healthcare system. The taxonomy of health providers in India has five levels including community health centers, primary health centers, secondary level hospitals, tertiary level hospitals, and super-specialty hospitals

The diffusion and sustained growth of telemedicine in India can be linked to the following factors:

- Improved telecom infrastructure in the country: In 1995, with around 12 million telephone operational lines, India was ranked 14th in the world in terms of number of main telephone lines in operation. By 2001 the country had moved to 7th rank with total number of telephone lines increasing to almost 35 million [8], by 2003 this figure had increased to almost 49 million [9].
- Increased affordability of tele-services: Monopoly of fixed line telephone services was being enjoyed by Government owned Bharat Sanchar Nigam Limited (BSNL) until 2000 and Videsh Sanchar Nigam Limited (VSNL) until 2002. In 2000, few private sector fixed line telephone service providers started their operations. The list of private telecom operators included Tata, Bharti Tele-ventures Limited and Reliance Telecom Limited. Tariffs experienced a sudden fall, soon after the opening up of telecom sector to the private operators. Call tariffs for domestic long-distance calls dropped by 56%, international long distance tariffs dropped by 47%, further more, cell phone to cell phone domestic long distance call tariffs dropped by 70% [10]. Table 1 shows the tariff trends from 2000 to 2003.

Table 1. Trends in telecom tariff (2000-2003)

Trends in Tariff (in USD)				
	2000	2001	2002	2003
National Long Distance (beyond 1000 KMs) Tariff	0.67	0.53	0.21	0.10
International Calls to United States	1.36	1.09	0.90	0.53
				1 USD = 45 Indian Rs.

Increased availability of infrastructure and drops in the cost of telecommunication services is reflected in the increased teledensity, number of fixed telephone lines per citizen, and ownership of personal computers (PC). Teledensity has increased from 2.5% in 2000 to 9% in 2005; PC penetration has increased from 4.3 per 1000 people in 2000 to 14 per 1000 people in 2004.

3. Case study

Four telemedicine case studies, two each from public and private hospitals, were conducted in this study.

3.1. Government Telemedicine Projects

India's Department of Information Technology (DIT) at Ministry of Communications & Information Technology and Indian Space Research Organization (ISRO), Department of Space, are leading telemedicine implementation in selected hospitals. MCIT and ISRO complement each other's role. ISRO has been implementing basic telemedicine projects at primary level remote hospitals, and it has linked these hospitals with the respective referral hospitals; DIT has linked tertiary level hospitals.

Department of Information Technology: Endeavors of DIT with regard to telemedicine include indigenizing telemedicine solutions, linking tertiary level hospitals, running telemedicine pilots in selected specialties including oncology and tropical diseases, seek solutions for all specialties by developing generic telemedicine systems, and in formulating recommendations guidelines and standards for practice of telemedicine in India. DIT has also put forth the framework for Information Technology Infrastructure for Health (ITIH) in India. In this paper we discuss DIT's two telemedicine initiatives.

3.1.1. Case 1: Development of Telemedicine Technology (DTT) Project

Development of Telemedicine Technology (DTT) is India's pioneering government sponsored telemedicine initiative. This project was launched to set up a national telemedicine network in a phased manner. The main objective of the project was to develop and implement indigenous telemedicine concept for optimization of medical resources. This was realized through involvement of local clinicians, doctors, and staff in the design process. This pilot project initiated development of an integrated telemedicine application software compatible to the appropriate medical peripherals. The application software under study is called Sanjeevani, an integrated telemedicine application developed by Center for Development of Advanced Computing.

The telemedicine application facilitates tele-consultation for radiology, pathology and cardiology clinicians at three tertiary level hospitals. The participating hospitals include All India Institute of Medical Sciences (AIIMS) in New Delhi, Post Graduate Institute of Medical Education and Research (PGIMER) in Chandigarh, and Sanjay Gandhi Post Graduate Institute of Medical Sciences (SGPGI) in Lucknow in the state of Uttar Pradesh. New Delhi, Chandigarh and Lucknow are major regional cities with reasonably good telecommunication connectivity; the hospitals were linked via integrated services digital network (ISDN). Medical data can also be transmitted by using other options like Plain Old Telephone System (POTS) and Very Small Aperture Terminal (VSAT). The sender has the option of selecting the modality as well as the bandwidth in which the medical data be sent to the specialist.

The integrated telemedicine application utilized a comprehensive Electronic Patient Record (EPR). The EPR includes patient's demographics—name, age, sex, address, etc.; physiological parameters—blood pressure heart rate, and temperature; and clinical details—medical images, patient history, clinical examination reports, physical examination reports, etc. Physiological parameters are either captured directly from the medical peripheral instruments or are recorded manually.

Images from x-ray machine, ultrasound scanner, CT scan, MRI, gamma camera are acquired (or digitized) in .jpg and/or .dcm format. These images can be converted from general purpose image file formats like .tiff, .jpg, .gif etc into a .dcm format before archival. Up to 192 (48 x 4) images from one imaging modality can be stored with each patient record. The telemedicine application, Sanjeevani, supports the display, archival and retrieval of TWAIN compliant images in the case of pathological images that are acquired through Leica's TWAIN compliant video microscope. Imaging module converts any raw data, from a TWAIN compatible device, into its part 10 secondary capture DICOM format. The imaging module enables the doctors to annotate data on images. Doctors can also mark region of interest, enhance image's readability by zooming in/out, increase contrast, brightness, etc.

The telemedicine application is a stand-alone application that connects two computers either by POTS or ISDN lines. It uses windows RAS APIs for remote connections to detect the type of connectivity available. The communication protocol used is TCP/IP, and all TCP/IP negotiations required for connections are executed automatically. Sanjeevani is being used at these three hospitals can also be used for other generic medical requirements in other specialties too [11]. The application at each site is managed by a senior doctor who is the telemedicine nodal officer. The telemedicine application can be used to connect referring doctors with specialists or referring doctors with patients; it works interchangeably as a patient-end or a specialist-end.

The patient information in the EPR is accessible to the specialist; all of the tele-consultation including videoconferencing between the doctors takes place within the telemedicine application. The application also enables clinicians to create, edit and view EPR, generate prescriptions, work out interpretations for radiographs and pathological reports besides annotating digitized images, and acquire and display ECGs. Reports regarding diagnosis, treatment chart, next visit to hospital, etc. are generated.

Medical peripherals connected to the telemedicine application include medical film scanner, video microscope, electronic stethoscope, PC-based ECG machine, PC-based Spiro-meter and video conferencing.

In preparation for the telemedicine implementation the doctors received training specially designed for them [12]. The technology is currently being used for tele-consultations and tele-education. The three tertiary hospitals in this case study are now being connected to a secondary hospital. Informal reports indicate that the technology is gaining grounds amongst clinicians in all three hospitals.

3.1.2. Case 2: OncoNET Kerala Project

The OncoNET project is an oncology network that provides telemedicine services for cancer detection, treatment and pain relief.

Prior to the OncoNET telemedicine system implementation oncology patients, after seen by theperipheral hostpital doctor, are sent to the regional cnacer center for pathological and radiological examinations [13]. The regional cancer centers prior to the OncoNET system register about 10,000 new patients every year, and handle over 50 daily follow-ups. Each follow-up visit at the regional cancer centers costs \$11-\$38 USD. Figure 2 depicts the process prior to the OncoNET implementation.

To ease the workload on the regional cancer centers the OncoNET telemedicine project was established at five peripheral centers: Kollam, Ernakulam, Palakkad, Pathanamthitta and Kannur, all five cities are within the state of Kerala. The OncoNET project is implemented in southern India state of Kerala. The project is funded by DIT, same funding source as the first case study. Participating organizations include Centre for Development of Advanced Computing in Thiruvanthapuram, Indian Space Research Organisation (ISRO) and Regional Cancer Centre in Thiruvananthapuram.

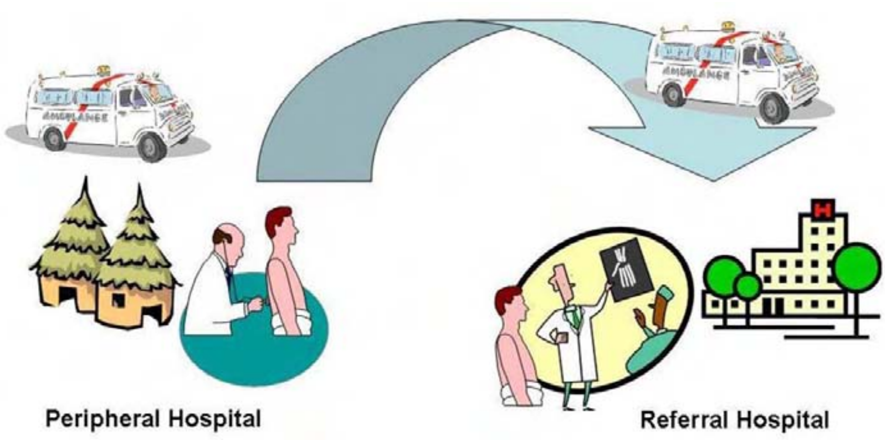

Figure 2. OncoNET process without telemedicine

In 2003 over 800 patients were received from Kollam alone, one of the five peripheral centers. The five peripheral centers are expected to reduce the regional cancer center's work load by at least 30% [14].

OncoNET uses hub and spoke model. It supports real-time and asynchronous modalities. The regional cancer centers serve as the hub, and the peripheral hospitals serve as the spoke. The hub and spoke network is connected with a high bandwidth VSAT. The spokes are equipped with a real-time high quality video conferencing system and video microscopy systems to acquire digital pathological images. The pathological and radiological images are sent to regional cancer centers for expert consultations. A graphical representation of the OncoNET telemedicine process is shown in Figure 3.

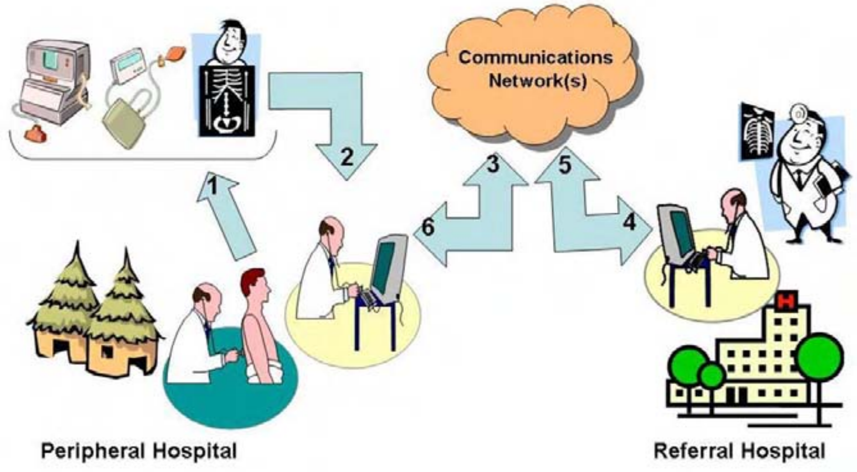

Figure 3. OncoNET process with telemedicine

The regional cancers are connected to the internet through a 64 Kbps leased line; the peripheral centers are connected through dial-up. The infrastructure at the peripheral centers includes tele-pathology, tele-radiology and videoconferencing. The OncoNET telemedicine system costs $27,000 USD (1 USD = 45 Indian Rs.) per site. Sample OncoNET usage statistics are available at http://www.rcctvm.org/Report.htm

In addition to telemedicine services, OncoNET is used as a tele-education resource center by the regional cancer center. The tele-education center provides cancer related information to clinicians, researchers, health workers and administrators across a multi site telemedicine network. This linkage provides learners access to various databases on CD-ROM server, library's medical and clinical databases like library catalog, journal holdings, bibliographies and other resources pertaining to oncology.

3.2. Private Telemedicine Projects

In the past few decades the Indian Government has been nurturing the private health sector. The government wants the private healthcare service providers to lead the way in modernizing the country's healthcare sector. Today over 80% of Indian doctors are affiliated to the private sector and almost 70% of country's healthcare infrastructure is managed by the private healthcare providers. In 2001, the private healthcare sector generated 86% ($21.3 Billion USD) of India's healthcare economy. Indian healthcare industry is expected to grow between 13 to 15% annually [15].

The Indian healthcare infrastructure is a work in progress, nevertheless the private sector is making huge strides to match world class healthcare delivery systems and services. In this paper we look at two telemedicine projects from the private sector.

3.2.1. Case 3: Manipal Telemedicine and Telehealth (MTT) Project

Manipal Enterprises has made its name by doing pioneering work in the fields of education and healthcare. It is comprised of 14 teaching hospitals (including specialized colleges of dentistry, allied health, nursing and pharmacy) with over 9000 students and 275 faculty members; 6 healthcare hubs located at Bangalore, Manipal, Mangalore, Sikkim (Gangtok), Pokhara (Nepal), and Melaka (Malaysia); 3 feeder hospitals, 19 primary healthcare centers, and over 55 community development projects; specialty hospitals for treatment of cancer and cardiac ailments; and healthcare divisions with over 1250 doctors and 4250 beds, 7 government associate hospitals with 2565 beds, and 7 rural health centers. The group had treated over 1.2 million patients till 2005.

The telemedicine network in Bangalore, the flagship hospital, has 275 doctors and 1700 support staff, it provides 40 healthcare specialties. The Bangalore telemedicine network is linked to 7 hospitals in India; it also has an intercontinental linkage with Clinic du Nord - a secondary level private hospital in Mauritius, Africa. The hospitals are linked via ISDN (128 / 384 Kbps). The Manipal telemedicine network architecture is shown in Figure 4. The remote node on the left depicts the technology intense patient-end that is basically a browser based client in this hub and spoke model. The specialist node is shown to have a technology that enables viewing, processing and annotation for the date that is received from the remote node. The clinical information is stored in the server.

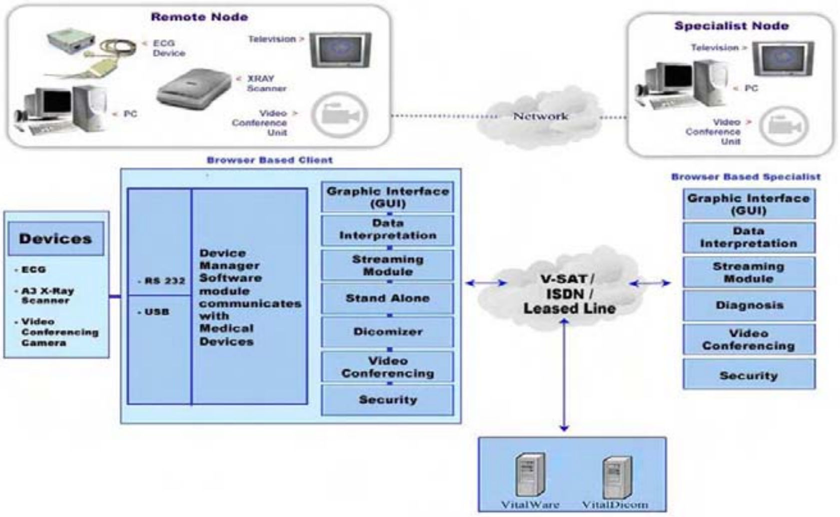

Figure 4. Manipal Telemedicine Network Architecture

Manipal telemedicine project provides several services: remote consultations for second opinions and follow-ups; sharing of best practices by way of conducting an online Continuing Medical Education (CME) programs and patient awareness programs; organizing virtual camps for medical fraternity; and utilizes the linkages for orientation and training of nurses and paramedical personnel.

3.2.2. Case 4: Apollo Telemedicine Network (ATN) Project

For the last two decades Apollo group of hospitals has been providing world-class healthcare services to millions of South East Asians. In 2001, the Apollo group pioneered to link a 50 bed rural hospital in Aragonda to one of the super specialty hospitals in the city of Hyderabad (Andhra Pradesh). This marked the country's first rural telemedicine station [15]. It has since expanded to over 110 centers in India and abroad. Over 200 more are expected to come up in 2006.

The Apollo telemedicine project is used for providing second opinion, remote consultations, complex interpretations, follow ups and continuing medical education. Apollo is also facilitating the linkage for nine Army hospitals with two of its hospitals for consultation during ware time and disaster relief operation. The project has developed an integrated delivery network with three telemedicine specialty centers (New Delhi, Hyderabad and Chennai). Each of these specialty centers are linked to at least one of the 110 telemedicine consulting centers via ISDN and/or VSAT linkages. Average number of weekly tele-consultations range from 50 to 75; the turnaround time for teleconsultations is only 2-4 hours. The Apollo telemedicine project has conducted over 20,000 tele-consultations in the last five years. Apollo's telemedicine consulting centers are equipped with high-end medical peripherals like ultrasound, color Doppler, video microscopes, PC based ECG machines, electronic stethoscopes etc. The telemedicine application is HL 2.3.1 and DICOM 3 compliant and is an application that uses 128 bit encryption for data's security. It enables transfer of data through multiple networking modalities including LAN, POTS, ISDN, DSL, VSAT, GSM, CDMA and WiFi.

4. Discussion

Considering the HIT integration challenges and the critical role of healthcare actors the cases suggest when the healthcare actor (supporter) is a public institution focusing on consumer health information and health and medical education leads to success. Countries and institutions that wish to use telemedicine for clinical medical services will be better served by private healthcare actors (supporter).

The American Telemedicine Association (ATA) has developed a framework delineating three areas where Telemedicine supports healthcare: consumer health information, health and medical education, and clinical medical services (ATA, 2006). The case studies show that telemedicine in public hospitals do well in the first two and lag in clinical medical services. Private hospitals on the other hand excel in all three areas. By this we mean that public hospitals are doing well only on the first two applications of the three ATA identified telemedicine applications: consumer health information, health and medical education, and clinical medical services. Where as private hospitals showed success in all the three application areas. Key reasons for this difference in the adoption of telemedicine between private and public hospitals are: first, telemedicine has been pushed into public hospitals primarily with top-down approach; this was a technology-push rather than needs' pull. It can be said so because not many clinicians have been found to be computer literate specifically in peripheral centers. Telemedicine technology trainings have 'followed' implementations. Second, in private hospitals telemedicine has been implemented following more of a needs' pull phenomenon.

Socio-technical issues have to be considered when discussing telemedicine because telemedicine is as much a socio-cultural innovation as it is technological [1][16]. In the design of the systems discussed in this paper we achieved socio-technical success through a proactive design approaches: first, the interview process involved indigenous doctors to understand various processes they were following while delivering healthcare services, second, staff interview and analysis of formal procedures were used to prepare patient file records, third, the design team used input from clinicians to design an intuitive and user friendly user interface as a result the development had to be highly modular and each module was cleared for acceptance by the clinicians. Hence, integrating socio-technical aspects in the design process has shown to be successful.

Telemedicine systems fail for many reasons, but a major contributing factor is the failure of designers to facilitate the interaction of incompatible cultural subsystems that prevent the transfer of knowledge from one cultural context to another [17]. Clinicians were fully involved in the process and cultural and social context were considered.

Telemedicine is frequently designed as if it were a technical system or a medical system, when failure occurs it's not just the technology that fails but the integrated technology, medicine, social systems and culture all fail[17]. The case studies suggest that integration of socio-technical issues in telemedicine implementation leads to success.

5. Conclusion

This onsite study of India's public and private telemedicine initiatives reveals some pertinent differences between both initiatives that require further research:

1. The implementation of Telemedicine in the private sector has been quick.
2. Telemedicine has been pushed into public hospitals primarily with top-down approach.
3. In public hospitals the telemedicine has been a technology-push rather than needs' pull. It can be said so because not many clinicians have been found to be computer literate specifically in peripheral centers. Telemedicine technology trainings have 'followed' implementations.
4. In private hospitals telemedicine has been implemented following more of a needs' pull phenomenon.
5. In private hospitals telemedicine has evolved pretty faster and clinicians have come up with few research publications as against public hospitals where telemedicine is primarily being used as a tool for education (tele-education).
6. Private hospitals have well structured telemedicine departments (i.e., telemedicine), have been adopted to an extent that it has formed place for itself in the organizational structure. It is thus a part of the system.
7. In public hospitals it is yet seen as an additional responsibility (besides routine task), there is very little or no dedicated manpower available for telemedicine. Telemedicine is yet not a part of the system as answers to the issue of sustainability are still pending.

While we do not claim that telemedicine will solve all (or even most) of India's healthcare problems, we contend that it is a starting point to offer important contributions to combating such problems using IT and related technologies. There is unarguably much more to be done for India to enjoy higher capabilities that telemedicine can offer, i.e remote surgeries (tele-surgery). We believe that as India continues to develop its telemedicine infrastructures, especially with continued government support through subsidies to private telemedicine initiatives, its upward trend in healthcare will continue. This we believe will put India on the path to increase its life expectancy rates, especially for it rural community which constitute over 70% of its populace.

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Conceptualisation of Socio-technical Integrated Information Technology Solutions to Improve Incident Reporting through Maslow's Hierarchy of Needs: A Qualitative Study of Junior Doctors

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Abstract. Medical errors are common, especially within the acute healthcare delivery. The identification of systemic factors associated with adverse events and the construction of models to improve the safety of the healthcare system seems straightforward, this process has been proven to be much more difficult in the realism of medical practice due to the failure of the incident reporting system to capture the essential information, especially from the perspective of junior doctors. The failure of incidence reporting system has been related to the lack of socio-technical consideration for both system designs and system implementations. The main reason of non-reporting can be conceptualised through the motivation psychology model: Maslow's hierarchy of needs; in order to achieve a change in the socio-cultural domain for incident reporting. This paper presents a qualitative research methodology approach to generate contextual-rich insights into the socio-cultural and technological factors of incident reporting among junior doctors. The research illuminates the guiding principles for future socio-technical integrated information communication technology designs and implementations. Using Maslow's hierarchy of needs as the conceptual framework, the guiding principles aim to design electronic incident reporting systems which will motivate junior doctors to participate in the process. This research paper aims to make a significant contribution to the fields of socio-technical systems and medical errors management. The design and implementation of the new incident reporting system has great potential to motivate junior doctors to change the culture of incident reporting and to work towards a safer future healthcare system.

Keywords. Incident reporting system, socio-technical system, motivation psychology, technology, training.

Introduction

Medical errors are common within the healthcare delivery system. The Quality in Australian Health Care Study reported an adverse event rate of 16.6% among all hospital

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admissions [1]. Every year 1,800 patients died in Australia due to iatrogenic injuries [2]. This is a problem worldwide with daunting statistics reported both in the United States [3] and the United Kingdom [4]. Since the publication of these studies [1] [3] [4], many approaches have been advocated to improve patient safety. Over the last decades, the healthcare system is starting to realise the need to abandon its long-hold belief in professional perfectionism and the need to focus on systemic "latent" factors within the complex system, through the adaptation of the Swiss Cheese Model [5]. While the focus on systemic problems and therefore systemic solutions is important, the difficulty of the process is the identification of the most effective systemic solution. On the more fundamental level, however, there needs to be an understanding of the underlying "latent" factors for adverse events, if not the adverse events themselves. Different countries have different systems in the identification of adverse events which warrant compulsory investigations [6]. In Australia, there is the sentinel event notification as well as the root-cause analysis program [6]. While these processes are useful to investigate serious incidences, it might not include common incidences with less harmful outcomes [6]. Therefore, while both sentinel event notification and root-cause analysis might prevent serious incidences from recurring [6], they are far from driving the healthcare system to towards a safer system overall.

There is another system in place, with the aim of capturing all adverse events and "near misses" especially within the acute care delivery setting -- the incident reporting system [7]. The incident reporting system is supposed to capture all incidences regardless of their severity and likelihood of recurrence [7]. An adequate incident reporting process is a core requirement for accreditation of healthcare institutions in Australia [8]. Incident reports generated through this process are often used to guide patient safety and quality improvement initiatives [9].

The fundamental assumption guiding this process is the presumed direct relationship between incidences, reports and patient safety [10]. The report generated through the incident reporting system is supposed to provide a true and holistic account of the incident [10]. Many systems have been built to facilitate the process of incident reporting [9]. These systems range from simple paper-based system [11] to complicated electronic system [12]. The systems are often built to facilitate the analysis of the incident reporting. Therefore, users are often required to document incident types, causation factors and contributing factors. The analysis of incident reports, if the guiding assumption is true, then can easily be used to identify frequency of underlying systemic "latent" factors in error causation [9]. More recently, electronic incident reporting systems have been developed to facilitate the analysis of large volumes of data. The electronic incident reporting systems are often built with multiple drop-down fields that require users to select a pre-defined information category [9]. With the electronic categorisation in place during the initial incident reporting process, the analysis of these reports becomes an easy task. This in theory will allow healthcare professionals to build a safer healthcare system.

Unfortunately, there are significant problems associated with the current incident reporting systems [13] [14] [15]. These problems are related to the fundamental assumption of a direct relationship between an incident, a report and patient safety [10]. Significantly, there is a lack of understanding of the perception of incident reporting culture among medical doctors [16]. More significantly, the electronic and other incident reporting systems are built on the false premises that the incident reporting system represents a true account and a true snapshot of the medical errors occurring within the hospital setting [13]. When these problems are dissected to its bare-bone, it is clear that neither the underlying assumption nor the systems development takes into account the socio-cultural aspects of incident reporting. Therefore, while the technology is perfect, there is a significant lack of techno-social integration to facilitate the process of incident reporting.

The incident reporting rates, especially among medical doctors are low [13] [15] [16]. This is especially a problem among junior doctors [16]. Junior doctors are the ones who are thought to be most likely to make errors [17], however, they often took on a passive role regarding incident reporting [16]. There are quantitative and qualitative studies which attempt to identify the reasons of non-reporting among doctors [14] [15] [18] [19] [20] [21]. Many studies identify the socio-cultural factor as the most important factor for non-reporting. These studies, however, are carried out through the positivist lens and they fail to take into account the important socio-cultural contextual setting of system implementation within the realism of medical world through the view of junior medical officers (JMOs). In order to successfully design, develop and implement a new system, the Maslow's hierarchy of needs dictates that there are various psycho-socio-cultural issues that need to be addressed [22]. Therefore, in order to achieve the desired cultural change among JMOs regarding incident reporting system and as a consequence, the ability to truly obtain a holistic view of adverse events and 'near misses', a socio-cultural-technical integrated solution is required.

This paper presents a qualitative study of JMOs working at a tertiary referral hospital in an attempt to conceptualise the process of incident reporting through the view of Maslow's hierarchy of needs [22]. The study aims to provide a clear understanding of the psycho-socio-cultural issues pertaining incident reporting among JMOs. It then aims to provide some guiding principles for future information technology designs in order to facilitate the process of incident reporting. The paper concludes by examining the potential of a socio-technical integrated implementation process, which will have the power to transform the culture of incident reporting among JMOs working in acute care hospital.

Methodology

In order to understand the socio-cultural construct of incident reporting, through the eyes of junior medical doctors, we utilised a qualitative research methodology with an interpretivist epistemology to investigate the perception of incident reporting system, the perception of electronic incident reporting system and the reasons behind non-reporting of medical errors and near-misses among JMOs. This study aims to investigate the following research questions:

1. What are the perceptions of the current incident reporting system among JMOs?
2. What are the activators and inhibitors for incident reporting from the perspective of JMOs?

3. What are the perceptions of the current electronic incident reporting system among JMOs?
4. What are the socio-technical issues regarding electronic incident reporting systems for JMOs?
5. What are the socio-technical design requirements for electronic incident reporting system which might encourage incident reporting among JMOs?

The study was carried out in 2006 using semi-structured interviews with voluntary participation of JMOs. All first year JMOs were invited to participate in the study. First year JMOs were chosen in order to provide the insights through the least culturally affected group of JMOs, which were most likely to be amendable to change. There were 12 JMOs who agreed to participate in the study. Previous studies in the field have indicated the reluctance of medical doctors, especially JMOs to provide information regarding incident reporting [16]. A different approach, integrating the Maslow's hierarchy of needs [22] was therefore utilised in the research process.

The interviews were carried out outside the working hours in a relaxed environment. This was to eliminate the problem of constant work interruptions and potential lack of confidentiality of the interview process. During the interviews, field notes were obtained and documentations of the interviews were performed rapidly. We intentionally did not audiotape the interview sessions due to the sensitivity of the data. While we did not encourage the disclosure of any particular event, we did not interrupt the interviewees when they tried to explain their views with real-life examples. This was based on previous experience that the understanding of significant socio-cultural insights would be affected if junior medical officers were not allowed to discuss real-life examples [16]. These examples, however, were taken out of the data documentation and coding process

The field notes and documentations were coded using open coding. We then analysed the data through thematic analysis. The themes were selected based on the frequency of appearance among the interviews and the perceived importance by the interviewee, as interpreted by the interviewer. The analysis of the data drew on the principles of grounded theory in order to provide a holistic socio-cultural view of the issues examined

Results

There were many significant socio-cultural issues identified through this study. Significantly, the research methodology utilised in this particular study allowed the generation of holistic insights into the perception of incident reporting among JMOs. More significantly, our study has identified very important socio-technical issues for future design requirements of electronic incident reporting systems for JMOs. During the interview process, it became clear that JMOs preferred a narrative process to explain adverse events with real-life clinical examples. By using clinical examples, JMOs were able to provide more responses to the interview questions. Furthermore, JMOs often discussed adverse events based on their perception of the world with no clear understanding of the systemic factors involved. These two observations, identified through our research have significant implications for the design of future incident reporting system.

The analysis of the field notes and documentations revealed five themes. The first important theme was the discouraging nature of the current incident reporting process. The incident reporting rate among this group of JMOs was low. The experience of incident reporting was discouraging from the view of JMOs. While the electronic incident reporting system was supposed to guarantee confidentiality, there was a perception of lack of confidentiality, especially during the investigative phase of the process. Significantly, the negative perception of incident reporting was not due to the process of reporting. Instead, the negative perception was due to the lack of formal acknowledgement or feedback after the submission of the report.

Secondly, the results show a significant problem with the perception of incident reporting and the culture of incident reporting among JMOs. The purposes of incident reporting were not well understood or embraced by JMOs. More significantly, the process of evaluation and investigations of reported incidences was completely misinterpreted by JMOs. Our results revealed that incident reporting was thought to be a quality assurance process. It was the belief of JMOs that incidences reported would be used against individuals in performance evaluation and future career development. The culture within the institution discouraged proactive incident reporting.

Thirdly, the results revealed that the utilisation of information technology did not have a strong positive correlation with the incident reporting culture. The main reasons behind non-reporting in our study were neither time constrains nor the information technology designs. JMOs found that the lack of education and understanding of the incident reporting process and the lack of trust within the system as the major barriers to incident reporting. Significantly, while many JMOs in the study had worked in the healthcare system for a while, they have not been educated regarding the purpose of incident reporting. There was also a significant lack of understanding regarding the approach to investigate reported incidences. More significantly, JMOs found the dissociation between the incident reporter and the reviewer of the incidences created by the electronic incident reporting system as a major barrier to incident reporting. JMOs would only report incidences to colleagues that they trust, instead of an anonymous reviewer who would review the submitted reports.

The fourth theme which emerged from the research revealed some damaging consequences of the current incident reporting system. The interviews revealed that incident reporting process had been used to generate personal threats in order to achieve certain outcomes. The electronic incident reporting system which required entry from the reporter and a medical officer as mandatory fields was perceived as a process which was particularly prone to be misused as a tool to generate inter-professional disharmony.

Finally, a socio-technical integrated solution might improve the incident reporting process. It was believed that the mobile wireless technology might assist with incident reporting as it allowed a more private and confidential entry of incidences. The information technology interface for incident reporting must be simple to use with minimum time constrains added to the already heavy workload.

While the data analysis itself has important implications for information technology design, the analysis of the interview process has also revealed very important results. Despite the fact that the interviewer was a junior medical officer, working together with the interviewees in the same environment at the same level; many interviewees did not feel comfortable to discuss the issue of incident reporting freely. The answers to the questions were interrupted by many pauses and the answers were generally short with limited data volunteered by the interviewees. This again showed the problematic culture and perception of medical errors and incident reporting within the medical profession.

Discussion

This study has provided a detail socio-cultural and technical account and generated significant contextual insights into the perception of incident reporting system from the perspective of junior doctors. It is obvious from this study that there are multiple socio-cultural and technical factors which affect the perception of incident reporting among JMOs. More importantly, the dynamic interaction of these socio-cultural factors with the technological factors as perceived by each individual plays the most important role in determining the consequences of electronic incident reporting system implementation. This individual perception of the interaction is much more important than individual factors, especially with the technological factors, in achieving a better incident reporting rate among JMOs. While information technology solution might provide easier analysis of the reports generated, it does not provide a solution to the most important aspect of incident reporting – the perception and culture of incident reporting among JMOs. In effect, the electronic incident reporting system has significant adverse and potentially harmful consequences as revealed in our study.

The implementation of electronic incident reporting systems as well as other initiatives to improve incident reporting system had not had a dramatic success from the perspective of JMOs [13]. This is unlikely due to the failure of the system or individual initiative, but due to the lack of consideration of the socio-cultural factors and the interaction of socio-cultural factors with the systemic and technological factors. While the arguments for educational programs and cultural changes [23] using the current incident reporting are worthy of consideration and discussion, this study has challenged the fundamental validity of the arguments from the socio-cultural-technical perspective. The problem, as evident from this study, is the sensitive nature of the topic, which challenges all five levels of Maslow's hierarchy of psychological needs of an individual to contribute in an organisation [22]. Therefore, if an incident reporting system is going to be utilised by JMOs, then there is a need to develop a new system with socio-technical integrated implementation, which address the Maslow's hierarchy of needs, namely: physical needs, security, social belongingness, self-esteem and self-actualisation.

Electronic incident reporting systems have great potential to deliver the essential characteristics of a successful system while maintaining the essential functions of incident reporting, through a socio-technical integrated design and implementation process. The in-depth understanding of the socio-cultural and technological insights generated by this study provides some guiding principles for the development of a new electronic incident reporting systems to fulfill the needs of JMOs.

The first level of psychological need to motivate JMOs to change the culture of incident reporting is the physical needs. While the pure implementation of electronic incident reporting system itself might not be able to fulfill the physical needs, the mobile nature of some electronic devices will allow the chance for JMOs to utilise the incident reporting system with full shelter from hungry, cold and other physical requirements. This fact is well supported by the fact that mobile wireless technology for incident reporting has great success in certain centres [24].

Secondly, the new system needs to provide security for users. From the technological perspective, the incident reporting system interface design should be simple and should allow narrative account. Any attempt to classify incidences during the reporting process might not provide the full picture of the events. This is especially true for the systemic factors associated with the event as evident in our study. Therefore, the system should only require a snapshot which allows the reviewer to investigate the problem without prejudice. Furthermore, mobile wireless technology, which allows users to enter the incident away from interferences of others would provide the necessary security to motivate JMOs to use the incident reporting system. Therefore, a simple and easy to use, mobile wireless system will be essential for future system designs.

After the system creates security, it then should move into the next level on Maslow's hierarchy of needs and should aim to provide social belongingness for JMOs. The difficulty with electronic incident reporting system is the creation of an environment which lacks "social presence" [25]. The third principle is therefore the need for the new incident reporting system to create the sense of social belongingness. There need to be some changes in both socio-cultural aspect and technological aspect of incident reporting system in order to achieve social belongingness. The reviewer of the reports needs to be someone that clinicians can trust and therefore it should be a clinician trained in the area. The incident review process needs to establish accountability. With these socio-cultural aspects in place, then the electronic incident reporting system will need to have in-built acknowledgement and feedback system. The reporter of the incident should be provided with direct acknowledgement that the report has been received as well as the individual who will review the incident. With a well designed electronic incident reporting system, all these could be achieved without breaching the confidentiality of the reporter.

Maslow suggested that the next level of psychological needs is self-esteem for motivation [22]. While information technology implementation, such as electronic incident reporting system is supposed to enhance communication and to encourage participation by workers in the decision making process, research studies have shown that the opinion of frontline workers has often been manipulated, misunderstood and ignored [25]. The electronic incident reporting has the same image with JMOs. The incidnces are often perceived as a contribution to the numbers or histograms of reports, rather than perceived as "real" incidences requiring attention. This is especially the case with the incident reporting system which requires users to submit pre-defined, mandatory information fields using drop-down lists. Therefore, the next principle for the new socio-cultural-technical integrated design is the need to provide direct progress feedback to reporters for every report submitted. It has to be a compulsory functionality that the new electronic incident reporting system has an information display panel for each individual reporter, assessed only by the specific reporter, regarding the progress of the investigation process. This direct visualised feedback system will have one of the strongest positive effect to motive JMOs for incident reporting based on the analysis of our study.

While technology has promised to "provide everyone, that has access to it, unlimited means of learning, exploring, and developing; a way to become self-actualised" [26], this promise has fallen far short of expectation. Self-actualisation has created significant challenges for individual and organisation as commonly there is a significant disharmony between them. This is a common problem with technology implementation due to the lack of socio-technical and organisational integration [27]. More significantly, the objectives and outcomes of self-actualisation for the organisation are often so vague that it becomes irrelevant to most frontline workers. For the users of the incident reporting system, the self-actualisation process often means improvement towards perfection. The current electronic incident reporting practice of automated categorisation of incidences does not provide self-actualisation for JMOs. Therefore, a new socio-cultural-technical integrated system will need to provide education and training to the users regarding the incidences. It should also provide direct feedback to individual JMO involved in the incidences in a non-threatening manner to allow self-actualisation, self-development and self-fulfillment. The electronic incident reporting system has the potential to deliver all these while maintaining the confidential nature of the incident reporting system.

In summary, our study suggests a few very important guiding principles for the design of implementation of electronic incident reporting system. These guiding principles:

1. The system has to be mobile and allow reporters to enter incidences during a time that is away from physical threats such as cold and hunger.
2. The system should have minimal classification system and drop-down list.
3. The system should allow narrative account of the event by doctors.
4. The system needs to provide accountability and trust to the users by directly indicating the incident reviewer.
5. The system needs to provide direct feedback regarding the progress of the investigation process to the reporter.
6. The system needs to provide security.
7. The system needs to provide education and training.

Given our understanding of socio-cultural issues through this study, the user-centred guiding design principles presented here will deliver a new electronic incident reporting system which will encourage incident reporting among JMOs. More importantly, the paper presented a socio-cultural-technical integrated implementation strategy, using the Maslow's hierarchy of needs model, which will encourage the involvement of JMOs in the incident reporting system. The success of the new system, with new socio-technical integration will ensure a successful change in the culture and perception of incident reporting among JMOs. This will be a major step forward to build a safer healthcare system!

Conclusion

The current incident reporting system has not achieved its main purpose of identification of incidences and "near-misses" within the healthcare system, especially when JMOs are involved. The implementation of electronic incident reporting system, which does not take end-user requirements into account, has exacerbated the problem. The problems are related to the lack of consideration of socio-cultural aspects of incident reporting, especially the lack of understanding of human behaviours through the lens of motivational psychology. In order to achieve a cultural change in incident reporting and to build a safer healthcare system, we need to develop new socio-cultural-technological integrated solutions. This paper presented a qualitative research which generated in-depth socio-cultural insights into the perception of incident reporting among JMOs. This paper then presented the user-centred design principles through the analysis of the study, for electronic incident reporting system. These principles are:

1. The system has to be mobile.
2. The system should have minimal classification system and drop-down list.
3. The system should allow narrative account of the event by doctors.
4. The system needs to provide accountability by indicating the incident reviewer.
5. The system needs to provide direct feedback regarding the progress of the investigation process to the reporter.
6. The system needs to provide security.
7. The system needs to provide education and training.

These design principles are complemented by the principles for user-centred socio-cultural-technological integrated implementation process. The success of this process will ensure successful cultural changes among JMOs to enhance the safety of our healthcare system.

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Socio-Cultural Issues and Patient Safety: A Case Study into the Development of an Electronic Support Tool for Clinical Handover

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Abstract. This paper describes a case study into the development of an electronic support tool for clinical handover conducted in the Royal Hobart Hospital's Department of General Internal Medicine. By directly involving clinicians as co-participants in the development, and by conceptualising the system to be built as a support tool rather than as a 'total solution' this case study outlines the practical experience of dealing with a diversity of user requirements. The approach involved in-depth fieldwork to understand the factors and their inter-relationships in clinical handover processes. From an analysis of the data generated key issues relating to work processes and potential impacts on patient safety were identified and discussed with clinicians. A support tool incorporating a series of design features aimed at improving patient safety and supporting existing work processes identified as important by the clinicians was developed. Through early and continual involvement of clinicians in the project, this case study highlights how socio-cultural analysis can be translated meaningfully (in terms of the end-users) into systems design. The paper aims to contribute to a stronger recognition within the domain of eHealth of user-centred approach to systems development for patient safety.

Keywords. Socio-cultural systems, clinical handover, information communication technology, health informatics, patient safety

Introduction

The need to 'involve users' in information and communication technology (ICT) projects has become almost a mantra amongst information systems specialists. Information Systems (IS) has increasingly seen its role as bridging the divide between end-users needs and requirements and technological developments. In recent years, a variety of approaches have been deployed to support user involvement including user-centered design; participatory design; prototyping & joint application design; human factor engineering and usability testing. All of these approaches have been used with the aim of improving information systems analysis, design and implementation [1]. In health care,

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information and communication technologies (ICTs) have been recognised as having great potential to generate and transform the working conditions of healthcare professionals and development of a safer system [2]. However, to date there has been only limited success with the utilisation of ICT in the healthcare system beyond clinical treatment and diagnostic tools. Some successes have been reported with clinical decision support tools. These studies have shown improvement in patient safety and clinical performances with the introduction of clinical decision support tools. [3][4]. Many of these successfully implemented systems involve features which assist clinician's workflow [5]. On the other hand, previous studies have reported that 75% of large IT projects in health care fail [6]. From an IS perspective these figures can be partly attributed to both a failure to adequately understand and/or respond to the workflow of health professionals and, a failure to meaningfully involve them as users in the design, development and implementation of these systems.

More specifically, recent investigations into the deployment of ICTs to improve patient safety have revealed alarming outcomes. Han et al (2005) reported on the implementation of a commercially available computerised physician order entry (CPOE) system aimed to improve patient safety [7]. Five months after the implementation of the CPOE system, there was an increase in mortality from 2.8% before implementation to 6.57% afterwards which has been attributed to the lack of socio-technical integration during the implementation process [7].

More generally medical errors remain an all too common problem within the acute healthcare delivery [8]. In Australia, it is estimated that 16.6% of hospital admissions are associated with adverse events [9]. While the statistics varies around the world, the common theme is the unacceptable high level of errors that are costing thousands of lives in Australia [9], USA [10] and UK [11], and other countries around the world. While ICT holds significant promises to improve patient safety, these promises have not been achieved outside research institutions as shown in the aforementioned CPOE example [12].

An analysis of ICT project failures within health care reveals the importance of socio-cultural factors for success [13]. Too often these ICT health care projects are underpinned by problematic 'techno-centric' and/or 'info-centric' assumptions about how ICT benefits will be generated. Technology design processes are often aimed at achieving feature or functional complexity that work well within a controlled laboratory environments but fail in the 'real-world' [13]. Simplistic rhetoric about delivering 'the right information to the right people at the right place & time' [12] also marginalises an understanding of the complexity of socio-cultural factors in making these determinations dynamically in ever-changing circumstances. This gives rise to the need to generate socio-cultural insights into the medical workplace before attempting ICT design and implementation [14]. Following an understanding of these socio-cultural factors, engaging end-users in any design processes will also improve the chances that any system will be adopted and utilised [15]. Unfortunately to date there are few case studies giving guidance on how to generate understanding of socio-cultural factors in health care domains [15], or on the process of translating socio-cultural insights into ICT system design that involves users as co-participants [13].

This paper describes a case study into the development of an electronic support tool for clinical handover conducted in the Royal Hobart Hospital's Department of General

Internal Medicine . This case study outlines the practical experience of dealing with a diversity of user requirements. The approach involved in-depth fieldwork to understand the factors and their inter-relationships in clinical handover processes. From an analysis of the data generated key issues relating to work processes and potential impacts on patient safety were identified and discussed with clinicians. An electronic support tool incorporating a series of design features aimed at improving patient safety and supporting existing work processes identified as important by the clinicians was developed. Through early and continual involvement of clinicians in the project, this case study highlights how socio-cultural analysis can translated meaningfully (in terms of the end-users) into systems design.

1. Project background

The Department of General Intern Medicine (DGIM) at the Royal Hobart Hospital (RHH) has recognised the need to improve clinical handover. As a result, this project was initiated to determine the best way to improve clinical handover and hence patient safety. Handover is 'the transfer of professional responsibility and accountability for some or all aspects of care for a patient, or group of patients, to another person or professional group on a temporary or permanent basis.' [16] A review of the literature regarding clinical handover has revealed a significant assumption that clinical handovers serve to transfer patient information from one team to another [17] [18] [19]. Given the cost-effectiveness and reliability of ICTs in information delivery, many studies and guidelines have therefore advocated the implementation of ICTs in clinical handover. It has been shown that information transfer is much more efficient with the use of ICTs [19]. However, this does not axiomatically lead to improved effectiveness and efficiency of clinical handovers. In fact, the definition of effectiveness and efficiency of clinical handovers are unclear [20]. Therefore, this research project does not automatically assume that the use of ICTs will improve clinical handover. It aims to generate a socio-cultural understanding of the clinical handover process and design strategies to improve clinical handover, which might include ICT implementation.

The DGIM is staffed by five medical units, each consisting of a team of Junior Medical officers (JMOs) - one intern and one registrar, and two consultants. From 0800hrs till 1700hrs, patients admitted under the care of DGIM are serviced by one of the five units. On average, each unit looks after 10-20 patients each day. At 1700hrs, the staffing level is reduced from five units to one after-hours team, consisting of two interns, one resident and one registrar with an on-call consultant providing necessary support. All pertinent patient information or outstanding jobs will be handed over by the five units to that one evening team. The evening team then has to handover the information to the night team consisting of one intern, one resident, one registrar, and one consultant providing on-call support at 2130hrs. The current clinical handover process includes a formal morning handover from 0800hrs to 0830 hrs. Patients admitted by the night team, as well as problems encountered with patients overnight are then handed over to their respective units. Information presented about the patient is verbal with the receiving unit taking down important notes with a pen and paper. Both the evening handovers and night handovers tend to be more informal consisting of a verbal handover with a short list of patient names or stickers which serve as a reminder about their clinical conditions.

2. Methods to obtain socio-cultural insights

In approaching the analysis of socio-cultural issues impacting on medical errors this case study focused on understanding the clinical handover processes. This involved three key phases of work: Literature Review; stakeholder endorsement and fieldwork at the hospital.

2.1. Literature review

Considerable research has been conducted into the factors that contribute to medical errors [21]. Reason's Swiss Cheese Model of medical error draws attention to latent systemic factors in error causation [22]. Analysis of the causes of medical errors has identified physician fatigue as the most important human factor and communication and information availability as the most critical systemic problem [21]. Therefore, given the reliability of ICTs in transferring information and enhancing communication, it is proposed that a possible solution would be to develop an ICT to improve clinical handover.

A review of clinical handover literature revealed that multiple factors affect clinical handovers [20]. While each individual factor is important, it is suggested that the interrelationship of these factors within the socio-cultural, organisational and environmental settings are more important [23]. Information is only part of the problem and hence solely addressing that issue is only part of the solution. A systemic solution to clinical handover is required.

2.2. Stakeholder endorsement

Following this review, the project team commenced a process of acquiring endorsement from stakeholders involved to ensure support at all levels which involved highlighting the problems and negotiating the proposed solutions through clinical case discussions. More specifically, this meant endorsements from:

- Department of General Internal Medicine, Royal Hobart Hospital;
- School of Medicine, University of Tasmania;
- Department of Health & Human Services, State Government;
- School of Information Systems, University of Tasmania.

2.3. Fieldwork

Clinicians were invited to participate in the early stages of the project regardless of their clinical seniority. While the focus was on JMOs as the primary end-users, comments, insights and experiences were also captured from senior clinicians.

The research team utilised two main data collection techniques in the process of familiarisation with the actual practice of clinical handover. Firstly, a total of 50 non-participant observation sessions were conducted over a time frame of between 15 minutes to 45 minutes each during the morning handover and night handover over three extended holiday periods where staff numbers are down to their minimum and adequate handover is extremely important for patient care. Some of these observations were consecutive and some of them were conducted in random to minimise the Hawthorn effect [24] Secondly, 20 semi-structured interviews were conducted individually with both experienced and inexperienced interns, registrars and consultants to gather their perceptions on clinical handover and how they think it can be improved. These interviews were audio recorded and transcribed within 48 hours. Both the observation sessions and the interviews were analysed using open, axial semantic coding, drawing on the principles of grounded theory [24]. The data from the observations and interviews were then reconciled to obtain an in-depth understanding of the clinical handover process. This in-depth understanding was discussed with clinicians at the hospital.

3. Analysis of socio-cultural issues

The analysis of the data collected through observations and semi-structured interviews revealed that there was a significant difference between what was thought to be the handover process and what actually happened at handover. Interviews conducted with consultants revealed that clinical handover was an efficient process with a well formulated structure facilitating adequate information exchange and was attended by all involved and at times included an education component for JMOs. Observations sessions however, revealed that there were multiple factors, including cultural, environmental, human and other factors that determine the structure, attendance and efficiency of the clinical handover process. Norman describes the issue of difference in clinician perceptions and actual observations [24].

Given the differences between the “mythical” handover process and the actual way in which handover was carried out, a decision had to be made as to whether the system was built to address the needs of the “mythical” handover or the actual handover process. Through a thorough brainstorming session, the project team arrived at the decision to build an IT system to support the “mythical” handover process would risk failure because it would not fit in with what was actually done at handover. A decision to build an IT system to support the actual handover process would risk failure because some clinicians might feel that their opinion was not taken into consideration. After much deliberation, it was decided that it would be better to build a system based on the actual handover process as that would serve to better address the safety issues in clinical practice. This concept was then introduced through workshops and a consensus among end-users was analysed. The final decision of building an IT system was obtained through combining the decisions of the project team and end-users.

Through the socio-cultural analysis of the field data, six issues were identified as impacting on patient safety. These include

- Providing an incorrect URN or Patient Name
- Patients missing from on-take list
- Failure to follow up on blood results
- No management plan given
- Patients not getting handed over as required
- Handover information disappearing

4. Systems development: Clinicians as co-participants

The first stage of the study of clinical handover had provided important socio-cultural insights into the problems of clinical handover. It became apparent that previous attempts at introducing guidelines had minimal impact on the clinical handover process itself. It was also obvious through the analysis and interpretation of the data that a well-designed purpose-built clinical handover support tool that integrated socio-cultural factors might improve the clinical handover process and hence patient safety.

The next step in determining the requirements for systems development involved an analysis of 50 handwritten clinical handover messages provided by the clinical handover leader. This was done to identify the minimal field data set required for effective clinical handover.

A series of 6 workshops drawing on the principles of participatory design [23] were then conducted to work through the minimal field data set and IT specifications. These participatory design workshops involved clinicians of all levels but were primarily aimed at JMOs as they were to be the main users of the system. The workshops were conducted through open invitation and based on the principle of inclusiveness. The workshop initially utilised a narrative method to generate ICT design principles and specifications. A whiteboard and marker was used to create a graphical representation of the system. Consensus was obtained through negotiations when there were uncertainties of conflicts regarding the system design. Clinical examples were used and opinions from participants regarding the data requirements, presentation and delivery were documented.

All material gathered from the workshops including participants' responses regarding the system and their comments were documented as soon as possible after the workshop. At the end of the workshop series, the research team had a relatively clear understanding of the ICT design requirements. A simple template of the user-computer interface, fulfilling the ICT design requirement was created and distributed to all participants. Comments were invited in both written and verbal forms. This template forms the basis for the information systems research to generate the information technology design specification.

It became apparent in the workshops that clinicians are not a homogenous group. Some clinicians were very enthusiastic and had great confidence in the implementation of the electronic clinical handover support tool while others were a little more sceptical. Mobile wireless technology was one of the solutions brought up by some clinicians as a potential solution to clinical handover whereas others preferred the traditional pen and paper. Therefore, the ICT design should take into account the heterogeneity of the clinicians and their views on technology. To manage this and to maintain clinician's involvement, we used version management, with a view of designing a future system for handover which could possibly include mobile wireless technology.

The socio-technical ICT design phase has provided significant guidance regarding the socio-technical implementation process in order to integrate properly with the organisation. A web-based system was developed to introduce clinicians to the concept of electronic handover. System testing was carried out by clinicians using real data. This allows clinicians to fine tune the system design and also allows for familiarization of the interface. The electronic clinical handover support tool is offered as a complementary system to the current process. Clinicians are encouraged to use the electronic system but the system is not meant to replace the current handover process.

A trial version of the clinical handover support tool was developed from the design and specifications obtained through the workshops. All doctors were given access to the trial version and they were asked to test the system using real-life data. Comments and feedback from the participants were collected in various forms including email, formal and informal discussions. Modifications were made and repeated testing was carried out based on the comments and feedback obtained to improve the usability and adaptability of the system. End-users were encouraged to use the system in parallel with the current mode of handover as the clinical handover support tool was designed to complement rather than replace the current handover process. Observations were carried out to examine how the system was used in practice.

5. Results and discussion

The socio-cultural and contextual insights generated through our study have identified safety features which were incorporated into the development of the electronic clinical handover support tool. Some of these features were intrinsically linked to the process of clinical handover, as defined by the transfer of information, responsibility and accountability. Other features were outside the process of clinical handover, which through the ICT implementation, created a safe system at the clinical handover as well as at the clinical practice of patient care.

Many of these safety features were made possible through the observations and analysis of written handover notes. More importantly, some these features were not conceptualised by clinicians through the interview process.

5.1. Extraction of patient information from existing systems

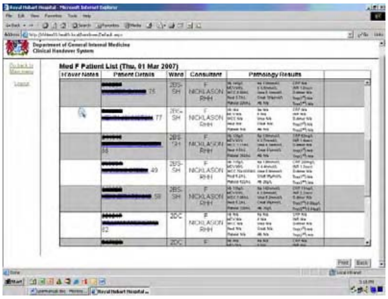
To ensure that there were minimal data entry errors, the electronic clinical handover support tool developed extracted data from two separate information systems – the patient administration system and the pathology system. Demographic information about a patient was extracted through the patient administration system and related blood results were extracted from the pathology system. This information was displayed in a manner which fitted in with the clinician's workflow.

5.2. 24hrs admission list for all admissions

The next safety feature which appears on the main menu is a link to view all admissions under the Department of General Internal Medicine over the last 24hrs. This feature was incorporated because observation sessions revealed that some patients were allocated to the wrong unit and were therefore not seen by a consultant within a reasonable time frame. A comparison of this list with the current patient list in each respective medical unit will ensure that all patients that have been admitted are seen by the treating team within 24hrs.

5.3. Pathology results

Pathology results are the next safety feature that has been incorporated into our system (refer to Figure 1). This feature automatically retrieves the latest results for a particular patient with results released within the last 24hrs displayed in bold. This feature attempts to reduce the number of blood test that has been requested for but not followed up. Clinicians have also indicated in the workshops that incorporating pathology results into the electronic handover support tool will help with their workflow.



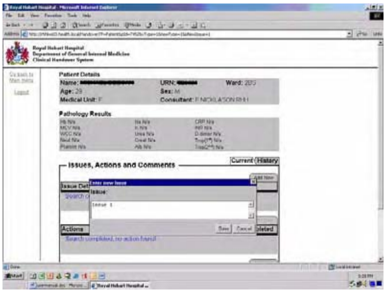
Med F Patient List (Thu, 01 Mar 2007)

H'over Notes	Patient Details	Ward	Consultant	Pathology Results	
	[redacted] 75	2BS-SH	F NICKLASON RHH	[illegible]	
	[redacted] 77	2BC-SH	F NICKLASON RHH	[illegible]	
	[redacted] 88	2BS-SH	F NICKLASON RHH	[illegible]	
	[redacted] 49	2BS-SH	F NICKLASON RHH	[illegible]	
	[redacted] 58	2BS-SH	F NICKLASON RHH	[illegible]	
	[redacted] 82	2DC	F NICKLASON RHH	[illegible]	
	[redacted]	2DC	F	[illegible]	

Figure 1. Patient List with pathology results

5.4. Issues, actions and comments: Continuity of patient care.

The electronic support tool was designed in this manner because data from the observation sessions and interviews have revealed that there is currently no structure in the way handover information is presented. This is an attempt to improve the structure of handover information presented to ensure that there are no missing details. Clinicians are required to enter the handover information in three sections – Issues, Actions and Comments (refer to Figure 2). Issues provide background information about actions that are required. Actions are what needs to be done to the patient and comments provide a management plan or advice relating to an action. For example, Issue – Severe Headache, Action – Computer Tomography Scan, Comments – Neurosurgical review if bleeding, otherwise analgesia. This ensures continuity of patient care.



Patient Details
Name: [redacted] URN: [redacted] Ward:
Age: 29 Sex: M
Medical Unit: F Consultant:

Pathology Results
Hb N/a Na N/a CRP N/a
MCV N/a K N/a INR N/a
WCC N/a Urea N/a D dimer N/a
Neut N/a Creat N/a
Platelet N/a Alb N/a

Issues, Actions and Comments

Enter new issue
Issue:
Issue 1

Search completed, no action found

Figure 2. Patient Handover Details

5.5. *Safety feature 4 – Transfer of responsibility*

Clinical handover apart from information transfer, is also the transfer of responsibility and accountability [13]. Current handover practices do not account for this transfer of responsibility and accountability. The electronic clinical handover support tool requires clinicians to tick off electronically all the actions that have been performed. This provides a proper record of who has done what to which patient.

5.6. *Safety feature 5 – Handover categorisation*

The categorisation feature provides clinicians with an overview of all the patients that have been handed over to them in order of urgency. This creates a sense of situational awareness regarding patient care as well as an overall view of the patients in the wards. Whilst clinicians have been given guidelines regarding urgency categorisation, they are free to exercise their own clinical autonomy to assign urgency. This is especially important as a safety management of uncertainty and personal intuition using electronic systems.

5.7. *Safety feature 6 – Handover alert*

All patients that have an active handover message relating to them will be highlighted both on the patient list and the handover list. These features incorporate the alert of handover messages into the routine of clinical practice, i.e printing of patient list for ward rounds (refer to Figure 1).

Conclusion

This paper has described a case study into the development of an electronic support tool for clinical handover conducted in the Royal Hobart Hospital's Department of General Internal Medicine. It has illustrated an approach to both acquiring a deep understanding of socio-cultural issues and how to meaningfully involve clinicians as co-participants in the development. Conceptualising the system to be built as a support tool rather than as a 'total solution' has enabled better accommodation of insights generated from the experience of dealing with a diversity of user requirements. The approach highlighted that it is important to look at the factors and their inter-relationships which impact on clinical handover processes. An analysis of the data has generated key issues relating to work processes and potential impacts on patient safety were identified and discussed with clinicians. A support tool incorporating a series of design features aimed at improving patient safety and supporting existing work processes identified as important by the clinicians was developed. Through early and continual involvement of clinicians in the project, this case study has highlighted how socio-cultural analysis can be translated meaningfully (in terms of the end-users) into systems design.

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Methodology for analysis of work practice with video observation

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Abstract. Prior to developing and implementing health informatics systems it is essential to acquire information about the work practice. Interviews are often used but they don't always capture important details. In this project we used video cameras to observe the work practice of two medical secretaries at Department of Urology at Århus University Hospital, Skejby. The project was carried out with a clear user influence in all phases of the project. The observation and the analysis focused on interruptions of the work processes, of which we found numerous that we categorized in three different types. The use of video and audio proved to be powerful tools for analysis of work practice, although it is very labor intensive method.

Keywords. Video analysis, work practice, participatory methods

Introduction

When new IT systems are introduced in health care organisations it is often discussed how organisational change can be managed and planned for. Reduction of staff is frequently a desired outcome of the specific plans. As a basis for these plans various analyses of the work flow are usually carried out, often by private consultant companies or planning departments within the health organization. Sometimes the staff participates in generating the needed data.

Workflow analysis can be adequate for focusing on the formal work. The theoretical background for these analyses originates in automated industrial productions, and they are quite adequate for analyzing rational production processes. In health care, however, the staff has special assignments centered on people with many different diseases which constantly change in a non- determined pattern. In addition to all the rational and formal work processes that to a certain extent can be planned and controlled there is a great number of informal and derived processes necessary for keeping/binding the organization together and make the health care activities run smoothly. These processes are difficult to scrutinize by means of a traditional rational analytical framework.

From cognitive studies it is well-known that there is a difference between what people say they do, think they do and actually do and all methods are not adequate for a study of the three levels. Questionnaires and committees may be suitable for studying what the clinical staff says they do. By means of different questioning techniques interviews can uncover what the staff think they do, but to uncover what they actually do it is necessary for a third party to observe the specific work practice. This type of study is known from anthropological field studies and can be very time consuming, difficult and expensive to carry out. Further it must be carried out by researchers who are experienced observers and familiar with the content of the specific health care work.

The aims of the study

The application of video recorders in observational studies of work practice is becoming more common. The necessary technical equipment for recording and editing has reached a manageable price range, it has acceptable physical dimensions, and the operation of the equipment does not require time consuming special training.

The work practice of physicians and nurses has been surveyed in a few projects while that of medical secretaries - to our knowledge - has not been investigated in great detail. The first medical secretary in Denmark was employed in the end of the 1930s with the purpose of assisting the clinicians with their documentation work. In Danish hospitals medical secretaries are employed at department or ward level. Over time they build up knowledge of the medical specialty of the ward in which they are employed e.g. cardiology, ophthalmology, urology, etc. and they apply this knowledge when talking to patients or their next of kin (over the telephone) to assess or prioritize further communication and how urgent it is. They also apply their knowledge when they correct errors in dictations.

Hence their work functions are predominantly supporting the core business and results of their work are usually immaterial and hardly ever leave visible or sustainable traces.

The purpose of this project was to survey and document the most important characteristics of the medical secretaries’ work practice at the urology department at Skejby Hospital. Characteristics that normally remains hidden, if the work practice is surveyed exclusively by traditional interview methods and questionnaires.

The specific research objectives were to use a multi-method participatory approach incorporating focus groups, video observation, and feedback sessions to reveal tacit knowledge

Methods

Observation is, in the western world, mainly based on what we see. Technologies are and have been, since the invention of the camera obscura in the Italian Renaissance, developed in order to enhance our visual perception, to the exclusion of other senses. The digital video-camera is in one sense just another tool that relates to the hegemony of the eye, although sound is present in the recording. Observation with the video reflects, paradoxically, the positivist way of dealing with knowledge and science. But as long as this is taken into considerations in the analysis of what is recorded, emphasis can be given to body language, emotion and the unveiling of tacit knowledge, thereby taking into account the lifeworld in the final conclusions. (Habermas 1981)

In mobile video observation, participating subjects are part of the investigator/ investigated relationship in a particular time and space. This has an impact on the investigated field. Methodologically it means there is a difference between the stationary video observation and the traditional written questionnaires. But there are also certain affinities to the interview as an investigative tool. There is a constant negotiation between the investigator and the field. This negotiation is both situated and reflective involving the empirical data, the interpreter and those interviewed (Kvale 1996).

It is also important to understand that the technical device is an extension, expansion and enhancement of the body, bringing forth properties and qualities inherent in the human body (McLuhan 1964). Within a phenomenological approach the body possesses the capability of 'prelogical synthesis', acting meaningfully and reasonably in any situation and position without any formal reasoning process. And as the American philosopher of technology states: "Technics is the symbiosis of artefact and user within human action." (Ihde 1990) referring to the well known picture by Heidegger: "In driving a nail with a hammer (as opposed to thinking of a hammer), I need not make use of an explicit representation of a hammer. My ability to act comes from my familiarity with hammering, not my knowledge of the hammer." (Heidegger 1977)

In questionnaires and interviews we are recalling and remembering situations and things, which means we are "thinking of the hammer" and analysing in an empirical analytical way. The method of observation is entangled with the world and seeks to reveal this very same aspect of entanglement in the investigated world. The risk is that, many blind spots will occur and the unseen and the unheard may remain secret to the observer. But as Martin Heidegger writes in Holzwege (1950): "Wood is an old name for forest. In the wood are paths that mostly wind along until they end quite suddenly in an impenetrable thicket. They are called "woodpaths". Each goes its peculiar way, but in the same forest. Often it seems as though one were identical to another. Yet it only seems so. Woodcutters and foresters are familiar with these paths. They know what it means to be on a woodpath." (Heidegger 1993) This means that as we proceed in the world we are constantly on woodpaths, which are not dead ends, but unpredictable and out of mechanical control. We are forced to enter into unknown territory and to retrace our steps in order to understand the meaning. If we, like the woodcutter, are familiar with the path, we will know by intentions and experience how to act properly on that path.

Mark B. N. Hansen writes in *New Philosophy for a New Media* that: "…embodied aesthetic response appears to undergo a certain emancipation from the technical image: instead of simply registering the force of the image, here the spectator's bodily response seems to move beyond a strict correlation with the image and thus to become the vehicle for an affective experience of itself" (Hansen 2004: 239-40) We are talking about a quality in the video-image that deals the temporality of body in space, which goes beyond the mere chronological documentation and registration of events and situations. This means that the classical setup for registration and documentation with video cameras, which consists of a total covering of physical space and a clock running somewhere in the image, by no means capture the body as a "vehicle for an affective experience of itself". But merely register events and situations in a machinic and technical manner. The video replaces in this case observants with stop-watches and notebooks, becoming a relatively economic device for surveillance and monitoring.

This study has a different aim which means that the methodological setup is quite different. In the following we will describe the actual setup.

To avoid data overload of the specific work practice, it is important to define a focus for the survey and that it is selected in close cooperation with the involved secretaries. Afterwards a first interview is conducted to get an impression of the character of the work, and the most salient cooperative relations. The interview contributes data about the secretaries' work practice, and in the dialog elaborating questions can unveil what they think their work task are about. The interview takes place at the ward in the hospital, and the physical surroundings and patterns of movements of the secretaries are observed at the same time. During the interview the secretaries move around as they point out and talk about the various artifacts used in their daily routines. During the interview the potential camera angles are decided on, and the important actions of the day are described: when do the patients arrive, when do the consultant and the nurse who are part of the "booking team" usually drop by to discuss that day's operation program. At the end of the interview the specific date for the video recordings are agreed on.

On the recording day the video team shows up at the same time as the secretaries – they put on their white coats and commence recording immediately. In this project three video cameras were used: one camera followed the first secretary Christina, the second camera followed the second secretary Lene, and the last camera was used to follow spontaneous situations, the interaction between the two secretaries and the situation in general.

The white coats were used in order not to distract daily routines and to blend in with the staff, and the cameras were kept close to the body, instead of in front of the face.

Figure 1. Video recording of the two secretaries work practice

A debriefing among the camera team was held immediately after the recordings and the observers wrote down the most important highlights and key episodes on yellow PostIt-notes ®. These notes are combined and ordered in a sequence so they are ensured significance in the succeeding analysis.

Recordings from one day result in almost 20 hours of video tape, which is rendered to a computer hard disk, and at the same time one person looks through the entire sequence. While watching, the person writes down a story board and timestamps the important episodes. The story board is compared to the result of the debriefing and the noted episodes are flagged and time stamped as well. It often occurs that by watching the raw material new episodes have appeared to be so significant and important that they are flagged off as well.

The next step is to edit the tapes down to approximately 45 minutes duration. A workshop is organized between the involved staff from the department and the video team, the recordings are presented, and the content discussed. The participants from the hospital department are observed in order to register their reactions to work practices they have been unaware of, and hence explicitly react to. During the workshop the video team had a number of questions for elucidation of specific episodes in the work – situations and episodes which are not obvious to outsiders. The secretaries also pointed out common situations from their daily work that are not sufficiently represented.

On the basis of the results from the first workshop the material is reedited and shortened to approximately 20-25 minutes. The video sequences are presented to the staff to get their last comments, which are incorporated into the final version of the video. This video is now considered approved by the involved parties and can as such be a constituent part of a further analysis.

Results

The initial discussion with the secretaries at the Department of Urology, Aarhus University Hospital, Skejby concluded that it should focus on interruptions. It was a daily burden felt by everyone, but it was difficult to explicate and communicate. Furthermore there was a need to document the work carried out, to be able to design the future work practice and the work tasks of the department.

The interviews described the multitude of work tasks in the department. Telephone communication was clearly dominating – patients call to change appointments, and to ask questions about tests or operations, other departments call to change booked appointments or to request information on patients. Christina participates in the group that handles operation bookings, she constantly updates the information in “the big black book” also in accordance with bookings in related departments. Additionally she sends messages and general information material to patients, writes the patient records from the physician’s dictation, and keeps an eye on the reception desk in case the other secretary Lene, is not be present when patients arrive. Lene is in general the first person to welcome the patients when they arrive at the Department. She is registering that the patient has arrived, checks that the patient has signed the informed consent form, she enlist the patient’s medicine in the CPOE system, hands out urine test tubes, explain to the patient what the procedures are, etc. Furthermore Lene enters the physician’s dictation in the patient record, and sees to that the patient record belonging to the arrived patients always are ready to be picked up by the next available physician who is going to examine the patient.

The video recordings show all the details in the daily work practice and the observations show that the secretaries work on several patients at the same time. It is very rare that a work task with one patient i.e. writing in the patient's record from a voice recorder is performed without interruptions – interruptions which often makes it necessary to temporarily close the task and computer window they are working in, just to open an new window to work on another patient.

Discussion

We have not quantified phone calls or interruptions. It would not be sensible as long as there is no clear classification system for calls or interrupts. We have made a first draft of a classification system for the interrupts we have seen on the video recordings. There are three basic types of interrupts:

Physical interrupts – where the interrupted person has to move physically to complete an alternative work task – e.g. go to the record archive to fetch a record.

Professional interrupts – bring about a shift in the professional focus – e.g. from writing in a patient record from a voice recorder to complete a rebooking of a patient.

Emotional interrupts – bring about a shift in the mental focus – e.g. a telephone call from an elderly patient who has to change a booking because he had fallen in the bathroom during the night calls for sympathy, while a new call immediately following from a young woman who jubilantly announces that she has finally become pregnant and wants to know how it influences a planned operation, calls for a different kind of empathy.

Finally we have seen many situations where the secretaries are carrying out more than one work task at the same time – so called multitasking. While Christina for example is writing in a patient record she is at the same time participating in an ad hoc meeting with the operation booking team discussing a specific patient right behind her. It is indicated because she removes one of the headphones from the ear so she can hear what they are talking about while she is still typing.

Conclusion

Video observation has proven useful for the display and analysis of work practice. This project clearly demonstrated how observation of the daily work practice, by recording pictures and sound, has made it possible to discover, analyze and document the specific content of the work practice of the medical secretaries at the Department of Urology, Aarhus University Hospital, Skejby. The gained insight in how the work practice often is interrupted, provides a foundation for further qualitative studies, and offers a valuable input for designing future changes in the work practice.

The method used for this video-based observation study is very labor intensive, it is very time consuming to watch 20 hours of video to make a story board. But it is indispensable to get into the details of the complex work practice. We used three cameras, it could be considered to reduce the number, but it will decrease the quality of the data capture remarkably. A reduction of the number of cameras will make it necessary to focus the observation and the analysis significantly.

At the same time a reduction of cameras and a thematic/analytical narrowing will result in a field dependency and hence increase the risk that the reality of the final video just mirrors the knowledge, we already obtained through the use of conventional methods where we rely on what people say they do in their daily work.

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Modelling the Effect of Limited or Vulnerable Resources on the Use of Computerised Hospital Information Systems (CHISs) in South Africa

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Abstract. A conceptual model of computerised hospital information system (CHIS) use has been developed, based on the results of case studies in four South African regional (level 2) hospitals, interviews with local experts, and related work on modelling and evaluation of health information systems. In addition to factors within hospitals, factors which reflect the decisionmaking and resource allocation processes at provincial level have also been included in the model. The applicability of the model is demonstrated through an analysis of the effects of limited or vulnerable resources on CHIS implementation and use at hospital level. Some potential approaches to overcoming these effects are suggested.

Keywords. Hospital information systems, evaluation, model, limited resources

Introduction

Case studies of the use of basic computerised hospital information systems (CHISs) in four level 2 hospitals in South Africa (SA) have shown that access (or lack of access) to resources to support the CHIS implementation is a significant factor in the effective use of CHISs in the study hospitals. A conceptual model of CHIS use developed on the basis of the study results describes the relationship between access to resources and other factors which affect the use of CHISs in these environments. The aim of this paper is to demonstrate the applicability of the conceptual model in analysing the effect of limited or vulnerable access to resources on CHIS use.

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1. Background

1.1. Context

The implementation of CHISs in environments with limited access to the resources required to support such systems (skilled personnel, physical infrastructure, finance for maintenance and support, etc) is a particular challenge. Where resources are available, they could also be vulnerable to disruption, as when the single CHIS support person is unavailable for a period without warning. Lack of resources, or the potential for lack of resources (e.g. at the end of a donation period or a funded project such as the SA hospital revitalisation project) have to be taken into account, both in the development and implementation phases, and in planning for the sustainability of information systems [1]. The case studies conducted for this project showed that the study hospitals are environments of limited or vulnerable resources (LVR) for CHIS implementation and maintenance [2]. A recent study of eight public hospitals in South Africa described the hospitals as institutions under stress, due to lack of personnel and other resources [3].

In the SA public healthcare sector, decisions about CHIS selection for the hospitals in a province are made at provincial level. CHIS contract administration, as well as allocation of resources for CHIS implementation and maintenance also take place at provincial level. The primary aim of this process is to ensure consistency and interoperability between CHIS implementations and facilitate the deployment of related personnel across a province. However, this also means that, in practice, hospital staff are unlikely to have any direct input into the choice of a CHIS, but are required to use and manage and maintain the CHIS at hospital level. This is similar to the situation in New South Wales, Australia, described by Southon and colleagues [4], where common selection criteria were developed for all the public hospitals in one State.

In this paper it will be argued that the context of limited or vulnerable resources affects CHIS use. Therefore, this context should also be taken into account explicitly in CHIS requirement specification, selection, adaptation and implementation.

1.2. Related projects

The model of HIS (health information system) implementation developed by Korpela and colleagues for the INDEHELA-methods project [5], the ITPOSMO model of Heeks and colleagues [6], and the IS success model of Ballantine et al [7] are among the models reviewed to date which specifically take account of context, although none of them specifically addresses the issue of limited and vulnerable resources for IS and HIS implementation and use. DeLone and McLean postulate in their revised model of IS (information system) success [8] that IS success can be described in terms of information quality, system quality, service quality, the extent to which the IS is used (or there is an intention to use it), the degree of user satisfaction with the IS and the net benefits to an organisation of the use of the IS. The model does not specifically address the context in which an IS is being implemented, but the authors note that context must be taken into account in any analysis.

The conceptual model of CHIS use developed in this project [2] incorporates resources as a factor both explicitly ('allocation of resources') and implicitly (e.g. in relation to system performance (linked to resources for system support, access to equipment, access to bandwidth, etc), and knowledge and understanding of CHIS (linked to resources for training)).

Resource availability is incorporated in the 'bowl' model of HIS context of Tiihonen and colleagues [9] in terms of 'infrastructure', 'economy' (finances) and 'human resources'. Braa and colleagues [10] analyse requirements for HIS sustainability across developing countries, taking account of scarcity of resources among other factors, and Piotti and Macome [11] highlight the need for multiple changing context factors to be taken into account in planning for the implementation of ICT (information and communication technology) to support healthcare in Mozambique. Jayasuriya [12] proposed a contextualist framework for analysing health services in the Philippines, concluding that 'organisational, environmental and cultural issues' must be taken into account, especially in transferring information systems from one environment to another.

2. Methods

Data for this study were derived mainly from case studies at four secondary level public sector hospitals in South Africa using the same CHIS [2]. Data obtained from hospital case studies were complemented by insights on CHIS implementation and sustainability gained from interviews with South African HIS experts and from the literature on context issues which affect HIS use, as described in section 3.2.

The aim of the case studies was to gain an understanding of factors associated with perceptions of success or lack of success of the CHIS implementations at the study hospitals. A combination of observation of the CHIS in use and semi-structured interviews with representatives of hospital management (clinical, nursing and/or administrative), specialist information management personnel (if present), case managers responsible for co-ordinating services for any private patients in the hospitals, and CHIS end users was used to obtain data for the study. A standard set of questions was used as a guide for all interviews. Between four and eight interviews were conducted at each study hospital. Study hospitals were selected on the basis of accessibility, and in order to obtain a set of results which is broadly representative of conditions in district and regional hospitals in SA in which a CHIS has been implemented. The study hospitals have approximately 400 beds each, with similar management structures. Two of the hospitals are situated in a major urban centre, one is approximately 100 km from the urban centre, and one is approximately 400 km away.

The CHIS in use has limited scope: Admission/Discharge/Transfer (ADT) and billing modules, and is therefore used in conjunction with other manual and computerised information systems to provide the information necessary to support the management of the study hospitals. Since the CHIS makes only limited provision for the capture of clinical data, and the clinical data collected does not cover all patients, the CHIS data are used only to a limited extent by clinical personnel at the hospitals.

3. Results: An extended conceptual model of CHIS use

3.1. Conceptual model of CHIS use at hospital level

A conceptual model of CHIS use developed on the basis of case study results identified factors which are associated with CHIS success or lack of success at the level of individual hospitals [2]. The conceptual model developed in the first phase of the project has been extended to take account of some of the context factors at provincial level which could affect CHIS success (see figure 1).

This conceptual model of CHIS use has followed the approach of models such as those of DeLone and McLean [8] in describing factors associated with IS success. In this model, 'effective use of CHIS and/or CHIS outputs' is a key desired outcome of the CHIS implementation. No attempt is made to describe CHIS success completely through this model, but effective use is proposed as an important requirement for CHIS implementation. A recent paper by LeRouge and colleagues [13] proposes the concept of 'use quality' as a reflection of the usefulness of an information system, especially to members of the hospital management. The term 'effective use' has been used in the conceptual model to reflect a similar concept. For the case studies, 'effective use' was assessed in terms of issues such as the correct use of the CHIS by end users, the extent to which information from the CHIS was used to support routine management decision-making, and whether the CHIS was used directly by any members of the hospital staff who were not required to do so in terms of their job descriptions.

'Perception of usefulness of the CHIS', and 'management commitment to ensuring CHIS success' were identified as key factors at hospital level influencing the effective use of CHISs. In the case studies, these were the factors which varied significantly between hospitals, and among different users within hospitals. For example, at one of the study hospitals, the hospital manager perceived the CHIS as resulting in little benefit for the management of the hospital, while the case manager at the hospital (who is responsible for ensuring accurate and complete billing for private patients at the hospital) perceived the CHIS is being very useful in supporting the management and billing of private patients.

At hospital level, the following factors were identified as affecting perception of usefulness of the CHIS:

- Knowledge and understanding of CHIS ('knowledge');
- Appropriateness of CHIS design ('design');
- CHIS performance ('performance');
- Availability of (hospital) resources for implementation, related training and ongoing support of the CHIS ('hospital resources').

All these factors rely to some or other extent on the availability of resources to ensure that the related functions, such as user training (knowledge), adaptation of the CHIS to meet local user requirements (design), and the allocation of human resources to ensure the satisfactory performance of the CHIS (performance) are carried out.

3.2. Extended conceptual model of CHIS use: factors at provincial level

The hospital-level factors reflect the CHIS life cycle phases of system implementation and use. Provincial level factors have been included to reflect the provincial role in decisionmaking about CHIS selection, and preparation for implementation, including the adaptation of the CHIS for use in SA (district and regional) hospitals, as well as ongoing implementation and maintenance.

Factors identified at provincial level (i.e. external to hospital level) which could affect the success of CHIS implementation include

- CHIS supplier knowledge and understanding of the environment;
- CHIS software fit with user requirements;
- Organisational and contractual mechanisms;
- Resource availability.

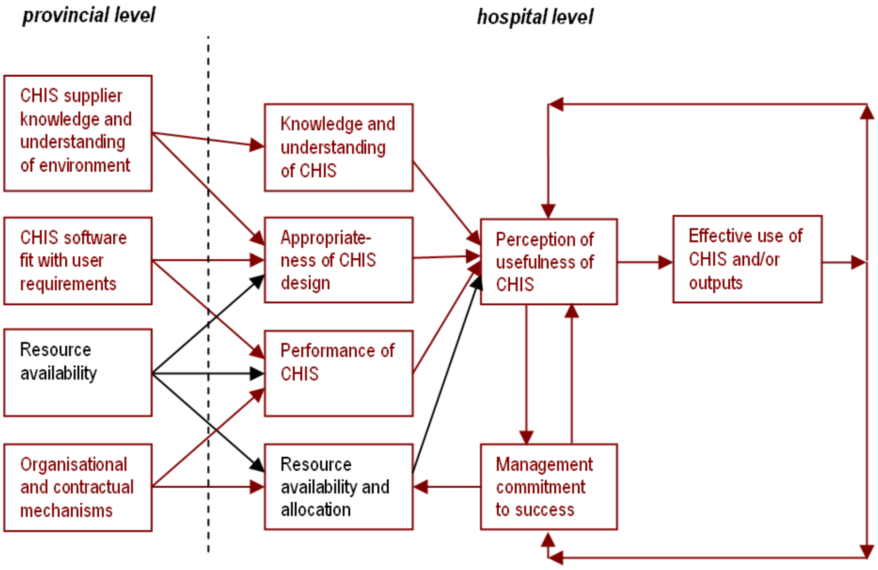

Figure 1. Extended conceptual model of CHIS use

3.2.1. HIS supplier knowledge and understanding of environment

Anecdotal evidence from South Africa suggests that one of the factors which affect the potential for CHIS success in public sector hospitals is knowledge and understanding of the SA public healthcare sector of the CHIS supplier/developer. A representative of a long-term supplier of CHISs in South Africa, for example, has identified applicability (meeting local user requirements), maintainability and cost as being areas in which locally-developed software products are likely to have an edge over products developed outside the country.[2] This factor affecting CHIS use will be investigated further in the next phase of this project.

3.2.2. CHIS software fit with user requirements

Characteristics of the CHIS such as the degree of fit between the CHIS software and user requirement specifications, and between the organisational environment for which the CHIS software was designed and the organisational environment in which it will be implemented can have a major effect on the use of the CHIS at hospital level. Broadly, this factor corresponds to the 'conception-reality gap' between the design of an information system and the potential for that system to meet the needs and capabilities in the (hospital) environment identified by Heeks and colleagues [6]. In the information system use literature, the related concept of task-technology fit has been extensively examined [14, 15]. In their analysis of the problems which had arisen in a CHIS implementation in the Limpopo province of South Africa, Littlejohns and colleagues [16] identified the difference between the environment for which a system had been designed and the environment in which it was being implemented as one of the factors which complicated the South African implementation. In the Australian case reported by Southon and colleagues [4] it was these organisational issues which were among the most significant factors leading to the failure of the CHIS implementation.

3.2.3. Organisational and contractual mechanisms

Even allowing for the context factors above, there are still situations in which problems arise with CHIS implementations, which could be due to the fact that organisational and contractual processes have not been established to facilitate and enable the CHIS implementation, including contractual arrangements with CHIS suppliers; policies and standards for CHIS acquisition; and mechanisms for ensuring local sustainability of the CHIS implementations. For example, once the decision has been made to acquire a CHIS, it is necessary for the purchaser organisation (the province, for SA district and regional hospitals) and the user organisation (hospitals in which the CHIS is implemented) to ensure that the contract with the CHIS supplier includes service level agreements and clear guidelines and timeframes for processes such as customisation (application software changes which do not require reprogramming) and adaptation (application software changes which do require reprogramming). This aspect of the acquisition and implementation process is especially crucial in cases where the CHIS supplier is based outside the implementing country and all or some of the software modifications are not being done within the province or the country. Unregulated, the software modification process can result in increased resource requirements due to large costs and long delays. This factor will be investigated further in subsequent phases of this project.

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[2] Interview with Chris Stevenson of Delta 9 reported in ICT World online newsletter, Issue 199, August 2006 (www.ictworld.co.za).

3.3. Resources

In this extended conceptual model of CHIS use, availability of resources for functions such as system adaptation, user training, system maintenance, ensuring the quality of the data in the system, and ongoing development/enhancement of a CHIS are explicitly identified as factors associated with CHIS use. There are two 'resource' factors in the model: resource availability at provincial level, and hospital resource availability and allocation (see figure 1). Of particular importance in the study environment is the fact that access to resources is vulnerable, since resources could be subject to disruption (e.g. due to the resignation of a key member of the support personnel) or termination (e.g. due to the end of project funding).

3.3.1. Resource availability at provincial level

Resource availability at provincial level refers to requirements for resources at multiple stages, including resources for the preparation for implementation at hospital level in terms of adaptation of the application software to meet local needs and the provision of the required equipment and infrastructure, and resources for the ongoing maintenance and support of the CHIS after implementation. Availability of resources for the development of skills related to effective CHIS use is a critical component of this factor. In terms of the extended conceptual model for CHIS use, resource availability at provincial level influences not only resource availability at hospital level, but could also influence the performance of the CHIS. The appropriateness of the CHIS design at hospital level is influenced in the sense that CHIS adaptation to meet hospital needs could be limited by lack of access to the resources required to effect the changes. Hence, changes and/or limitations in the availability of resources at provincial level can have major knock-on effects at hospital level.

During the interviews and case studies, limitations of resources of various kinds emerged as a recurring theme. Two of the interviewees interpreted the problem of outstanding CHIS adaptations (i.e. adaptations identified by users as being required prior to system implementation in one or more hospitals) as being due to insufficient resources being made available for this function. Southon and colleagues [4] also identified this as one of the problems leading to the failure of the CHIS implementation which they analysed. Case study hospitals all experienced limitations of resource availability for both hardware and software system support, the most glaring of which is the unavailability of support outside office hours.

The very limited number of skilled personnel available to provide support for the CHIS implementation at provincial and hospital levels was identified as a concern in all study hospitals and by all interviewees.

3.3.2. Hospital resource availability and allocation

The availability of hospital resources for implementation, training and maintenance of the CHIS at hospital level is modelled as one of the factors which affect perception of usefulness of the CHIS at hospital level. In terms of this model, available hospital resources are a reflection both of resource availability at provincial level (e.g. resources available to hospitals for infrastructure and/or application software support in terms of provincial service level agreements with service and system suppliers) and of resource availability at hospital level from hospital resources.

The allocation of hospital resources to support the CHIS implementation and for ongoing development and extension of the CHIS at hospital level is modelled as a reflection of hospital management commitment to ensuring success of the CHIS implementation. 'Management commitment' influences 'perception of usefulness' in this model. Positive user perception of usefulness' could also persuade management to commit resources to ensure the effective operation of the CHIS. Since 'perception of usefulness' reflects user attitude to the CHIS, this two-way link reflects a connection between management and user attitudes to the CHIS (noting also that members of management who use CHIS outputs could be among the 'users').

Availability and allocation of hospital resources ('hospital resources') has been identified as a separate factor to reflect differences identified between study hospitals, especially in relation to the allocation of hospital personnel to information management (IM) functions. There were striking differences between the study hospitals in the allocation of personnel resources to ensuring the effective use of the CHIS: The medical superintendents of two of the hospitals had assigned specific responsibility for the preparation of management reports, based on data from the CHIS and from other systems, to full-time clerks responsible directly to them. At a third hospital, the responsibility for preparation of management reports was divided among members of the management team, and the staff member responsible for reception and fees office staff, since the person previously responsible for this function had had to be moved to another position. At this hospital, the hospital manager, the most senior administrative staff member, was responsible for the final collation of hospital reports required by the provincial department of health. At the fourth hospital, an information manager had been appointed at senior management level to take overall responsibility for all reporting for the hospital. Comparing the study hospitals, the degree of user satisfaction with the CHIS seemed to correlate directly with the allocation of hospital personnel time to ensure accuracy and completeness of the data on the CHIS. At the hospital at which there was no full-time person responsible for data management, there was the greatest degree of dissatisfaction with the CHIS, and the impression gained by the researcher was that there was less management commitment to CHIS success than at the other study hospitals.

Allocation of hospital resources for the extension or further development of the CHIS at the hospital was also included in this factor as a reflection of management commitment to ensuring the ongoing usefulness and use of the CHIS at the hospital. Two of the study hospitals have been included in the national revitalization programme for hospitals, in terms of which additional funding is made available for physical and organizational development of a hospital, typically in a three-year programme. Hospital management have some discretion in terms of allocation of financial resources for organizational development. At one of the study hospitals, the hospital management made the decision to purchase an additional module of the CHIS from these additional resources, while they were available.

Jacucci et al [17] identified the need for resources to ensure the local sustainability of an externally-chosen IS. They found that the effectiveness of this process depends on various factors in the local hospital environment, including some of those identified in the case studies, such as the extent to which internal hospital resources are deployed towards ensuring that the CHIS is used effectively for the benefit of the hospital in the first instance, and knowledge and understanding of the CHIS among hospital personnel.

4. Discussion

The analysis of the conceptual model of CHIS use in the preceding sections demonstrates the interpretation of results from the case studies, from targeted interviews and from the literature, through the lens of a model. The model takes account of factors which reflect the context in which CHISs are implemented, recognising that context has a major effect on CHIS implementation and use. Specific analysis of the 'resource' factors affecting CHIS success has highlighted the importance of taking resource factors into account if progress is to be achieved towards the successful implementation of CHISs in LVR environments.

The experiences at some of the study hospitals demonstrate also that it is possible to achieve success in CHIS use despite limitations of resources. For example, the fact that the CHIS in the study hospitals has proven to be robust and stable has enabled the hospitals to use the system despite the very limited resources available for hardware and software support. In one of the study hospitals, distance from the support services (400 km) was partly offset by the arrangements that had been made for local hardware support, and for the local hardware support service provider to assist with software problems wherever possible, in telephone consultation with the software support personnel. Jacucci and colleagues [17] demonstrated how the pooling of skills within the hospital, and strong management support, have made it possible to achieve successful implementation of a different health information system in a rural hospital in another SA province. One of the interviewees described another hospital in which strong management support had offset limitations in the scope and functionality of the locally-implemented CHIS to the point where the CHIS had become an essential management tool in that environment. Further examples of such best practices, and the local factors which contribute to them, will be sought in a planned survey of district and regional hospitals.

The following tentative proposals are made for coping with the limitations of resources in many CHIS implementations, based on the results to date of this project:

- Management and end users require the best possible understanding of the capabilities of the CHIS to enable effective use of the available functionality. At all the study hospitals, members of the management team expressed concern about their own limited understanding of the CHIS, and the lack of opportunity to enhance their understanding of the CHIS.
- Management support for and ongoing commitment of resources to the CHIS implementation, and efforts to ensure data quality and consistency in particular, is a key factor in ensuring effective CHIS use within a hospital.
- Appropriate contractual and service level agreements are essential to ensure that ongoing hospital needs are taken into account in CHIS implementations.

5. Conclusion

The analysis of this conceptual model of CHIS use demonstrates that, especially in environments where access to resources is limited or vulnerable, availability and allocation of resources are among the key factors which affect CHIS use. Further work is planned to support the refinement of the conceptual model, mainly through a survey of level 1 and level 2 public sector hospitals in two provinces in South Africa. The analysis of the results of the planned survey should provide further rich data to contribute to modelling of CHIS use in hospitals. Attempts will be made at that stage to assess the extent to which the results of this study could be generalised to similar hospitals within and beyond South Africa, and to the implementation of CHISs in hospitals other than public sector level 2 hospitals.

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