CONTEXT SENSITIVE HEALTH INFORMATICS: MANY PLACES, MANY USERS, MANY CONTEXTS, MANY USES

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Context Sensitive Health Informatics: Many Places, Many Users, Many Contexts, Many Uses

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Theories and Methods for Context Sensitive Health Informatics

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Abstract. Context is a key issue when designing, implementing, and evaluating health information technology. Advanced and well-designed systems may not achieve desired outcomes because of complex contextual issues, and unintended consequences are often reported in the literature. The conference introduced in this article integrates sociotechnical and human factors based theories and methods for analysis and evaluation of complex health information technologies in diverse environments demanding high context sensitivity.

Keywords. Context, sociotechnical, human factors, health information technology

Introduction

In Greek mythology Procrustes was a rogue smith and innkeeper who lived in Attica. He invited passing strangers in for a pleasant meal and a night's sleep in his iron bed. He told his guests that his unique bed had a length that exactly matched whoever lay upon it. However, he did not reveal his methods to achieve this: if the guest was shorter than the bed he stretched him by hammering or racking the body to fit. If the guest was longer than the bed he would chop off the guest's legs to make him fit. This was a very brutal way of enforcing a "one size fits all" principle, which ended. Theseus, the hero, captured him and "fitted" him into his own bed.

The conference on context sensitive health informatics is not going to be the Theseus who can free the world from the "one size fits all" syndrome that we have experienced in health informatics, but rather a humble attempt to bring forward examples and experience on how we can analyze and solve some of the contextual problems we encounter in the design, implementation and use of health informatics systems.

The health care systems around the world are all in a transition state trying to adopt technologies in order to deal with the problems of an aging population, an increase in number of chronically ill citizens and a limited amount of resources. However, while individual countries have made advances in developing innovative health informatics systems in response to local contexts and healthcare needs, these innovative advances have not always been exported to other countries to enable adaptation to other systems of care. Important innovations are coming from both developed and developing nations and differing countries around the world are emerging as leaders in health informatics

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design. These leaders are challenging other countries to use health information systems in new contexts to address the challenges of providing healthcare. Despite our cultural and geographical differences we are all united by the desire to improve the safety, access and quality of healthcare delivery. Therefore it is essential that we learn from each other and use our collective experiences to support the design of innovative new health informatics systems.

Healthcare is taking place in many different locations and the information necessary to provide care must be present at these places. Many different professionals use this information to do their job, and as a relatively new phenomenon, patients and citizens have become important users of information regarding their own health. As a further contribution to this complexity, it is obvious that the many users use the information for different objectives. The papers in this volume all concern how health informatics systems are developed, implemented and evaluated in a complex environment of many places, many users, many uses and in many contexts. The papers can be grouped into four themes described below: (a) different users in different contexts, (b) evaluating for context through usability testing and ensuring patient safety, (c) organizational and social issues in different places, and (d) understanding different contexts using theory.

1. Different Users in Different Contexts

A number of papers in this issue look at users that work in differing contexts and how this affects user needs, requirements, adoption and satisfaction with the systems they use. Anderson et al. take a global perspective to this issue by directly examining the challenges, consequences and mitigation strategies in developing *Marketable eHealth Systems* that lead to an efficient research and development process, an integration of all stakeholder interests and facilitate design within the context of regulatory requirements [1]. Parv et al. [2] consider primary care physician users in office, clinic and in-patient settings (i.e. differing contexts) and their user needs where e-Prescribing is concerned. Here, the work describes the outcomes of a survey study that focuses on the national Estonian e-prescribing service and the medication management tools that might be used by primary care physicians. Griffith and colleagues' [3] work describes how physicians are pressured to order diagnostic imaging services for patients and how decision support systems could be used in the office or clinic context to facilitate discussion between patients and physicians about when to/when not to order diagnostic imaging tests. Monkman and Kushniruk [4] extend the focus on users beyond that of physicians to that of consumers who use differing types of health information systems. The authors describe how these technologies can be used by consumers to manage their own health. Here, the researchers purpose a model of consumer health information system adoption. The authors suggest that usability and usefulness influence consumers' adoption, value and successful use of consumer health information systems. Solvoll and colleagues [5] focus their work on alarms and how they influence nurses', patients' and other healthcare actors' communication patterns in in-patient contexts (i.e. hospital). They examine the use of alarms in healthcare settings and how they can be improved to help enhance communication among nurses, patients and other healthcare professionals. Cummings et al. [6] employ a country context approach when considering how nursing informatics is being taught in Australia, Canada and Denmark. The work looks at the historical influences and future directions and strategies towards incorporating nursing

informatics into undergraduate curricula in three comparable countries. Lastly, Borycki and others [7] examine nurse practitioner perspectives regarding the impacts of introducing electronic medical records into their work in primary care (e.g. clinic context). Here, the research describes the improvements that have arisen from introducing the technology to the nurse practitioner workplace as well as the challenges that still remain in customizing electronic medical records to fit nurse practitioner work.

2. Evaluating for Context through Usability Testing and Ensuring Patient Safety

There have been a number of advances in the development of methods for evaluating the impact of context on usability and safety of healthcare IT systems. In this issue Marcilly and colleagues [8] describe a trend towards the use of evidence about usability engineering in healthcare and discuss evidence based usability practices that accrue from gathering, comparing and synthesizing publication findings in this area. Lesselroth and colleagues [9] describe a methodological approach to evaluating a medication reconciliation and allergy review kiosk that applies and integrates clinical simulations with heuristic evaluation in the triangulation of usability findings and evidence. An area that has remained relatively unexplored in the published literature has been the development of evidence-based coding schemes for analyzing usability data in healthcare. Kushniruk and Borycki [10] in their paper provide a practical, theory-based coding scheme for analyzing video and audio recordings resulting from usability testing and clinical simulations. In a different methodological direction, Kaltoft et al [11] describe the dual use of a decision quality measure to explore impact of systems at both the level of higher-level feedback as well as impact at a personal level. Using the MyDecisionQuality instrument they show how individuals can in an online survey contribute feedback to providers as well as lead to personal benefit. At the level of workflow processes, Wawrzyniak and colleagues [12] describe their work in analyzing and improving medication review processes using human factors approaches, including interviews, shadowing and video recording. Closely related to the work being conducted in human factors analyses is research on improving the safety of healthcare systems and two papers in this issue directly address this area. Senathirajah [13] describes a new method for designing user interfaces for healthcare information systems where users themselves have control of the design by applying a modular composable approach. The implications of this approach to the safety of healthcare systems are explored by Senathirajah. Finally, in a paper by Liang and Gong [14] the application of a text classification system (using K-nearest Neighbor classifier) is explored as a way to analyze reports about patient safety events. Such automated approaches will become more important as the number of reported incidence of technology-induced error grows over time.

3. Organizational and Social issues in Different Places

While much of our system design efforts focus on the technology per se, there is also an increased realization that organizational and social issues are a key consideration in how we design and evaluate health information systems. In this issue Borim et al. propose an evaluative method that integrates evaluation approaches for software quality and approaches specific to the health domain [15]. Cornett and Kuziemsky look at is-

sues pertaining to implementation of team based workflow. Specifically, they highlight how information issues and contextual factors may be an underlying cause of implementation challenges for team based workflows [16]. Johansen and colleagues studied quality-assurance work conducted by medical transcriptionists in the production of medical records and how it impacts the design of an electronic patient record (EPR) system [17]. Their findings suggest that corrections and quality-assurance tasks done by medical transcriptionists need to be compensated for as part of EPR design. Kaufman et al. look at the problem of clinical workflow as a cause of usability problems and suggest how quantitative methods of analysis can yield critical insights in robust designs that better support clinical workflow [18]. Mather and Cummings look at the mobile learning paradox and how healthcare work redesign must include learning and teaching that supports professional identity formation of students during work integrated learning [19]. Petersen points out that while e-health research is often focused on development and implementation there is a need to consider IS maintenance and management [20]. She points out how the IT department is a central partner and can be both a catalyst and barrier to change. Villumsen and colleagues look at how log data can provide meaningful insights on practical use of eHealth systems [21]. They highlight that a large challenge is defining a common set of indicators for monitoring practical use of eHealth through in depth discussions of definitions of indicators and insight into the architecture and content of the national databases. Watbled et al. state the need for studies of impact of HIT to consider socio-technical characteristics of the work system in which the technology is implemented [22]. They identify hidden variables that can explain why inconsistency of impact of performance, quality and satisfaction occurs in studies of HIT.

4. Understanding Different Contexts Using Theory

Contextual factors are among the main issues when analyzing and explaining design and evaluation of health information systems and this section of papers focus on how different contexts can be understood through a theoretical approach. Botin [23] brings attention to the role of narratives in the construction of health information platforms and how different voices should have space for speech on these platforms. He argues that certain interactions and voices are absent from the construction of platforms, because they are regarded as outside of the text of computational and medical practice and expertise. Kuziemsky and colleagues [24] articulates the current state of patient safety research and health information technology from the perspective of three different International Medical Informatics Association (IMIA) working groups and integrates them into a model to support research, education and policy development. By the way of an example from a large-scale openEHR project in Norway Pedersen et al [25] consider how the contextualization of clinical templates is governed over multiple national boundaries, which exhibits complexity due to the dependency of clinical resources. They examine how local, regional, and national organizers maneuver to standardize within openEHR technology. In a different theoretical direction Kaltoft et al [26] analyze how ‘symbolic violence’ is experienced by individuals at any and all levels of general literacy because a particular form of functional decision literacy is not recognized. They propose a different response to exploit the alternative generic decision literacy used for many consumer services and products on comparative websites and magazines.

5. Conclusion

There is much to be learned from the myth of Procrustes. A "one size fits all" approach may limit country and/or local healthcare system innovation. Innovation is a key source of knowledge and advancement in health informatics. Research and development that stimulates health informatics innovation in developing and developed countries will lead to overall healthcare system advances as differing parts of the world learn from each other. As well, importing healthcare technologies and allowing for local, contextual changes may improve local adoption of the technology, and may also lead to unexpected innovations in already established technologies. A continual investment in research and a recognition that context has an important role stimulating such innovation will lead to further knowledge development and innovation. Such work is critical to ensuring the successful introduction and adaption of healthcare systems to new countries, contexts and health care settings.

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Different Users in Different Contexts

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From Research Prototypes to a Marketable eHealth System

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Abstract. This paper presents three distinct challenges to research and development (R&D) of marketable eHealth systems and suggests strategies to mitigate them. The eHealth system in question is designed to improve self-care and collaboration between remotely monitored heart failure patients and clinicians. By way of introspection and reflection on a current and a previous project, the authors propose solutions for mitigating the central challenges.

Keywords. Methods, research and development, eHealth, regulatory requirements, mitigation

Introduction

Patient-centered eHealth is expected to improve health outcomes. For more than a decade it has been a cornerstone in eHealth research to engage patients in their own treatment and care. Many studies in Health Informatics and HCI show promising potentials of self-management and remote collaboration between clinicians and patients [1, 4, 6, 12]. Yet few prototypes leave the research lab to become marketable systems. Moreover, contradictory to the overly positive potentials, stands the evaluation of collaborative eHealth systems that are currently available and in use by patients and clinicians. A critical review of telemonitoring systems, for example, shows the lack of high quality evidence for improved outcomes or cost-effectiveness [7], while others reveal unintended consequences e.g. complicate the patient-physician relation [8, 9].

We address the multi-edged challenge in R&D of marketable eHealth that hold commercial value, support patient self-management, and improve remote collaboration between clinicians and patients. We describe challenges in running large-scale experiments, and at the same time, mobilizing a transition from research prototypes into a regulatory approved implementation process that ends with a marketable eHealth system. By introspection and critical reflection, we analyse the problems encountered in a previous project (CITH) and propose the mitigation strategies that we try out in a newly started project (SCAUT). We use the concept of 'context' to highlight the gaps that exist when moving between the contexts of design and use and between research- and commercially-oriented contexts. We have experienced three challenges in bridging these gaps due to only partly overlapping experiences, concerns, and rationales.

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1. New Contexts: From CITH to SCAUT

We are an interdisciplinary group of cardiologists, public health and computer scientists. In our prior work [see 1, 2], we discuss challenges and opportunities as to features and affordances of eHealth systems to support self-care and collaboration between patients and clinicians. Instead, here we address methodological issues related to making the transition and move research and development (R&D) prototypes to a market that has high regulatory demands. We base our reflections and recommendation on two projects that deal with remotely monitored patients with implantable cardiac devices (ICDs and pacemakers).

The purpose of the CITH-project (2008-13) was to explore the solution space and develop concepts and prototypes. In the SCAUT project (2014-18) we have teamed up with a software company and a medical device manufacturer to further explore the solution space and to transform prototypes into products. The combined purpose of SCAUT is to bring an eHealth system to the market, while still delivering traditional research in the form of papers and theses. The overall R&D approach is presented below. First, however, we describe how the contexts of the two projects are similar and how they differ. In section 2 we discuss the challenges induced by these differences and the mitigation strategies that we propose.

1.1. Use Contexts

Firstly, the use context is shared by the two projects, and it has three main elements: patients' homes and two clinical settings. Patients and clinicians live and work in different contexts and they hold different views on disease, treatment and care [2, 5]. The ways in which patients relate to their disease vary according to where they are in their trajectory. Partly therefore, they have developed a diverse set of strategies for handling the different types of information they collect or receive related to their disease, and they use different media for that purpose. In the two clinical settings decisions are taken whether or not to change the treatment. At the university hospital any alteration of the treatment is primarily based on interpretation of data from the cardiac device. However, at the local hospital or at the general practitioner's office the patients overall situation and the medication are the main issues.

1.2. Project Contexts

Secondly, there are the project contexts, where the design, development and implementation take place and where the two projects are clearly different. We strive for design, development and implementation to be more intertwined than indicated below, but for clarity we distinguish between three project contexts: (a) the IT-researchers' habitat that mainly includes patients' homes, clinical settings, the university and the two companies; (b) the software company, which holds the primary responsibility for the development and implementation; and (c) the medical device manufacturer that employs its own R&D departments in the US and in Europe, and will licence the software, if we are successful.

As also pointed out in Eng [15] there exist some tensions between academic institutions and commercial companies: researchers' primarily strive to produce new knowledge, while companies are in the project to explore new market opportunities. However, SCAUT participants acknowledge, that both parties are critical for academic

as well as commercial success.

1.3. Overall R&D Approach for Both Projects

The diverse use contexts motivate that we start out with ethnographic techniques to explore existing practices in patients' homes and in clinics. We used prototyping to experiment with versions of a Personal Health Record and with a set of (re-)designed tools and services supporting the work of clinicians, patients, and relatives. Based on such experiments, we iteratively adjust the prototype, the tasks, and the roles, but we also learn about new issues in the current practices, which then inform the next round of design activities. Initially, the experiments are conducted in isolation from the daily practices, but as the prototype matures we intervene to cautiously try out the prototype, the tasks, and the roles as part of real life practices. This takes place within an overall participatory approach for users to have a say and to foster mutual learning [3]. Clinicians, patients and relatives participate actively in defining the aim of the project as well as in analyses, design, and evaluation. A final element in the methodological approach is theoretical reflections on the use of evolving prototypes based on medical phenomenology [5] and studies of other researchers [see e.g. 10, 11].

2. Bringing Health Informatics to the Market: Three Challenges

We have experienced three challenges in bridging the gaps between the contexts of design and use and between research- and commercially-oriented contexts. Below we argue that these challenges are rooted in the only partly overlapping experiences, concerns, and rationales of the researchers and industrial partners, who have joined forces for the purpose of developing a marketable eHealth system. An overview of the challenges, their potential consequences and suggested mitigation strategies are listed in table 1, and they are argued for below.

Table 1. Overview of challenges, consequences and strategies for mitigations

Challenge	Potential Consequence	Mitigation strategies
Create an efficient R&D process	Cumbersome coordinative work Scaling becomes unmanageable Increased overhead work	R&D tool that supports: - recruting patients - communication with users - overview of (non-)use - easy to introduce new features to many users
Integrate all stakeholders' interests	Losing commitment from key stakeholders	Active user participation Business Model Canvas for pre-assessing the value pro-positions of the prototypes Adjust The Stage Gate Model using Scrum
Design within regulatory requirements	Product will not be approved	Treat regulatory issues as design parameters Integrate a regulatory process into the production process from the start

2.1. The Challenge of Establishing an Efficient R&D Process

The first challenge is to establish an efficient R&D process. In the CITH project, the R&D process progressed through three stages. As it turned out, the coordinative efforts intensified and overhead work related to preparing and setting up the experiments grew critically in the last stage where we tried out prototypes that connected people. For example, we developed and distributed information material and started to keep various spreadsheets and other documents with updated information on e.g. which version of the prototype patients were using, dates of healthcare appointments and notes on which researcher had been in contact with the patient, when and what they discussed. This was to ensure coordination among the researchers and to keep an overview of what was going on in terms of patient participation. We worked intensively to set up experiments where patients and clinicians could collaborate remotely [1].
We termed some of this work "bike-integration," since every experiment involved personal agreement on date and time with many patients (~25), producing and mailing out information material, calling or visiting patients prior to the experiment as well as bicycling to the hospital on the day prior to the experiment to ensure the needed printouts were there for the clinicians to use during the experiment. A major reason for the overhead work in CITH was the increase in dependencies when trying out prototype features that connect different people, as well as the fact that we introduced new technology features that changed work practices and required introduction.

In the SCAUT project, we have taken measures to mitigate overhead work since we need to scale up the number of participants involved in the prototype experiments. This primarily involves designing and building a software tool - an R&D engine - to support the coordination work related to the participatory prototyping process.

Scaling up the number of participants is a means to increase the chances of delivering a product that meets users' needs and thus holds market potentials. This introduces the need for making the process more efficient than earlier. For example, we need efficient ways to communicate with individuals and groups of patients. We need to be able to keep an overview of patients' use and non-use of the different app features as well as simple ways to keep them interested and informed about progression of the project. We need to be able to communicate needs and requirements to developers so there will be a natural inflow of prototypes to be evaluated by end users. Inspired by for example customer-relation management systems, medical progress notes, and online video guides we are building a customized R&D tool that is tightly connected to the app- and web-prototypes. The purpose is to support a R&D process with fewer resources involved when experimenting with the prototypes. We will make it easy to introduce new features to many participants by providing in-app videos and by developing a message module. We aim to make use of in-app newsletters and create an idea-voting system as a way to involve many participants. We aim to make it easy to follow use and non-use by creating 'use-scores' and making it possible to easily keep track of individuals and groups of patients by elaborated personal profiles with information relevant to running the process. Here, we aim also to include indicators such as 'take a look at' or 'contact patient', which can be set manually or automatically.

2.2. The Challenge of Integrating All Stakeholders' Interests Up Front

The methodological approach needs to take into account that the SCAUT project will deliver a commercial product. Instead, the purpose of the CITH project was to

investigate opportunities and concepts, and progress was evaluated as the degree to which patients and clinicians found the developed concepts, features and affordances meaningful, actionable and organizationally feasible [2]. It was not part of the agenda to investigate the commercial potential in detail. However, in SCAUT the market plays a much more central role. The market interests are primarily taken care of by the software company and the device manufacturer. One of their natural concerns is the commercial potential of the prototypes. From a methodological point of view this means that we need to find ways to integrate also their interests in the transition from one prototype to the next.

We propose three mitigation strategies for this. First, we advocate involving users more than is typical in commercial settings - and in additional roles. Patients and clinicians need to be involved not only for the purpose of testing or approving assumptions, but also for the purpose of exploring, experimenting and evaluating features and affordances of the evolving prototypes [3]. Second, we pre-assess the value propositions of the prototypes by using the Business Model Canvas [14], the results of which will feed into the third mitigation strategy: The Stage Gate Model. However, the latter is inscribed in a waterfall model in order to have "well defined gates", and prototyping is not used until requirements are fixed. Therefor, and inspired by Scrum [16], we have adjusted The Stage Gate Model to include explorative and experimental prototyping up front. This will produce more relevant materials at the gates based on real users' real experiences with evolving prototypes.

2.3. The Challenge of Designing Within Regulatory Requirements

To be able to bring an eHealth system (all the way) to the market, means that we have to ensure the system will meet regulatory requirements. Rather than postponingthis, we recommend engaging with the regulatory issues early in the process. Even though the system is solely software-based, it is considered a 'medical device' in regulatory terms [13] and will have to pass regulatory assessment and approval by the relevant authorities (e.g. FDA for the US market and EU MDD for the European). Many R&D endeavors postpone (or neglect to consider) the regulatory process, mostly because it is either too complicated early in the process or because the knowledge of what the product will be is too uncertain to begin structuring a regulatory process around it.

However, although it might seem wise to hold off regulatory considerations until it is clear what the eHealth system actually consists of, this will almost inevitably result in a system that is nearly impossible to get approved. This is because some of the requirements have implications that extend all the way into how the fieldwork is conducted in order to enable proper documentation of user needs, and features to support those needs, later in the process. Other requirements have implications for whether the system 'displays' information (lower requirements) or rather transforms information (more strict requirements). The differences in those categories are monumental [13]. Hence, we argue to engage the requirements early on and work with them as 'just' another actor or constraint on the project. On way we do this in SCAUT is to modularize the software (architecture) to isolate and minimize the components that 'transform' information. Another way is that when we sketch and mock-up features that are informed by the fieldwork, we carefully consider whether we can accomplish the same without transforming the information right away, or leave the transformation to later. In other words, we recommend that regulatory demands are treated as design parameters and seen as a resource for the project. The requirements should be dealt

with early in the process and should not be postponed to the final stages.

3. Concluding Remarks

Based on reflections on two projects, we propose mitigation strategies to be considered when engaging in R&D of marketable eHealth systems. The strategies suggest how to establish an efficient R&D process in order to scale and evaluate the system with many patients, and how to integrate stakeholders' interests early on in order to align commercial interest with those of patients and clinicians. Finally, we suggest how to consider regulatory demands and integrate them as design parameters for the project.

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Context Sensitive Health Informatics: Many Places, Many Users, Many Contexts, Many Uses
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User Preferences for Improving the Estonian National e-Prescription Service

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Abstract. National e-Prescription services are becoming more common in Europe. While enhancing communication between levels of health care, few solutions have demonstrated enhanced quality of care and patient safety benefits. The article presents the results of a project to map the user needs the Estonian national e-prescription service. A survey was conducted among primary care physicians (PCPs) to inquire about their needs in the medication management process. The results showed that PCPs lacked a medication management tool to support patient care across different care settings. A mockup for the national service was developed based on the survey results. The medication management tool features a visual presentation of a patient's medication list and includes decision support functions for allergies and potential interactions. This mockup will be used to further investigate the needs of PCPs as well as other care providers in the medication management process.

Keywords. e-prescription, medication reconciliation

Electronic prescription (e-prescription) systems are becoming more widespread as an increasing number of countries such as Denmark, Sweden, Finland and Estonia have implemented national services for transmitting prescriptions electronically [1]. The Estonian e-prescription service has been implemented since 2010. National surveys in Estonia have regularly reported high user satisfaction with the service among citizens, physicians, and pharmacists alike [2,3]. It has yielded efficiency benefits through improved quality of reporting prescription information and resource costs regarding paper prescription pads [4]. Like Denmark, Estonian prescription information is stored in a repository where it can be accessed by any pharmacy information system [1]. The data transmission is standardized across the country. Physicians and patients have full access to information regarding prescribed and purchased medications; pharmacists only have access to prescriptions that are prescribed but not yet dispensed.

National e-prescription services can potentially support faster and more accurate data transmission across levels of healthcare [5]. Patient safety benefits have been associated with local information systems, such as computerized provider order entry (CPOE) and prescription decision support tools [6,7]. However, evidence of e-prescriptions yielding quality improvements in the medication management process remains limited [8]. Although electronic transmission enables better access to

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information about what medications have been prescribed and dispensed for the patient, it does not necessarily improve prescriber behavior. Problems with dosing instructions and fragmented information about actual medication use persist even with e-prescription services [9].

The Estonian Health Insurance Fund (EHIF) is the national organization responsible for purchasing health care services in Estonia. In 2014, EHIF commissioned a preliminary study to gather stakeholder preferences about the future services enabled through the national e-prescription framework. This article outlines some of the results of this study and presents which functionalities of the Estonian national e-prescription can improve the safety and quality of prescribing and dispensing medications according to Estonian primary care physicians (PCPs). Moreover, the study presents a preliminary mockup for the national medication management user interface design that can be used in the design process of the actual service.

1. Materials and Methods

Two web-based surveys were distributed among primary care physicians and pharmacists in Estonia to inquire about their needs regarding the medication management process. These user groups were chosen since PCPs have a central role in coordinating patient care and pharmacists are typically responsible for dispensing medications in Estonia. Despite their importance in the medication management process, their information needs fall outside the scope of this paper.

The questionnaires included introductory questions about general attitudes towards the e-prescription service followed by questions about the information needs and services identified by the interviewees. Participants were also asked to rank hypothetical e-prescription functionalities, which aimed to reveal their priorities. The questionnaires were administered through the Qualtrics survey tool (Qualtrics.com) and disseminated using both the PCP and pharmacists professional associations' mailing lists. Based on insights from PCPs respondents, the first mockup of the medication management service was developed.

2. Results

Altogether, 13% of PCPs with a registered patient list (n = 105) completed the questionnaire. The main suggestion from PCPs indicated the need for a common and integrated drug interaction decision support functionality and medication management tool.

Fewer than half of PCPs (44% of respondents) use an interaction database or a web-based tool to search for medication related information. They generally rely on their experience for managing potential interactions. Still, the majority of PCP respondents (90%) expressed their willingness to start regularly using a national decision support service for prescribing.

The medication management tool should give all physicians, patients, and pharmacists the most current and accurate overview of a patient's medication list. PCPs expect the medication management tool to be integrated into physicians' existing software. The functionalities of the medication management tool with highest priority according to the PCP were:

- View a list of medication prescribed and bought by the patient
- View a list of medication related allergies
- Decision support service to automatically detect drug interactions
- Physicians can alter the medications prescribed by other physicians

The majority of PCP respondents (79%) also highlighted the need to include medication administered in the inpatient setting in the medication management tool. Additionally, 77% of PCPs also considered information about some OTC medication relevant for the care process. However, the PCP ranking question revealed that OTC information is more often considered a convenience (51% of respondents) rather than an essential function (33% of respondents).

2.1. Medication management tool mockup

The mockup was developed based on the features suggested by the PCPs and included all the functionalities most frequently mentioned by the survey respondents (see previous section). The image shown here is the timeline view of medications for a PCP user (see Figure 1). This view seeks to provide users with an overview of a patients' prescribed medications, any changes that have occurred to prescriptions, whether there are any outstanding prescriptions that have not yet been purchased, and whether there are any potential interactions (e.g., incompatible pairs of medications, medication allergies). The mockup leveraged the common user interface guidelines for the patient banner (www.cui.nhs.uk/). Prescriptions were colour coded according to whether they were prescribed in the inpatient or outpatient setting, discontinued, OTC and herbal remedies, or prescribed and not yet dispensed (see Table 1). Additionally, symbols were used to identify different medication reconciliation behaviours (i.e., formulary substitutions, prescription changes, and discontinuations) and invoke displays of relevant information.

The timeline view of the medication management tool (see Figure 1) provides a summary of the patient's prescription(s) on the left but users can click on different aspects of the display to access more detailed information (see Table 1). Additionally, if a medication change results in a decrease of the total daily dose, the new prescription is displayed a line below the old prescription to naturally map the decrease. In contrast, an increase in total daily dose is displayed above the old prescription (see Figure 1). When a full prescription is displayed (i.e., the user clicks on the prescription button on the left of the bar), physicians can easily re-prescribe medications with the same information. Therefore, prescription renewals will be more convenient for all physicians.

This approach will allow potential users to critique a concrete example of the potential tool, before investing in development. This method may facilitate clarification and understanding between users and researchers by allowing them to speak to reference the image rather than internal abstractions.

Figure 1. The medication management tool mockup

Table 1. Legend for the medication management tool mockup

Colour and/or Symbol	Description	Click Invoked Display
	Discontinued Prescription	The original prescription and description from physician on why it was discontinued
	Inpatient Prescription Not Yet Dispensed	The original inpatient prescription
	Dispensed Inpatient Prescription	The original inpatient prescription including the date it was dispensed
	Outpatient Prescription Not Yet Dispensed	The original outpatient prescription
	Dispensed Outpatient Prescription	The original outpatient prescription including the date it was dispensed
	Over the counter medications and herbal remedies	Patient reported quantities and durations of non-prescription medications
	Add a new prescription	Template for PCPs to generate a new prescription
	Formulary Substitution	A side-by-side comparison of the Outpatient-Inpatient prescriptions or the Inpatient-Outpatient prescriptions
	Prescription Change (e.g., change in dose, route, or frequency)	A side-by-side comparison of the previous prescription and the new prescription
	Discontinued Prescription	The original prescription and description from physician on why it was discontinued
Interaction Profile	Interaction Profile	A description of potential compounds that might interact and provide options eliminating potential interactions
Allergies	Allergies Profile	A description of the patient's allergies to medication(s)
	Allergy to Prescribed Medication	A description of the patient's allergies to medication(s) with the allergy problematic for the specific prescription highlighted

3. Discussion

Based on data collected from PCPs, a mockup of a potential view of the national medication management tool was developed. The tool aims to provide PCPs, hospitals, and pharmacists with a complete list of a patient's medications to enhance coordination across levels of care and to ensure medication errors during care handoffs are minimized. Moreover, the decision support function aims to increase patient safety regarding medication management through detecting potential interactions. The medication management tool will also be available for patients and therefore future studies will have to address the needs of other stakeholders (e.g., patients, pharmacists).

In developing a national service with expected benefits on the entire population, it is paramount that the tool is adopted by all PCPs. From the EHIF perspective, it is expected to increase physicians' responsibility and awareness about the impact of their prescribing decisions. A technical challenge around creating the tool lies in the fact that most physicians enter dosage information as free text. In addition, medication orders in the inpatient setting are primarily written on paper, creating challenges for including this information in the national database. This is the first iteration of the tool and further exploration is required to determine what specific information PCPs need about medications, how to organize the list of medications and if users need more flexibility of how the information is displayed. Future research will use the mockup as a tool to elicit further insight from additional prototypical users to determine necessary modifications, additional features, and tailoring for different user groups of the medication management tool.

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Physician Experiences with Perceived Pressure to Order Diagnostic Imaging Services

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Abstract. The overuse of diagnostic imaging (DI) services, which is estimated to be 30% in Canada, can expose patients to unnecessary radiation, and strain human and financial resources. This study explored the DI ordering practices of physicians in Canada through semi-structured interviews to gain a deeper understanding of the factors contributing to the overuse of DI services. The majority of participants (n=11; 91%) described feeling pressured by patients to order DI services in circumstances that were unwarranted. The results are followed by a discussion about ways technology (such as a decision support system) could aid in facilitating a dialogue between physicians and patients about when and when not to order DI.

Keywords. Patient demand, patient pressure, diagnostic imaging, medical imaging, decision support system

Introduction

With the Canadian Association of Radiologists suggesting that approximately 30% of DI in Canada could be unnecessary [1, 2], exploring ways to reduce this overuse is important. Unnecessary DI includes cases where: (a) the most ideal imaging modality is not selected, (b) imaging results would not change or support a patient's management, (c) examinations are performed too early to obtain a diagnosis, and (d) duplication occurs [3].

Some DI modalities expose patients to radiation (e.g. x-ray, computed tomography, and positron emission tomography) [3]. Although patient safety concerns are low for individual patients, DI radiation exposure may be of concern on a population level in the future [4]. Similarly, the overuse of DI services can strain human and financial resources [5]. In 2005/6, approximately $2.2 billion were spent on DI services in Canadian hospitals [2, 6]. Thus, reducing the overuse of DI services could result in financial savings to the health care system [2] as well as limit unwarranted radiation exposure to patients. This paper focuses on patient pressure to order DI services, which was one of several emergent themes from a qualitative study exploring DI ordering practices.

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1. Methods

Non-radiologist physicians, who were able to order DI services in their Canadian jurisdiction, were invited by email to participate in a semi-structured interview. Details of the recruitment methods are described elsewhere [7]. The interviews included questions about DI ordering practices, including questions related to whether the participant thought appropriate DI ordering was or was not occurring in the Canadian medical field.

All interviews were audio-recorded and transcribed. The transcriptions were qualitatively coded using grounded theory. Two researchers coded the first two transcripts together to establish a coding framework and ensure inter-coder reliability. After this point, one researcher coded the remaining interviews. Interviews continued until the data had reached saturation.

2. Results

In total, 12 non-radiologist physicians participated in the study. The response rate was 4.5%. Participant demographics are presented in Table 1.

Table 1. Results from the demographic questionnaire.

Participant Demographics	
Physician experience	9/12 (75%) Over 15 years of experience
Education	Canada (7/12; 58%) UK (3/12; 25%)
Specialty	General practitioners (4/12; 33%) Various specialties (8/12; 67%)

Most participants (11/12; 92%) expressed feeling pressure from patients to order DI services. Physicians described this pressure as stemming from patients who have poor health literacy, patient anxiety, and the threat of a patient leaving to seek the consult of another physician. These categories are described in more detail in the following subsections.

2.1. Patient Health Literacy: Patient Demand Based on Misinformation or Incomplete Information

Health literacy refers to "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" [8, p. 7]. Consumers have unparalleled access to health information (e.g., symptoms, diagnoses, diagnostic testing). However, the information they encounter may be of low quality, unreliable, and incomplete, and therefore guide them to poor health related decision-making, even if they are able to understand the content. For example, the potential health repercussions of diagnostic imaging or actual diagnostic capabilities (i.e., at what point an issue is detectable and how accurate the test is) may not be included in health information consumers encounter online. The majority of participants (7/12; 64%) described how they have felt patients demand DI

services based on information from unreliable sources such as the Internet, or from family and friends. The following interview excerpts describe this finding:

> *"A lot of people look-up and Google things and look things up, and 95% of the things people look-up I would say are garbage. The Internet is a very dangerous place." (Participant 10)*

> *"People come in and say "I think I need an MRI" or, you know, "I've been reading about such and such test, do you think that I need that?" and I think, again, usually I try to only order things that are going to change the management of the patient or that I agree [are] appropriate." (Participant 2)*

Participants also identified how patients may have unrealistic expectations about what DI examinations can detect. This is highlighted through these interview quotes:

> *"Patients will demand or have definite expectations [that] they want a total body MRI just to be safe." (Participant 5)*

> *"There are certain things that we don't have tests for. But, [doctors], instead of explaining that to the patient, they just keep on doing more tests."(Participant 11)*

Similarly, participants described how patients sometimes request to have DI examinations performed earlier or more frequently than what would be clinically recommended. This is illustrated through the following excerpt:

> *"For example, if there was a plan to follow-up on some finding in 6 months, the patient request might be "why can't it be done next week, or in three weeks?" And usually that involves an explanation on what's being followed; if it's going to change, it's not going to change fast enough to make this worthwhile, in which case, you've just had the radiation exposure without any realistic chance of it showing anything new*." *(Participant 3)*

Overall, the majority of participants expressed how patients may request DI because they have received misinformation or incomplete information and have not appraised the quality of that information.

2.2. Patient Anxiety

As well, some participants (5/11; 45%) also discussed how they may be influenced to order DI services to ease patient anxiety. This finding is highlighted in the following interview quotes:

> *"Sometimes, if there's a significant amount of patient anxiety, or yea, if they are not going to rest until that happens, then, I think, sometimes probably imaging is done in that case, unnecessarily."(Participant 2)*

> *"But there is a sway in the sense that patient anxiety around a specific condition that sometimes a test was done to alleviate their anxiety. That means, even though it was derived that we shouldn't have done the test based on best evidence that*

sometimes the personal aspects of the patient interaction are such that we would be swayed into doing a test just simply to reduce worry and anxiety and so forth." (Participant 6)

Generally, participants described how they may feel pressured to order DI examinations to alleviate a patient's anxiety, even in unnecessary circumstances.

2.3. Threat of Patients Leaving

Two participants (18%) identified how physicians may feel pressure to order DI services in unnecessary circumstances because they fear the patient will leave to seek the consult of another physician. The following excerpts illustrates this finding:

"If they come and see you and they don't like what you say they can turn around and see somebody else the next day or even the same day, right. So they are the biggest driver and they are not the smartest driver because they don't know anything about guidelines or clinical decision support, but they do drive you because it is, unfortunately, a business, and they're forcing you to do things that are inappropriate."(Participant 10)

"I've lost some patients over the years because I've said, "no we're not going to do that because we don't need to." (Participant 5)

Participants identified the threat of patients leaving their care, if they do not order DI services.

3. Discussion

The majority of participants described feeling pressure from patients to order DI services that they would not have otherwise ordered. This pressure stemmed from patients who have poor health literacy and/or poor quality information, patient anxiety, and the threat of a patient leaving to consult another physician. As some DI examinations expose patients to radiation, promoting more appropriate ordering practices could reduce population health concerns [9].

In 2014, the Choosing Wisely Canada campaign began which seeks to support patients and physicians in discussions about unnecessary tests, procedures, and treatments. It is modeled after a similar campaign in the US [10]. In this campaign, participating specialties developed lists of "tests, treatments or procedures commonly used in each specialty, but are not supported by evidence, and/or could expose patients to unnecessary harm" [10, para. 3]. The campaign produced resources for both physicians and patients. The resources for patients were designed to be educational and engaging and are presented in plain language [10]. Hopefully, this campaign will help facilitate discussions between physicians and patients, and mitigate some of the pressure felt by physicians.

In the US, the Choosing Wisely recommendations were embedded into an electronic health record at the Cedars-Sinai Medical Center [11]. Here, the Choosing Wisely recommendations are presented with additional information about why the order may not be necessary when a physician attempts to order an examination or

treatment included in the recommendations [11]. Having this information available in a decision support system at the point of care could prompt physicians into discussing why DI may not be appropriate [12] and alleviating the pressure that physicians experience when patients request DI. However, research related to physician perceptions of using these resources is necessary, as data collection occurred before the campaign was introduced in Canada.

Overall, more research is necessary to determine how technology, such as decision support systems, could be used to facilitate discussions between physicians and patients about appropriate DI services and offer physicians support when experiencing pressure to order DI. These findings could be used to inform and motivate research in other areas of health care such as perceived pressure to prescribe medications and laboratory work.

4. Conclusion

If nearly one third of DI services in Canada are indeed unnecessary as estimated, determining ways to mitigate this overuse is imperative. This research highlighted the pressure physicians may feel from patients to order DI services, even in situations where it is not necessary. The recent Choosing Wisely Canada campaign may help to engage physicians and patients into discussions about when DI is and when it is not necessary. Moreover, embedding resources from this campaign or other guidelines into a decision support system or other electronic systems could increase the uptake of these recommendations, by having them available at the point of care and support physicians when they feel pressure to order DI. However, more research on the feasibility and effectiveness of this strategy is necessary.

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The Consumer Health Information System Adoption Model

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Abstract. Derived from overlapping concepts in consumer health, a *consumer health information system* refers to any of the broad range of applications, tools, and educational resources developed to empower consumers with knowledge, techniques, and strategies, to manage their own health. As consumer health information systems become increasingly popular, it is important to explore the factors that impact their adoption and success. Accumulating evidence indicates a relationship between usability and consumers' eHealth Literacy skills and the demands consumer HISs place on their skills. Here, we present a new model called the Consumer Health Information System Adoption Model, which depicts both consumer eHealth literacy skills and system demands on eHealth literacy as moderators with the potential to affect the strength of relationship between usefulness and usability (predictors of usage) and adoption, value, and successful use (actual usage outcomes). Strategies for aligning these two moderating factors are described.

Keywords. Consumer health informatics, consumer health information systems, usability, eHealth literacy, health literacy

Introduction

To begin, a definition of consumer HIS will be derived from definitions of similar concepts. Canada Health Infoway defined a *consumer health application* as "an electronic solution that enables the consumer to collect, retrieve, manage, use and share personal information and other health-related data" [1]. In contrast, the American Agency for Healthcare Research and Quality (AHRQ) defined *consumer health IT [information technology] applications* more broadly as the "wide range of hardware, software, and Web-based applications that allows patients to participate in their own health care via electronic means" [2]. In this paper, the definition for consumer HIS will be inferred from the description of the study of these systems known as *consumer health informatics*. AMIA (the American Medical Informatics Association) argues that the focus of consumer health informatics "is on information structures and processes that empower consumers to manage their own health--for example health information literacy, consumer-friendly language, personal health records, and Internet-based strategies and resources" [3]. Thus, a *consumer HIS* refers to any of the broad range of applications, tools, and educational resources developed to empower consumers with knowledge, techniques, and strategies, to manage their own health.

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Driven by consumers who want tools and information to manage, monitor, and improve their health, there is an increasing demand for consumer HISs. Consumer HISs have the potential to play important role in facilitating patient-centred care and self-management. Consumer HISs are diverse and examples include but are not limited to: online health resources, health risk assessments on the Internet, mobile health applications, and Personal Health Records (PHRs). This paper will be used to outline usefulness, usability, and eHealth literacy with respect to consumer HISs, as well as propose a model of how these factors might interact and influence the adoption, successful use, and value of consumer HISs.

1. Usability, Usefulness, and eHealth Literacy

Once an idea for a useful consumer HIS has been conceived (i.e., a system that serves a specific user need or needs), the next priority should be ensuring that resultant system that is usable for its intended users. "Usability is the effectiveness, efficiency and satisfaction with which specific users can achieve a specific set of tasks in a particular environment" [p. 6, 4]. Effectiveness is measured by the accuracy and the completeness of task, whereas efficiency is related to the resources (e.g., time, effort) expended to complete the task [5]. Usability is argued to have the following five attributes: learnability, efficiency, memorability, errors, and satisfaction [6].

Driven by the increased use of computers, mobile devices, and the Internet for health information seeking and delivery, the concept of eHealth literacy emerged as an elaboration on the concept of health literacy by incorporating the role of health information technology in information delivery. *Health literacy* is "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" [p. 7, 7]. The term *eHealth* has been defined as "the use of emerging information and communication technology, especially the Internet, to improve or enable health and health care" [p. 2, 8]. These definitions were integrated to generate the following definition of *eHealth literacy*: "the ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge gained to addressing or solving a health problem" [p. 3, 9].

2. The Consumer Health Information System Adoption Model

In contrast to the majority of HISs, consumer HISs are unique in that their users (i.e., consumers or laypeople) often have limited or no healthcare experience and/or knowledge [10]. eHealth literacy, usefulness, and usability are crucial factors in the development and eventual success of consumer HISs. Consumer HIS designers need to ensure that consumers can understand the systems' content [11]. If users cannot understand the content of a system, how can they be expected to use it effectively? Thus, to optimize consumer HISs, it is imperative that they are designed to a) be useful and usable and b) place appropriate demands on consumers' levels eHealth literacy.

A high level framework has been proposed for exploring consumer health informatics [12], yet it is also important to examine this topic from a more in depth perspective. To this end, we draw upon the Technology Acceptance Model (TAM) [13]. TAM is popular information systems model supported by evidence that the two best

predictors of technology usage are perceived usefulness and perceived ease of use (usability), respectively [13].

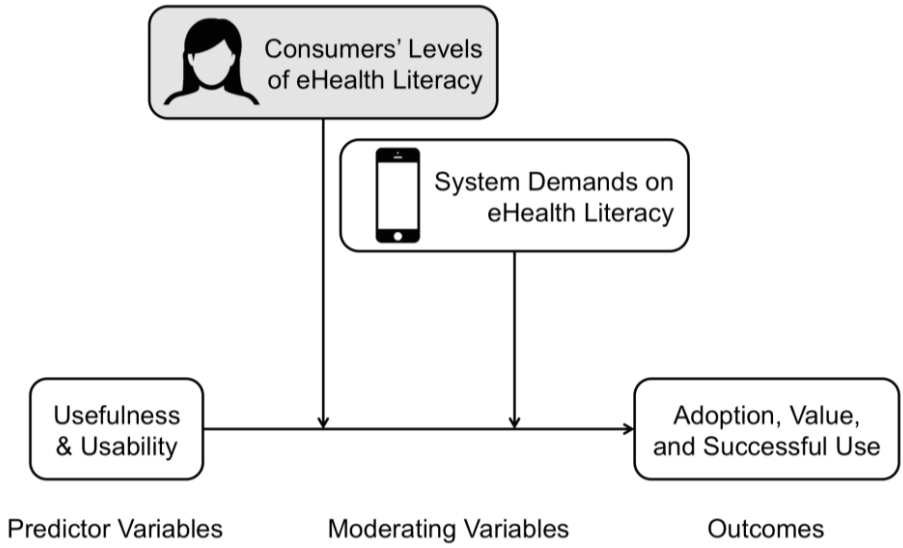

Figure 1. The Consumer Health Information System Adoption Model

We posit that eHealth literacy is a critical two faceted factor demanding consideration, which impacts not only usage but system value and successful consumer HIS use. The identification of eHealth literacy issues during functionality (an index of usefulness) and usability evaluations without seeking them intentionally [e.g., 10, 14] suggest that issues around eHealth literacy can impede usefulness, and usability. Further, designing for low literacy may improve usability (i.e., more tasks completed, reduced task times) [15]. These findings suggest that the capabilities of the user (such as eHealth literacy skills) and the system design (including demands on eHealth literacy skills) impact the usefulness and usability of consumer HISs, which according to the TAM [13] would then influence adoption. Thus, we posit that consumer HIS demands on eHealth literacy and users' levels of eHealth literacy moderate (i.e., strengthen or weaken) the relationship between usability and usefulness and adoption in the Consumer Health Information System Adoption Model (Figure 1). In this model, consumers' levels of eHealth literacy and system demands on eHealth literacy (moderating variables) moderate the relationship between usefulness and usability (predictor variables) and adoption, value, and successful use of consumer HISs (outcomes). Thus, usefulness and usability have a direct impact on consumer HIS adoption and success, but the strength of this relationship depends on users' eHealth literacy skills and the demands the system places on eHealth literacy. This model emphasizes the potential impact of both users' eHealth literacy skills and system demands place on eHealth literacy and how either, or both of these factors can affect whether a consumer HIS will be adopted or abandoned, its perceived value, and whether or not users will be able to use the system effectively.

As insinuated by the positioning in Figure 1, it is imperative users' eHealth literacy skills are aligned or exceed the demands these systems place on eHealth literacy that to ensure consumer HISs are useful and useable. When a mismatch or discrepancy

between the demands consumer HISs place on eHealth literacy and the users' eHealth literacy skills (as depicted in Figure 2a) exists, the usefulness and usability of the systems may be compromised. Specifically, if the consumers' eHealth literacy skills are not adequate to access, process, and understand and the health information provided by a consumer HISs, both the usefulness and a usability of the system may be negatively impacted. That is, if the information in a consumer HIS is written such that it exceeds the users' capability of understanding, the system cannot be considered useful to the consumer and as the user is unlikely to be able to use the system to achieve her goals (e.g., understanding relevant health information). Similarly, if consumers have difficulty using the system to find relevant health information, user goals are impeded regardless of the appropriateness of the system content.

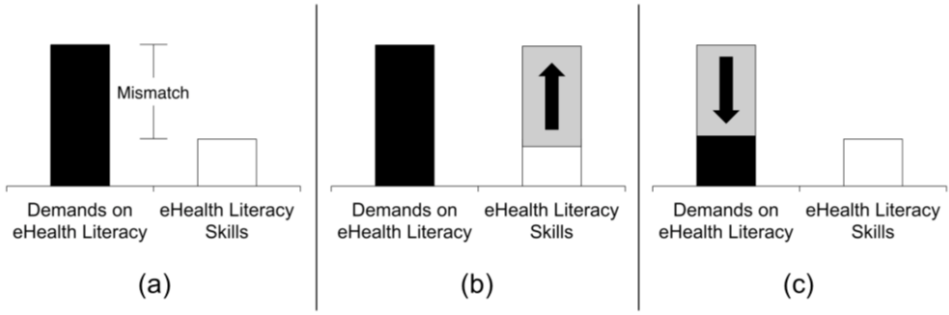

Figure 2. Strategies for Improving Alignment of System Demands on eHealth Literacy and Users' eHealth Literacy Skills: (a) Discrepancy Between Demands on eHealth Literacy and eHealth Literacy Skills (b) Lowering Demands on Health Literacy (b) Increasing Consumers' Levels of Health Literacy.

There are two primary strategies for mitigating discrepancies between consumer HIS demands on users' levels of eHealth literacy and users' actual eHealth literacy levels. First, consumers' levels of health literacy can be increased to meet demands consumer HISs place on eHealth literacy, as shown in Figure 2b. Alternatively, the demands placed on eHealth literacy by consumer HISs can be lowered to meet users' levels of eHealth literacy, as depicted in Figure 2c. Additionally, both of these strategies can be used in conjunction.

3. Discussion

This paper defined what is meant by a consumer HIS and proposed a new model for how the adoption of consumer HISs may be influenced by such factors as usability, usefulness, demands on eHealth literacy and users' eHealth literacy skills. However, the factors identified here are not considered the only factors that influence adoption. For example, younger designers neglecting to accommodate the unique requirements of older consumers has been argued to lead to low adoption of consume HISs [16]. In response, the value of developing personas to represent different types (including needs, goals, behaviour patterns etc.) of users is important for the development of consumer HISs [16]. User-centered design (UCD) methods should be practiced to ensure that consumer HISs are appropriate for their target users. Although many factors are likely to influence the uptake of consumer HISs, demands on eHealth Literacy and consumers' eHealth literacy skills are considered of primary importance. These factors are considered imperative because evidence indicates that these factors influence the

predictor variables (i.e., usefulness and usability), which has been shown to affect the outcome variables (i.e., adoption, value, and successful use).

This model is not meant to imply that use patterns of consumer HISs are static. Usage is likely variable due to specific needs at certain time points, which will create fluctuations in use patterns. For example, after initial diagnosis, consumers may have an increased need for information about factors that exacerbate their condition and how to manage it. If consumer HISs are successful in equipping consumers with strategies to control their conditions, these behaviours may become more automatic and therefore consumers would rely on the system less.

This model was developed with three objectives. First, the Consumer Health Information System Adoption Model emphasized the important roles that demands on eHealth Literacy and eHealth literacy skills are likely to play in the success and adoption of consumer HIS based on indirect evidence. Second, this model was meant to draw attention to the argument that consumer HIS adoption, successful use, and perceived value hinges on the alignment between system demands on eHealth Literacy and users' eHealth literacy skills. That is, a usable consumer HIS for users with advanced eHealth literacy skills is not necessarily appropriate for users with limited eHealth literacy, which might in turn result in lowered adoption or unsuccessful use for this latter user group. Further, approaches to mitigating mismatches when demands on eHealth literacy exceed users' capabilities were discussed. Third, this model sought to elucidate how eHealth literacy skills as well as demands on eHealth literacy have the potential to moderate (i.e., strengthen or weaken) the relationship between 1) usefulness and usability 2) adoption, value, and successful use. Importantly, these issues are garnering attention. For example, efforts are being made to develop interventions to scaffold eHealth literacy [17] as well as lowering demands on users' eHealth literacy skills through design guidance [e.g., 18, 19]. Additionally, research on methods for evaluating consumer HISs from this combined perspective is beginning to emerge [e.g., 20, 21]. The Consumer Health Information System Adoption Model promises to provide a useful framework for exploring how these factors interact and impact adoption and success of consumer HISs. Future work will involve testing and validating the model and identifying other important factors influencing the adoption of these systems.

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Communication Pattern Regarding Alarms and Patient Signals Between Nurses, Other Health Care Actors, Patients and Devices

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Abstract. CallMeSmart is a context aware communication system for hospitals. The system is being used by nurses and the physicians at the Oncology department, University Hospital of North Norway. CallMeSmart has been designed to increase the efficiency of communication between the nurse-physician and physician-physician. In this study, we have looked at the communication pathways between nurse-nurse and patient-nurse: how nurses define a preference of calling somebody, how alarms and tasks are prioritized, and how this could be implemented into the CallMeSmart system to improve the system for the nurses. This paper discusses how the communication pathways of the patient alarm system can be improved for health care actors in hospitals by revealing the communication patterns according to an alarm between those actors. We address the communication pattern between nurses, other health care actors, patients and the devices used, and discuss possible improvements of this communication.

Keywords. Context awareness, communication patterns, mobile communication, hospital communication, alarm systems

Introduction

Earlier studies show that physicians in hospitals are interrupted unnecessarily by mobile devices in situations where such interruptions should be avoided [1]. Unwanted interruptions should be minimized. This is the primary design goal of CallmeSmart (CMS), a system developed at Norwegian Centre for Integrated Care and Telemedicine, which focuses on a simple and safer way to communicate, especially for hospitals. CMS routes information directly to the right person at the right time and balances interruptions and availability, all in one device.

Different studies showed that wireless phones can conquer most of the limits of pagers and facilitate communication within a hospital setting [2]. The solution developed in the CMS project is a context aware system. For understanding the meaning of 'context aware system', it is useful to understand each word separately. A *system* is a set of interacting or interdependent components forming an integrated whole. The behavior of this whole has observable Inter-Process Communications. "*Context is any information that can be used to characterize the situation of an entity.*

An entity is a person, place or object that is considered relevant for the interaction between a user and an application, including the user and applications themselves" [3].

This definition shows that a context system is a system allowing interactions between multiple entities using relevant information. It also shows that the starting point to build a context system is to know which information is relevant or not. A system is context-aware if it uses context to provide relevant information and/or services to the user, where relevancy depends on the users' task [4]. The definition above shows that a context-aware system adapts its behavior and uses information according to the context.

The system that is developed, CallMeSmart, has been tested in real life settings. CMS has very high novelty value, and received immediate enthusiasm and commitment by people who used the system. The CMS prototype senses the context automatically from different sensors, calendar information, work schedule, etc., to change the physicians' availability and the phones profile, according to the collected context information. At the same time, the caller is given feedback about the physicians' availability, and thereby it is possible for the caller to force through an emergency call, or forward the call to another physician at the same level, that is available. However, we have realized that this smart solution dedicated doctor-doctor communication could be even smarter [1]. We have established a generic CMS solution: A fundamental new ICT infrastructure for all health care actors (not only doctors), and other actors with complex, temporarily and time critical communication patterns.

This paper focuses on the communication pathways of the patient alarm system to be improved for health care actors in hospitals by revealing the communication patterns according to an alarm between those actors. We will include the communication pattern between nurses, other health care actors, patients and the devices used.

1. Methods

The research method used in this paper is based on the ideas from the PICO-method: Population, Intervention, Comparison and Outcome [5].

1.1. Defining the Actors (Population)

Patients can push the alarm button next to their bed [6, 7] for medical questions, ask for help, medicine, water or urgenct calls [8]. **Nurses** call a pager mostly to get informed about the patients' health [8]. **Head Nurses** make calls to get information about the patients they have to take care of [8]. **Physicians** were carrying pagers [9]. Most of them carry more than one pager at the time [2]. There are **Senior Physicians** and **Junior Physicians** [10, 11], where there is are differences in usage of the pagers and the communication between senior and junior physicians [11]. The information both need when calling someone is in 75% of the time information about a patient [12]. **Laboratories** page to inform physicians and nurses about their patients [13]. **Devices,** i.e. heart rate monitor, etc. **Technicians** also wear pagers to get the alarms when a device is not working or damaged [6]. **Heads of department** use the pager to be available for information and emergency calls [14].

1.2. Defining Pathways Between Health Care Actors

The actors described in the previous section communicate with each other. For the nurses and the head nurses, the communication is mostly with other health care actors. The patient can only page the nurse and the head nurse using the bedside alarm button [6, 7]. They do not have a pager and cannot be paged. The devices can only send alarms to the caregivers, in this case the nurse, head nurse and technicians [6].

1.3. Improvement (Outcome)

This part will have a theoretical look about how to improve CMS according to earlier research. The improvement will focus on the alarms sent to the nurses. This improvement is divided into the following parts: Separate alarms according to patient risk, Preference for patients, Preference for physician, Differentiation of device alarm or patient alarm, and Priority of alarms.

1.4. Interviews (Comparison)

After we define which theoretical improvements we want to investigate, we tested the improvements on the nurses through a 26 question questionnaire. For each subject, questions are asked if they would like to have this improvement, how it is today, and how it can be implemented into CMS.

2. Results

2.1. Interview with the Head Nurse

Priority of Alarms

The nurses at a hospital have different levels of education. There are six different types of nurses at the oncology department at the UNN, ranked in the following order: 1. Head nurse, 2. Specialist in oncology, 3. Specialist in psychiatry, 4. Nurse, 5. Nursing assistant, 6. Assistant for cleaning the bed etc.

Every morning there is a meeting at the ward to discuss and delegate the responsibility for each patient. The nurses do not have a predefined schedule on their work, unless there is a very ill patient, which demands full attention. In these situations, the responsible nurse should not be interrupted. The nurses should neither be interrupted when they are calculating medicines and visiting the patients together with the physician. In such cases, seeing the priority of the alarm could help delegate the alarm to a nurse lower in the hierarchy.

Separate Alarm According to Patient Risks

At the oncology department, almost all the patients have a high risk. When a nurse gives chemotherapy, they know that they could not leave the patient, and that a call or alarm from that room is urgent. They prioritize the alarms by themselves, and decide by themselves who takes care of the alarms from the patients.

Differentiation of Device Alarm or Patient Alarm

The nurses get alarms from patients using the alarm button next to their bed or in the sanitary room. The nurses know which rooms and beds, or what sanitary room the alarm comes from. The devices at the department do not send alarms to the nurses' pagers, but nurses would still like to know if the alarm is from a device (manually from the patient) or from the patient.

Preference of Calling a Physician

They have a preference to call a specific physician, mostly based on that patient's responsible physician, or from experience. *"I would like to call the head of the group, because he knows the most" (Head nurse).*

Preference for Patients

Each health care worker has a preference for which patient to treat. This depends on the disease or knowledge of the patient. *"It is important to have the same nurse at the bed every day; the patients are coming back a lot at this department"(Head nurse).*

2.2. Questionnaire

15 of the employees at the department filled in the questionnaires. 1 head nurse, 1 specialist in oncology, 11 nurses, 1 secretary and 1 undefined. Due to page limits, we will only focus on a few of the questions in the questionnaire.

Priority of the Alarm

Question 1: *"Do you think seeing the priority of the alarm from a patient gives you a better idea of how soon you have to go to the patient".*

9 *"yes"* and 6 *"no"*, where all the *"no"* came from nurses, 2 *"yes"* from others, 1 from a specialist in oncology, 5 from nurses and 1 from the head nurse. The explanation for *"yes"* was argued by sending the right person to the patient when they know the priority, or they could see if they can wait or finish their current task before they go. Most explanations for *"no"* were related to the responsibility, if a patient needs help they have to go and the priority of the call does not matter.

Differentiation of Device Alarm or Patient Alarm

Question 7: *"Do you want to know if the alarm is from a device or from a patient itself?"*

9 *"yes"* and 3 *"no"*, where 7 *"yes"* came from nurses, 1 from the head nurse and 1 from the others. 3 *"no"* where given, 1 of them from the others and 2 from nurses.

Preference for Physician

9 out of 11 have a preference to call a specific physician. They defined the best suitable physician by the one that is responsible for the group or the patient. The ward has a head physician that the nurses can call and get help on who to contact.

Preference for Patients

11 out of 12 have a preference to treat a specific patient. Mostly, they defined the preference by the medication the patient needed, the basic needs of the patient, or by the nurses education. The nurses want to have continuity in their patients' treatment.

3. Discussion

When evaluating the answers from the head nurse we learned that the devices did not send alarms to the nurses. An alarm in the form of a device, like a heart rate sensor, the patient had to push the bedside alarm button manually.

A patient can only send an alarm to the nurse by pushing the alarm button. The nurse has to go to the patient to see what the problem is. Most of these alarms are not urgent, and thereby, if the nurse could in some way know more about the alarm, it will be easier to decide better on the prioritization of the patient alarms.

Nurses have a preference to call a specific physician, and if that person is not available, they normally have a backup person. These preferences normally depend on the patient and the treatment. Therefore, it will be hard to implement this into the system. However, taking a better look at the pathways of finding the available physicians indicates a good way of implementing the choice into the system. The nurses now call the on-call-duty physician who either helps them or tells them who can. Also by knowing the availability and location of the nurse or physician, they will save time on passing messages and thereby the system can find the closest available nurse in urgent cases.

The prioritizing of the current task of the nurses should be investigated more. They use a lot of time searching for resources or other healthcare workers. For now, the system does not know what priority the task has. Such prioritization could route an alarm sent by a patient with a certain priority to a specific nurse.

The system is not totally smart yet; the nurses still have to make decisions by themselves. This will reduce the errors in the beginning, but more research is needed to find the error effect before implementing new features into the system.

4. Conclusion

Without changing a lot of the decisions the nurses make nowadays, the following priorities will be given to the alarms that can be sent from a patients' bed and bathroom. When a patient pushes the bedside alarm button, the alarm will have the priority *normal*. When the patient pushes the button at the sanitary place, the alarm will have priority *urgent*. Pushing the button by a nurse, this is a "nurse call" next to the bed of the patient, will have priority *very urgent*. This means that the nurse needs assistance. The last priority that can be given to an alarm is *emergency*; this will only exist when a nurse pushes the "heart stop" alarm next to the bed of the patient. It was not clear if the users want to see the priority of the alarm, thereby this should be configurable for the users of CMS.

Separate Alarm in Patient Risk

All the patients at the oncology department are high risks patients. The nurses use a whiteboard where they put information about the patients (radiation, chemotherapy, fasting, palliative care and diabetic). Some patients get an icon behind their names. These icons say something about their health and risks. Since all patients are high risk, it is a good idea to implement these icons into the system. This risk implemented into the system could give an alarm from one specific patient a higher priority than from another patient.

Differentiation of Device Alarm or Patient Alarm

Known from the interviews, there is no alarm sent from a device to a nurse. The device is only bleeping and the patient has to push the button next to their bed by themselves. There are systems available that send alarms from a device to the nurses. Most of the participants want to know if an alarm is from a patient or from a device, so that the right person can go help.

Preference for Patients

A nurse is given preference to treat a specific patient. Except for emergency situations, a nurse is allowed to not treat a patient but then needs to find others who can help. The reason why nurses are given a preference to treat a patient relies on continuity, medication, basic needs, and the priority of the patients. A patient, who needs urgent help, will get help first. When patients are given a profile with these terms, it will be easier to find the best suitable nurse to help the specific patient when an alarm button is pushed.

Preference for Physician

The nurse also had a preference to call a specific physician to ask for help. This is, most of the time, the physician that is responsible for the patient, or the physician on duty. Normally they call the physician that has on-call-duty at the ward, which will forward the right person. With this implemented into CMS it will be possible to call the physician that is responsible for the patient.

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Teaching Nursing Informatics in Australia, Canada and Denmark

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Abstract. Whilst there is a strong interest in nursing informatics in the graduate nurse population, nursing informatics has been slow to be incorporated into the undergraduate nursing curriculum. Nursing schools in Australia, Canada, and Denmark are all currently involved in redeveloping their curricula to include nursing informatics in a meaningful way. This paper provides a brief historical description of the uptake of nursing informatics in each of the three countries and discusses the required future directions and strategies towards incorporating nursing informatics into the undergraduate curriculum.

Keywords. Nursing informatics, nursing education, nursing curriculum, informatics education

Introduction

The explosion in the number of health information technologies (HIT) that are being implemented in health care settings has resulted in a transformation of work practices. Internationally, there is a belief, common to most policy makers and clinicians, that HIT can improve the quality of patient care and deliver cost efficient patient health outcomes. However, it is essential that entry-level members of the nursing profession possess the knowledge and skills to incorporate HIT into their practice in a meaningful way. This requires undergraduate nurses to be provided with the knowledge, skills, judgment as well as the means for learning about the use of HIT in the context of undergraduate nursing curricula. This involves students' understanding the importance of informatics from the commencement of their training. In this paper we provide a historical description of the uptake of nursing informatics in Australia, Canada, and Denmark demonstrating the different approaches in terms of past and current strategies that are being used to incorporate nursing informatics into undergraduate curricula.

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1. Historical Development of Nursing Informatics Education

Nursing informatics is an area that needs to be integrated into the nursing curricula internationally. Around the world, countries are in differing stages of this process. Internationally, nurses can learn from each other where these competencies are concerned. For example, Australia, Canada, and Denmark, each have developed differing strategies for introducing nursing informatics into the nursing curriculum. We begin by reviewing the development of nursing informatics in these countries. It is interesting and worthy to note that each country has engaged in formative work in this area for up to 30 years in advance.

1.1. Australia

Australian nursing informatics began in 1984 and as a discipline has had a significant impact on the education of nurses and other health professionals in relation to the use of digitised health information. However, the focus in the past was on post-registration training or adoption of nursing informatics and to a degree resulted in the development of specialists in the area, albeit specialists with a broad scope of practice [1]. Ribbons [2] reported on a study of all Australian Schools of Nursing conducted in 1993. This study examined the perceived most significant obstacles to providing IT education to student nurses. It found the most significant barrier was that staff felt they were "hampered by a lack of time, developmental or technical assistance, faculty skills, funding, training opportunities, faculty commitment and appropriate software" [2]. A study by Hardy and colleagues [3] explored the perceptions of students commencing a bachelors level nursing degree. This study asked the students about their actual and desired knowledge about technology as it relates to nursing care. The respondents indicated that they need more, and relevant, experiences with the applications and systems used in the daily care of patients. They also indicated a need for an increased theoretical understanding of informatics [3]. However, despite these early studies into the educational needs of Australian undergraduate nursing students limited informatics content was introduced into the undergraduate curriculum.

1.2. Canada

In Canada nurses first began to take an interest in nursing informatics with the introduction of hospital based information systems in the 1980's, but it was not until 1998 when the Canadian Nurses Association (CNA) initiated the National Nursing Informatics Project in an effort "to begin to develop a national consensus and priorities in nursing informatics development" [4]. This initial work focused on developing a definition of nursing informatics, recommending informatics competencies for entry level nurses, educators, specialists, managers and educators. In addition to this, suggestions were made about how to include nursing informatics competency development in a nursing curriculum at a basic level, and priorities were set for implementing nursing informatics education in Canada [4]. As part of this work the CNA also spearheaded the development of a nursing minimum data set that reflects nursing care, followed by the release of several key documents defining and outlining aspects of nursing informatics [4, 5].

In 2002-2003 the Canadian Nursing Informatics Association (CNIA) in conjunction with the Office of the Information Highway and Health Canada researched

the state of nursing informatics education in Canada. The level of nursing faculty preparedness in the area, and the information and communication technology infrastructures present in Canadian nursing schools were studied [6]. Findings from this work revealed that undergraduate nursing programs lacked the basic content necessary to fully educate students about nursing informatics, and that "efforts to engage nurse educators in discussions regarding the significance of informatics for tomorrow's nurses had been met with limited interest and understanding" [6]. The research also suggested "there was an obvious need to heighten the awareness and active participation of nurse leaders in the development of strategies to attend to the informatics education needs of Canadian nurses" [6].

1.3. Denmark

Nursing informatics was introduced in Denmark in the early 1990's. It was strongly inspired by the international working group for Health informatics of the International Medical Informatics Association (IMIA). The International European Nightingale project had an impact on Danish development of nursing informatics in nursing schools [7] and was followed by the SIP project that was aimed at pushing "technical education for nursing students and the telematics project" led by Mantas [8], but it was not integrated in the Nursing bachelor's curriculum until 2001.

2. Current State

As outlined above, the focus of nursing informatics education was more upon skilling registered nurses to become informaticians rather than developing nursing informatics competencies in nursing students. However, it has become evident that all nurses require an understanding of informatics irrespective of their level and location.

2.1. Australia

A 2007 study of nurses and information technology by Hegney et al. [9] indicated that nurses continue to be underprepared to incorporate information technology in their practice. The study found that approximately one third of nurses had received formal training in the use of basic software. It is also concerning to note that as recently as 2008 Thompson and Skiba [10] found that nursing informatics training continued to be equated to computer and information literacy. Since this research was published, there has been an increasing drive to ensure that universities include nursing informatics at all levels. The Coalition of National Nursing Organizations (CONNO) in its 2008 position statement [11] indicated that support is required to provide nursing informatics in the core content of undergraduate curricula and should be provided to all nursing education providers. CONNO states that it is "vital that nurses remain engaged with the issues associated with the development and roll-out of clinical communications systems to ensure the unique discipline of nursing, and its interventions and associated outcomes, are accurately captured by the clinical information systems being implemented" [11]. In 2012 the Australian Nursing and Midwifery Accreditation Council (ANMAC) released new standards for accreditation of nursing education. The new standards include informatics requirements including "familiarity with health informatics, including person-controlled electronic health care records" [12]. ANMAC

acknowledges the importance of developing "the capacity to innovatively use information technology and electronic resources to research the growing evidence base for improved care and treatment methods" [12]. For a nursing degree to be accredited in Australia it must include informatics. There remains a missing piece in the puzzle though: despite the development of national NI competencies for undergraduate nursing students in Australia [13] the competencies are yet to be accepted by the regulating bodies. With approved competencies linked to the ANMAC accreditation standards it will become easier to gain consistency in the inclusion of NI in the undergraduate curriculum.

2.2. Canada

In Canada since 2003, we have seen an increase in the number of nursing informatics courses and certificate programs being offered in Schools of Nursing at the undergraduate and graduate level [14, 15]. In 2009 the first graduate program in nursing informatics was approved [16]. The program was developed through a partnership between a school of nursing and health informatics, and includes graduate courses in nursing and health informatics as well as two experiential learning opportunities, where students work in industry roles that allow them to develop their nursing informatics expertise [17]. The program allows nurses to graduate with Masters level competencies in nursing and health informatics [16]. In 2012, the Canadian Association of Schools of Nursing (CASN) in partnership with Canada Health Infoway developed Nursing Informatics Competencies for Entry-to-practice for Registered Nurses [see 18] and learning tools and resources that can help faculty to teach undergraduate nursing informatics competencies to students [19]. The work was critical to identifying modern, entry level nursing informatics competencies [13, 18]. Today, CASN is actively involved in supporting faculty in a peer to peer network to help faculty master nursing informatics competencies and integrate them into nursing curricula across the country. Peer leaders will engage nursing faculty across the country and provide mentorship and support to faculty members in Schools of Nursing [20].

2.3. Denmark

In Denmark, the nursing curriculum is prescribed at a national level by the Ministry of Education through Departmental Order 29, which determined that a program includes theoretical and clinical technological development is required in the nursing degree [21]. Order 29 contains specific requirements for the inclusion of theory relating to: nursing terminology; electronic structured nursing documentation; clinical databases and quality development; electronic communication with the patient/citizens; and electronic communication between hospitals and primary health care [22]. This ensures that nursing informatics commences in the bachelors program, 18 months after start and meets the prescribed minimum content requirements. It contains IT based communication, cooperation and understanding about how health informatics is used in relation to the health care professional area. This discrete module, worth two ECT points, consists of 27 lectures, mandatory assignments, and an individual oral exam.

3. Discussion

It is evident that all three countries continue to be aiming to produce beginning level nurses with nursing informatics skills, knowledge and judgment. These are nurses who "have fundamental information management and computer technology skills and use existing information systems and available information to manage their practice" [23]. Based on work by Schulte [24] there are a number of components of a basic course that help to get students to the level of beginning nurses in relation to Nursing Informatics that can be applied here. These basic skills include:

- Select, access, and search appropriate databases and the Web; evaluate Web sites; relate information technology, information literacy, and evidence- based practice
- Define, describe, and discuss basics about standardized languages and their impact
- Describe the transformation of data and information into knowledge (knowledge management)
- Introduction to electronic health and medical records
- Understand how to handle patient information ethically, data security, social media use and communication

One key issue in successfully incorporating nursing informatics into undergraduate degrees is the developing up our educators so that they are confident and competent. Recently, there has been recognition that there are few faculty members who have preparation in nursing informatics and these individuals are not uniformly distributed among nursing programs. This recognition has led to Canada developing peer-to-peer faculty networks across university schools of nursing so that faculty who have expertise in teaching nursing and informatics can help faculty who do not have this type of expertise to develop informatics related competencies and to exchange experiences in terms of teaching the competencies and how they might be integrated into education [20].

To date, it appears that Denmark has integrated nursing informatics into the undergraduate nursing programs more successfully than both Canada and Australia, who are only beginning to embark on this process. Informatics is uniformly present in nursing curricula and there are nurses who are prepared in the field of nursing informatics who teach these courses. Australia and Canada have recently developed nursing informatics competencies that can be integrated into an undergraduate curriculum.

4. Conclusion

Whilst there are differences in the development, evolution and integration of nursing informatics into undergraduate education between the three countries there is evidence of an increased recognition of the importance of NI education. It is becoming increasingly important that our new graduate nurses are able to understand and incorporate NI into their work from the first shift in the workplace. To achieve this, there is a requirement to incorporate entry level competencies and develop skills and competence in the nursing education workforce.

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Nurse Practitioner Perceptions of the Impact of Electronic Medical Records Upon Clinical Practice

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Abstract. A survey was conducted in the province of British Columba, Canada with nurse practitioners (NP). This paper reports on the quantitative and qualitative findings of the survey questions specifically focused on NP perceptions of the clinical impacts associated with using electronic medical records (EMRs) in a primary care setting. Findings suggest that although NPs perceived EMRs to improve the overall quality of clinical decisions, challenges remain in terms of tailoring the design of EMRs to address NP needs.

Keywords. Nurse practitioners, nurses, electronic medical record, adoption, perceptions, clinical informatics, interface design

Introduction

Electronic medical records (EMRs) are being implemented in primary care settings around the world. Yet, the focus of much of this research has been upon physician adoption and perceptions of the technology rather than taking into account the perceptions of other health professionals who use EMRs such as nurse practitioners (NPs) [1,2]. NPs have advanced education that allows them to autonomously diagnose health conditions, order and interpret diagnostic tests, prescribe medications, and perform procedures within their legislated scope of practice [4]. To date little research has been done investigating NPs perceptions and use of EMRs in primary care settings [3]. Prior research has found that disciplinary differences affect health professional EMR usage in terms of the type of information sought and information seeking activities involving the technologies [5-7]. Such disciplinary differences need to be considered in light of the design of separate, disciplinary specifc healthcare professional "views" of patient information in an EMR [8]. Increasing numbers of NPs are independently providing primary care, but most EMRs were designed to support physician primary care practice [9]. Therefore, research is needed to understand if the EMRs that NP's are currently using are perceived to be supportive of their work. Given the rapidly expanding number of NPs using EMRs, such research is essential to informing next generation EMR design for NPs. In this paper we report on NP

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perceptions regarding the impact of EMRs upon the: (a) quality of NP clinical decisions, (b) NP access to information, (c) support of NP communication, (d) NP medication prescribing, and (e) NP delivery of preventive and chronic care services. This study is one of the few studies that focuses on NP perceptions of EMRs.

1. Review of the Literature

There have been many publications documenting the differences in physician, nurse practitioner and nurse practice [1, 2, 5, 6, 10]. For example, research has shown that physicians, NPs and nurses attend to differing types of information in the patient record and that information seeking behaviours involving EMRs are influenced by differences in education and experience [5,7,11]. As outlined earlier less attention has been paid to understanding NP's perceptions of EMRs originally designed for physician use in primary care settings [9]. In a recent search of PubMed and CINAHL conducted by the authors using the search terms "electronic medical record" and "nurse practitioner" as well as "electronic health record " and "nurse practitioner", 362 articles were returned but only five articles were noted to specifically discuss NP use of EMRs. Andrews et al. (2004) conducted a survey of primary care practitioners in the US who work in a practice-based research network in Kentucky (their sample included NPs, physicians and physician assistants). In their survey the researchers found that 21% of primary care practitioners were using an EMR while the remaining survey participants were "planning to use", "would like to use" or "have no interest in using an EMR". The researchers reported the biggest barriers to survey participants' using the technology were concerns over privacy (4%), the cost of an EMR (58%) and a lack of knowledge (16%) about how to use the technology. A limitation of the study is that researchers did not specifically report on NP responses to the survey questions so it is not clear if there are differences between the health professionals surveyed in terms of their perceptions of EMRs. Therefore, it is difficult to acertain if there are any differences in the responses between NPs, physicians and physician office assistants [12].

In another study Li and colleagues (2012) conducted semi-structured interviews with clinicians in an emergency department (ED) in two teaching hospitals in Australia in an attempt to learn more about how NPs incorporated information and communication technologies (ICT) into their practice. This included collecting information about how NPs integrated the EMR and other ICT's into their work. Five NPs were interviewed along with four senior physicians and five senior nurses (i.e. nurse managers, a senior nurse and an advanced clinical practice nurse). The NPs worked in a hybrid envrionment where some patient information was accessed electronically and other information was documented electronically by NP's, printed, and later added to a paper patient record. Physician and nurse participants agreed that advanced practice and holistic care characterized the role of the NP in the ED. NPs believed they used the electronic records much like their physician counterparts; accessing ED triage information, clinical notes, laboratory results and diagnostic imaging results in the process of providing patient care. NPs indicated they believed the information made accessible via the electronic record facilitated clinical decision making and reduced the likelihood that information would be lost or misplaced. NPs identified the need for future EMR functions to include progress notes and medication management [6]. A limitation of this study is that it reports on NPs who work in an ED setting and use a

hospital based electronic record. This study is also limited in that it focuses on NP's whose work context and use of hospital based electronic records may differ from that of NP's who work in primary care settings. It must also be noted a small number of NPs (n=5) participated in this study.

In 2012, researchers documented NP use of EMR clinical decision support systems (CDSS). Fathauer and Meek (2012) examined the effects of an EMR CDSS that provided NPs with information about Hepatitis C treatment guidelines [13]. The system led to high rates of quality indicator completion by NPs. Other researchers (i.e. Savinon et al., 2012) conducted a restrospective analysis of EMR data to determine the impact of introducing childhood guidelines upon the frequency of recording child body mass index, growth charts and questionaires in the EMR. The focus of both these studies was a CDSS used in conjunction with an EMR upon clinical documentation [14]. More recently, Borycki et al. (2014) conducted a qualitative, semi-structured interview study with several NPs who were working in a primary care setting in Canada (n=15). The interviews revealed NP's used differing EMR features and functions when caring for an individual patient as compared to caring for a group of patients at a clinic level. EMR features and functions (e.g. clinic notes, reminder tasks and careplans) were used to support NP clinical practice in the context of individual patient encounters to provide patient specific care. Alternatively, NP's used the EMR's report generating functions to identify groups of patients who would benefit from patient wellness and chronic disease management activities at a clinic level [15]. None of these studies fully examine NP perceptions of EMRs as they are used in primary care. Researchers are only beginning to learn about how NPs, as a specific type of health professional, perceive EMRs.

2. Methods

2.1. Sample

NPs from across BC were invited to complete the Nurse Practitioner Practice Patterns Survey (NPPPS) if they were: a) registered with the College of Registered Nurses of BC, and b) had consented on their registration to be asked about participating in the research. Some of the questions on the NPPS were related to perceptions about the EMR. In British Columbia the majority of NPs work in primary care settings.

2.2. Setting

BC is a province in Canada that is larger than France, Germany and the Netherlands combined. Most of BC's population lives in Vancouver and Victoria [16]. NPs practice across a wide variety of primary care settings including urban, rural and remote areas of BC.

2.3. Procedure and Analysis

The NPPPS was hosted on Fluid Surveys® which is an online survey application. NPs who had previously indicated a desire to participate in research were sent letters of invitation by mail by the College of Registered Nurses of BC (CRNBC) on behalf of

the researcher. NPs were also invited to participate by email via the University of Victoria NP alumni list serve. Finally, an invitation to participate and a URL were posted on the BC Nurse Practitioner Association website. NPs who wished to participate in the study clicked on the entered URL in the search box of their browser or simply clicked on the entered URL to be redirected to the survey on Fluid Surveys. The survey had both open and closed-ended questions. Here, we report on NP perceptions in response to ten closed ended questions that focus on quality of care, communication and prescribing as well as two open ended questions that ask NPs to list the benefits and challenges of using EMRs (see [3,15] for other publications associated with this work). NP demographic data and responses to statements about perceptions were analyzed using descriptive statistics. Answers to open ended questions about the benefits and challenges of using EMRs were qualitatively coded using thematic analysis.

3. Results

In this section, the researchers report on demographic characteristics of the sample and NP perceptions of the EMR as they influence the quality of NP clinical decisions, access to information, communication, medication prescribing, and delivery of preventive and chronic care services.

3.1. Demographic Data

Thirty one NPs completed the survey (response rate of 14%). This is consistent with response rates for other online surveys [6] and the relative newness of the NP role (i.e. the role was introduced in 2005). NPs completing the survey were mostly female (85%) and were an average age of 46 years (range 28-60 years). They practiced an average of 19 years as a registered nurse prior to becoming an NP. NPs had practiced an average of three years as an NP. Five were using full electronic records, and 17 were using hybrid paper-electronic records. The remaining respondents used paper charts. This is consistent with other NP EMR studies who report use of paper and hybrid EMRs in this group of health professionals.

3.2. Quantitative and Qualitative Data

NP participants who used full or hybrid EMRs were asked a number of questions relating to the quality of clinical information, communication, medications and access to EMRs. NPs were asked to rate a number of statements on a five point Likert scale from major positive to major negative impacts of the EMR on NP practice from an NP perspective. On the x-axis of Table 1 are the NP practice statements that the researchers asked the NPs to rate positively and negatively. On the y-axis we provide the percentages of NPs who provided ratings from the major positive to the negative perspective on the practice statements. Our findings indicate most NPs perceived the EMR to have had a major positive to positive impact on the quality of their clinical decisions, yet there were a high number of NP's who believed that the EMR had no impact on preventative and chronic illness care. Sixty seven percent of NPs believed that the EMR improved communication between healthcare providers. NPs also

believed the EMR contributed to timely access to medical records, prescription refills and to avoiding medication errors (see Table 1).

Participants were asked to list the benefits and challenges associated with using an EMR. Participants believed EMRs improved communication between healthcare professionals, provided information supports, supported patient care activities, and decreased the likelihood of medical errors as illustrated by the following comments: "*communication between practitioners is consistent*", "*access, remotely to the EMR when at home or working at my other site…permits me to view that patient's chart and diagnostics as needed*", and "*shared case notes assist in continuity of care between care providers*". Participants also noted the EMR provided information and patient care activity supports as illustrated by the following comments: "*graphing results for patients*", "*easing access to and support patient care activities by providing opportunities for creating call/back follow-up issues*" and [allowing for] *"keeping track of tasks*. More importantly, participants indicated the EMR decreased the likelihood of medical errors occurring as illustrated by the following participant comment: "*typing is more legible*" [than written records].

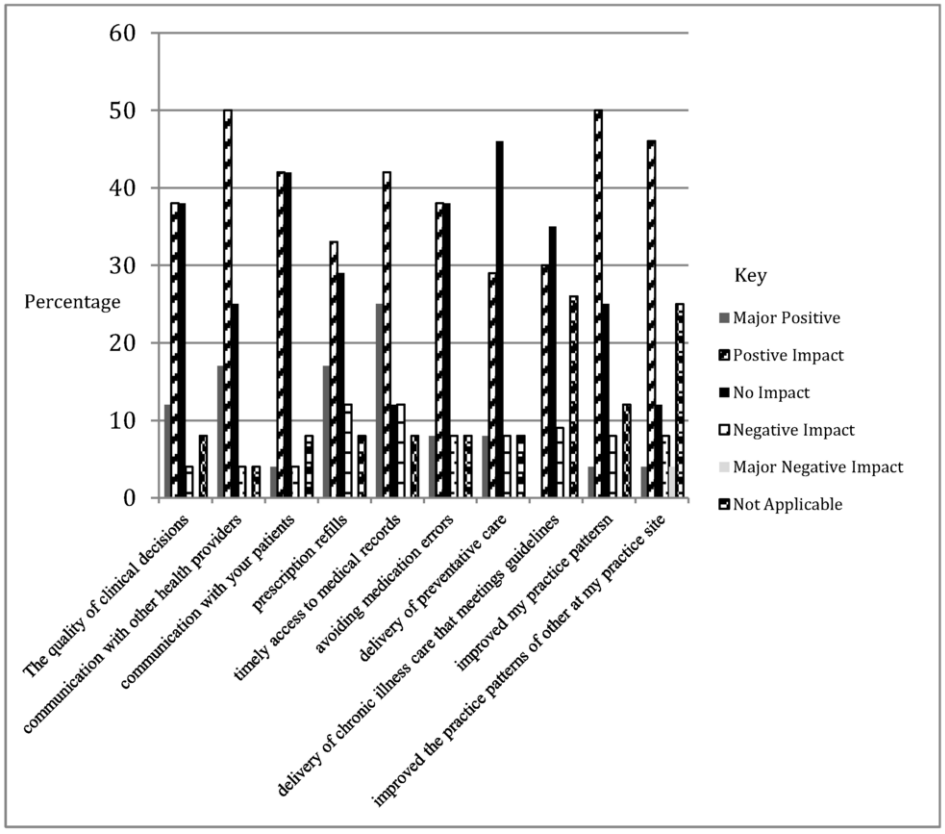

Table 1: NP perceptions of EMRs

NP participants' identified: system performance issues, issues associated with hybrid charts, lack of interoperability between systems and system content issues as

challenges. Systems performance issues included the: "*computer is very slow*","*crashes*", and "*technical difficulties like loss of information already entered or system down or frozen*".

Hybrid charts were also considered a challenge as issues arose from patient data being spread out across paper and electronic records, there being incomplete records and a need to rely on paper requisitions as illustrated by the following participant comment: "*sometimes medication profiles are written, other times in the computer"*, "*spend a significant amount of time filling out requisitions and then ensuring they get to the department*", and [hybrid charts lead to] "*incomplete records*".

Lack of interoperability between systems was also a concern. Participants noted that systems do not transfer information between each other and this sometimes leads to additional work to seek out necessary information to support decision making as outlined in the following quotes: "*paper and EMR and different EMR systems depending on where client is and they do not "talk" to one another*", "*lab results do not pull through from all locations requiring multiple searches*" and systems "*do not allow for porting* [transferring of information from] *clinical forms*".

Finally, EMR content was considered a challenge. NPs identified that in some cases EMRs were not updated with new clinical information or did not allow for fulsome documentation of information as noted below: "*non-responsive to clinical changes/updates*", "*unable to make timely changes (within 5 years)*" and "*limited text*".

4. Discussion

We have reported quantitative and qualitative data collected about NP perceptions of the impact of EMRs upon quality of patient care, access to information and support of communication, medication prescribing, and delivery of preventive and chronic care. NPs believed that EMRs that are currently in use improved the quality of patient care, access to information, communication and prescribing. This is consistent with prior research published in this area [6]. Yet, NPs believed EMRs had no impact on preventative or chronic patient care – two important areas of NP practice focus. This is an interesting finding as EMRs may contribute to overall improvements in health care processes that influence quality and safety (such as improving communication, timely access to care or improvements in the quality of clinical decision-making). It may be that EMRs that NPs use may not be able to fully support an NP's long term management of individual patients and groups who are suffering from a chronic illnesses or are at risk for developing health problems. This is reflected in study participants' qualitative comments. There is a need to conduct research with NP's to document the types of preventative and chronic care activities that NP's undertake with their patients. This work might inform the development and design of specific preventative care and chronic disease management order sets, EMR templates and CDSS that could be used by NPs. In addition to this, NP's were concerned about the currency of clinical information and guidelines in EMRs. The development and testing of EMR CDSS that provide alerts and reminders and up-to-date clinical information is key to supporting NP activities and may need to be further enhanced. These findings are consistent with the work of Fataheur and Meek [13] and Savinon et al. [14], who found that the introduction of CDSS as part of an electronic record leads to changes in NP practice. NPs appreciated the ability of the EMR to improve communication between team members, continuity of care and patient collaboration. Yet, given the the

lack of interoperability between systems and hybrid charts in BC, NP's identified that there is a need to focus on data interchange between EMR systems to reduce the amount of missing information. This concern was also reported in the physician EMR literature focusing on interoperability [17]. To date, little research has been published about NP use of EMRs or their need for EMR systems interoperability (n= 5 articles). As NPs are a differing type of health professional (i.e. they differ from physicians, nurses and physician assistants) in terms of their information needs, information seeking behaviour and perspectives towards patient care [5-7], there is a need to design EMRs that better fit NP practice (as EMRs were historically designed for physician use in primary care) [9]. It must be noted that even though some NP perceptions of EMRs were similar to physician perceptions (as published in the EMR literature) [9]. Other NP participant perceptions such as the belief that the EMR does not fully support preventative and chronic care differ. This is a new finding for the NP literature. Next generation design of EMRs to support NP practice should include NP's in the design of systems (e.g. using participative approaches). This would lead to the development of order sets, templates and CDSS that are specific to NP information needs, information seeking and patient care activities.

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Evaluating for Context Through Usability Testing and Ensuring Patient Safety

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Context Sensitive Health Informatics: Many Places, Many Users, Many Contexts, Many Uses
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Towards Evidence Based Usability in Health Informatics?

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Abstract. In a Health Information Technology (HIT) regulatory context in which the usability of this technology is more and more a critical issue, there is an increasing need for evidence based usability practice. However, a clear definition of evidence based usability practice and how to achieve it is still lacking. This paper underlines the need for evidence based HIT design and provides a definition of evidence based usability practice as the conscientious, explicit and judicious use of current best evidence in making decisions in design of interactive systems in health by applying usability engineering and usability design principles that have proven their value in practice. Current issues that hamper evidence based usability practice are highlighted and steps needed to achieve evidence are presented.

Keywords. Human engineering, ergonomics, evidence, evaluation, health informatics

1. Introduction

Health Information Technology (HIT) is increasingly disseminated and implemented to improve patient safety, performance and healthcare quality. Nonetheless, HIT applications face several acceptance issues, and because of these are often abandoned or fail their objective [1]. Their potential to improve healthcare is critically viewed upon due to the reports on induced medical errors [2] that may ultimately lead to patient harm or death [3-5]. A major cause of those problems has been attributed to problems in usability of HIT [4-5] where usability is the "extend to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specific context of use" [6]. Usability concerns the elements of the graphical user interface, their arrangement, navigational structures, the behavior of the system in response to users' actions along with the completeness of functions and the work model implemented in the system. A HIT with a high usability supports users achieving their tasks efficiently, effectively and with satisfaction in a safe context. When a HIT is poorly designed, users' interaction is negatively affected (e.g. increasing

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their workload). Ultimately, this can impact the work system in which the HIT is implemented, by causing usability-induced use-errors that may harm the patient [7].

To prevent consequences of usability issues, usability must be considered all along the design and evaluation process of HIT. This need has become part of the essential requirements governing the European Conformity marking of medical devices that also applies to certain categories of HIT [8], e.g., typically Decision Support Systems (DSS). To accomplish this, two types of usability knowledge are considered essential:

- Knowledge of the design engineering process and related usability methods;
- Knowledge of usability design principles that apply to the type of HIT[2] under consideration and of concrete instances of their violations (usability flaws).

This distinction is commonly made for clarity sake (e.g. separate ANSI/AAMI guidelines [9-10]), however both types are closely intertwined within design's practice: right design principles need the right engineering process for the HIT be effective.

To improve the integration of the usability knowledge within the HIT design team[3] practice, it is necessary to promote engineering and usability principles that have proven their value in practice. For this purpose, evidence regarding HIT usability knowledge needs to be recorded and provided to the design team in a usable way. Ultimately, such an evidence will be helpful in decreasing the risk of usability-induced use-errors with potential harmful consequences for patients.

Regarding HIT, the process of accumulating empirical data that evidently improve HIT design is still in its infancy. Even while international medical informatics associations consider usability as a dimension of HIT of which the design has to be evidence based [11], evidence based usability practice and how to achieve it are still lacking distinctive definitions. This paper provides a definition for evidence based usability practice in the context of interactive HIT and for the steps needed to achieve it.

2. Defining Evidence Based Usability Practice

The concept of evidence in medicine comes from Sackett et al. [12]. They defined evidence based medicine as “the conscientious, explicit and judicious use of current best evidence in making decisions about the care of the individual patients”. According to this approach, clinicians' decision making process has to be fed by their expertise and by evidence from literature, applied to the patient case (Figure 1). Then, evidence based practice has been extended to other fields such as health informatics [13].

In the field of HIT design, decisions are made by the design team. This team has its own expertise in the development of HIT and adapt it to the intended type of technology. By analogy to medicine, evidence based usability practice can be defined as *the conscientious, explicit and judicious use of current best evidence in making decisions in design of interactive systems in health by applying usability engineering and usability design principles that have proven their value in practice*. This definition first implies that the HIT design team needs evidence demonstrating that the application of usability engineering and design principles is efficient and effective in

[2] In the absence of known taxonomy of HIT, "type of technology" refers to a homogenous category of technology supporting the same task (e.g. alerting systems, Computerized Physician Order Entry etc.)

[3] The design team includes designers, developers, project managers, sometimes informed by experts knowledgeable of Human Factors (HF) engineering and design principles.

preventing usability-induced use-errors. Second, they need to integrate this evidence within their design expertise to make informed decisions in HIT design (Figure 1).

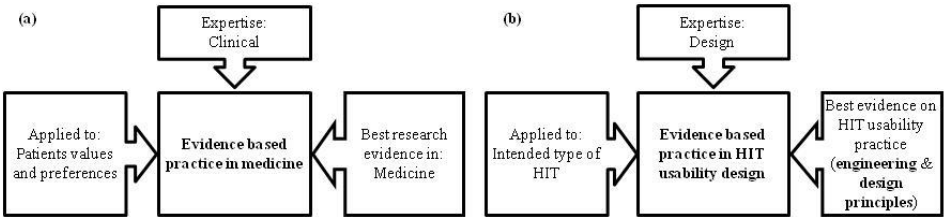

Figure 1. Schematic representation of (a) Evidence Based Medicine and (b) Evidence Based Usability.

3. Steps Needed to Achieve Evidence Based Usability Practice

Progress has been made in the field of evidence based usability engineering as a topic by the development of guidelines and standards aiming at design processes of HIT and/or medical devices [14-16]. However, developing a transversal evidence based usability design practice applicable to a given type of HIT and use context requires an approach. Inspired by [11] we propose the following steps to achieve this goal.

3.1. Perform High Quality Usability Evaluations

Gathering best available evidence first requires extracting relevant data from high quality studies on the impact of HIT usability in certain use contexts. Performing high quality studies is the only way to ensure the validity of the results. Although not specifically dedicated to usability evaluation studies, the "Guidelines for Evaluation Practices in Health Informatics" (GEP-HI) [17] can be used to plan and perform high quality usability evaluations of HIT and analyze their results. Moreover, an increasing number of publications focuses on the (dis)advantages, requirements and pitfalls for applying usability evaluation methods (e.g. usability testing, heuristic evaluation, cognitive walkthrough [18-20]). Those good practices in usability evaluation of HIT must be promoted and HF experts and design teams should be encouraged to apply standardized relevant evaluation methods.

As in medicine where pathology of a patient evolves in a complex environment of genetic, cultural, societal and personal factors, usability-induced use-errors appear during complex interactions between the specific HIT, user(s) with specific profile(s), a given work system and a specific context of use. While HIT experimental evaluation studies in which context variables are controlled provide rich information on the short-term impact of usability characteristics on users, these studies do not provide insight into long-term and indirect consequences of HIT designs on users, their work processes and on the consequences of potential use-errors. Moreover, by controlling for biases, contextual variables interfering with the usage of a HIT technology are not considered. Case studies and post implementation surveillance provide richer and more nuanced data. Therefore, those types of studies should be promoted to get a deeper understanding of the interrelations between specific HIT designs, users' characteristics and contexts of use.

3.2. Publish and Identify Usability Studies

Once those studies are performed, their publication must report on necessary data to seek evidence on HIT usability aspects that improve users' performance in certain working contexts. A recent Delphi study has identified various types of data that should be reported in publications on HIT usability studies, among which [21]:

- List of usability issues uncovered by the study,
- Description of the HIT to be able to merge data from similar HIT,
- Applied usability principles and methods, the contextual factors of HIT use,
- Context of evaluation, stage of the design process, purpose of the study.

However, most of the usability studies on HIT are poorly reported [22-23]. Only a limited number of uncovered usability issues are reported per publication; details on the HIT, user groups, methods and evaluation's context are weakly described.

Improving reports requires applying reporting standards. The "STAtement for Reporting of Evaluation studies in Health Informatics" (STARE-HI) [24] does not fully support reporting on HIT usability evaluation studies because it does not consider specificities of usability evaluations such as the iterative process. To help authors define, conduct and report on completely and accurately high quality HIT usability evaluations, a "Tool for the Reporting of Usability and human factors Evaluation of HIT" (TRUE-HIT) is under development that is based on the results of the Delphi study. Its use should be encouraged. In addition, journals' on-line appendices should be used to publish details on the full set of uncovered usability issues.

Finally, the referencing of usability studies should be improved: "Usability" or "Human Factors" are no MeSH terms. Few researchers know they must use synonyms instead ("Human Engineering", "Ergonomics"). Moreover, "usability" is not always mentioned in the title, abstract or keywords of studies including usability evaluations of HIT (e.g. [25]). It seems relevant to include "Usability" in the MeSH terms while encouraging authors to explicitly identify usability activities in their publications.

3.3. Gather Relevant Publications and Extract Relevant Data

Gathering the best available evidence requires a systematically search, critically appraisal and synthesis of the usability literature for each type of HIT. To help researchers gather relevant usability publications, a HIT usability publications data base should be built on the model of the "IT evaluation database" [26] with adapted usability-related sorting features (e.g. type of usability method applied). Once the potential sources of evidence are identified and gathered, relevant detailed data must be extracted (e.g. type of HIT/method, usability issues and consequences, cf. section 3.2.).

3.4. Compare and Synthesize Publications' Findings

Syntheses should allow (i) assessing the effectiveness of the evaluation methods to uncover usability issues (ii) identifying the specific usability characteristics (flaws or positive ones) reported for a given type of HIT (e.g. [23,27]) and (iii) highlighting what are the consequences of a specific usability characteristic for a given type of HIT on users and work system (e.g. [28]). Meta-analysis is the favored method to synthesize data from various sources. However, even if this method enables to describe the types

of usability characteristics uncovered for each HIT type, it does not provide insight into the consequences of usability for the user and the work system from a qualitative perspective. "Qualitative comparison analysis" [29] allows identifying the causal contribution of various conditions to an outcome of interest. This method should be favored to analyze the ongoing (positive/negative) consequences of usability characteristics of HIT on users and work systems,

3.5. Formulate Usability Design Principles and Develop a Usability Data Base

Ultimately, the results of those syntheses should be used to formulate related usability design principles for each specific type of HIT. Since one better learns from one's mistake, it seems sensible to illustrate those principles with actual instances of their violations extracted from publications. An open usability data base should therefore be developed that present exhaustively and in a structured way usability design principles and related uncovered usability flaws and consequences. This data base could take for instance the shape of a usability ontology (e.g. [30-31]).

3.6. Disseminate Evidence Based Usability Knowledge

Finally the evidence based knowledge should be provided to the HIT design team including HF experts, to support its design decisions. Presenting both usability design principles and actual examples of their violations will help the design team becoming aware of the good and bad usability practices for a given HIT in a specific context of use. This knowledge should be disseminated during the medical informatics curriculum or through seminars or training of HIT manufacturers.

4. Conclusion

In a context in which usability of HIT is more and more considered essential, evidence based usability knowledge is needed. This paper provides the first definition of evidence based usability practice. This topic is still in its infancy and several activities have to be realized in order to develop evidence based usability knowledge on HIT: improve the quality of HIT usability studies and of their report, perform systematic qualitative comparison analyses to identify the ongoing influence of usability characteristics of HIT, derive illustrated evidence based usability engineering and design principles and make available this knowledge to the design team so that it can integrate this evidence within its decision making process concerning HIT design.

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Usability Evaluation of a Medication Reconciliation and Allergy Review (MRAR) Kiosk: A Methodological Approach for Analyzing User Interactions

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Abstract. Internationally, major efforts are underway to improve medication safety and reduce medication errors during transitions of care. One strategy that has emerged to improve data accuracy and close information gaps is the introduction of software applications and workflow models that allow patients to review, enter, and modify their own patient data (e.g. information about medications they are taking). Evaluating the quality and effectiveness of such patient-facing healthcare applications is critical, especially when this approach is applied to high-stakes clinical tasks such as medication reconciliation. In this paper we describe an approach that has been used to assess the usability of a patient-facing medication reconciliation and allergy review (MRAR) kiosk. The phases involved are described along with implications and challenges of carrying out this work.

Keywords. Medication reconciliation, allergy review, usability engineering, usability testing, usability inspection, patient kiosk

Introduction

There have been major efforts nationally and internationally to reduce medication errors at transitions of care. Medication reconciliation (MR) – a standardized method for comparing patient medication adherence to organizational documentation – has been heralded as an effective way to close information gaps and improve patient communication [1-3]. Along these lines, Lesselroth and colleagues at the NorthWest Innovation Center, based at the United States Veterans Affairs Portland Health Care System (VAPORHCS), pioneered the use of patient self-service kiosks to collect data about medication adherence. The Automated Patient History Intake Device (APHID) is a novel software application accessed using a kiosk located in the clinic lobby. It allows patients to review the names, dosage and frequency of their medications prior to their appointments [4]. The system automatically generates a report in the health record for a provider to review with the patient during the interview. Time-motion analysis and discrete event simulation indicated the approach could integrate into

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workflow [5]. Also, a provider survey of tool adoption indicated that most respondents thought the device improved patient safety [6].

Within the last year, the VAPORHCS team conducted a usability evaluation on the patient interface of medication review and allergy review (MRAR) software to determine its effectiveness in gathering structured data for business analytics. A variety of health systems assessment methods have been employed in the literature [7]. One method is heuristic evaluation, whereby one or more analysts step through the user interface, noting violations of standard heuristics [8]. Another method is known as usability testing, whereby participants are observed using the system to complete tasks or scenarios. Previous research has shown that expert inspection and test scenarios can be complementary. Findings can be integrated to improve validity and provide a more robust picture of usability issues besetting health information systems [9]. Furthermore, there are now a number of rapid usability testing methods such as the rapid low-cost usability engineering method [10] and the Rapid Usability Evaluation [11] that combine methods to improve the speed of knowledge creation and compress the development lifecycle. In addition, the term "clinical simulation" has begun to be applied to highlight the simulation aspects of testing involving realistic use cases, settings and contexts [12].

In this paper, we describe an integrated methodological approach to evaluating the usability of MRAR patient interfaces. The rationale behind the approach and some key usability findings from this type of integrated evaluation will be discussed.

1. Methodologic Approach

Our Innovation Team applied a multi-phase approach that integrated a heuristic evaluation with usability testing (as shown in Figure 1 and described below). The goals of testing were to: 1) estimate the learnability and ease of use of the interface; 2) identify and prioritize design concerns that might limit adoption or effectiveness; 3) identify data validity risks that might affect device safety. To describe each phase, we offer herein a case study describing the evaluation of the MRAR at the VAPORHCS.

Phase 1 – Generation of Evaluation Questions:
The team generated questions to determine whether the user interface and workflow would permit patients to complete designated tasks effectively, efficiently and safely. Questions included: Can patients understand the information displayed? Can they identify discrepancies in their medications? Can they learn how to enter new medication information?

Phase 2 – Scenario (Use Case) Development:
The team next created a set of use cases to apply to both heuristic evaluation and usability testing. The software's functional requirements drove use case content. To determine the minimum number of use cases required, a table was created that listed each functional component and the allowable inputs (e.g., user responses, software states, environmental conditions) for that component [13]. We then designed use cases that enabled us to evaluate the behavior of each function in response to a given input (see Figure 2). In our example, 15 use cases were developed to test the following tasks: review medication information, identify medication discrepancies, identify out-of-date medications, and enter new medications. For each use case, a single corresponding

simulation (including an exit interview) was written for heuristic evaluation and usability testing.

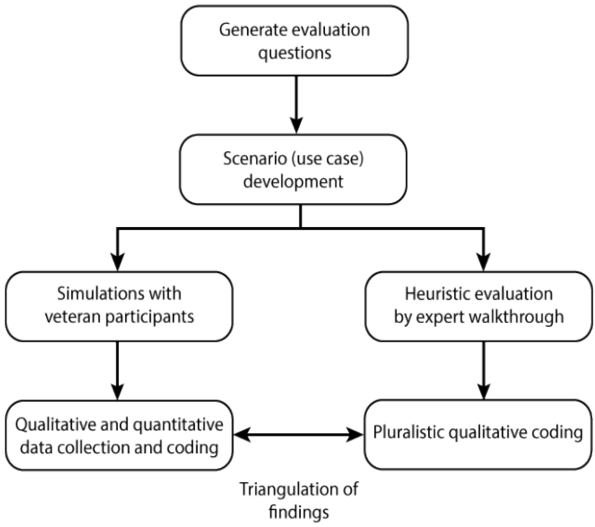

Figure 1. Multi-phase approach to analysis of kiosk use by patients.

Use case: Enter medication discrepancies

Description: A patient has medications on file in the local electronic health record. The patient completes a medication review session and must indicate information changes. The patient adjudicates perceived errors in the prescription list using the touch-screen controls and the comments input capability.

System state:
- active local prescription for lisinopril
- active over-the-counter record for vitamin D
- expired prescription for albuterol

Goals:
- Determine to what extent participant understands on-screen information.
- Verify the participant can designate a descrepancy in the prescription.
- Assess how easy a participant can add information about a new medication.

Conditions and inputs:
- Patient is on time for appointment.
- Patient is taking lisinopril and requests a refill.
- Patient is taking vitamin D according to a different schedule.
- Patient is not taking albuterol and indicates it causes tremors.

Figure 2. Example use-case.

Phase 3 – Heuristic Evaluation by Expert Walkthrough:
For each task, subject matter experts on the team completed a heuristic evaluation using a published rating instrument that measured Nielsen's ten heuristics [9]: Aesthetics, Control, Documentation, Error Prevention, Flexibility, Help, Match, Recognition, Standards, and Visibility. Each finding was documented and assigned one or more usability violation codes on a collection form with screenshots. Several evaluators independently completed the evaluation; discrepancies were resolved through discussion.

Phase 4 – Usability Testing with Participants:
Usability testing was broken into sub-tasks: 1) recruit a user sample, 2) observe subjects completing use-cases, and 3) perform a short exit interview. We used a screening instrument to select subjects (US veteran patients actively enrolled and receiving care at our medical center) based upon age, level of health, and eHealth literacy. To be included in the study, participants had to have at least 3 active prescriptions and must have previously used an automated teller machine (ATM). Participants were furnished with a set of simulated tasks to complete (identified in Phase 2) and encouraged to use the Think-Aloud technique while one or more researchers collected observational data [11]. In our example, this involved recruiting a convenience sample of 17 veterans (average age 68 years) with scheduled clinic appointments. We escorted subjects to a simulation laboratory equipped with a kiosk linked to a test database. The study team recorded interface performance on an instrument that included task goals, anticipated workflow, and sample interface screens. The team recorded task completion rates, qualitative descriptions of participant behaviors (including sample quotes), and design issues marked on the printed screenshots. In addition, a set of open-ended questions drove a semi-structured post-task interview about whether participants found the information easy to understand, and if they found the tasks easy to complete or not. After each participant session, the study team reviewed all findings together, assigned a usability violation code using Nielsen's categories in a top-down manner, and organized interface specific problems into bottom-up categories based upon screen design, function, or workflow point.

Phase 5 – Data Coding, Analysis, and Triangulation of Findings:
For each task, function, or screen (identified in Phase 2), the team noted in a findings table: 1) root-cause heuristic violations, 2) interface design problems, and 3) a consolidated list of user problems prioritized by frequency (see Table 1 for a representative sample). Findings were recorded independently for each method and then combined. There was a modest degree of overlap between methods; many findings were only identified using one method. For findings that appeared in both methods, root-cause heuristic codes were compared and either combined or adjudicated based upon team review and consensus. By applying the same top-down heuristic codes to both methods and then comparing findings, the team was able to 1) assess the degree of correspondence identified through either method (an estimate of criterion validity), 2) speculate upon the root-causes of user error (an estimate of construct validity), and 3) furnish a more complete evaluation to developers.

Phase 6 – Summarization and Reporting:
All results and issues identified in phases 3, 4 and 5 were summarized using several methods. We aggregated major or recurrent heuristic and design themes into a table for developers. The team also collected granular observations and errors in a requirements traceability matrix to help map design specifications to actual performance. Finally, a major findings "map" – a graphic display of the software workflow – was drawn out with the key failure points highlighted. This format was intended to help the architects and software engineers visualize the "stress-points" in the workflow.

2. Results

The multiphase approach outlined above proved to be an efficient method for identifying usability concerns (summarized in Table 1). First, simulation testing helped recognize interface design and visibility problems (e.g., participants frequently failed to see or use the "Add comments" button). Second, by observing users entering comments with the interface, the team identified a number of workflow and navigation missteps. Third, using two techniques in combination surfaced more usability findings than either would have alone. In circumstances where findings overlapped, usability testing tended to validate concerns identified during heuristic evaluation while heuristic evaluation helped focus the observation sessions and attach root causes to error. Overall, both evaluation methods revealed that free text entry tasks were challenging for veteran patient participants to complete or track for consistency and recording. The feedback from the evaluation is currently being used to revise and optimize the patient-facing user interface for a further round of evaluation and testing.

Table 1. Major findings map to the key software functions and workflow paths. In many instances, findings were identified using both usability methods.

Method	Requirement	Screen	Finding/Heuristic Violation
Simulation	Patient should be able to enter a comment about each prescription	"Current medication review"	Participants did not notice or identify the "Add comment" button
Simulation/ heuristic inspection	Patients can select a comment using pre-filled response buttons	"Add comment"	Participants did not know if selections were confirmed or saved; consistency of design violation
Heuristic inspection	Saved input should match pre-filled response buttons	"Add comment"	Pre-filled response buttons inserted string fragments; mental model violation
Simulation	Patients should be able to enter a free text comment	"Add other comment"	Participants did not notice or identify "Other" option
Heuristic inspection	Patients should be able see and verify their input	"Add other comment"	Cannot determine what content is saved with multiple entries; visibility of status violation
Simulation/ heuristic inspection	Patients should be able to enter a free text comment	"Keyboard and entry dialog"	Participants did not understand instructions; participants struggled with format and entry; consistency of design violation
Heuristic inspection	Patients should be able to see when entries are large	"Keyboard and entry dialog	Limited ability to view and scroll through large text blocks; mental model violation
Simulation/ heuristic inspection	Patients should be prompted to report any over-the-counter agents	"Additional products prompt"	Participants thought the instructions were difficult to understand; help documentation violation

Method	Requirement	Screen	Finding/Heuristic Violation
Simulation/ heuristic inspection	Patients should enter and save each product name one at a time	"Additional products entry"	Participants typed multiple responses in one entry; participants could not recall prior entries; mental model violation
Heuristic inspection	Patients should be able to see that new items have been saved	"Additional products entry"	Information did not clearly indicate information was saved; visibility of status violation
Simulation/ heuristic inspection	Patients should be able to modify entries with frequency and instructions	"Frequency and direction"	Participants did not understand how to complete task; error prevention and recovery violation
Simulation/ heuristic violation	Patients should be able to confirm or correct entries	"Summary and confirmation screen"	Participants did not recognize the entries could be edited individually; mental model violation
Heuristic inspection	Contents should be consistently rendered on screen	"Summary and confirmation screen"	Order of items shifted unpredictably when editing contents
Simulation	Patients should be furnished with controls to correct entries	"Additional products edit"	Participants did understand goals of interface or how to update frequency/instructions
Simulation	Patients should be able to close a session at any point and receive confirmation	"Exit program feature"	Participants did not always notice or identify the "Exit" button and feared losing data

3. Methodologic Issues

We encountered a number of methodologic issues during usability testing with participants. For example, in the simulations it was difficult for participants to relate to cases that did not match their own personal medical conditions (i.e., many struggled with the abstract thinking required to assume a hypothetical role in the scenarios). In addition, local Institutional Review Board policies governing quality improvement efforts with enrolled veteran patients prohibited collection of audio or video data.

4. Discussion and Future Work

This paper has presented the framework for a mixed-method assessment combining heuristic evaluation with 'typical' usability testing (i.e. representative end-users completing use cases). We are using the approach that we have piloted and described in this paper for a full scale evaluation including usability tests of a complementary provider-facing interface. Another area of study is the refinement of use case and task generation that subjects find "natural". A further planned extension of the approach described in this paper is to conduct naturalistic recording of use of MRAR for real patient interactions. In addition, because health literacy appears to be a major factor in the adoption of such technology, the relation of eHealth literacy and patients' ability to effectively use the MRAR is another area that is currently being targeted by the authors for future research work.

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Context Sensitive Health Informatics: Many Places, Many Users, Many Contexts, Many Uses
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Development of a Video Coding Scheme for Analyzing the Usability and Usefulness of Health Information Systems

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Abstract. Usability has been identified as a key issue in health informatics. Worldwide numerous projects have been carried out in an attempt to increase and optimize health system usability. Usability testing, involving observing end users interacting with systems, has been widely applied and numerous publications have appeared describing such studies. However, to date, fewer works have been published describing methodological approaches to analyzing the rich data stream that results from usability testing. This includes analysis of video, audio and screen recordings. In this paper we describe our work in the development and application of a coding scheme for analyzing the usability of health information systems. The phases involved in such analyses are described.

Keywords. Usability, video analysis, human engineering, simulations, patient safety, human factors

Introduction

In recent years methods such as usability testing and clinical simulation have been increasingly applied to the design and deployment of more effective and usable health information systems [1]. Usability testing typically involves collection of screen and audio recordings of users as they interact with systems to carry out work tasks. The resultant screen recordings of user interactions are captured by continuous screen recordings. The audio portion of the interactions may consist of study participants' thinking aloud or making other verbalizations while carrying out tasks [2-4]. This approach has been applied in order to identify usability problems from data that is collected.

The Think Aloud protocol analysis approach has been found to be very useful for identifying usability problems with healthcare information systems [1-4]. In addition, clinical simulations have extended this approach and have produced data that includes recordings of user's screen interactions and audio from user's verbalizations while carrying out realistic tasks [5]. In the area of medical cognition, a number of coding schemes have been presented that may be used to examine cognitive aspects of user interaction and patient safety [6]. In addition, work from the general area of human-computer interaction has relevance for analyzing video data from a theoretical perspective (e.g. work based on the human information processor model [7] as well as

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work based on distributed cognition [8]). For example, categories that can be used for analyzing video data can be modified from heuristics developed and scientifically validated by Jacob Nielsen [9] for a different purpose – namely for coding video data obtained from conducting usability tests and clinical simulations [1]. Also, Norman's concepts of user slips and mistakes can be modified for inclusion in video coding [15].

In recent years, there has been an ever increasing number of usability tests being conducted with health information systems [1]. However, despite the increased use of this type of data collection (which typically involves recording of user interactions with a health information system while carrying out tasks) and a scientific basis from the human factors and other related literatures [7-8], there are few published works that focus on providing researchers and investigators with extensible coding schemes that can guide the combined analysis of digital video and audio data. In this paper we describe a coding scheme we have developed for this purpose.

1. Methodological Approach

There are a wide range of approaches to coding and analyzing data that results from video collected during usability testing. These include approaches such as grounded theory, where codes are inductively developed from the data itself. On the other hand coding approaches may include content and protocol analysis where pre-existing codes are used to identify patterns in the data (e.g. use of strategies in interacting with a computer system). In this paper we focus on an approach that borrows from both perspectives. In particular, a set of pre-existing codes that have been used on many of our projects will be presented. Also, in line with an approach known as direct coding, both a set of pre-existing codes are used to analyze data, as well as emergent codes (i.e. codes not previously discussed in the literature) that are akin to the inductive codes of grounded theory. The ideas for coding categories in this paper came from examination of different coding categories that have been developed from the HCI literature, evidence-based sources and our experience over 20 years of video coding in healthcare usability. These have included:

- Modification of categories from standardized questionnaires [10] to be used for a new purpose – i.e. video analysis
- Video coding categories emerging from modifying approaches to cognitive analysis in medical decision making theory and research [6]
- Categories that have emerged from our own prior work (as previous emergent codes that have been added to our growing list of codes) [1]
- Categories that have been borrowed from Nielsen's heuristics (for heuristic evaluation) that we have modified for use as video coding categories [10]
- Categories from research on evidence-based user interface guidelines [11]

The development of the coding scheme presented in this paper was not the result of a single effort at one point in time, but rather has evolved from our first publication in this area in 1995 [12], through to publication of a methodological overview paper in 2004, and our subsequent work in areas related to studying the links between usability and technology-induced error in healthcare IT in 2005 [13]. In this section of the paper we describe the coding categories that we have used and incorporated into our coding scheme for analyzing video data resulting from usability tests and clinical simulations.

The codes are used to tag and identify sections of video and audio log files that can be characterized by the categories (as will be illustrated in a subsequent section of this paper). The codes are given below, with the codes themselves capitalized along with their definitions, thus forming a coding dictionary that is referred to by an analyst when going through and tagging video and audio data.

Usability Problem Codes

These codes are used to describe usability problems and issues identified when analyzing video usability data. The codes focus on aspects of the user interface and the user-system interaction and were derived from application of usability categories developed for other purposes (e.g. questionnaire scales, heuristic evaluation research and cognitive theory) but uniquely modified for use in coding video based process data.

NAVIGATION – Coded when a review of the video data indicates the user has problems moving through a system or user interface.

CONSISTENCY – Coded when a review of the video indicates the user has problems due to a lack of consistency in the user interface.

MEANING OF ICONS/TERMINOLOGY – Coded when a review of the video data indicates the user does not understand language or labels used in the interface.

VISIBILITY OF SYSTEM STATUS – Coded when a review of the video data indicates the user does not know what the system is doing.

UNDERSTANDING ERROR MESSAGES – Coded when a review of the video data indicates the user does not understand meaning of error messages.

UNDERSTANDING INSTRUCTIONS – Coded when a review of the video data indicates the user does not understand user instructions.

WORKFLOW ISSUES – Coded when a review of the video data indicates when there are issues with system workflow negatively impacting user interaction.

GRAPHICS – Coded when a review of the video data indicates there are issues with graphics.

LAYOUT – Coded when a review of the video data indicates there are problems with the layout of screens or information on those screens.

SPEED/RESPONSE TIME – Coded when a review of the video data indicates the system is slow or response time is an issue.

COLOR – Coded when a review of the video data indicates the user does not like color or color schemes used in the interface.

FONT – Coded when a review of the video data indicates the font is too small or not readable.

OVERALL EASE OF USE – Coded when the user comments on overall usability of the user interface.

Usefulness of Content Codes

These codes are used to describe issues regarding the usefulness of the user interface or system being evaluated from analyzing the data. The usefulness of the content of health information systems is extremely important to end users and can be differentiated from usability problems (e.g. a system may be usable but contain data or information that is not deemed useful to a healthcare worker).

APPLICABILITY – Coded when a review of the video data indicates that information presented is not applicable to real healthcare practice or cases encountered.

ACCURACY/CORRECTNESS – Coded when review of data or user comments indicates information or advice provided by system is not correct or accurate.

RELEVANCE – Coded when a review of the video data or user comments indicate information presented by a system is not relevant to their carrying out their task.

TIMELINESS – Coded when a review of the video data or user comments indicate that information is not timely.

IMPACT ON WORK ACTIVITIES – Coded when a review of video data or comments indicates unexpected impact of the system on work activities.

Safety and Technology-Induced Error Codes

These codes are used to identify and tag errors made by users when analyzing data [13].

SLIP – Coded when a review of the video data indicates the user has made a mistake but corrects the mistake.

MISTAKE – Coded when a review of the data indicates the user has made a mistake that is not corrected.

WORKAROUND – Coded when the user is not using the approach to carrying out work that is recommended by the healthcare organization or computer system. These can be sub-coded as NEGATIVE (e.g. use of incorrect, suboptimal or dangerous approaches), NEUTRAL (i.e. no impact on safety) or POSITIVE (i.e. increases safety).

2. Phases of Video Analysis

Transforming video data (resulting from usability testing and simulations) into a form where the above coding scheme can be applied involves several stages described below.

Transcription and Log File Creation Phase

Data obtained from usability testing and clinical simulations typically includes screen recordings from the application the user is interacting with (obtained from screen recording software such as Hypercam®), along with the audio recordings of user verbalizations (which may consist of think-aloud verbalizations, or audio recordings of the user interacting with the researcher or other users). In our approach we begin by having the audio portion of the interaction first transcribed in its entirely to begin creation of a log file (initially this file just contains the text of user and test monitor verbalizations). The log file may consist of a Word file, or as will be described, the log file can be imported into one of a number of qualitative coding tools.

Annotation (Coding) Phase

In this phase of analysis, the analyst(s) plays back and review the video recording of the user's interactions from usability testing or clinical simulations. As the user interaction is reviewed, the analyst marks up the log file (resulting from the transcription phase) with annotations and time stamps (obtained from watching the video recording) to demarcate key user actions (e.g. entering a new function in a

system, or exiting the program), system responses (e.g. system crash), or other interesting aspects of the user-system interaction. These annotations are entered directly into the log file of user verbalizations as the appropriate point in the audio transcriptions. In addition to marking up or annotating key user-system interactions of interest, this is the phase where the coding scheme described above in this paper can be applied to identify and mark specific types of usability problems, usefulness issues and safety related codes (e.g. slips or mistakes).

In addition, to marking up and coding the video data using the above categories of codes, problems or issues may be identified that were not predicted from a pre-existing coding scheme (i.e. "emergent" issues or problems). These emergent codes should be demarcated in the log file and annotated to indicate they were not contained in a coding scheme but rather "emerged" from the data itself. This can be referred to as "inductive" coding and from a practical perspective can be integrated with the predetermined coding scheme as described above (which can be referred to as "deductive" coding). The approach described above (that may include both deductive and inductive coding) has been referred to as "direct coding" in the qualitative analysis literature [14].

Summarization Phase

In this phase, the log files (from each user-system interaction) are analyzed to create a summary of usability problems, usefulness concerns or issues and safety problems both within and across users. This may include tabulation of the number of user problems, their severity, and their potential impact. How many users had a particular problem can also be taken into account when providing recommendations from the data for system or user interface redesign or optimization. The summary can be used for providing input to system developers and implementers as well as providing a basis for publishing technical and academic reports about types of healthcare information applications.

3. Example of Use of the Coding Scheme

In this section of the paper we provide an illustrative excerpt to show how the coding scheme described above can be applied to analysis of a user's (i.e. a physician) interaction with a new medication administration system. The excerpt below gives a section of a coded log file of user interactions. The participant's verbalizations are given in quotations and the log file has also been annotated with time stamps and marked up to indicate what actions the user is doing on the computer in italics. In addition, codes have been added to the log file and are indicated in caps:

00:00:00 *Start of testing session – user is given instructions to enter the medication "Darvon"*

"I am waiting for the medication entry screen to appear, I have clicked what I think is the enter medication icon, but I am not sure"

MEANING OF ICONS/TERMINOLOGY PROBLEM

00:00:45 *Medication entry screen comes up*

"Ok, it finally came up, but it seems like it took forever"

SPEED/RESPONSE TIME PROBLEM

00:01:05 *Participant begins to enter medication name into the text box that appears*

"Ok, here we go, the patient in your scenario has back pain and I am going to prescribe him the medication Darvon, which I sometimes prescribe for this problem"

00:01:30 *The system responds with names of medications that start with the letter "D" and user scans the list*

00:01:35 "Ok I will select from this list, but my eyesight is getting poor and this font is too small"
FONT PROBLEM

00:01:45 *User highlights and selects the medication "Diovan" from the list displayed*
MISTAKE – WRONG MEDICATION ENTERED – "Diovan entered instead of Darvon"

4. Discussion

The coding scheme presented in this paper is not meant to be exhaustive nor to be recommended to be the only approach to coding usability data. Indeed, in our studies we have modified and extended the basic coding categories described in this paper to suit the analysis for a specific category of health information system (such as study of electronic medication reconciliation). However, the categories and approaches described in this paper have proven generalizable enough to have been employed on a wide range of projects that involved collection and analysis of data from usability studies as well as clinical simulations. We have developed and presented the categories in this paper as a template that can be modified for use in different study contexts.

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Enhancing Healthcare Provider Feedback and Personal Health Literacy: Dual Use of a Decision Quality Measure

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Abstract. In this protocol for a pilot study we seek to establish the feasibility of using a web-based survey to simultaneously supply healthcare organisations and agencies with feedback on a key aspect of the care experience they provide and increase the generic health decision literacy of the individuals responding. The focus is on the person's involvement in decision making, an aspect of care which is seriously under-represented in current surveys if one adopts the perspective of person-centred care. By engaging with an instrument to assess decision quality the person can, in the one action, provide a retrospective evaluation of a past decision making experience in a specific provider context and enhance their competency in future decision making in any setting. We see this as an exercise in context-sensitive educational health informatics.

Keywords. Informed choice, health literacy, person-centred care, empowerment, patient experience surveys, patient-reported outcome measure

Introduction

Against the wider backdrop of the Aarhus convention and other efforts (http://www.unece.org/env/pp/treatytext.html) to promote individual, societal and environmental health there are significant moves to increase person and citizen involvement in the promotion of health and provision of healthcare services. They take two broad forms.

On the one hand are initiatives emanating from providers responsible for health services at a community or national level, seeking to gain more and better information and feedback from patients viewed collectively, as a whole or as members of subgroup. Anonymised feedback in the form of satisfaction surveys has been the traditional source and these are now becoming even more prominent, while undergoing the much-needed revisions that take advantage of web-based technologies and rapidly increasing access to the internet. Most bodies now accept that self-reported 'satisfaction' is not an appropriate concept and replace it with requests for reports on the person's experience of specified events or actions. In recent years these wider surveys have been accompanied by efforts to increase 'user involvement' in top-level organisational and research settings, representatives of patients or patient groups, or lay persons, being invited to the table. [1–3]. Citizen juries, focus groups, and similar community-based arrangements, provide an intermediate mechanism, giving the possibility of deeper, if narrower, feedback than a survey, but remaining outside the responsible body [4].

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On the other hand are the initiatives that focus on the individual, seeing him or her as a person/patient seeking optimal health and healthcare within the existing system and organizational arrangements. These efforts have been initiated mainly by professional and academic groups, often in collaboration with patient organisations. Their aim is to provide better support to the person in the context of their personal health journey, some taking the form of information or decision aids, some mechanisms for emotional or social support.

There is clear overlap between the two and a few national organisations are now moving into the second area of personalised support through decision aids. However, the basic distinction remains valid and the following study protocol is based on the assumption that a connection can be made so that the individual can simultaneously contribute to the higher-level feedback process *and* benefit personally. This dual strategy is designed to minimise both cost and respondent fatigue and maximise the return to healthcare provider and person in relation to decision making quality.

The protocol focuses on decision making, because we see individual involvement in decisions as a central aspect of the quality of the person's care experience and a key indicator of any organisation's commitment to person-centred care. Using the MyDecisionQuality (MDQ) instrument we seek to show how the individual can, in one online survey, simultaneously contribute enhanced feedback to providers on past decisions and benefit personally from the increased generic health decision literacy that may improve the quality of their future health decisions.

1. Limitations of Existing Surveys

Surveys seeking patient feedback or assessments of patient experience typically suffer from at least three limitations from the perspective of person-centred care.

First, they are typically confined to eliciting ratings on a number of indicators. If these are weighted to produce an overall index, rather than left as a profile, the weights are supplied by the instrument developers. They are quite often simple equal weights as in the Patient Experience Questionnaire (PEQ) [5] subsequently cluster-analysed in Bjerknaes [6]. Only those built within the Dutch Consumer Quality Index (CQI) framework incorporate patient weightings into the assessment [7]. The condition-specific CQI instrument is [8] in fact two instruments. CQI Experience elicits ratings on each item. CQI Importance elicits importance weightings for each item, both on four point Likert scales. The percentage of respondents giving the lowest experience rating to an indicator is multiplied by the percentage giving it the highest weighting to produce a Quality Improvement Score for use in prioritisation. These are clearly group level results and we learn nothing about the individual level relationship between experience and importance.

Second, surveys underemphasise the person's participation in decision making. Remarkably neither the PEQ nor Bjerknaes paper contains the words 'decision' or 'preference'. The defence that this may not emerge from literature reviews or patient focus groups is not convincing. It is the product of long socialisation into the largely passive and disempowered status as a patient of a provider, a patient who is to be 'informed', 'communicated with', 'have things explained clearly', 'listened to attentively', 'treated with respect', 'taken seriously', etc.

The third limitation involves the restriction to patients' treatment experience within an illness care context and provider facility. This means omitting invitations issued to

persons regarding screening, vaccination and other preventive actions. Our protocol, which involves dissemination to community residents as well as patients, rectifies this.

The protocol has been developed initially for the Danish context, where we already observe large scale and successful efforts in making Patient-Reported Outcome Measures the centre of an integrated electronic system [9]. But we see this Danish study as just one instantiation of a higher level 'proto protocol', adaptable and sensitive to other countries and settings, through translation to the professional, legal and ethical circumstances in the jurisdiction. In the Danish piloting we will offer both Danish and English versions of the DQ4ALL survey, embedding the MDQ instrument.

2. Objectives

To explore the feasibility and acceptability of the MDQ instrument to persons in the community to (i) provide feedback to providers on self-rated dually-personalised decision quality as a key aspect of the person's health and healthcare experience, and (ii) increase the health decision literacy of the person in relation to evaluating past decisions and preparing for future ones.

3. Methods

The DQ4ALL is a randomised survey with two arms one of which includes MDQ. The randomization occurs at the point of access to the anonymous survey. Both arms elicit year of birth, sex and health status measure (EQ-5D) before responding to the Control Preferences Scale [10] and to recall one healthcare decision, taken in any setting (primary/secondary/community). They are then asked when this recalled decision happened (4 ranges), and whether it was about testing/screening), treatment (initiation, change, discontinuation), rehabilitation, or prevention (e.g. vaccination, lifestyle/behaviour change). At this point, they respond to the Satisfaction With Decision instrument [11] and the Control Preference Scale, both modified to apply to the recalled decision.

3.1. MyDecisionQuality (MDQ)

The MDQ instrument is then responded to in respect of the recalled decision.
MDQ is a dually-personalised instrument based on Multi-Criteria Decision Analysis [12]. MDQ is generic in the sense that the criteria are phrased without reference to any particular decision or context. Information relating to the specific decision, must be provided outside the MDQ instrument, such as in the wider condition-decision support system in which MDQ will often be situated [13].
The Ratings items for MyDecisionQuality appear below. (The Weightings are phrased as the importance of each criterion. Both are elicited on a 0 to 10 scale.)
OPTIONS: I was clear about the possible options for me and what they involve;
EFFECTS: I was clear about the possible effects and outcomes of the options for me;
IMPORTANCE: I was clear about the relative importance of the different effects and outcomes for me;
CHANCES: I was clear about the chances of the different effects and outcomes happening to me, including the uncertainties surrounding the best estimates;
TRUST: I trusted the information I have been given is the best possible;

SUPPORT: I was satisfied with the level of support and consideration I received throughout the decision process, especially in regard to communicating at my level;
CONTROL: I felt in control of the decision to the extent I wish.
COMMITMENT: I was committed to acting on the decision

As with all implementations of the simple 'weighted-sum' version of MCDA, MDQ combines a set of importance weights for multiple criteria with performance ratings for each option on these criteria, and calculates the overall score as the expected value of eight criteria of decision quality. The MDQ Score, unique to the person and to the particular occasion, is shown with the partial contributions of each criterion to it displayed in segments; its weighting and rating are highlighted when the segment is touched or cursor is rolled over it. The resulting visual picture appears in Figure 1.

Figure 1. MDQ screen (in Annalisa implementation [12]) showing 8 criteria, Weightings, Ratings, and Score, with Score breakdown by criterion.

The respondent is also provided with insight into the priorities for future quality improvement by being shown the quality gains possible from improved rating on each criterion, weightings unchanged. For example, in figure 1 we can inform the person of the effect on their decision quality score of improving their rating on Importance, lowly rated at 0.3, given the relatively high weight of 0.188 they have assigned it. Achieving perfect rating on this criterion would increase their score by 0.7 x 0.188 or 0.132, equivalent to a 20% improvement. Feeding back the result of the same calculation for each of the criteria generates a personalised list of future priorities for decision making.

MDQ has been used as the primary outcome in a trial of two decision aids for the PSA screening decision in Australia [14]. Most relevantly here, the initial Danish version of the survey underwent some limited pre-piloting through a patient organization and medical department.

We will approach the Danish Knowledge Center for User Involvement in Health Care (ViBIS) to achieve a wide distribution of the survey among the residents of Denmark, including migrants.

3.2. Ethics

Since the survey is being distributed to persons in the community rather than patients, consent is by opting into its completion, and all data is anonymous, we expect no ethics

approval will be required. Respondents will be able to give meta-consent to being approached in relation to this research by providing an e-mail address.

3.3. Health Decision Literacy

A final set of questions in DQ4ALL seek to determine whether completing it in relation to a recalled decision has helped evaluate or reevaluate that decision, and increased their perceived ability to enter into future decision making processes more fully and competently. In other words we seek to establish whether their perceived health decision literacy has been enhanced, by an implicit nudge of how to think proactively and more slowly. We do this by administering a subset of 6 items of the Preparation for Decision Making Scale relevant to this generic setting [16].

Health decision literacy is a wider and more diffuse concept than Decision Making Competence, though it can be seen as a background contributing factor. It has been the subject of extensive theorisation and measurement, notably by Fischhoff and colleagues [15]. They see it as a multidimensional construct, but show it is capable of being differentiated from general cognitive ability.

4. Analysis and Results

For feedback to provider purposes a range of descriptive statistics relating to the rating, weighting and scores for MDQ will be produced at group and subgroup level. These will be subjected to latent class analysis to determine the existence of preference-based clusters. Both the individual and clustered results will be regressed on sociodemographic and other characteristics, including type and location of the recalled decision, as part of a hypothesis generation, not hypothesis testing, process.

To assess the impact on perceived effect on generic health decision literacy we compare the responses to the subset of items of the preparation for decision making scale.

For those who have experienced the MDQ arm there will be further analysis of the perceived usefulness of the MDQ score and prioritisation suggestions.

Since all the responses are online, web-logging will enable analysis of the time spent on individual pages of the survey, as well as total time spent. This data will supply additional variables for analysis in both the feedback and literacy contexts.

5. Conclusion

In this pilot study we seek to establish the feasibility of using a web-based survey to simultaneously supply healthcare organisations and agencies with feedback on a key aspect of the care experience they provide, and increase the generic health decision literacy of the individuals responding. The focus is on the person's involvement in decision making, an aspect of care which is under-represented in current surveys from the perspective of person-centred care. By engaging with an instrument to assess decision quality the person can, in the one action, provide a retrospective evaluation of a past decision making experience in a specific provider context and enhance their competency in relation to future decision making in any provider setting. We seek to combine organisational and educational health informatics in a context-sensitive way.

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Medication Review: Human Factors Study Aiming at Helping an Acute Geriatric Unit to Sustain and Systematize the Process

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Abstract. *Background:* Medication Review (MRev) has been implemented in many hospitals to improve patient safety and well-being. However, it seems sometimes difficult to implement, maintain and systematize this process, especially when key-elements are absent. This study focuses on the analysis of a MRev process implemented in an Acute Geriatric Unit (AGU) which, at the time of the study, had no Computerized Physician Order Entry (CPOE) and no sufficient staff to - normally - support the process. *Objective:* This study describes the MRev process as existing in the AGU with a particular focus on the preparatory MRev meeting phase and presents our recommendations to maintain and optimize it. *Methods:* Human Factor experts have collected and analyzed data during MRev process by interviews, shadowing observations and video recording from April to October 2014 at Lille University Hospital. *Results:* MRev process consists of three phases (meeting preparation, MRev meeting and patient discharge) and includes seven main tasks for which actors, documented supports, outcomes and difficulties are identified. Although allocating a fulltime pharmacist for the AGU would solve several problems, the main realistic recommendations concern training for junior and senior actors according to their roles and the improvement of some tasks processes. *Conclusion:* Despite less than optimal conditions as compared to those recommended by the literature, the observed AGU performs an efficient review based on well designed tools and processes.

Keywords. Medication review, human engineering, organizational case studies, acute geriatric unit.

Introduction

Medication Review (MRev) process is increasingly implemented in hospitals in order to reduce and prevent Adverse Drug Events (ADEs) and maximize patients' benefit during care transitions [1]. This process is described in the literature pointing at its positive clinical impact (e.g. decreasing medication errors, better patient compliance) [1-3] and its facilitators (e.g. multidisciplinary team, use of electronic-based support, presence of a leader) [2-3]. Furthermore, medication reconciliation process is

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considered as a necessary step to perform a qualitative MRev [3,4]. Nevertheless, both processes are also considered difficult to implement and to maintain by healthcare institutions. Barriers are identified, most of them related to Human Factor (HF) aspects (e.g. turnover, lack of resources, absence of leadership, unfamiliarity with procedures, no access to patient information, no multidisciplinary approach, no Computerized Physician Order Entry (CPOE)) [3-7]. According to these elements, adopting a HF approach makes sense in order to analyze and optimize the process.
We present here a case study of the implementation of a MRev process in an Acute Geriatric Unit (AGU) characterized by chronic lack of pharmacy resources and no available CPOE. This AGU (academic hospital of Lille) started the MRev process implementation in January 2014 in order to improve the continuity of care between hospital and home return. In line with the MRev leader expectations, the aims of the present study were (i) to formalize the MRev process and identify each role and associated actors along with their contribution to decision making and (ii) to identify room for improvement in order to propose guidance to improve, maintain and routinize the process in the AGU.

1. Methods

This study was conducted from April to October 2014 at the University Hospital of Lille (France), a 3500-bed hospital. It was carried out in a 28-bed AGU. Data were collected by three HF experts through several methods to cross-check data (Table 1):

- exploratory interviews to understand clinician's goals and personal perception of the MRev process. Interviews were based on the 5Ws method (Who, What, Where, When, Why) and were audio-recorded.
- shadowing observations; HF experts took field notes on information gathering and documentation and communications between involved clinicians.
- observations of MRev meetings, supported by field notes.
- individual debriefing interviews where clinicians were confronted to documentation forms and asked to explain the rationale behind information gathering and documentation.

Table 1. Number, duration and participants involved for the four methods.

	Exploratory interviews	**Shadowing observations**	**MRev meeting observations**	**Individual interviews**
Number	6	7	18	4
Duration	4h15mn	40h45mn	16h45mn	1h15mn
Actors implicated	2 geriatricians 1 pharmacist 2 pharmacy students 1 nursing manager	2 geriatricians 3 pharmacy students 2 nurses	Multidisciplinary team	1 geriatrician 1 pharmacist 1 resident physician 1 pharmacy student

All data were transcribed and analyzed in order to understand and describe the collective decision making process during the MRev meeting. The analysis identified actors, roles, aims, tasks, workflows and information flows, and barriers and facilitators.

2. Results

2.1. Description of the MRev Process

In the AGU, medical and pharmacy staff are both involved in the MRev process although it's mainly led and supported by medical staff. At the time of the study, in terms of medical resources, up to 7 physicians (3 geriatricians and 2 to 4 residents) were involved in the MRev process. Each resident is more specifically in charge of a portion of the AGU's patients (25 to 50 % depending on their number).Two geriatricians act as MRev leader. Clinical pharmacy resources are limited to about 10 hours per week, distributed over 1 senior pharmacist (5 hours) and 2 residents (about 2h30mn each). This time is dedicated exclusively to the MRev process. It happens quite often that pharmacists put in extra working hours to complete their tasks. Additionally 3 pharmacy-students (4th and 5th year) do their internship in the department where they work two days a week. Their time is also entirely dedicated to MRev. Turnover time is 6 months for residents and 3 months for students.

MRev concerns all patients to be discharged from hospital. However, patients here play a minor role: 80% of them are not in a position to provide information needed for MRev or to benefit from therapeutic education cause of chronic or acute severe dependency, delirium, cognitive disorders, visual or motor deficits, depression, etc.

A form (named *MRev support*) has been elaborated during the eight first months of the MRev project to support the process. It is continuously documented for each patient from the admission in the AGU to the end of the MRev meeting. It collects information about patient's contacts (e.g. community pharmacist, family, GP), a geriatric synthesis including patient demographics (e.g. gender, age, place of residence) and patient conditions (e.g. undernutrition, dementia, falls, dependence), essential medical antecedents specifying information sources and reliability, the clinical pharmacy information (e.g. weight, albumin, renal function, allergy, crushed drugs, swallowing disorders, medication use process at home i.e. how and when the treatment is taken by the patient), a compliance score (the Girerd score), the Best Possible Medication History (BPMH) and the list of medication to be added for the discharge treatment.

There also exists a *pharmacist medication checklist* including the BPMH (copied out from the MRev support) and the hospitalization treatment (recovered from the Medication Administration Record (MAR)) as well as the prescription analysis and comments. It is only documented and used by pharmacists.

Three main phases have been identified to characterize the MRev process as it is implemented in the AGU: (1) meeting preparation (declined in five tasks (T1 to T5)), (2) MRev meeting and (3) patient discharge. Each phase is characterized by specific tasks, main actors, filled supports and outcomes (Table 2).

1. MRev preparation. The BPMH is mainly established (T1) by pharmacy students when a new patient is admitted in AGU. They identify as precisely as possible the medications taken before AGU's admission, i.e. medications taken at home or administered in the emergency department or other unit. They carry out this task by interviewing/phoning/reviewing several sources: the patient, their family, the GP, the community pharmacist, specialized physicians, prescriptions, medical letters. In parallel, they also document the clinical pharmacy section on the MRev support and the compliance score (Girerd score) (T2). Both tasks (T1 and T2) are easier when patients come from a medical unit/retirement home than from their own home. Then, twice a week, a MRev leader lists patients to be discharged (T3) in the upcoming three days

(no discharge during weekend). No specific support is allocated for the listing; it can be documented on a sheet of paper or a paperboard. When the listing is completed, each resident physician documents the MRev support (T4) for their patients concerned by discharge; they document patient's general information, medical antecedents and the geriatric synthesis. In parallel, a pharmacist (senior or resident) gathers information about listed patients and copies on the pharmacist prescription support the patient's BPMH and hospital treatment (T5). S/he compares and analyses both lists of medication in order to prepare the MRev meeting. The pharmacist focuses on potential ADE's, therapeutic justification of each drug and assesses the treatment's adequacy to the patient condition and also prepares questions and comments to be addressed during MRev meeting.

Table 2. Three main phases of MRev process including tasks, actors, documented supports and outcomes (Tasks T1 and T2, and tasks T4 and T5 can be respectively carried in parallel).

Main phases	Tasks	Main actors	Filled support	Outcomes
1. Mrev preparation	(T1) Establishing BPMH	Pharmacy students	MRev support	Necessary data for MRev meeting
	(T2) Retrieving information on clinical pharmacy and calculation of the Girerd score	Pharmacy students	MRev support	
	(T3) Identifying and listing patients to be discharged in the upcoming 3 days	MRev leader	No specific support (temporary document)	
	(T4) Documenting the geriatric summary and medical antecedents	Resident physicians	MRev support	
	(T5) Comparing the BPMH with the hospitalization treatment and checking for potential ADEs	Pharmacists (resident and/or senior)	Pharmacist medication checklist	
2. MRev meeting	Reviewing medications for each patient	Medical and pharmacy staffs	MRev support	BPMDP and justifications
3. Patient discharge	Writing patient discharge letter	Medical staff	Discharge letter	Discharge letter with BPMDP and justifications

2. MRev meeting. It involves three main actors: the pharmacist, the resident physician in charge of the patient(s) and the leader (geriatrician) of the meeting. Each participant relies on his/her own support: the MRev support for the leader, the patient record and especially medications prescription and administration record for the resident, and the prescription checklist for the pharmacist. This allows for triangulation of information. The meeting is organized as follows: (i) the resident presents the patient: age, gender, reason for hospitalization and evolution, home life, future after discharge and clinical information specific for the patient. During the presentation: the leader eventually completes the MRev support if necessary with missing or relevant information; s/he and the pharmacist ask several questions to complete their understanding of the patient case. (ii) Then, the leader spells out loud each drug of the BMPH and the resident answers with "continued", "stopped" or "modified"; for stopped or modified drugs, the leader asks "why", the pharmacist may add comments and the leader ultimately documents the final decision. (iii) Next, the resident mentions

each medication added during the hospitalization and whether it has been reevaluated or not and justifications for this modifications. For each medication discussed, the leader makes the final decision in case of disagreement between the participants. The MRev support is then used to establish the Best Possible Medication Discharge Plan (BPMDP), i.e. the new treatment with continued, modified and also stopped medications and justifications for all changes, to be integrated in the discharge letter.

3. Patient discharge. The patient discharge letter is written by medical staff. It includes the discharge summary and the BPMDP. It is directly addressed to the GP and sometimes also given to the patient.

2.2. Identified Problems (with Causes and Consequences) and Recommendations

Despite the fact that the AGU has no CPOE and is chronically understaffed (as regards geriatrician and pharmacist resources), the MRev team succeeded in implementing an efficient enough process. Nevertheless, this study highlights several problems and associated causes which bring about four main negative consequences on MRev process (Table 3).

Table 3. List of consequences, associated problems and causes recorded during observations.

Consequences	Problems	Causes
Meeting cancellation	Key actors missing (leader or pharmacist)	Understaffing
Unreviewed patient	BPMH not documented on the MRev support	Pharmacy students turnover
	Patients listing incomplete (unidentified patient for the MRev meeting)	Unplanned discharge Task performed by MRev leader (suboptimal task allocation) Lack of shared dedicated support
Diminution of MRev quality	BPMH incomplete or not reliable	Pharmacy students turnover Difficulties to retrieve information
	Missing information in clinical pharmacy section on the MRev support	
	Patients listing incomplete (patient identified just before the meeting; prescription analysis cannot be done)	Suboptimal task allocation Lack of shared dedicated support
Diminution of MRev process efficiency	Geriatric summary and medical antecedents not documented on the MRev support	Resident physicians turnover Lack of time of resident physicians Perceived as a double documentation task by resident physicians
	Time of students' task learning	Students and residents turnover

Two transversal causes have been identified: understaffing and turnover. Understaffing causes lack of resources and difficulties to allocate tasks among actors. The turnover generates lack of expertise and understanding about MRev issues among newcomers (students and residents). Although the allocation of a clinical pharmacist for the AGU could solve most of the identified problems, one of the MRev leaders stressed that this solution is impossible for many administrative and financial reasons. More realistic recommendations have been proposed to the AGU.

Regarding actors: (i) include a well-documented training session upon their arrival, guided by a pharmacist expert and a leader in order to explain them the MRev process and its medical and organizational consequences; (ii) train a third or a fourth leader to lead the meeting and help systematizing the MRev process at each phase when main leaders are absent; (iii) secure a half-time resident pharmacist position.

Regarding tools: (iv) provide a shared dedicated support (e.g. whiteboard, IT tool) to complete patients listing and avoid omissions; (v) recover automatically patient data (e.g. past and current treatments, medical history) to make pharmacy student's or resident physicians' investigation easier.

3. Discussion

This HF study aimed to formalize the MRev process and to suggest guidance to improve, maintain and systematize it in the AGU. Although the unit is characterized by a chronic lack of pharmacy resources and no available CPOE, AGU staff succeeds in reviewing patients effectively. Indeed, they have created and continuously improved paper-based tools (e.g. MRev support, Pharmacist medication checklist) and procedures (e.g. face to face MRev meeting between key actors) during the first months after MRev process implementation. However, understaffing along with students' and residents' turnover affect significantly the quality, the efficiency or even the organization of the MRev meeting. Recommendations have been proposed, some being difficult to implement and others already adopted.

This HF study on the MRev process is valuable. Most of problems identified by the literature were observed and more precisely described with their associated causes and consequences on the process. It also highlights the adaptability of the AGU staff despite the lack of resources and the possibility to carry out the MRev process without CPOE. There are two main limits in this study: (i) the study is focused on one specific AGU, recommendations cannot be extended to all hospitals; (ii) beyond the clinicians experimenting the process, there is a need to collaborate also with hospital stakeholders (e.g. administrators and internal patient safety and quality departments) to be able to provide efficient recommendations. This preliminary study introduces an international work on the MRev process aiming at identifying and generalizing the socio-technical factors determining this work process. The ultimate purpose is to be able to suggest adapted recommendations depending on specificities of different work contexts.

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Safer Design - Composable EHRs and Mechanisms for Safety

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Abstract. As the deployment of health information technology progresses, issues of usability and safety, including the possibility of technology-induced errors have come to the fore. Increased complexity of care delivery models and emergent conditions such as the Ebola scare in the US point to the difficulty of design that allows for human cognitive limits while meeting complex needs. We previously described a modular composable approach to health information systems, which gives the end-user some control of design and allows for creation of systems meeting myriad and varied needs. Here we discuss how the different drag/drop interaction paradigm has implications for health IT safety via several mechanisms. These include display fragmentation and the need to changeably prioritize information elements, interruptions, fit to tasks and contexts, and rapid changeability allowing low-cost readjustments when lack of fit is found.

Keywords. User-configurable EHR, user-composable EHR EMR, electronic health record, MedWISE, human-computer interaction, cognitive support.

Introduction

Healthcare information technology ('health IT') and electronic health records (EHRs) have great promise to improve care, reduce costs, and create a 'learning healthcare system' in which continuous improvement is possible by using data to analyze which treatments are most effective. However optimal interaction design of such software has proven difficult, with potential for health IT to itself introduce safety concerns.

The US Institute of Medicine 2011 report [1] identifies several concerns related to fragmented displays and the conventional interaction approach in which information location is fixed by the programmer and users navigate through menus. These concerns include mismatch between programmer assumptions and actual work environment, and mismatch between developer and clinician backgrounds, resulting in unmet needs. Current displays may not reflect clinical associations, presenting related data separately. Activities are treated as belonging to individual clinicians, instead of to a sociotechnical system with many intercommunicating components and unpredictable ways [1]. Inflexible order sequences may require providers to hold orders in mind while navigating, and time spent on cumbersome data retrieval and remodeling is time taken from other clinical demands [1]. Middleton et al. and others [2] note that a source of potential error is the mismatch between the user's model of the task/outcome and what actually happens[3, 4]. In a recent study of 147 malpractice claims arising from health IT at one of the most experienced institutions, 9% were caused by 'failure of

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system design to meet the need'. Half the total claims resulted in severe injury [5]. Display fragmentation is a major problem [6]. Prior work shows conventional EHRs have a roughly six-fold greater number of clicks and screen transitions required to view complete information [7], than composable approaches for the same cases. Conversely, appropriate information juxtaposition can foster insight, creativity, sensemaking, and problem solving [8-11].

Lack of fit to task is also a problem and can take many forms; here we are primarily concerned with specialty and contextual differences in information needs and interface design. Extensive logfile analysis shows those in different specialties and roles use hundreds of different sets of paths through conventional systems [12]. Design needs vary heavily according to context [2].

Interruptions in clinical EHR work can have serious consequences; Collins et al. found that in a 2-hour CPOE session in a MICU interruptions occurred on an average of every 5 minutes and preceded 2 errors [13]. Alvarez and Coeira found interruptions approached 30% of clinical communication [14].

Understanding and solving these problems to create truly safe and usable health IT requires careful study of cognition and efficiency effects of current interaction design coupled with imaginative software redesign, and testing. In order to understand and improve this 'cognitive ergonomics' using distributed cognition theory we consider a novel approach and system, in which the end user can assemble needed information elements by drag/drop. We have termed this the 'composable approach'. This allows testing of the above phenomena, rapid prototyping and re-testing.

The composable approach itself can have safety advantages. The flexible software paradigm in which nonprogrammers can rapidly change then lock the system, means unsafe designs can be changed in seconds, vastly reducing risk exposure time. We believe this overarching design principle may have major effects for health IT safety.

1. The Composable Paradigm and System Description

The new paradigm we proposed is briefly described in [18]. Giving nonprogrammer clinician users the ability to assemble EHR information via drag/drop and create tools and interfaces has advantages for technology fit to task and user, and is the ultimate 'user-centred' approach. By capitalizing on clinician deep domain (medical) knowledge, it seeks to improve technology fit to task, accommodate rapid change, evolve with user needs, and address some aspects of poor usability.

MedWISE (Medical Widget-based Information Sharing Environment) is an example electronic health record (EHR) platform built to exemplify the composable approach [18]. It has a modular composable architecture that provides a drag-drop platform for users to create and share their own resources, tools, and social networking, in combination with some automation. Users can assemble any desired elements from any part of the clinical information system together on the same screen, at any time before or during case review. The user can rearrange items in seconds as his/her thinking about the case changes. Some input can also use composition. These features (analogous to providing building blocks for the user to arrange) and sharing capability are also intended to facilitate 'produsage', i.e. the eventual creation of a large set of user-created resources and tools adapted to user needs and different contexts. MedWISE architecture and some aspects of performance are described in [16,22]. Two relevant concepts emerge from the theory of distributed cognition: a) the division of

resources internal or external to the user (i.e. kept in the users' minds or on screen) is important for system usability; the more externalization, the greater the usability[23, 24]. b) cognition should be thought of as occurring across the entire system of humans, artefacts, computers, etc., and not something that only occurs within individuals[21]. The composable approach constitutes a different interaction mode, with different effects, mechanisms and safety implications, described in section 2.

2. Safety Threats Arising From Conventional Interaction Modes and Composable Approaches to Address Them

2.1. Cognitive Load Imposed by Screen Switching

Conventional systems fragment the display of needed information by locating different types on different screens (for example, lab results, orders, and notes are usually found in different parts of the EHR and cannot be displayed together). This requires that the user click around and view multiple screens, retain relevant information in memory, (or write it down) then integrate it in mind. This imposes cognitive load (load on working memory) [1]. Often users must re-view information because they forget it [17,29]. By contrast, the composable approach allows drag/drop assembly of all information the user considers relevant on the same screen, avoiding screen switching and thus the associated cognitive load[16,17].. Our early work gives several indirect indications that composable approaches decrease cognitive load [17]. These are: significantly decreased repetitious navigation, user self-report that cognition is easier, lack of need to use supplementary tools to jot down data, fewer clicks and steps required, and greater externalization of representations. It is well established that human cognitive resources (perception, attention and memory) are finite [25]. If the task of finding and integrating information overloads these resources, fewer resources are available for the essential tasks of diagnosis and treatment. The safety implication is that inability to see everything relevant together may result in failure to integrate important facts into decision-making.

2.2. Composable Approaches Can Be Used to Create Patient-specific Displays

In conventional systems each clinician treating the same patient has to search for information in different pages and integrate them in his/her mind. By contrast, with the composable system only the first team member has to do this; then the patient-specific summary can simply be shared among team members and updated with a few actions. This means that it can serve as a 'common ground' display for clinical communication [26, 27]. Beyond templates, these patient-specific displays can exactly summarize the patient condition by including all the relevant elements and excluding those not important for this particular patient. This has a safety and efficiency consequence. It has been shown that when it takes too long to locate information, time-pressed clinicians may give up searching, or reorder tests. Thus for borderline cases diagnoses may be missed due to inability to find existing information.

2.3. Interruptions, Nonlinear Workflow, and 'Wrong Patient' Errors

Interruptions are common in healthcare work and constitute an avenue for potential major errors such as wrong patient errors, particularly if several people share computers, or where system state is not preserved during automated logouts. Ability to create patient-specific displays could mitigate the effects of interruptions/multitasking, since the user can return to the display without the need to re-search elements. The user returning from an interruption comes back to a (partially completed) patient-specific display and can simply continue at the point at which he/she left off. The existing display will also help to mentally reorient the clinician.

Moreover, object arrangement is frequently used by workers to track stages in a process and allow quick reorientation after interruptions [28]. We found this use among clinicians in our preliminary studies [16]. For example, one user stacked up all the labs to review on the left, opened and compared them to the note juxtaposed on screen, then moved them all to a right-hand column when finished with them. This is a typical use of movable components to track a process [28]. As much clinical work involves nonlinear workflow in which users care for multiple patients simultaneously, the patient-specific display contained on a single tab allows switching between records with no need to re-find information, nor remember or re-do what was done previously. Distinctive patient displays (perhaps aided by deliberate safety design patterns such as different backgrounds, photos etc.) can be a tool to address the 'wrong patient' risk.

2.4. Lack of Fit to Task

The ability to select and arrange elements and create shareable templates could increase fit to task, so that different specialties or professions could design their own displays for specific purposes/contexts. Testing and redesign can be done in minutes.

Information availability and prominence are particularly important in emergent circumstances, as was amply demonstrated in the 2014 US Ebola case in which an infected patient was improperly not admitted to hospital. This was despite the fact that his travel history was, collected by the nurse and subsequently available (in the EHR) to the doctor. In such cases it is useful to be able to bring to the surface, mark (e.g. by coloring headers) and display any elements prominently, without programmer intervention. This is easily changeable as the situation progresses (as happens with changing public health emergencies).

2.5. Cognitive Support

Composable approach capabilities can provide cognitive support, allowing juxtaposition of related elements together, rearrangement as thinking about a case changes, marking of important elements, arrangement in order of importance to diagnosis, or communicating one's thinking to others. Matching interface to task can allow more exact representation matching and greater externalization of information, (e.g., a user could place problems in order of importance instead of keeping this order in memory), reducing cognitive load, as per distributed cognition theory. See [16, 29] for further description of how they were used in prior work. Checklist effects are possible if clinicians create templates with all required information for particular contexts. Users state that the mere presence of such collections serves as a reminder, fostering complete information review [29].

2.6. Extensibility and Vetting

Public internet applications are highly usable because of a history of extensive research designed to foster smooth commercial shopping experiences for the widest possible range of users. Its ethos of free code sharing has meant web developers can leverage design patterns developed for one use, for many others. Web-based composable approaches allow for similar leveraging of public design patterns, with independent code environments for each widget. New safer visualizations or interaction modes could be rapidly incorporated. Examples are list selection including multimodal confirmation, or visually specifying lesion location. As with free or open source software, the 'many eyes' vetting of interfaces by colleagues can correct omissions.

3. Summary of Risks in Conventional and Composable Interaction Approaches.

Conventional approaches in which information locations are fixed impose certain risks in comparison to a composable approach in which all relevant information could be gathered together. These risks are: a) the user must search for each type of element at each session, and risks not finding them, possibly leading to omissions, b) the user must keep information in working memory between screens, engage in back and forth navigation, and therefore risks forgetting or omissions; c) more time may be taken, increasing stress, d) the user may not know what the previous colleague saw, nor whether a colleague's information review was complete; e) items which should be located together (e.g. systolic and diastolic blood pressure) may not be; and the user cannot force this juxtaposition. f) checklist effects possible with composable approaches are not possible in conventional approaches. Composable EHR risks include: a) error-causing omissions by a user designing a page, and b) sharing of the omission without detection propagating the errors (Dx momentum), c) cognitive load could increase for one user using an unfamiliar template designed by another. See Table 1. There is further discussion about comparative risks in the two systems, and comparative accuracy findings, in [29].

Table 1. Partial list of potential risks in conventional and composable approaches.

Conventional EHR risks	Composable EHR risks
a. Omission by user in search, → error	a.Omission by user → error
b. Cognitive load due to need to retain items in Working Memory	b.Shared omission →Dx momentum error?
d. User viewing patterns hard to view	c.Cognitive load due to different interfaces
e. Possible lack of fit to patient case, specialty, role	
f. No checklist	
Hard to change as per situation -->potential error?	

4. Conclusion

Safer design of electronic health records requires methods to address the human-computer interaction risks in our current conventional systems. Consideration of composable approaches may provide ways to address these risks, by decreasing display fragmentation, increasing fit to task, providing cognitive support, and allowing for rapid readjustment by nonprogrammers when suboptimal arrangements are found.

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Enhancing Patient Safety Event Reporting by K-nearest Neighbor Classifier

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Abstract. Data quality was placed as a major reason for the low utility of patient safety event reporting systems. A pressing need in improving data quality has advanced recent research focus in data entry associated with human factors. The debate on structured data entry or unstructured data entry reveals not only a trade-off problem among data accuracy, completeness, and timeliness, but also a technical gap on text mining. The present study suggested a text classification method, k-nearest neighbor (KNN), for predicting subject categories as in our proposed reporting system. Our results demonstrated the feasibility of KNN classifier used for text classification and indicated the advantage of such an application to raise data quality and clinical decision support in reporting patient safety events.

Keywords. Patient safety, medical error, clinical decision support, text classification

Introduction

Much attention has been paid to how patient safety reporting system can improve the quality and safety of health service [1]. Among many factors fundamental for a successful voluntary patient safety system, data quality has been a major concern. The incompleteness and inaccuracy of data were identified as two major problems of such systems [2,3]. To solve these problems, researchers have found close associations between human factors and system performance in terms of completeness and accuracy of the data [4]. Lacking of human factors was unfortunately found as a common shortcoming across patient safety reporting systems and has not brought much attention over the past decade [5].

Data quality is greatly impacted by the process of data entry, where data entry plays a critical role in healthcare information systems [6-8]. The majority of patient safety data is recorded in free text. Although this might be an efficient and natural means for users to deliver an informative case, it could be costly to turn the raw data into cognitively organized and manageable information for professionals to use. It was reported the usage of pre-defined reporting categories as a key component in patient safety reporting system to improve data quality [2]. However, structured data entry as such could be limited on both timeliness and accuracy [6]. To solve this problem, a text prediction method was developed in unstructured data entry for balancing data quality among accuracy, completeness, and timeliness [9]. The innovative use of this technique

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improved the system performance (13.0% time reduction and 3.9% accuracy increase), with the only concern being that the cognitive mechanisms underlying the prediction lists remain unveiled as in the original study the lists were manually prepared by domain experts. When applying the mechanisms to large-scale data entry beyond controlled settings in the real world, we have to make them scalable and reduce the dependence on domain experts.

One way to improve data entry is to incorporate both structured and unstructured data entry with text classification. If the reporting system can grow a list of categories based on unstructured data, where the list represents the taxonomy of the case, then we could create a system being able to assign report entered data into categories and thus accepting the unstructured data in an organized format. With the explosive growth of information in patient safety, it is no longer efficient for human experts to manually classify reported cases. As a result, we investigate computerized approach of predicting the event categories presented in text document, which is more significant in handling large set of data. Text classification techniques, through which documents are divided into one or more categories, are commonly used in handling large text collections, filtering spam emails, and search engine [10]. In healthcare, text classification is typically used as an effective tool for automated data processing in text data, images and many other data types [11].

We propose a text classification method, K-nearest neighbor (KNN), for predicting the event taxonomy based on unstructured free text reports. We also provide an overview of our proposed reporting system where the KNN classifier serves as the core component. Generally speaking, KNN text classification is superior to other methods in the present case because of three reasons: (1) The performance of KNN in the text classification can be greatly improved when the learning algorithm for distance metric and the training sets are well selected [12]. Distance metric indicates the similarity between objects, where objects close in distance are potentially similar. Training sets are the input of the KNN classifier and consist of the k closest vectors in the feature space. (2) KNN classifier is cost saving in categorizing patient safety cases with minimized human effort. (3) KNN is more applicable to patient safety cases, which contain a greater portion of narratives than semi-structured data in electronic medical records (EMR).

A general procedure of applying KNN model in event cases is described as follows: a report is manually labeled with a category, selected from a category list, such as safety target, error type, clinical area, and so forth. Each category may contain several sub-categories, applied as appropriate. Following such a manual process, domain experts will develop a set of k-nearest training sample cases with proper category labels. Then, the samples will be used to train the KNN model. Through an iterative and incremental process, the model eventually is expected to classify unlabeled text documents without human supervision.

1. The KNN Classifier

We used KNN algorithm [12] to classify 110 event reports from Morbidity and Mortality Rounds on the Web (WebM&M). WebM&M holds patient safety cases cross-labeled into 6 categories (safety target, error type, approach to improve safety, clinical area, target audience, and setting of care), and each category contains two or three levels of subcategories. The corpus we selected is under ‘safety target’, and has

been separated into two subcategories by domain experts, which are 'device-related complications' (n = 30) and 'diagnostic errors' (n = 80). We used 70% of the corpus for training and the rest for testing the model, which resulted in 18 'device-related complications' documents and 59 'diagnostic errors' documents as training samples, and 12 'device-related complications' documents and 21 'diagnostic errors' documents as testing samples. All the documents have been pre-categorized by domain experts when we extracted them from WebM&M, and these categories serve as the gold standard when testing the model predictions.

We implemented the KNN classifier in R along with 'XML', 'tm', 'FNN', and 'plyr' packages loaded. 'XML' was used for extracting free text data from the web. Other packages such as 'tm', 'plyr' and 'FNN' contain commonly used functions for data manipulation and KNN algorithms. The corpus extracted from WebM&M passed a set of cleaning procedures as follows. (1) Punctuations were removed from the original text. (2) Words were toggled to lower case. (3) White space was stripped off. (4) Stop words in English were removed from the text. When these procedures had finished, we transformed the documents into a term-document matrix. All the documents were labeled with either 'diagnostic errors' or 'device-related complications' prior to being loaded in the model. This ensures a later comparison between predicted classification and the gold standard and consequentially allows the calculation on accuracy and F measure.

The text classification was separated into two phases, training and testing. In the training phase, we offered a set of labeled documents so that the model can learn to map a list of correct categories to the corresponding documents. In the testing phase, the model attempted to map a correct document to a certain list of categories. The training samples (70 %, 77 documents) were randomly selected from the pool (110 documents). By default, the number of the closest neighbors (k) is set to be 1. We tested the model performance by increasing the k from 5 at an interval of 5 until the F measure is out of capacity.

2. Model Performance

The following figures (Figure 1) show the KNN classifier performance at a set of different k values. The top performance is achieved when k is at 5 for both F measure (.75) and accuracy (.88), where the precision value is .86 and recall value is .67. We observed a decrease on performance as k increases from 5 to 20. F measure is no longer capable when k is larger than 20.

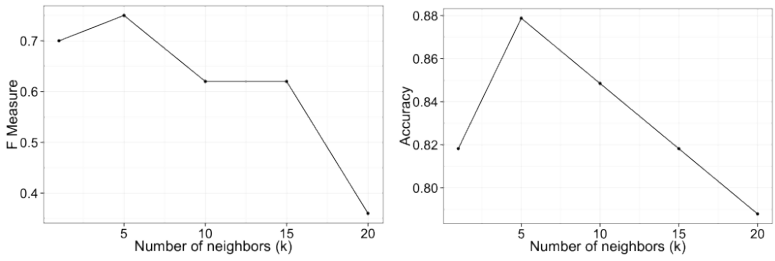

Figure 1. Performance of KNN classifier on different k. The left chart shows F measure. The right chart shows accuracy.

We observed a trade-off between a small number of neighbors (k) and large k. When the KNN classifier has the best performance, a contingency table depicts the predictions per categories (Table 1).

Table 1. Contingency table per category.

		Actual	
		A_1	A_2
Predicted	P_1	6	1
	P_2	3	23

A_1 indicates 'device-related complications';
A_2 indicates 'diagnostic errors';
P_1 indicates 'device-related complications';
P_2 indicates 'diagnostic errors'.

3. System Overview

To establish an improved patient safety reporting system, we strive to synthetically set up other components for cooperating with the KNN classifier. In the previous section, we described the implementation and performance of the KNN classifier, which in turn explained the potential generalizability of the proposed approach. In our approach, a web-based patient safety reporting system is comprised of data collection, data management, and data reporting. The outcomes of the KNN classifier extends to several applications that aid to improve the overall system performance in terms of data quality and clinical decision support (CDS) in patient safety events.

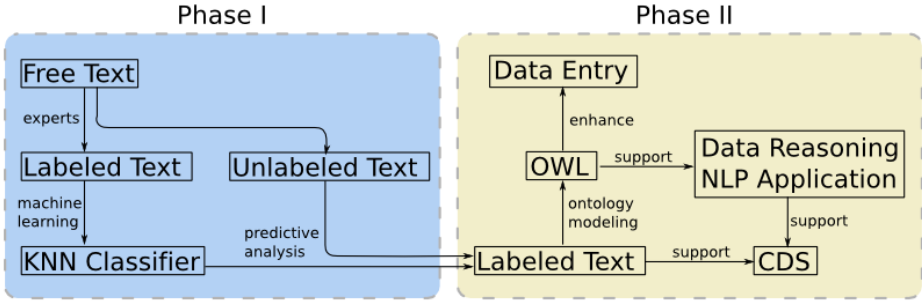

Figure 2. Major components in the proposed patient safety reporting system. Phase I describes the implementation workflow of KNN classifier depicting how patient safety data transformed from free text to labeled text. Phase II emphasizes on the application facet of the system. With the extensive usage of semantic web ontology and natural language processing (NLP), the outcomes of KNN classifier help enhance clinical decision support (CDS) and data entry.

As shown in Figure 2, labeled text serves as building blocks for supporting knowledge-based implementation of CDS where natural language processing (NLP) and other data reasoning techniques will help maximize data value. The difficulties of implementing CDS lie in the transformation processes from narrative data into computerizable data. In particular, the development of CDS systems is based upon

domain concepts and the concept relations which are usually buried within free text [13]. By taking advantage of the KNN classifier, the labeled text was organized in a taxonomy that contains hierarchical domain concepts. In our proposed system, semantic web based ontology is implemented by W3C open standard web ontology language (OWL) in order to model these concepts and concepts relations. This ontology not only supports semantic data reasoning and NLP applications, but also enhances data entry. When users enter reports in the system, semantic web ontology provides a robust semantic knowledgebase for the participants to guide their data entry. Therefore, we suggest the application of ontology in data entry should largely maximize the consistency of structured data.

4. Discussion and Future Study

The present study demonstrated the feasibility of adopting KNN classifier in classifying patient safety reports. As a simple-to-use method for classification, KNN has been evaluated effectiveness for text classification in information retrieval [14-17]. By identifying a neighbor through what language the neighbor speaks, KNN is a simple algorithm to apply because it requires no training on the model itself. In the context of event reporting, KNN meets the demand of finding neighbors, since some language will be used frequently when describing similar cases.

In our study, the implementation of KNN classifier yielded a substantial improvement in automatically classifying the events. The model reached a fairly good performance where k was set to be around 5. With an accuracy of 88%, we are confident in using text classification technique for improving data quality in the following ways. First, the KNN can be used to classify text data with minimum supervision. As the data grows rapidly, an outstanding reporting system requires the capability of extracting most useful information in a short time. As long as our KNN classifier outputs with high accuracy, the classifier may replace domain experts and therefore reduce the high cost of manual classification. Second, the KNN allows the system to be flexible to accept unstructured data format. Unstructured data format, such as free text narrative, has been used with a long tradition because it is easy for reporters to freely express. Nonetheless, the professionals who review the event reports also need an efficient and effective way to interpret and organize the reports, which appears to be an unsolved problem. Fortunately, our method holds the potential to solve the problem. Third, it sheds light on how to build an effective taxonomy of patient safety events and a sharable knowledgebase. Although the reusing of unstructured event data can be challenging, text categorization provides a promising way to develop an ontological knowledgebase of patient safety events.

Data quality has been a barrier for improving healthcare quality through patient safety event reporting system. Issues with negative effects on data quality are found associated with human factors [2,18,19]. It has been a challenge balancing the completeness and efficiency of unstructured data entry and the effectiveness of structured data entry. To meet this challenge, our approach holds promise by adopting text classification as a data analytical technique. The major advantage of our method is thought to be emancipating the people, who use the data entry system to report cases, from arbitrary selections while still being able to extract useful information from the raw data, specifically, free text data. Although natural language provides the richest information that conveys details of patient safety events [20,21], it prevents traditional

computerized system from effectively processing the data when manually categorizing large-scale dataset is not practical. By utilizing KNN classifier, we discovered a new approach for coordinating the richness of unstructured data and technical barriers of classifying the data. Similar situations also exist in EMR systems [22]. Therefore, we envision the application of text classification would extend to other clinical information systems where human factors play a key role.

Although the KNN classifier revealed an impressive performance in our study, some limitations are worth to notice. The KNN algorithm is criticized due to its dependency on the selection of k value [14]. That being said, the best selection of k, which brings about the best performance on prediction, varies as the text documents differ. Therefore, text documents lacking completeness may not be a good use case. In addition, the sample size we tested in the present study is small and only contains two categories. In the real-world situation, patient safety taxonomies usually have hierarchical structures, which may contain up to three or four levels, and each level having up to three or eight subcategories. Future studies should evaluate different sources of data with more categories.

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Integrating Methods to Evaluate Health Information Systems

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Abstract. There are different methods to evaluate Health Information Systems (HIS), such as Quality Evaluation of software products, human factors, and socio-technical approaches. This work aims to identify the main aspects used to evaluate HIS, and whether there are relationships between issues considered in assessment of software quality and the ones applied specific to the health domain. This was an exploratory study that included a literature search related to HIS evaluation and software quality analyses applying the norms of the International Organization for Standardization (ISO/IEC), to identify aspects and features applied during the assessment process. The result is a proposal of an evaluation method based on the integration of these two evaluative approaches, combining or complementing the considered aspects. The method was applied to an evaluation of a natural language processing system to identify continuity of care in discharge summaries.

Keywords. Technology assessment, health information system, evaluation methodologies, evaluation studies, quality software validation.

1. Introduction

Improving a patient's treatment and health management using a Health Information System (HIS) is a priority for health services and professionals. In this context, a strict evaluation of HIS is needed to assure the quality of information, effectiveness, and a full understanding of the effects, and impacts of its application [1,2].

One of the main methods to evaluate the quality of Information Systems has been the International Standard Organization's Software product Quality Requirements and Evaluation (SQuaRE) – Guide to SQuaRE, last reviewed in 2014 (ISO/IEC 25000) [3,4]. The focus is particularly on software quality [5]. To evaluate specifically the use of HIS, approaches related to human factors and socio-technical theories are often applied. These methods consider aspects such as efficiency, effectiveness, information quality, usability, and context. However, there is no tradition for HIS evaluations that integrate software quality and human factors approaches [6].

In an article that addresses the problems and challenges of evaluation of HIS, Ammenwerth [7] states that there is a need to understand information technologies as part of the information system of an organization. It is clear that an assessment will not only focus on hardware and software, but on the processing of information, namely on the interaction between IT and users in a given environment (human factors and socio-

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technical). This means that often more than one aspect of an HIS is evaluated in a single product. The evaluation requires not only an understanding of computer technology, but also social and behavioral processes that affect and are affected by technology. To compensate for this flaw, this paper aims to identify the main features used to evaluate HIS, and to analyze its relation to software quality to specify a possible integration of the two approaches. This was applied in a case study to evaluate "IRDischarge" [8], a natural language processing system to support the identification of continuity of care in discharge summary narratives.

2. Method

The study started with a search of the PubMed database to identify publications from the last ten years (until May 2015) related to HIS evaluation, applying the terms: "evaluation" OR "assessment" AND "electronic health record". The search found 4835 articles, but only 105 articles were related to HIS evaluation considering human factors or sociotechnical issues. Reading the articles revealed 17 different features used to evaluate HIS. Usability, effectiveness (precision and recall), sensitivity and specificity were the most frequently found.

Hereafter, a new search was performed using the terms "Evaluation of quality in health information systems". As this search did not provide any relevant information, the search was redone using the terms "Evaluation of software quality". Sixteen articles were identified, although only two applied a regulatory norm in the evaluation. In these cases the ISO/IEC 9126 was used. An additional search using the terms ISO/IEC 9126, 14598 and 25000 was carried out. The analysis of this led to the conclusion that even the most recent publications are not related to the use of the norms ISO/IEC in the software evaluation, since the new series SQuaRe that was published in 2005, reviewed in 2008 and 2014 is not used in any paper [3].

The analysis of the methods that applied a socio-technical approach revealed few aspects that can be integrated to complement the ISO approach. From that, the authors attempted to integrate the methods that were carried out by composing a completely new approach that ensured the system's quality certification, was complemented by human factors and socio-technical evaluation, and was specific to HIS. This was performed by: combining similar aspects into one item, joining the ones that are complementary in a new item, and incorporating the specific aspects, involved in each approach, to reach the final proposal. To demonstrate the strength of the new proposed method, it was applied in the IRDischarge evaluation.

3. Results and Discussion

The decision to integrate different kinds of evaluation approaches has the aim to improve the process, whereas there are features that are repeated, others are complemented, and a few are indispensable for the system to work and to assure benefits. It does not mean that these features are insufficient if they are done separately. Each feature fulfills exceptionally well its role to evaluate, however, together they complement each other and are able to guarantee that a system has quality while it brings benefits when utilized.

Figure 1 shows features considered by the human factors approach in the left column and the right column presents the aspects evaluated by ISO. By analyzing both approaches it is possible to see that the aspects of usability and efficiency are the same. These aspects can guarantee a user-friendly system, in other words, a system that is easy to use by any professional, and will reach its goal without great efforts.

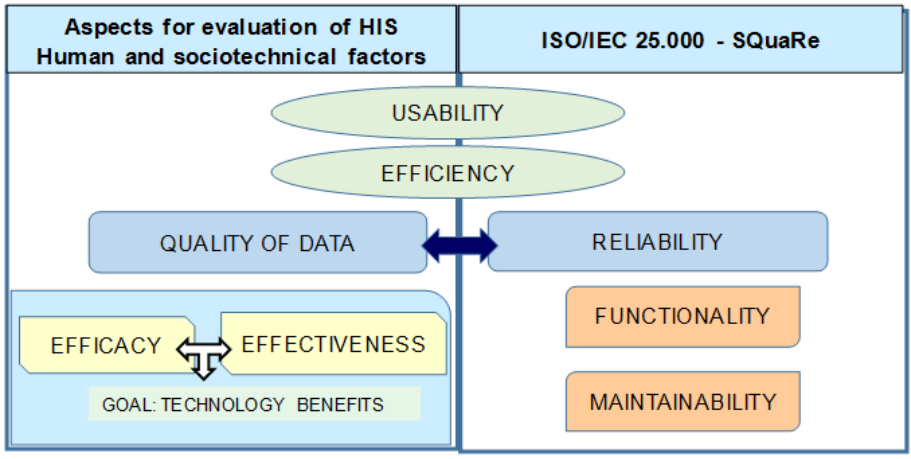

Figure 1. Relation between the evaluation methods based in human factors and in the ISO.

Also, in observing what is common between the two evaluations, Oleto [9] asserts that when we analyze the information quality of the product, it emphasizes the information as an object, giving the information quality some dimensions or attributes, such as reliability. Therefore, we understand that with this view, reliability is an aspect to be evaluated inside the big group of information quality.

Efficacy and effectiveness are essential during evaluation to show whether the new technology will bring the requested benefits or not. These features are not included in the ISO/IEC 25000 approach. On the other hand, the aspects of functionality and maintainability, which guarantee the system to be liable to execute tasks, and that it can be sustained, are not covered sufficiently by the human factors and socio-technical approaches.

To use the socio-technical and human factors approach to evaluate the HIS and aggregate it to the series SQuaRe, would be a way to complement the evaluation.

Items to be evaluated	Evaluation's goal
Literature	What are the methods used until this moment for this kind of HIS?
Evaluation design	Define the goals and how they are going to be reached.
Functionality	Will the system be reliable to use?
Maintainability	Can the system be kept up or changed if necessary?
Information quality	Are the results, data generated or entered trustworthy?
Efficacy	Will this system bring benefits in ideal situations?
Effectiveness	Will this system bring benefits in real situations?
Usability	Will this system be easy to use?
Availability	Will this system be able to reach the goal of minimizing loss of resources?

Figure 2. Presentation and description of the evaluation items.

However, before launching any evaluation study it is required to determine the type of evaluation, the aspects of a particular type of system, as well as the results aimed for. A literature review is the best way to identify this information. This step helps to start the characterization of the study design, in other words, to choose what suits the system evaluation best, based in what has previously been studied and used.

Based in these surveys, the proposed method is composed by nine items that associate aspects from both approaches, also including an initial analysis performed by a literature review. Figure 2 shows these items with their description.

Figure 3 shows what has to be done in each of the items of the proposed method to evaluate the natural language processing system, IRDischarge.

Evaluation item	Example in *IRDischarge* Evaluation
Literature	Information retrieval systems are mainly evaluated regarding precision and recall.
Evaluation design	Is IRDischarge able to support physicians during discharge summaries elaboration, advising them on the absence of continuity of care description?
Functionality	Can IRDischarge be used in health institutions? Can it be incorporated into Electronic Health Records?
Maintainability	If there is any modification in continuity of care description, could the *IRDischarge* make these modification? If there is a necessity to recover any other information inside the discharge summary, is it possible to insert this new functionality in a simple way?
Information quality	Is the presence or absence of continuity of care indicated correctly?
Efficacy	Precision and recall evaluation.
Effectiveness	When used in health institutions, will the system bring benefits for the society? For example, facilitating health treatment continuing after a hospital discharge?
Usability	Is the system interface clear and user-friendly to the health professionals when elaborating the discharge summary?
Availability	Will the system indicate the presence or absence of continuity of care, with the best quality and using the minimum resource as possible?

Figure 3. Example of the proposed method to evaluate the IRDischarge.

4. Conclusion

HIS have to be developed with the aim to facilitate a health professional's work. To reach this goal, systems have to be evaluated properly. This paper presents an improved method, including pre-evaluation steps and features to be analyzed that assure the quality of the product and the benefits of the new technology for society.

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Organizational and Social Issues in Different Contexts

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Information Issues and Contexts that Impair Team Based Communication Workflow: A Palliative Sedation Case Study

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Abstract. Implementing team based workflows can be complex because of the scope of providers involved and the extent of information exchange and communication that needs to occur. While a workflow may represent the ideal structure of communication that needs to occur, information issues and contextual factors may impact how the workflow is implemented in practice. Understanding these issues will help us better design systems to support team based workflows. In this paper we use a case study of palliative sedation therapy (PST) to model a PST workflow and then use it to identify purposes of communication, information issues and contextual factors that impact them. We then suggest how our findings could inform health information technology (HIT) design to support team based communication workflows.

Keywords. Context, workflow, communication, information issues, healthcare teams

Introduction

The information-communication relationship is a key part of healthcare delivery. Information has been described as the lifeblood of healthcare with communication being the heart that pumps it [1]. However, information and communication issues are common and can lead to a number of unintended events including workflow issues, inefficiencies and adverse patient outcomes [2-3]. Communication is particularly challenging in team based care delivery due to the number of providers, their diverse training, and the range of different processes and information sources that comprise communication [4]. As a result of the above issues, communication failure has been repeatedly identified as a cause of medical errors [3, 5].

Consequently, there have been calls to improve communication practices to reduce adverse events such as medical errors [6]. However, reporting error frequencies without understanding the communication and information practices that comprise the errors will not lead to safer care delivery [7-8]. Further, studies have made a distinction between understanding the structure and behavior of team based care delivery [9]. While workflow may model the structure of an activity and how it should be done it is

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often behavioral aspects that define its success. However, there is a shortage of studies that define both the structure and behavior of team based workflows, and more importantly, the role that information and communication behaviors play in workflow activities. This paper addresses the above shortcoming by using a case study of palliative sedation therapy (PST) to model a workflow of PST and then use it to identify purposes of communication and information issues and contextual factors that impact the communication purposes.

1. Methods

We studied PST on an inpatient palliative care unit to gain insight into how an interdisciplinary team communicates to promote best practices and deliver patient care. A qualitative perspective was used as it has the ability to understand the complexity of communication surrounding care delivery and the use of PST on the unit.

1.1. Data Sources

Three different clinical teams were studied on the inpatient unit. The difference between the teams was that the medical staff (e.g. physicians and residents) were team specific while the nurses and allied health providers moved across the teams. The data sources included non-participant observations, semi-structured interviews, document reviews and shadowing. In total, 107 individuals were involved in observations including medical staff (physicians & residents), nursing and allied health. 17 of these individuals participated in interviews and one individual was shadowed to gain insight into the nursing workflow. These interviews included representatives from all participant groups. Document reviews included the PST Guidelines and Protocols, which were considered as the ideal "best practice" document for PST in this setting. Blank copies of charting documents were also obtained and reviewed.

1.2. Data Analysis

In total, 404 pages of observation data (44 transcripts) and 169 pages of interview data (17 transcripts) were transcribed. The data was reviewed and coded in NVivo© using directed qualitative content analysis [10], drawing upon existing communication models including [11,12]. A coding tree was developed and analysis continued until the two authors determined that saturation of the data had been achieved.

2. Results

Our results are presented in three sections. First, we developed an overall PST workflow model to outline all processes and to highlight communication and information practices. Second, we categorized communication into two overarching communication purposes: formal and informal. We also identified three information issues that impact the two categories of communication and determined the frequency of each issue for the communication purposes. Third, we identified contexts that further influence the communication practices. Each of the three sections are described below.

2.1. PST Workflow

Fig. 1 shows the overall PST workflow. PST originates from either the nurse or the physician. Discussion with other health professionals and the patient, and/or patient's family, then occurs prior to any decision being made. If the decision is made that PST may be needed, the patient's medical chart is documented to indicate this. When the decision is made that PST should begin the physician writes a medication and treatment order, which is sent to the pharmacy. Upon receiving the necessary information, the nurse begins PST with their patient. Medication doses are increased and/or decreased in consultation with the patient's physician.

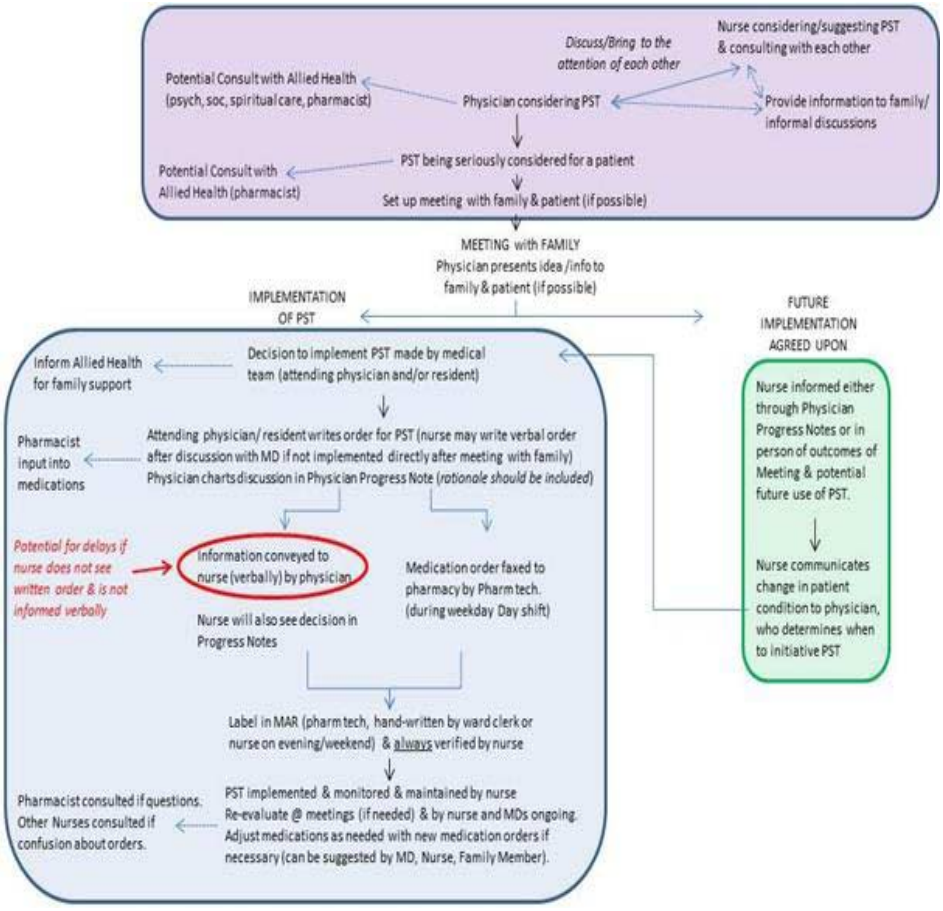

Figure 1. PST workflow outlining information and communication practices.

Each of these different actions can be considered a separate step within the practice of PST. The number of steps involved in the practice of PST, the number of different interdisciplinary team members that can be involved in any given step, and the different methods of communication that can be used at each step highlights the complexity of this particular practice.

2.2. Purposes of Communication and Associated Information Issues

In order to make the PST workflow model as detailed as possible from the perspective of information and communication we developed a table of communication purposes and information issues that impact communication (table 1).

Table 1. Purposes of communication and information issues that impact communication

		Information Issue		
Purpose of Communication		**Quality of Information – Issues**	**Access to Information/People – Issues**	**Awareness of Unit Practices – Issues**
Communication of Formal Processes	Communication regarding Formal Procedures/Protocols	15	2	7
Communication of Informal Processes	Communication regarding Informal Procedures/Protocols	7	4	0
	Information Exchange & Transfer among Team Members	48	6	7
	Education/Instruction Related	6	0	1
	Actions that Impact Workflow	68	19	8

Communication was classified as communication of formal and informal processes. Formal communication processes are events occurring as a result of a formal procedure or protocol that requires this communication to occur. Examples include verifying/co-signing medications or updating formal charting documents. Informal communication processes are not tied to any formal/explicit procedure or protocol but must occur in order for members of the healthcare team to provide care to their patients. Informal processes were further categorized into communication of informal protocols, information exchange among team members, education related, and actions that impact workflow.

We also identified three overarching information issues that impact both purposes of communication. Quality of information issues include missing information or information that, while available, the recipient questions the accuracy of. Access to information/people issues refers to the ability to access information when it is needed. When information cannot be accessed due to a lack of available resources, or the unavailability of other healthcare team members, it delays the ability of others to complete their work and may result in additional work. Finally, issues with awareness of unit practices refers to differences in practices that may occur across units and the need for members of the healthcare team working on the unit to understand the practices specific to this unit in order for them to function effectively as an individual and for the team to function effectively as a whole.

2.2.1. Formal Communication Processes

As shown in table 1, communication of formal processes was the minority (approx. 14%) of communication processes. The biggest information issue impacting formal

communication was information quality. For example, a formal process like medication verification was improperly done because of inaccuracies in documentation or unclear/ incomplete documentation. Access to information or people issues occurred when documentation is done by multiple people in different documents (e.g. patient medical chart, MAR) at different times of the day, and due to this someone else cannot access a needed document, or cannot find a team member needed for communication. Awareness of unit practice issues occurred when tasks are not completed in a timely manner (e.g. patient assignments for nurses or unit specific documentation is not updated) as it impacts the workflow (fig.1) of those who are waiting for tasks to be completed in order to complete a follow up task.

2.2.2. Informal Communication Processes

As shown in table 1, the majority of communication processes were informal. As with formal communication processes, the biggest information issue was information quality. Information quality issues were particularly significant in information exchange and transfer among team members and actions that impact workflow. Examples of the former include the fact that both written & verbal communication mediums are used, especially face-to-face verbal communication. As a result of the hybrid communication, team members may have different recollections or what was agreed upon. Examples of the latter include differences across individuals and the care team. While the PST workflow is a team based workflow, it is implemented by individual team members. Individual variations in charting may result in documents not having all requisite information (e.g. names, dates, and other contextual info), so that other team members are forced to go and look up the missing information.

2.3. Contexts Impacting Communication

While the PST workflow represents the ideal delivery of PST, contextual factors can influence workflow delivery. We identified three overarching contexts that impact communication. One was variation across shifts. As described in section 2.2.2, the information needed to support communication is often imperfect and as a result individuals must locate required information to carry out their part of the workflow. However, shift work was frequently commented on as a factor that impacted the ability of team members to obtain information in a timely manner as the resources that individuals have available to them, in the form of their colleagues, is reduced for the majority of the evening shift and the entire night shift. The medical team, in the form of an on-call physician – typically one of the unit's residents or fellows – is available by phone for all hours when a physician is not present on the unit. The consequence is that physicians must attempt to anticipate what their patients will need, and put their trust in the nurses to obtain any medications or contact the on-call physician should their patient's status suddenly change overnight. The physical layout of the unit was another context that influenced workflow. The unit in this study had three distinct physical wings, which often meant that an individual would be on one side of the unit when someone was looking for them on another unit. The extent of manual information processing that was required because of information issues was made more challenging because of the unit layout. The third context was the variation in tools that are used for information exchange and communication. These tools can be charting documents, technology or people, but they can also be pure communication tools such as the PA

system on the unit. The ability of different tools to act in different capacities exerts a context on information exchange and communication and it is essential to use the right tool in the right context. For example, making information available may be satisfactory in certain circumstances, while in other circumstances it is important that the information is received along with an acknowledged confirming it was received to confirm that communication has occurred. In other circumstances distributed communication among team members is needed if a group decision has to be made.

3. Discussion

In this paper we described a PST workflow and then used it to identify communication processes and information issues and contexts that influence how the processes are done. Key findings from our work is that while communication is an essential part of formal workflows like PST, the majority of it (approx. 86%) was informal communication. We also identified that information issues impacted communication processes (both formal and informal) with information quality issues being the majority of the issues. Finally, we described three contexts that impact how communication is implemented.

While workflows outline the ideal delivery of care delivery, we know that such a utopia state seldom exists. Therefore it is important to understand the causes of workflow issues at the information and communication levels and the contexts that shape these issues. Understanding how information and context shape communication will allow us to target specific solutions that fit the workflow where communication takes place. Health Information Technology (HIT) such as electronic health record systems can assist with alerts or reminders for task completion to ensure that individual tasks are completed so as not to delay group workflow activities or to formalize activities such as information documentation as opposed to having varied approaches (i.e. verbal and written). HIT can also support communication practices such as when a nurse may need to contact a physician if there is a change in patient status. However, HIT will not improve communication unless the behavioral aspects of communication are formalized and managed. One of the issues we identified was a lack of rules of engagement for how group communication practices should occur. A consequence of a lack of rules is that individuals may do tasks not realizing the impact on the larger group dynamics. Technology will not solve the rules of engagement issue but rather the rules must be established first and then HIT designed to support the rules. We also need more research on how contexts such as shiftwork, physical unit layouts, and variation in tool functionality impact communication practices and HIT design to support the practices.

Limitations of our work are that we only studied three palliative care teams on one clinical unit. Other information and communications issues and contexts may occur in other settings.

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The Role of Medical Transcriptionists in Producing High-Quality Documentation

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Abstract. This study aimed to investigate the quality-assurance work conducted by medical transcriptionists in the production of medical records, and the implications of these findings when designing a structured electronic patient record (EPR) system in which physicians are supposed to write documentation themselves. Both qualitative and quantitative methods were applied. Qualitative data were collected through informal discussions and focus-group interviews. Quantitative data were collected through the medical transcriptionists' daily recordings of their quality-assurance work. The results show the many essential quality-assurance tasks conducted by medical transcriptionists and the extent of this work. Each medical transcriptionist performs an average of more than six corrections per day, and approximately one of three dictations are corrected. We suggest that these correction and quality-assurance tasks need to be compensated for when designing and developing new structured EPRs. Some quality-assurance tasks may also advantageously be performed by secretaries in the future.

Keywords. Electronic patient record system, medical records, quality assurance, medical transcription, structured EPR

Introduction

Medical transcriptionists (MTs) have an important role in documenting patient visits in free-text electronic patient record (EPR) systems. The documentation work typically involves the doctor ordering the right template in the EPR, providing dictation, and sending the dictation to a MT for transcription. The MT transcribes the information and may send a note to the doctor if something is incorrect or unclear. The doctor then replies to the note. After the doctor receives, reads, and approves the transcribed document, the MT send it to the referring health provider, other involved health personnel and maybe also the patient.

Unfortunately, and independent of the MTs' work, free-text EPR systems create double or triple registrations, redundant documentation, and little opportunity for the extraction and reuse of the data or its transmission for quality registry or research. The logical solution to these problems is to structure and standardize the EPR systems.

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Structured EPR systems are expected to ensure improved quality [1], more completeness [2, 3], higher levels of correctness [2, 4], greater clarity [5], and fewer mistakes [6].

An implication of introducing highly structured EPRs is that the physicians have to record the data in the EPR; i.e., they have to write the patient documentation themselves. This implies a change in the existing medical record production practice, in which dictation is the predominant method [7].

However, doctors' change of work practice from dictating to recording may overlook the MTs' important role in producing high-quality documentation. When dictation is used, the MT performs a knowledge-intensive job of interpreting dictation correctly and transcribing it so that patient information is complete [7, 8]. The literature points out that medical transcriptionists even perform tasks that fall within the clinical range [9]. In addition, "a critical role of the MT is to detect dictator errors" [7] (p. 88). The errors, which are likely a result of bad dictation quality or technical problems, should be minimized when doctors conduct patient documentation themselves in the structured EPR. However, some of the MTs' quality-assurance work might also be relevant and useful when the structured EPR is established. In this respect, the change of work practice from free-text to structured, and from dictating to writing, requires a focus on the human, organizational, institutional, political, and technological complexity involved — issues that often are seriously underestimated [10].

It is therefore interesting to explore this further. We raise the following research questions: What kind of quality-assurance work do medical transcriptions perform in producing medical records, and what are the implications of the establishment of a new structured EPR in which the physicians write the documentation themselves?

Based on quantitative and qualitative methods, we have studied the work practices of medical transcriptionists at the University Hospital of North Norway (UNN) prior to a large-scale project in the Health Authority Northern Norway, where the aim is to implement a highly structured EPR.

1. Methods

Both qualitative and quantitative methods were applied. Qualitative methods were applied to: 1) understand how the doctors and the MTs actually used the EPR documentation system, rather than how the system was designed and intended to be used, because "plans and situated action" may differ [11]; 2) investigate the most common quality-assurance work conducted by the MTs that was not an intended part of their work tasks; and 3) explain the findings in the quantitative study. Quantitative methods were applied to investigate the extent of the quality-assurance work performed by the MTs.

For the qualitative research tasks, an interpretative study approach was used to produce deep insight into the information systems by focusing on human actions and interpretations concerning development and use of the computer-based information system [12, 13]. Data were collected through informal discussions and four focus-group interviews, lasting approximately one hour each, in order to promote a broader and more thorough discussion [14]. The focus-group interviews were conducted in 2014: March and April (including 23 different MTs), June (14 MTs), and November (33 MTs). For the last two interviews, MTs from Tromsø participated face-to-face, and the MTs from Narvik and Harstad participated via videoconference. The interviews

were not recorded, but detailed notes were written, and the main points from the previous meeting were presented at the next one.

A quantitative survey was designed to record the extent of the quality-assurance work identified in the qualitative study. The surveys were piloted on six people for one week in June/July, and corrected based on the pilot and on subsequent informal meetings and a focus-group meeting addressing the results from the pilot. The pilot identified that the MTs spent an average of 4.5 minutes completing the survey.

In November 2014, all MTs (approximately 60) were asked to fill out one anonymised survey form per day over two consecutive weeks, to cover normal variances in the workload. The results were recorded in Microsoft Excel. The survey was also intended to report how many minutes the MTs spent on each correction and quality-assurance task. However, these results had to be excluded, because the information about time spent was partly missing in the survey forms; in addition, some MTs revealed that they had different interpretations of what they should report. Some had reported the time they spent sending feedback (a yellow note) to the doctor or department, but did not include the time they spent searching for the reply and correcting mistakes after it was received. The MTs' language was Norwegian. Data on the number of dictations transcribed/week were extracted from the EPR's report system.

2. Results

The results from the qualitative part of the study identify that MTs perform many different correction and quality-assurance tasks originally not intended as part of their work tasks. Tables 1 and 2 present the most common correction and quality-assurance tasks, as identified in the qualitative study, and the frequency, as identified in the quantitative study.

The MTs transcribed an average of 3,658 dictations per week in 2014, and 3,602 and 3,635, respectively, for the two weeks in the study, which represents a normal workload. Transcription of dictations not requiring any correction or quality-assurance work were not recorded to minimise the MTs' interruptions and extra workload, but each MT was asked to fill out one survey form per day. Summing up all the survey forms, the survey results represent 193.5 days' work, exactly 50% of a total of 387 days' work carried out during this two-week period. Assuming that the 50% who have reported is as effective as the group who have not reported, the 193.5 days' work will represent approximately 3,618 transcriptions for this two-week period.

Table 1 shows that the MTs contacted the doctor or department 377 times to correct the patient records, and Table 2 shows that they corrected mistakes 832 times without any correspondence. This adds up to 1,209 corrections through 193.5 days' work, and more than six corrections per day for each MT. Approximately one out of three dictations were corrected. Work tasks 1, 2, and 3, presented in Table 1, normally required MTs to contact the dictating doctor; while work tasks 4, 5, and 6 required contact with administrative staff at the department. However, staff could also be contacted regarding work task 1. The survey results presented in Table 1 document that "indistinct dictation" was the most common mistake, in which the dictating doctor was contacted 135 times. Uncertainty regarding encoding (diagnostic codes/procedure codes) resulted in the doctor or department being contacted 93 times. Correct diagnoses and procedure codes are important for receiving correct reimbursement from the public healthcare insurance-system. The department was contacted 90 times about the patient

not being set up to the agreed control. Both indistinct dictation and lack of control appointments might have detrimental consequences for the quality of patient care. Incorrect registration of a referring doctor/health provider occurred 13 times. Incorrect registration could result in referrals sent to general practitioners (GPs) or other healthcare providers who have nothing to do with the patient, thus violating the patient's confidentiality. In one focus-group meeting discussing incorrect registration, five respondents estimated that they spend from 50 minutes to 2 hours during one week (five working days) correcting these mistakes, because it can be very time-consuming to identify the correct recipients.

Table 1. Correction and quality-assurance work requiring the medical transcriptionist to contact the dictating doctor or the department.

Id:	Reason for contact with doctor or department	Number of instances
1	Uncertainty regarding encoding (diagnostic codes/procedure codes)	93
2	Indistinct dictation	135
3	Despite obvious dictation, something seems to be wrong in the dictation	16
4	Patient not set up at the agreed control	90
5	Incorrect registration of referring doctor	13
6	Visit registration of outpatient contact missing	30

Table 2. Correction and quality-assurance work that did not require the medical transcriptionist to contact the dictating doctor or the department.

Id:	Corrections without contact with the doctor/department	Number of instances
7	Sloppy dictation (not included in Table 1)	211
8	Missing registration of general practitioner	171
9	Incorrect document template used by the doctor	101
10	Doctor dictating/reading text already entered in the EPR	77
11	Doctor dictates several identical sentences	33
12	Other quality/clean-up work not included above	239

Table 2 represents dictation that MTs correct without contacting the doctor or the department. Sloppy dictation required correction 211 times, in addition to the times reported in Table 1. Missing registrations of GPs were corrected 171 times, and the MTs had to correct the document template selected by the doctor 101 times. The MTs transcribed text that already existed in the journal 77 times, and they transcribed several identical sentences 33 times because doctors repeated themselves. The MTs conducted other correction/quality-assurance work not specified in the survey 239 times.

The qualitative methods and the comments from the survey revealed some of the correction work involved due to sloppy dictation. If the dictation jumped back and forth several times, the MTs had to rewind it several times and listen again through the entire text. MTs might also pull together disjointed text so the content would become more understandable to the reader. If the dictation was not clear or the doctor mumbled, an MT might engage a colleague to listen to it. The MTs corrected the language of foreign doctors, which sometimes included what they referred to as "qualified guessing based on the context." Sometimes their transcriptions had many empty spaces because words in the dictation were missing or impossible to understand. Surprisingly, the MTs might receive that document back as accepted by the doctor, with all empty spaces remaining. These doctors had accepted the transcription most likely without reading it. In some of these cases, if the missing words were of high importance, the MTs stopped

the transcribed document from being sent to the GP and patient and had to go a second round with the doctor involved.

According to the MTs' management group, the judgment and quality-assurance tasks presented here were not originally intended parts of their work; it is more of a *de facto* practice that has been established over the years. The focus groups revealed that the MTs consider the quality-assurance work they conduct as unintended and unnecessary interruption that is very frustrating and time-consuming. Some of the MTs described the doctors as being "sloppy" with the patient documentation work. They wonder if it is because the doctors are pressed for time, or because they know that the MTs will check the quality of the documented data and correct their mistakes. The MTs expressed that some doctors seem to believe that "it is the MT who is responsible for the correctness in the patient journal, not the doctor," which is the opposite of the fact.

However, when the new structured EPR is implemented, the need for MTs will decrease, and the need for EPR support will most likely increase. Therefore, UNN has started re-educating MTs to provide EPR support, advising doctors on how to write the structured EPR documentation and produce high-quality documentation.

3. Discussion and Conclusion

This study documented that MTs perform many essential correction and quality-assurance tasks when documenting patient visits in a free-text EPR system. Each MT conducted more than six corrections per day, and approximately one out of three dictations were corrected. This supports findings from other authors documenting that doctors make many and significant errors in dictations [15], and that MTs must rely on many different types of skills to provide high-quality transcription of medical records [7-9, 15]. The quality-assurance work presented in our study is not originally an intended part of the MTs' work, but demonstrates a work practice that has been established over the years.

All MTs were asked to fill out a survey form each day, but only 50% did, which is a limitation of the study. Even though the two selected weeks represent normal activity, it might be that the other 50% found recording their work too time-consuming and stressful. However, data representing 193.5 days' work over two weeks to cover normal variances in the workload should support the representativeness.

It is very important that the new structured EPR system design take into account the established practices, and draw on the expertise and the quality-assurance work the MTs perform. However, in the new system, tasks 2, 3, 7, 10, and 11 will not be entirely relevant when dictation not will be used, and because the part of these problems that is relevant for documentation in general can be minimized as a result of the structure. In addition, tasks 4, 5, 6, and 8 can be reduced to a minimum due to process support. However, logical faults, as in task 3, might still occur to some extent, even if the process and decision support is developed. Task 1 could also draw on process support to some extent, but it will be challenging to develop an automatic encoding system, so incorrect encoding by the doctors will still be possible. Task 9, incorrect document template, could also be reduced by process support, but can probably not be avoided entirely. In addition, there are other quality-assurance tasks that we have not identified, as reported in task 12.

Even if MTs are re-educated to provide EPR support, it may be appropriate for them to continue to perform some of the identified quality-assurance tasks to avoid faults that could have serious consequences. One such task is to check all outgoing

documents from the hospital and, if necessary, correct the registration of referring doctors and other health providers so the hospital can guarantee that the documents are sent to the correct recipients. It might also be appropriate for the MTs/EPR support to check the registrations of the medical encodings (diagnoses/processes), because this is of very high importance in order for the hospital to receive refunds for the patient visits or stays. MTs in this way maintain their long tradition of quality-assurance in the medical record production, a strategy that is recommended by other authors as well [15]. To conclude, this study shows the many essential quality-assurance tasks conducted by medical transcriptionists. All these tasks need to be considered and compensated for when designing and developing the new structured EPR. Some quality-assurance tasks, as pointed out above, may advantageously be performed by secretaries also in the future.

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A Sequential Data Analysis Approach to Electronic Health Record Workflow

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Abstract. Failure to understand clinical workflow across electronic health record (EHR) tasks is a significant contributor to usability problems. In this paper, we employed sequential data analysis methods with the aim of characterizing patterns of 5 clinicians' information-gathering across 66 patients. Two analyses were conducted. The first one characterized the most common sequential patterns as reflected in the screen transitions. The second analysis was designed to mine and quantify the frequency of sequence occurrence. We observed 27 screen-transition patterns that were employed from 2 to 7 times. Documents/Images and Intake/ Output screens were viewed for nearly all patients indicating the importance of these information sources. In some cases, they were viewed more than once which may show that users are following inefficient patterns in the information gathering process. New quantitative methods of analysis as applied to interaction data can yield critical insights in robust designs that better support clinical workflow.

Keywords. Electronic health records, usability, sequential pattern analysis, process mining

1. Introduction

The development and implementation of clinical information systems continue to proliferate at a rapid pace. Although Electronic Health Record systems (EHR) have the potential to transform patient care and clinical communication, they have thus far fallen well short of that objective. Studies have documented user dissatisfaction with current systems and usability problems [1]. In addition, poorly designed interfaces have been shown to compromise patient safety and are a known source of medical errors [1]. Clinicians in hospital settings spend much time on documentation. The absence of a focus on system usability and on understanding patterns of workflow is major impediment to adoption and widespread use.

Usability studies typically employ methods such as surveys, expert inspections and usability testing experiments [2]. Although these methods are informative, they involve a reliance on subjective judgment, may lack reliability and do not provide a sufficently rich window into the clinical workflow process. Zheng and colleagues [3] introduced *computational ethnography*, an emerging class of techniques for conducting Human-Computer Interaction (HCI) studies in healthcare. They leverage automated methods for collecting *in situ* data which captures users' actual behaviors using a system or a

device in real-world settings. Sequential pattern analysis employ log files to search for recurring patterns within a large number of event sequences [4]. The analysis can be used effectively in concert with other forms of data such as ethnography or video-capture of end-users performing clinical tasks.

Zheng et al [2] investigated users interaction with an EHR by uncovering hidden navigational patterns in EHR logfile data. Towards that end, they employed sequential pattern analysis to identify recurring feature access in a particular chronological sequence. Various patterns were seen to be at variance from optimal pathways as suggested by designers and individuals in clinical management. A similar study was conducted by Kannampallil et al [5]. They leveraged workflow logfile data to compare the information-seeking strategies of clinicians in critical care settings. Specifically, they characterized how distributed information within the settings was searched, retrieved and used during clinical workflow. They found that residents predominantly used a "patient-based" information-seeking strategy in which all information was collected for one patient at a time. On the other hand, nurse practitioners and physician assistants employed a "source-based" strategy in which similar information was aggregated for all patients at a time (e.g., vital signs). They concluded that there are costs (e.g. effort, time and cognitive load) associated with particular strategies.In addition, different interface designs are likely to better support particular strategies. For example, a source-based approach may be better supported by enriched external representations that facilitate visualization and rapid aggregation of patient data.

The objective of this research is to analyze sequential patterns of clinicians access of EHR screens in gathering patient information prior to morning rounds. This study is part of an active practice redesign effort at the Mayo Clinic that has been shown to enhance quality of care through improved health information technologies. A focal point of the research is to understand clinical workflow at varying levels of abstraction (e.g., individuals to teams) and organization (clinical departments and divisions). We studied clinicians as they engage in a range of tasks from preparing progress reports to order entry. A particular focus of the work presented in this paper is EHR workflow.

2. Materials and Methods

2.1. Clinical Setting

The study was conducted in the Colon and Rectal Surgery (CRS) Division at Mayo Clinic, Rochester, MN, an academic tertiary healthcare center equipped with a comprehensive EHR. Access to patient data is achieved through a customized interface, Synthesis. In the unit, patients are cared for by nurses, hospitalists, residents, fellows, and surgeons. We observed three hospitalists, a physician assistant (H1) and two nurse practitioners (H2 and H3), who both fill the same hospitalist (H) role in the unit, and two residents, a 2nd year (R1) and 4th year (R2). Hospitalists responsibilities include, but are not limited to, order entry, documentation, scheduling follow-up appointments, review and reconciling medications. H1, H2 and H3 were experienced users of the system and routinely performed the tasks we observed. R1 and R2 were doing a rotation in the unit and were less experienced users of the system in the CRS division. The study was reviewed by the Mayo Clinic IRB and judged to be exempt.

2.2. Data Collection and Analysis

The data was collected as the clinicians were completing pre-rounds information gathering. The pre-rounds data gathering task occurs close to the start of the 12-hour shift, approximately 6:00 am. Hospitalists and residents round together immediately afterwards. The goals of the task are to access the most recent information on patients' medical status, review care plans, and to anticipate patient needs for the current day.

Clinicians were observed in the clinical setting, performing pre-rounds information gathering in the context of their routine workflow. The participants verbalized their thoughts and the sessions were recorded using Morae™ video-analytic software. The software provides a screen capture and a set of analytics (e.g., mouse clicks). There were a total of 66 patients including 9 from H1, 21 from H2, 16 from H3, 12 from R1, and 8 from R2. Only two patients overlapped between H2 and H3. Morae™ was used to parse the file, note time and code screen transitions. The start time of the subsequent screen was used as the end time of the previous screen. Screen transitions are defined by a significant change in the display view that requires the participant to reorient themselves to a different set of data. Screen transitions included a transition between applications, transition between tabs or views within an application. Most of the screens corresponded to components of the EHR including Documents and Images, Intake-Output, Labs, Vital Signs, Patient Navigation Panel and Summary.

We conducted two sequential data analyses to investigate patterns of information-seeking. The analyses were conducted using PROM, a free process-mining workbench used for business process management, and most recently in healthcare [6], in view to improve productivity[7]. The input of PROM is a set of event logs (in our case the output from Morae™), which can be processed, analyzed, and visualized. For this study, we used 2 plug-ins for PROM 5.2 including the *Frequency Abstraction Miner* plug-in [7] to characterize the most common sequential patterns as reflected in the screen transitions across 5 subjects and 66 patients. The plug-in uses significance/correlation metrics to iteratively simplify the process model at a desired level of abstraction (in our case, 0.100). The importance of events and transition is evaluated by frequency, i.e. more frequently visited screens are considered more important. We used the *Performance Sequence Diagram Analysis* plug-in to mine and quantify the frequency of sequence occurrence. In pattern diagrams, identical sequences are represented by one pattern. We defined criteria to distinguish sequences as follows: a sequence of screen transition *S1-S2-S3… Sn* is similar to a sequence of transitions *T1-T2-T3... Tn* if and only if for all $0<i<n+1$: $Si=Ti$ independently of the temporal constraints (e.g., duration) of *Si* and *Ti*.

3. Results

The results from the *Frequency Abstraction Miner* documented recurrent patterns of transitions. For 66 patients, three screens were viewed more than 66 times: Navigation, Documents/Images, and Intake/Output. The most frequent screen transition pattern Navigation to Documents/Images to Intake/Output to End (**Pattern 1**: N-D-I-End) occurred nine times. The next two most frequent patterns occurred five times each including Navigation to Documents/Images to Intake/Output to Vital Signs to Labs to End (**Pattern 2**: N-D-I-V-L-End), and Navigation to Summary to Labs to Vital Signs to Intake/Output to Documents/Images to End (**Pattern 3**: N-S-L-V-I-D-End).

Upon selecting a patient in Navigation, the user is immediately transferred to a screen in the newly opened patient's chart. The transitions leading from Navigation to Documents/Images and Navigation to Summary are among the most probable, 0.451 and 0.378 respectively, because the observed users have one of these two screens set as the default opening screen. H2 and H3 have Documents/Images screen displayed when opening a patient's chart and never transition to the Summary screen. H1, R1 and R2 have the Summary display set as default screen when opening a patient's chart. In fact, the Summary screen has 51 occurrences across 29 patients because R1 visits the Summary display 2.75 times per patient (range 1 – 5). The Navigation Panel was accessed for all patients because it is the location of the patient list and the search field for a user to access a patient chart.

Documents/Images and Intake/Output screens were viewed for nearly all patients suggesting the importance of these displays as information sources. The fact that they were viewed more than once for some patients may suggest that users are following inefficient patterns in the information gathering task. Participants may navigate to these screens more than once for some patients because data gathered from another screen or from the paper handoff document used for note taking provokes them to return to a previously viewed screen.

Table 1 indicates the number of times each pattern was employed by the clinicians. The most frequent screen sequence (Pattern 1) was followed by H2 five times and by H3 four times. The next three most frequent screen sequences were each followed by one provider—H1 five times (Pattern 2), H2 five times (Pattern 3) and H3 three times (Pattern 4). Of the six patterns that had two repetitions each (Patterns 5-10), three were followed by the same clinician (H2 followed Patterns 7 and 10; R2 followed Pattern 8). The remaining 32 patients elicited a pattern that appeared only once (Patterns 11-42).

Table 1. Frequency of Pattern Type by User

User/Pattern	H1	H2	H3	R1	R2	Totals
1	0	5	4	0	0	9
2	5	0	0	0	0	5
3	0	5	0	0	0	5
4	0	0	3	0	0	3
5	1	0	0	0	1	2
6	0	0	0	1	1	2
7	0	2	0	0	0	2
8	0	0	0	0	2	2
9	0	1	1	0	0	2
10	0	2	0	0	0	2
11-42	3	6	8	11	4	32
Total	9	21	16	12	8	66

Table 2. Human-Computer Interaction Measures by Pattern of Transitions

Patterns	Screen Transitions	Mouse Clicks	Duration
1	3.3 (2.7)	7.7 (7.3)	63.0 (40.5)
2	5.0 (0.0)	11.4 (4.5)	75.1 (17.3)
3	4.0 (0.0)	10.6 (6.6)	59.6 (39.3)
4	4.7 (0.6)	11.7 (1.5)	86.4 (14.7)
5	4.0 (0.0)	7.5 (0.7)	84.5 (24.8)
6	2.0 (0.0)	7.0 (5.6)	55.5 (31.8)
7	2.5 (0.7)	4.5 (0.7)	39.4 (14.4)
8	9.5 (0.7)	15.0 (1.4)	125.0 (8.5)
9	7.5 (3.5)	19.0 (12.7)	145.2 (49.3)
10	3.0 (0.0)	6.0 (1.4)	48.8 (20.9)

Table 2 presents an analysis of the patterns according to HCI measures including screen transitions, mouse clicks and duration. The objective of this analysis is to

characterize the difference in complexity for each pattern. The first pattern, employed by 2 different hospitalists and for a total of 9 patients, is among the least complex involving an average of only 3.3 screen transitions, 8 mouse clicks and 63 seconds to complete. On the other hand, pattern 2 involved 5 screen transitions, 11 mouse clicks and 75 seconds to complete. This pattern, employed by a single hospitalist for 5 patients, involved sequential transitions from left to right corresponding to the order of tabs along the top of the screen. Although some of the complexity can be accounted for by the interface, others may reflect provider efficiency and clinical case complexity.

4. Discussion

Computational ethnography offers a new suite of quantitative tools and methods for studying interactive behavior [3]. Log-file analysis is increasingly being used as means to understand user behavior in a broad range of contexts. For example, Hripcsak et al employed audit logs to measure the amount of time clinicians spend authoring or reviewing EHR documentation [8]. Zhang employed audit logs to study improper access to patient records potentially resulting in violations of privacy protocols [9]. In this study, we conducted a sequential data analysis of clinician performing an information-gathering task. We employed a process mining tool (PROM 5.2) frequently used for business [10] and healthcare process management [6]. However, there have been only a few studies focused on sequential analysis of screen transition patterns. The results of this study further suggest that this is a promising method for understanding EHR workflow and for drawing design implications.

The study documented 3 sequential patterns of screen transitions that accounted for a total of 19/66 (29%) of patients, 7 additional patterns accounted for 15 patients (23%) and the patterns for the remaining 32 patients were entirely different from all others. Although we are just beginning to scrutinize the costs (e.g., time, cognitive load) associated with each interaction pattern, we can speculate that some patterns are more efficient than others. We did observe regressions in which a clinician made one or more return visits to the same screen. In addition, it is possible that certain patterns may deviate from clinical pathways. However, we cannot answer that question at this point, although the converging sources of data available to us (including a video record of all interactions) should yield insights into this important problem.

In this study, all interactions followed a patient-based approach rather than source-based approach found by Kannampallil [5]. That may be a function of the different systems or workflows. For example, it may be more costly for users in this study to go back and forth between patients. It could also be a matter of convention or clinical protocol that guided information gathering. These authors make a compelling case that different interfaces and external representations (e.g., visualizations) may best support the different patterns of interaction.

In this data set, we have several sources of sequential data including a think-aloud protocol, video-recordings of all interactions and now the process mining data involving screen transitions. We endeavored to correlate transitions patterns with various HCI measures. We observed that a transition resulted in 2 to 2.5 mouse clicks. The durations of interaction per patient were highly variable and could be associated with factors like interruptions and clinical case complexity.

We are currently exploring the use of this method for documentation tasks including progress reports and discharge summaries. It is likely that patterns of interaction will be quite different from the information-gathering task employed in this

study. It is our conjecture, that the mining of interaction behaviors across a range of tasks can yield a set of desiderata for clinical information systems design. This preliminary study employed a small data set of 66 patients and is best viewed as exploratory research. However, there are also advantages to this approach. The primary one is the ability to correlate process mining data with observed patterns of interaction. For example, if we notice aberrant patterns, we can explore the problem in considerable depth via the use of video and think-aloud protocols. This could potentially lead us to isolate the causes of such problems.

5. Conclusion

The last decade has witnessed extraordinary growth in the implementation and adoption of clinical information systems across hospital and ambulatory care settings. There is also ample evidence to suggest that it has been a bumpy ride for both implementers and end users. The quantitative and qualitative tools available to researchers and practitioners have developed immeasurably in recent years and were used in this work to characterize patterns of information-gathering that may vary in efficiency and in adherence to guidelines. There are techniques, included the process mining method explained here, that could potentially help us to discover, analyze and visualize records of HCI that could lead to improved EHR designs. A better understanding of clinical workflow is essential to support the next generation of EHR design.

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Unveiling the Mobile Learning Paradox

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Abstract. A mobile learning paradox exists in Australian healthcare settings. Although it is increasingly acknowledged that timely, easy, and convenient access to health information using mobile learning technologies can enhance care and improve patient outcomes, currently there is an inability for nurses to access information at the point of care. Rapid growth in the use of mobile technology has created challenges for learning and teaching in the workplace. Easy access to educational resources via mobile devices challenges traditional strategies of knowledge and skill acquisition. Redesign of learning and teaching in the undergraduate curriculum and the development of policies to support the use of mobile learning at point of care is overdue. This study explored mobile learning opportunities used by clinical supervisors in tertiary and community-based facilities in two Australian States. Individual, organisation and systems level *governance* were sub-themes of *professionalism* that emerged as the main theme and impacts on learning and teaching *in situ* in healthcare environments. It is imperative healthcare work redesign includes learning and teaching that supports professional identity formation of students during work integrated learning.

Keywords: Mobile learning, mlearning, clinical supervision, work integrated learning, learning in situ.

Introduction

Access by health professionals to mobile learning (mlearning) through the use of mobile or portable devices in healthcare settings is mixed [1]. Mobile learning in this context is defined as accessing or browsing content for the purpose of learning using a mobile or portable device, in situ, at point of care, in the workplace. Opportunities for mlearning are increasing, however, currently there are no standards, guidelines or protocols directing the use of mobile devices for nurses in the workplace [2, 3]. Currently, in Australia, there is a mobile learning paradox in healthcare settings. There is an inability of nurses to access mlearning, while it is increasingly recognised that utilisation of mobile or portable devices at point of care can improve care and improve patient outcomes [4, 5]. These studies demonstrate that further understanding about how mlearning and teaching (L&T) is currently undertaken by clinical supervisors who guide, support and facilitate learning of students and remain contemporary in their role is required. Additionally, modelling of professionalism to students by clinical supervisors has become increasingly important to promote work-readiness at registration. This qualitative study explored the current mlearning strategies undertaken by a group of clinical supervisors in tertiary and community-based healthcare settings to understand how they navigate L&T opportunities within the current mlearning paradox that exists in healthcare environments in Australia.

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1. Background

Previous research undertaken by the authors indicated there was a need to ensure clinical supervisors had an understanding of University requirements and they were competent and contemporary in theoretical knowledge and skills [1]. Continuing professional development of clinical supervisors was necessary to enable high quality clinical experiences for students. Further exploration of this issue to develop strategies to provide appropriate resources and strengthen partnerships between the University and supervisors of students in the workplace, found there were barriers and challenges, at individual, organisation and systems levels, to the use of mlearning by learners and teachers in a range of healthcare settings. Clinical supervisors were impeded through lack of educational preparation and confidence at an individual level [1]. Recent research demonstrated that support of clinical supervisors to become conversant with mobile technology can enable them to become 'change champions' to model and lead in the appropriate use of mobile technology within the workplace [1]. Although digital strategies used to inform and up-skill clinicians were well received, an evaluation found there was limited adoption in the workplace due to organisation and systems barriers. Impediments included inability to use mobile devices, peer disapproval and lack of access to data within healthcare settings. However, due to the distributed nature of work integrated learning (WIL) it remains essential that clinical supervisors and students have access to L&T resources. Undergraduate nurses' current and preferred use of mobile devices demonstrated an expectation of timely, easy, and convenient access to information to augment their learning. Clinical supervisors modelling behaviours that prepared students to transition to registered nurse during WIL and minimise transition shock was valuable [6].

Previous studies have indicated information communication technology (ICT) literacy among health professionals is mixed [4, 7]. The emergence and rapid adoption of the use of ICT now provides opportunity for deployment of mlearning within healthcare settings. Sharples, Taylor and Vavoula [8] offered a framework for theorising about mlearning that described the convergence between learning and technology, indicating it is the learning that is important rather than the technology afforded by its use. They identified that context is constructivist, as learners build knowledge through interacting with their environment [8]. The co-evolution of L&T and acceptance of mobile technology has implications for the integration of mlearning at the workplace. It could promote habits by students that support continuing professional development and life-long learning which are requirements for continuing registration [9].

Lambert and Glacken [10] discussed the importance of the role of clinical supervisor for supporting and guiding high quality clinical placements for learners. Research into factors that contribute to optimal WIL environments has indicated that if students receive more than clinical guidance and support from their supervisors, their experience is more positive [11, 12]. Enhanced learning by students created by the development of partnerships between supervisor, patient and learner is becoming more recognised as a learning strategy that assists with modelling of attributes that contribute to the formation of professional identity and minimise transition shock [11]. Enabling the use of mlearning at the workplace is a component of professional identity formation that needs exploring [13].

Over time, there is the expectation that deployment of mlearning in situ will become more common. It is imperative to understand how this activity can be

incorporated into L&T, informal learning and for professional development and be integral within the formation of professional identity. The aim of this qualitative study was to explore current mlearning strategies employed by clinical supervisors to augment learning in tertiary and community-based healthcare settings in two Australian States.

2. Methodology

Six focus groups were conducted between July and November 2014 by one researcher to elicit information about the use of mlearning strategies by clinical supervisors. Invitations to participate were emailed to clinical supervisors involved with guiding and supporting undergraduate students from one University. Each group was a mix from tertiary and community-based facilities and were comprised of between three and 7 participants. Focus groups were up to one-hour duration and audio-recorded, then transcribed verbatim. Data analysis was undertaken using thematic analysis. Themes were developed independently by two researchers and then cross-checked, to ensure validity. Minimum risk ethics committee approval was gained for this study (H13729).

3. Results

Six focus groups were held with 27 clinical supervisors participating. Approximately half of the respondents were from each State and were an equal mix of clinicians from tertiary and community-based facilities. The theme of *professionalism* was key to addressing mlearning opportunities used by clinical supervisors in situ, at point of care in the workplace. The key theme *professionalism* embodies competence and behaviour ascribed by the nursing profession. Student nurses develop their professional identity through a range of strategies including modelling behaviours they observe and perceive to be professional. Similarly, clinical supervisors recognise there is a standard of behaviour they are expected model with students. In Australia there is an identified minimum standard of knowledge, skills, attitudes and behaviour of nurses guided by the Australian and Midwifery Council Competency Standards [14] and Code of Professional Conduct [15]. Clinical supervisors in this study recognised 'workarounds' were developing when engaging in L&T in the workplace. Strategies used to solve limitations created by lack of, or access to mlearning impacted on clinical supervisors' emic perspective of the standard of professionalism.

Analysis of the data identified there were a range of positive and negative behaviours that impacted on the perception of *professionalism* by clinical supervisors. The capacity of them to model appropriate learning behaviour to students to assist with the formation of professional identity at an individual level created by the current mlearning paradox was arrested.

3.1. Individual Governance: Positive Professional Identity Formation

Positive attributes that access to mobile or portable devices in situ enabled included increased time with patients at the bedside; reducing the need to look up information away from point of care; and the potential to involve patients in their own care.

> "I would like to see not so much phones but things like iPads used for patient education. I think it would be really valuable… we tend, when patients ask things, to go back to the desk, look it up, and then print something out… patients are far more educated now than they've been but not always with the right sources… it would be nice to be able to give an iPad to a patient and say well, you know have a bit of a read…you could do that together as well… and actually point them in the right kind of information".

Clinical supervisors indicated there were opportunities to reduce errors as information could be looked up or verified in real-time and also prevent duplication. Mobile learning information could be used for prompting appropriate sequences when undertaking clinical procedures. Participants considered mobile devices could improve collegiality within teams by enabling communication with their peers even when absent from the workplace. Participants also indicated the provision of another learning style afforded by using mobile devices for patient education could strengthen the nurse-patient relationship. Furthermore, inclusion of students in this new pedagogical approach to learning was viewed as positive for the development of rapport with patients and clinical supervisors.

3.2. Individual Governance: Negative Professional Identity Formation

Negative attributes impeded opportunities for positive professional identity formation of students, were identified by clinical supervisors. Participants from organisations where mlearning was dissuaded were conscious of the 'ducking out', 'toilet learning' or 'loitering in their lockers' that occurred when a knowledge deficit, clarification or verification of information was identified by students or clinical supervisors. Focus group participants indicated they felt guilty "when actually I'm desperately trying to look up what something in handover meant". Clinical supervisors reported students were perplexed by some of their behaviour, which the clinicians construed as poor role modelling:

> "it's like well why can't you just bring that out and we can all learn from that because there's only, you know, a certain number of computers on the ward that students can look things up on… we've got so much access to information now, if an iPhone or iPad's the way to get that information why not just use it… I just find it very hidden".

Participants indicated they felt it was unprofessional to use mlearning when they were aware organisational policy precluded its use. Clinical supervisors were also conscious of body language that indicated peer disapproval when they undertook mlearning activities. Clinical supervisors reported the mlearning paradox created by inability to access information prevented the "side to side thing" of developing a learning partnership with students and patients.

3.3. Organisation Governance

Organisation governance directed *individual governance* at the workplace. Clinical supervisors suggested strategies to integrate mlearning into healthcare work. Participants indicated the need for presence when using mobile devices for mlearning. There was discussion about the need to "announce use" to avoid the assumption they were using their mobile device inappropriately. One participant noted that: "…if you're on a landline it'd probably be alright, she must be talking to a doctor or something. It's a difference without having a cord on it, isn't it?"

Some participants indicated using a mobile device for learning should be seen as a "tool of trade just like taking a blood pressure". Clinical supervisors agreed mobile devices needed to be used properly and "ground rules" were necessary to legitimise its use and ensure entrustability.

4. Discussion

This research demonstrates that professionalism issues at systems and organisation levels, impact on *individual governance* and will continue to impede the progression of mlearning in the workplace until there is the development of policies and standards to guide its use in healthcare settings. Lloyd-Williams and Denz [16] indicate there is acceptance of the value of ICT in healthcare, however, they propose deployment will be more problematic. Raman [2] suggests organisations need to permit student access to institutional information technology and develop policies on use of the internet/social media in clinical agencies. Role modelling of appropriate mlearning behaviour is imperative to ensure the next generation of nurses are prepared for their role as registered practitioners. They must be conversant with accepted professional standards of behaviour expected when accessing mlearning. Integration of mlearning can only become embedded when organisations enable professional identity formation about learning in situ to occur during WIL.

This study demonstrated healthcare organisations in Australia are yet to understand traditional pedagogical methods are no longer sufficient for preparation of work-readiness of students in the workplace. Whilst formation of professional identity occurs during WIL the quality of workplace-learning environments are affected by the culture and routine practices [12]. E-conversations and developing virtual communities of practice may be a strategy to ameliorate some of the communication issues and promote professional identity development. The findings of this study concurs clinical supervisors welcome the opportunity to engage with each other at, and away from the workplace. Furthermore, role modelling behaviours that promote communication, informal learning, and continuing professional development will be positive for clinical supervisors, students and patients. Empowerment of nurses to use mlearning may promote the socialisation necessary for positive professional identity formation and development of lifelong learning behaviours. Integrating mlearning as a legitimate nursing function will enable clinical supervisors to guide nursing student behaviour when learning to use mlearning during healthcare work.

For progression of the use of mobile technology to become the norm in healthcare environments, and accepted as part of healthcare work, there is a need to further unveil the mlearning paradox by developing strategies for deployment of mlearning, in situ at point of care. For development of a culture of learning, there needs to be development of policies and guidelines at an organisation and systems level to support and guide students and health professionals in the governance of using mobile devices at an individual level. The usability of mlearning networks will only be effective when appropriate and robust policy is developed to guide and support clinicians to learn how to use digital technology during healthcare work. Upholding the tenet of professional identity by conducting mlearning within an overt L&T framework in the workplace will assist in integrating this new pedagogical approach to learning in healthcare settings.

5. Conclusion

Organisation governance impacts on *individual governance* in mlearning. The study found that 'workarounds' are used by clinical supervisors to solve issues of timely, easy, access to information in the workplace. This group of clinicians are concerned about the impact of this behaviour on others view, especially students, on their professionalism. Redesign of L&T to include mlearning is overdue. Suggestions to enable legitimisation of mlearning as an integral nursing function during healthcare work were provided by clinical supervisors. Enabling mlearning to become an overt activity that is part of formation of professional identity will promote appropriate behaviour and empower the next generation of nurses to seek information in real-time and solve the mobile learning paradox.

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The Role of the IT Department in Organizational Redesign

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Abstract. Focus within eHealth research is often on development and implementation. However, the role of information systems maintenance and management is often neglected. In order for the IT department to accommodate the needs of the hospitals and continuous change of organization and practice there is a need for developing an understanding of the complex relationship between the IT department and clinical practice. In this paper the concept of redesign is used to deepen our understanding of IT related organizational change in healthcare organizations. In the paper I argue that the IT department is a central partner, steward and power in organizational change and learning in hospitals as the IT department serve both as a barrier and a catalyst of change and flexibility in the organization through management of information systems maintenance and redesign. Therefore it is important to consider and secure appropriate forms for stewarding redesign and learning in cooperation between the health care organizations and the IT department.

Keywords. Redesign, health informatics, information systems management, organizational implementation, organizational change

Introduction

Continuous organizational change is a condition in hospitals today. Change comes from many sources both in relation to best practice within care procedures, structural changes but also and to an increasing degree from introduction and redesign of information systems – both clinical, communicative and administrative. The change processes are in this paper characterized as redesign. Redesign is here understood in a broad sense as change processes having to do with both information systems as well as organizational change.

The importance of redesign in health care practices is among others highlighted by Shortliffe and Cimino [6]: "Organizations must and will undertake various process redesign initiatives - and these initiatives can lead to fundamental transformations of the enterprise. Indeed, work process redesign is essential if information systems are to become truly valuable to HCOs [Health Care Organizations]. Too often, however, the lack of a clear understanding of existing organizational dynamics leads to a misalignment of incentives, which is a significant barrier to change or the assumption that simply installing a new computer system will be sufficient to generate value. [There are] limits to the amount of change that any organization can absorb". [6, p492]

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Redesign of information systems and organizational processes requires knowledge of work practices as well as the technical possibilities of information systems. Shortliffe and Cimino argue that handling of people and processes as well as organizational understanding is crucial to information systems success [6].

In the organizational perspective there are different approaches to redesign within management and research, from large scale redesign to redesign on the local level. On a general level Leavitt explores the impact of technology change in organizations and highlights that organizations need to adjust to the environment to remain effective [3]. Organizational factors are central in the way work practices are adjusted and shaped around information systems [4]. On a local level Wentzer and Bygholm explores the challenges of continued change in relation to work practices and the systems development in a study of a computerized physician order entry (CPOE) [7]. They emphasize that the project organization need to support "local collaboration and renegotiation of time and place of enacting medication with CPOE, as well as set up feedback for maturation of the software for future clinical use" [7].

The importance of redesign or change processes in relations to the maintenance of information systems is also an issue that has been brought into focus in the IT support literature. Studies focus on different aspects such as the importance of flexible management structures [9-11], the learning aspects of support [12], how IT support can be seen as design [13, 14], how support can also be considered stewarding practices [16] and how technical supporters are actually also repairing and maintaining a social setting [15]. According to Orr [15], support is often seen as the diagnostic, repair and maintenance of technological artifacts. However, this is actually not the whole picture, as he points out: "[...] machine problems may actually be problems in the social relationship between costumer and machine, and large parts of service work might better be described as the repair and maintenance of social settings" [15]. The technician can be considered a mediator or someone engaged in the reconfiguration and repair of the relation between the user and the machine.

Below I will describe and exemplify the important role the information system managers play in the redesign of systems and organization.

1. Methods

The paper is built on data gathered through a study of IT management, support and services, both from the perspective of the IT department and hospital departments. The study is part of an ongoing investigation with a focus on organizational learning and stewarding of information systems in healthcare.

The study method was inspired by ethnomethodology and actor-network theory. The data was gathered through qualitative fieldwork in the North Denmark Region including 30 interviews, 10 meetings and 16 days of observations, supplemented by insight into a range of documents, reports and manuals. Data was validated through discussions of key understandings and themes with the informants. The interviewees and people followed were informants from the IT department and clinical practice from different levels and positions in the organization selected through key gatekeepers from middle management from the IT department and clinical practice. Management, IT supporters, IT project managers, secretary, physicians, radiologists and nurses were part of the study. The broad scope of the study weakens its depth, however, it provides insights into some issues of IT management across the organization that would have

otherwise been hard or impossible to trace. The method is in line with the actor-network approach of the study following the human as well as non-human actors that constitute hospital practices.

2. Results: Information Systems Management and Ongoing Development

In the following case the complex role of the IT department in organizational redesign in hospitals is described. The case study was executed in a Danish region. In Denmark the regions are the public managers of hospitals and the IT department is a central unit of the region providing services to the hospitals of the region. The IT department is therefore not part of the hospital organization structure, but a centralized unit. Redesign of information systems is handled by the information systems (IS) managers who are people employed by the IT department that are in charge of support, maintenance and redesign of the IS in use at the hospital. The role of IS manager is called "systems ownership" in the IT department. They are organized in teams that are specialized in management of specific systems across all hospitals in the region. The IS managers organize the redesign and change processes of the hospital IS. They are responsible for both the communication with the work groups that are set together for managing the system, the interface to other systems and communication with vendors. IS management involves competencies related to IS support as well as systems development in the ongoing maintenance and redesign of the information systems as will be described below.

2.1. The Work Tasks of IS Management

The process of IS management involves several steps and competencies. From interviews and observations of IS managers some core tasks were identified. These were: Gathering error reports based on adverse events; Gathering ideas for improvements; Meeting with work groups to discuss possible and actual changes; Meeting with vendors to discuss changes; Prioritizing possible changes internally, with workgroups and the vendors; Requesting changes from vendors; Managing new updates or versions from the vendors; Installing updates on test servers; Testing updates for bugs; Receiving revised version of systems from the vendor; Doing test runs on test server; Sending out guides for new features or changes in the system; Arranging courses and introductions in relation to revisions to the system if there are larger changes; Implementing updated system in one of the designated 'service windows' (there are rules for how many systems that can be updated each month). In addition to these IS redesign tasks the IS managers also are in charge of the ongoing courses for new users of the systems, the daily support of the use of the systems and supporting the super-users that are organized throughout the hospital. In the following an example of what the work of the IS managers consists in and a description of how they are involved in redesign is presented.

2.2. Example of Critical IS Error and the Role of the IS Manager

The management of information systems in the hospitals involves making sure the systems are developed or redesigned in accordance with and to enable the work practices of the hospitals. This involves getting feedback from the organization on

problems, errors, breakdowns and general requests for systems functionality. The importance of continuous development of information systems was apparent in many cases of the field study. One critical example of this is given by an IS manager:

"I am sitting with somebody […] and they have to print a list of the medicine for the day and it says that he needs 1.2 gram of something, but on the print it says 2.4 gram. Then I try to figure out where those 2.4 gram came from if I can. I think I know what it is but now I must see if I can find some evidence for it. Then you have to dig into it. I don't know if I have to contact the vendor from Iceland to see if he can figure out if they have deleted something. That kind of stuff takes a while."

This is one of the examples from the case study that shows both the danger of errors produced by the system redesign and the importance of finding quick solutions to these. Other examples of challenges of IS and organizational redesign from the case study includes system breakdown, calls about challenges of system use, challenges with login and accessibility, challenges of physical placement of computers, problems with new printer setups etc. The examples show the complex interaction between systems maintenance, work settings and work practices.

2.3. How Change Requests are Managed

The concept of change request is used for all the different feedback that is received by the IS manages on the systems, and this feedback is then logged in the change request system provided by the vendor. The requests can come from a range of sources, which include: Support calls, User requests; Requests received during courses; Adverse event reports; External demands for change; Requests from integrated/interacting systems or finally requests from system workgroup meetings.

All of these challenges are received and managed by the IS manager. The print error example above is a case of change requests logged on the basis of a support call, though it could also have been logged as an adverse event, even though it was caught in time. Errors in the system mostly get reported through clinicians calling in need of support. When clinicians encounter problems they will call support or send e mail about the error. Users sometimes provide direct feedback in the form of proposals for improvement, mostly through the workgroup connected with the system consisting of key user groups as well as stakeholders from interconnected systems and the vendor. The teachers doing courses on the systems at the hospital also identify changes originating directly from the users.

Requests for changes in the system can also come from the users or managers of integrated systems. The IS managers express during interview that there are challenges of integrating and maintain integrations for multiple systems. There are many opportunities of integrating different digital devices used in clinical practice into the core systems, but a constant hindrance is limited resources for covering the cost of changes.

Change requests come from many different sources as exemplified above. Receiving change requests is important in order to be able to develop the systems in relation to changing practices. However, the process of handling the change requests is not simple. There are generally four ways that the IS managers handle change requests based on the complexity of the request. These are:

- Internally in the IS management team
- In cooperation with the vendor
- In cooperation with the systems contact-group

- By having customer consultants consider these in cooperation with contacts in the hospitals.

If the request is minor or simple, they discuss it among themselves in the team and then contact the vendor and consider the options and formulate the systems demands on the basis of the requests that are reported in the request system and will figure in the priorities for requests for the system. However, if the request is extensive or complex it is taken to the systems work group that meets every other month. The work groups consists of stakeholders in the system for example clinicians, medical secretaries, specialists and other groups influenced by changes in the system, like the hospital pharmacy. The members of the team are mostly former members of the implementation team. The requests for changes can also be brought to the customer consultants of the IT department. The customer consultants will talk to the hospital departments about their needs for changes and thereby have a broader focus. There is a close cooperation with the vendor as changes to the systems are an ongoing negotiation and discussion where changes both originate from the vendor and is proposed by the IS managers.

Cooperation is generally a large part of the IS management tasks, not just with users and vendors but also with stakeholders that are responsible for interfacing systems and who provide information to the system. They are, however, not engaging in user driven innovation. The reasons given by the IS managers is that there is not enough money to honor all wishes from the users and also that the users have different opinions about the functionality of the systems.

3. Conclusion

The paper explores how IS management is concerned with IS redesign and thereby also organizational redesign. Every support call is a potential change request from a usability point of view, and the IS managers are gatekeepers of changes to the hospital information systems. As such the IS managers are key players in the continuous redesign of the organization as they manage the information systems that are structuring clinical work practice.

As we have seen, redesign is not just technical. The status and meaning of the systems in the organization is redesigned through user practices. They are interpreted in different ways depending on the local circumstances, cultures and needs. [10][13] The IT department is in this sense a subtle yet important part of managing the ongoing redesign of the work practices through there is also a need for being sensitive to the organizational interpretation of IS in use.

Information systems are not just tools used by clinicians to get the job done; they are also structuring the work practices and setting limits and possibilities for what clinicians can do. The importance of technologies in general and information systems (IS) in particular for work practices brings an increased demand on the joined coordination and acknowledgement between the IT departments and the hospitals. The IT department that supports the hospitals needs to have structures that 1) can handle the pressure and severity of the possibility of breakdowns and failures in the systems, 2) that can build structures which support the ever increasing use of IT systems by teaching and supporting the use of the systems in play in the hospitals 3) they need to be flexible in relation to organizational redesign of work practices 4) there is a need for acknowledging that the IS managers have power and therefore there is a need for making explicit the role, and authority of IS managers and redesign processes.

The continued redesign of organizational practices in the hospital and the need for redesigning both systems and work practices are evident and highlighted in the case study. Here the support structures play an important role. IS managers are engaged in the learning and change processes of the organization. They are central to securing appropriate and meaningful use of information technology and systems in the hospital and are therefor of key importance in providing quality care and safety for patients.

We have seen that managing an information system demands specialist knowledge of that system and related or integrated systems as well as organizational knowledge. It is also evident that the input from both general and local levels is important or even essential for the management of information systems. Moreover, the changes and development of information systems are only brought into use through good support and educating structures. In this light we must conclude that the IT department plays an integral and important, yet easily forgotten role in the redesign of the organization through the management of the redesign of information systems.

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Monitoring the Amount of Practical Use of eHealth on National Level by Use of Log Data: Lessons Learned

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Abstract. This paper set out to define the lessons learned from the process of characterizing the amount of practical use of eHealth on national level by collecting and comparing log data harvested from national logs in the Nordic countries. The health systems of the Nordic countries are quite similar in structure and their eHealth strategies include similar elements, however when confronted with the specific context in the different systems it proved challenging to define a common set of indicators for monitoring the practical use of eHealth. A thorough analysis of context leading to the definitions of the indicators is the basis needed due to the complexity of the data in the national logs. A comprehensive knowledge of the structure that underlines these logs is of utmost importance when striving for collecting comparable data. Although challenging, the process of defining indicators for practical use of eHealth by data harvested trough national logs is not an impossible task, but a task that requires in depth discussions of definitions of indicators as well as a substantial insight into the architecture and content of the national databases. There is need for continuous work on these indicators to ensure their quality and thus make sure that the defined indicators can meaningfully inform eHealth policies.

Keywords. eHealth, Log data, Indicator, Monitoring

1. Introduction

Several countries have formulated national eHealth policies and developed strategies for implementation [For a list of European strategies see: http://www.ehealth-era.org/database/database.html]. The Nordic countries have health systems that are quite similar in structure and their eHealth strategies include similar elements [1,2]. However, they lack comparable criteria for evaluation of the strategies. Hence monitor-

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ing the progress in development and implementation becomes strenuous. The most common approach to monitoring has been focusing on adoption or availability of functionalities and specific solutions. In 2012, the European Commission Joint Research Centre launched a survey to benchmark deployment of e-Health services [3]. The project gathered information on eHealth adoption in acute hospitals in all 28 EU Member States as well as Iceland and Norway. Use of the services was surveyed on a very coarse scale - "routinely", "occasionally" or "not used". The Organisation for Economic Co-operation and Development (OECD) launched in 2008 a multi-stakeholder initiative to develop a robust measurement framework and comparable cross-national measures. The task was accomplished in 2013 with the publication "Guide to Measuring ICTs in the Health Sector" [4]. The guide was developed by an expert group representing 30 countries and four task forces within i) Personal Health Record, ii) Telehealth, iii) Health Information Exchange, and iv) Electronic Health Records. The guide contains a model survey composed of self-contained modules that ensure flexibility and adaptability to a rapidly changing environment. A second part contains a methodological guide to aid implementation and promote validity and comparability of resulting benchmark measures. The European Commission applying their own survey measure and the OECD is relying on national data collection using the OECD model survey questions to achieve availability measures.

The Nordic eHealth Research Network (NeRN) has developed, tested and assessed a common set of indicators for monitoring eHealth in the Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden) for use by national and international policy makers and scientific communities in order to support development of Nordic welfare [1]. The experience from this work can be found in the study by Gilstad et al. [5]. At present, there are several national monitoring activities, however, harmonizing indicators for data collection among the Nordic countries is still in its early stages. The definition of the Nordic indicators has been developed iteratively using data from international workshops, stakeholder interviews, policy analysis and analysis of literature and existing surveys [1]. Availability of eHealth has been first line of monitoring, but the interesting part comes, when availability has reached a distribution level of 100% among all users. Then, the practical use is of great importance. It becomes interesting to know how much the available functionality is being used, and to what extent it is being used as originally intended.

As the Nordic countries are all close to 100% national distribution of the most significant eHealth functionalities (e.g. Health Information Exchange and Patient Portal functionalities) among all users, the NeRN group has developed a number of variables that measure practical use of eHealth systems by log data harvested from central servers. At first sight it appears to be an easy, reliable and valid approach. However it once more turns out that the "devil is in the detail".

The purpose of this paper is to discuss the lessons learned from the process of characterizing the amount of practical use of eHealth on national (or regional) level by identifying the main challenges when collecting and comparing log data harvested from national logs in the Nordic countries

2. Methods

The NeRN group has been developing, testing and assessing a common set of indicators for monitoring eHealth in the Nordic countries since 2012. At a meeting in De-

cember 2014 in Aalborg, Denmark, the NeRN members met to discuss the definition of indicators related to the usage of eHealth, in respect to national log data availability. Finland, Sweden, Norway, Island and Denmark were each represented by one to five participants.

After reviewing the list of indicators with experts in each country, a second meeting was held in Oslo, Norway in February 2015. Here, the definition of the indicators was determined further. The total number of eHealth intensity of use indicators was 21. At this meeting, the main difficulties were further discussed, striving for comparable data across the Nordic countries in order to learn and prepare for future comparisons. The process of specifying the main challenging in the collection of comparable log data is further detailed below.

2.1. Main Challenges when Collecting and Comparing Log Data

At the second meeting (February 2015) the main difficulties, when striving for comparable data across the Nordic countries, were discussed. All countries were asked to name the top three most difficult challenges in *collecting* and *comparing* log data regarding ePrescriptions; how many ePrescriptions are made, viewed by professionals and patients, and number of electronic renewal requests. All challenges were noted on the whiteboard (see Fig 1), and the group was then asked to individually prioritize the ones they found most important.

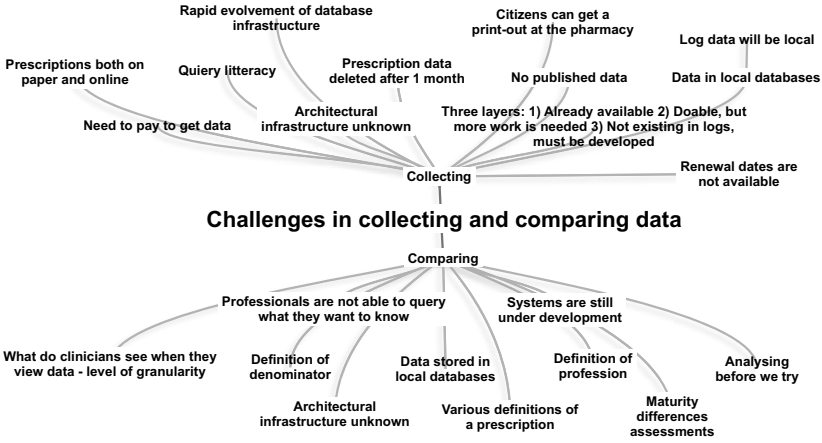

Figure 1. Map containing the most important challenges in collecting and comparing ePrescriptions data across the Nordic countries as named by the country representatives. Challenges chosen for prioritization are marked with grey.

This involved multiple steps in deciding on the challenge and ranking them in the order of importance: First, each individual participant chose the challenge most important to him/her and wrote it on a piece of paper. Second, all participants switched papers and teamed up in pairs. Through an iterative process of five rounds, in which each team used a 0-7 scale to rank two challenges for next to switch paper with another team,

generated a list of 7 prioritized challenge areas. The list was noted on the board and a consensus was reached on the prioritization of the challenges (see section 2).

3. Results

Through the NeRN meetings, the indicators evolved and the challenges in collecting and comparing data became more apparent.

Functionality and data availability, as known to the country representative, of indicators regarding ePrescriptions is noted in table 1. Table 2 gives an overview of the functionality and data availability in general of the 21 indicators regarding the intensity of use of eHealth in the Nordic countries.

Table 1. Functionality and log data availability of health information intensity of use indicators regarding ePrescriptions

Indicator	Functionality availability	Log data availability (1)
No. of prescriptions made electronically / all prescriptions made per year	DK, FI, IS, NO, SE	DK, FI, IS, NO
No. of prescription viewings by professionals (in or via a national database or system) / electronic prescriptions made per year	DK, FI, IS, NO, SE	DK, FI, IS, NO
No. of prescription viewings by patients (in or via a national database or system) / electronic prescriptions made per year	DK, FI, IS, NO, SE	DK, FI, NO
No. of electronic medication renewal requests made by patients / population of the country	DK, FI, IS, NO, SE	FI, SE
(1) The availability is stated by the country representative. Actual availability of data may vary, since data has to be collected through various organizations or databases.		

Table 2. Functionality distribution of the 21 health information intensity of use indicators

Availability	No. of indicators	Notes
Indicators with full cross country functionality AND log data availability	6	Mainly regarding prescriptions and medication errors
Indicators with full cross country functionality but NOT log data availability	2	Electronic bookings and renewal requests
Indicators with neither full cross country functionality or log data availability	13	Indicators regarding viewings of notes, test results, immunizations, ability to add supplement by patients, medicine lists etc.

The method of prioritization gave a common overview of the main challenges in collecting and comparing log data across the Nordic countries regarding ePrescriptions. The complete list can be seen in figure 1.

After reaching consensus, the main challenges in prioritized order were:

1. Definition of the denominator
2. No published data available
3. Prioritized equally:
    a. Query literacy – skills to perform queries that provide the wanted information

   b. Rapid evolvement or functionalities under development
4. Data stored in local databases
5. Prioritized equally:
   a. Analysing before doing – acquiring data relevant for the indicator may be more complex than first assumed.
   b. Citizens print out at pharmacy – which eschews usage rates
6. Need to pay to get data
7. Three layers in data availability: i) Data already available; ii) Data collection doable, but more work is needed before we can collect data; and iii) Data not existing in logs, so it must be developed.

4. Discussion

As the Nordic countries all are close to a distribution level of 100% among all users of the most significant eHealth functionalities, the interesting aspect of monitoring eHealth shifts towards practical use of eHealth instead. Monitoring how much the key functionalities of national information systems are used and if these systems are used as intended is needed to follow up on national eHealth strategies. In order to obtain monitoring data not compromised by low external validity or selection bias, log data harvested from central servers seems to be an easy, reliable and valid approach to collecting data regarding practical use of eHealth. However, as we go deeper into details collecting and comparing data, the challenges in using log data become apparent.

4.1. The Impact of the Definition of Indicators

The definition of indicators is of great importance to the interpretation of them afterwards. Apparently, very simple indicators regarding ePrescriptions proved to be quite complex because the term prescription is not perceived or translated similarly to some of the Nordic languages. As noted in Gilstad et al. [6] prescribing is a series of actions; the decision to medicate is the first step, where the health professional decides when and how the patient should be medicated. Further, the prescription is written and mediated electronically (electronic prescribing of medicine) by a *health professional to a patient* via a pharmacy, where the pharmacist retrieves, makes dispension markings to the prescription and then the medicine can be dispensed. The prescription is the document that gives the patient the right to pick up a medication at the pharmacy as well as the instruction of how to administer the medication. In the Nordic countries, these actions and information content transferred and collated vary, and there are different meanings to the terms used. Hence, when comparing data across the Nordic countries and further across the OECD countries, it needs to be agreed upon which terms should be used. Or rather – what does the used term translate into in the local settings? The choice of definition greatly influences the challenges in collecting and comparing data. Most of the indicators used in the NeRN cooperation were derived from similar indicators in the OECD collaboration. This was done to enable benchmarking of indicators. However, the deeper into the indicators the group got, the more difficult the data collection and comparisons proved to be. In the group, some of the very thoroughly discussed indicators regarded ePrescriptions. Therefore, this was chosen to be the starting point of the NeRN group´s discussion of the main challenges in collecting and comparing log data across the Nordic countries.

The prioritization of the main challenges showed that one of the most important things to consider when defining indicators from log data is the denominator. In order to compare countries, a percentage is preferable rather than absolute values that can be affected largely by the population size amongst other structural issues. With the 21 NeRN indicators on the usage of eHealth, 13 indicators use population of the country as the denominator. This applies to most of the indicators regarding viewings of data. The main reason for this choice was the sheer magnitude of effort involved in acquiring the alternative denominator, which would be "per number of data stored in or via a national database or system".

The second most important challenge was that very little of the required data is published/easily available. The NeRN was established by the Nordic Council of Ministers eHealth group to provide a common set of indicators for monitoring eHealth for use by national and international policy makers and scientific communities to support development of Nordic welfare. However, in order to collect data several different institutions and organizations in each country must be approached. This underlines one of the third most important challenges: Query literacy. When asking for data from an unfamiliar database, it can be difficult to ensure that the data wanted and the data delivered are coherent. Again, the definition of the indicators is of utmost importance when conveying it to the people in charge of data collection in the respective countries.

The fourth challenge in working with cross country data collection and comparisons is the rapid evolvement of eHealth. eHealth is continuously advancing and therefor structures and functionalities are also evolving. This again stresses the complexity in defining what to measure in order to provide meaningful indicators.

There are several other major challenges in collecting and comparing log data regarding ePrescriptions. These challenges are equally applicable to other indicators. One challenge is the need for deeper analysis of the context and data availability before determining the final definition of the indicators. Sometimes, there are real-world work-arounds that affect the measures of use and need to be addressed in order to deduce a reliable conclusion on the practical use of specific eHealth functionality. Further, the maturity of the national databases varies, with 3 layers of data availability: i) where data are readily available, ii) where data are stored in the database, but retrieving the data requires additional work, and iii) where data do not exist in the national logs or is incomplete due to e.g. voluntary registration. The last layer requires further development in order to provide data. This leads to the final major challenge in collecting data: the costs. If data are published or readily available, the costs in accessing data are minimal – if on the other hand the national databases do not encompass data on the practical use of eHealth, the costs to include these types of data could be sizeable. Further, the majority of log data are made for other purposes than cross-country benchmarking. This imposes the challenge, that even though the database superficially contains the right information, it does not necessarily have the data content required by the comparison process. This calls for an iterative process, where the national log data collection should learn from the common indicator work so the future version of logs can produce more exact data for comparison purposes.

5. Conclusion

This paper set out to define the lessons learned from the process of characterizing the amount of practical use of eHealth on national level collecting and comparing log data

harvested from national logs in the Nordic countries. The health systems of the Nordic countries are quite similar in structure and their eHealth strategies include similar elements, but still it proved challenging to define a common set of indicators for monitoring the practical use of eHealth, and the deeper into the analysis we got, the more challenges we encountered. A thorough analysis of context leading to the definitions of the indicators is the basis needed due to the complexity of the data in the national logs. A comprehensive knowledge of the structure that underlines these logs is of utmost importance when striving for collecting comparable data.

Although challenging, the process of collecting and comparing log data is not an impossible task, but a task that requires in depth discussions of definitions of indicators as well as a substantial insight into the architecture and content of the national databases, hereby their contextual frames. There is need for continuous work on these indicators to ensure their quality and thus ensure the defined indicators can meaningfully inform eHealth policies.

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Work System Characteristics Impacting the Performance and Quality of the Discharge Letter Process

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Abstract. Studies on the impact of a Health Information Technology seldom consider socio-technical characteristics of the work system in which the technology is implemented. Yet those dimensions may act as hidden variables that could explain the inconsistency of impact studies' results in terms of performance, quality and satisfaction. This paper reports on the identification of those variables in the discharge letter (DL) process. Human Factors experts performed an analysis of the work system of the DL process in 17 medical units. The DL process is composed of three sub-processes running with work system differing according to the distribution of tasks, the technology implemented and the work organization. Hidden variables identified are: verification by the physician, technology's integration, number of editing cycles, physicians' preferences etc. Those variables can be collected automatically or by questionnaire. Statistical analyses will have to be performed to know which variable explain impact indicators.

Keywords. Human engineering, discharge letter, evaluation studies

Introduction

Introducing a Health Information Technology (HIT) in a work system affects healthcare organization, healthcare delivery and outcome. An increasing number of studies are published that evaluate the impact of HIT in terms of satisfaction, performance and healthcare quality. In those impact studies, the socio-technical system in which the technology is implemented is seldom analyzed or described. Yet, some socio-technical dimensions may act as hidden explanatory variables that could explain, at least partly, the (absence of) results of those studies [1]. This paper reports on a national study that aims to develop a methodology for identifying the work system characteristics that may impact indicators of performance and quality of a health

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system. The final goal of this project is to apply this approach to all French hospitals to improve the evaluation of the impact of the HIT on the performance and quality of the healthcare system. A part of this project focuses on the Discharge Letter (DL) process, a key element in the care continuity and patient discharge process. This paper reports on the development of this approach, i.e. identifying the work system characteristics that may impact performance and quality indicators of the DL process.

1. Background

Numerous studies have been published on the impact of introducing a technology to support the DL process. Particularly, they compare "automatically generated" DL to other types of technology (e.g. electronic/analogical dictation) [2]. Those studies focus on four types of impact indicators: the satisfaction of the users [3], the performance of the process: delivery time to the recipient [4,5], process quality: errors in identifying patients/physicians, missing letters, the quality of the letter's content [5,6]: its completeness [6-8], presence of errors in the within the letter [7,8].

In these studies, the lack of description of the socio-technical context in which the technology is implemented prevents (i) identifying precisely the type of technology (process completely or partially performed electronically) and the way it is actually used and (ii) explaining the inconsistency of the results. Therefore, it is essential not to settle for the results in terms of impact but to look at them considering the socio-technical context in which the system being implemented. As far as we know, no study has been published that identifies these hidden explanatory variables. The paper at hand aims to identify the hidden variables that may explain the impact of technology on the DL process. More specifically, it focuses on the distribution of tasks and control during this process and on the impact it may have on satisfaction, performance and quality.

2. Methods

Data collection and analysis were performed by two Human Factors experts in Lille University Hospital (2965 bed). Data collection was performed before, during and after the implementation of the new HIS; the roll-out of the new HIS spread progressively from 2009 to 2014 in the medical units. During this period HF experts evaluated the feasibility of replacing the former HIS with a new one from a HF perspective, focusing on the DL process. They also supported the implementation of the HIS and of related tools supporting the DL process. Numerous medical units with a great variety of work system were investigated (cf. Table 1) in order to ensure results are suitable to the largest possible number of medical units. Data were collected through several methods:

- Observations supported by field notes and screen captures of professionals' interactions with the HIS: they focused on identifying the professionals involved in the creation and transmission of patient DL, their tasks, their work habits, the tools and media they use along with their work organization.
- Semi-oriented interviews: they focused on contextual factors that could influence the DL process and allowed refining data collected.
- Finally, a questionnaire was developed in order to assess the extendability of the results to other medical units.

Interviews and notes were transcribed. The workflow and the role of each professional involved in the DL process were modeled through the Analytic Method of Description (MAD) and the Business Process Model (BPM) formalisms. Finally, based on those results, HF experts identified key socio-technical dimensions that could impact the satisfaction, the performance and the quality of the DL process and content and they drawn hypothesis concerning this potential impact. This identification and the hypotheses drawn were cross-checked by 3 other HF experts.

3. Results

A total of 89 physicians and 86 medical secretaries from 11 medical units participated in the study representing a total 149h of observations/interviews. Questionnaires were filled in by 8 physicians and 12 medical secretaries from 6 medical units (cf. Table 1).

Table 1. Methods applied, number and profile of the participants and medical units investigated

Methods	Number and profile of participants	Medical units
Observations and Interviews	89 physicians 86 medical secretaries	Resuscitation, endocrinology, neurosurgery, cardiology, geriatrics, emergency department, internal medicine, psychiatrics, neurology, pediatrics, traumatology
Questionnaires	8 physicians 12 medical secretaries	Resuscitation, gynecology, urology, nephrology, obesity, oncology

3.1. Characterization of the Discharge Letter Process

The analysis identifies three main steps in the process which may be considered as sub-processes, each of them issuing an outcome, as described in Table 2. Each sub-process runs with different work system. These work systems differ according to:

- The distribution of tasks between the roles and actors and the technical system
- The technical system implemented and its' usage; the technical system includes the functions of the HIS supporting the DL process and the technical devices supporting the dictation task
- The organization of the entire process, which depends heavily on personal preferences of (senior) physicians in a given medical department.

Table 2. The three sub-processes constituting the DL process, characterized in terms of tasks and outcomes.

Sub-processes	Tasks	Outcomes
Sub-process 1: Draft the letter	Collect data / information	Draft letter - electronic document
	Phrase and dictate draft letter	
	Type dictated letter	
Sub-process 2: Validate the letter	Verification/ Correction	Validated / signed letter
	Validation and signature	Electronic doc / printed
Sub-process 3: Send the letter	Send signed letter	Sent and Archived letter
	Archive validated letter	

The three sub-systems are more or less independent from each other, meaning that all combinations of the various work system are possible across the three sub-systems. The following section describes more precisely these work systems per sub-process.

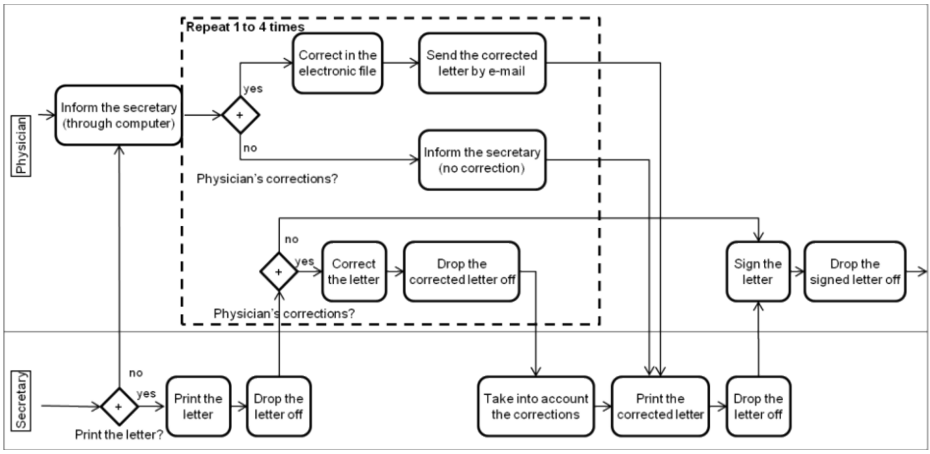

Figure 1. Schematic representation (BPM) of the verification/correction/signing of the letter.

3.2. Description of Sub-process 1 - Draft the Letter

The most usual distribution of tasks across roles and actors observed in this first sub-process remains rather traditional with (1) the physician collecting and selecting relevant information, then (2) phrasing and dictating the letter, before (3) handing the draft letter over to the medical secretary for (4) typing. Several types of devices are used to record the dictated letter (from analog to digital recording devices). Of note, magnetic tapes must be handed by physicians to secretaries. Digital voice recorders present several factors that impact the work system and their integration in the HIS:

- Digital sound files may be transmitted to the secretaries electronically
- Patient ID (and authoring physician identification) may or may not be systematically and properly attached to the file name and draft letter content
- Digital recording may be combined with voice recognition software. This eliminates typing. However, the quality of the document received by the secretary depends on the physician's work habits: some documents are not looked at before being sent to the secretary, while others thoroughly check the document before handing it to secretary.

Finally, HISs may provide functions that completely automate the process and issuing e-DL. In this case, the main role is devoted to the computer which, depending on parameterization, collects, selects and formats the medical data/information and generates the DL. This eliminates secretaries' typing task. At the end of the sub-process, whatever the work system, the outcome is a draft letter in the form of an e-document.

3.3. Description of Sub-process 2 - Validate the Letter

Most frequently, and especially in those situations where the secretary is in charge of typing a dictated letter, a verification-correction-validation process takes place where:

- The secretary transfers the typed letter to the authoring physician
- The authoring physician reviews the letter; notes needed corrections, and hands it back to the secretary for modification
- The secretary corrects the letter and hands it back to the validating physician

- The physician validates the final version of the letter and signs it.

The organization of this second sub-process varies widely across medical units and even within units, depending again on physicians' preferences:

- Some physicians review a paper copy of the letter while others review an electronically formatted document, eliminating the secretary's task of typing
- In some units, interns draft a first version which is then corrected by one or two senior. There may be up to 4 reviewing/signing physicians for a letter.

Table 3. Examples of variables in each sub-system that are likely to impact performance/quality indicators of the DL process. Striped cells point at relevant combinations "Variables X Indicators".

Discharge letter sub-processes	Variables	Indicators		
		Time from discharge day to recipient	Quality of the process	Quality of the letter Satisfaction
Sub-process 1	Technical system			
	Automated generation	■		■
	Voice recognition	■		
	Integration of dictation functions in HIS		■	
Sub-process 2	Local organization			
	Number of reviewing / editing cycles	■		■
	Physician's preference (review and edit paper/electronic doc)	■	■	
Sub-process 3	Technical system			
	Secure e-sending or snail-mail (paper)	■	■	

When functions for automated e-DL are available in the HIS, we observe that their usage depends again heavily on physicians' preferences: some physicians (mostly seniors) insist on checking and eventually correcting the computer selection and structure of information while others (mostly juniors or for simple and radical cases such as deceased patients) would simply trust the system and not even look at the letter automatically generated. In this case, sub-process 2 is skipped.

3.4. Description of Sub-process 3 - Send/Archive Letter

The third sub-process simply consists in sending the signed letter to all intended recipients and at the same time archiving an electronic version of the validated letter in the HIS and a paper copy in the medical record, as paper-based medical records are still a national regulatory obligation. The secretary is ordinarily in charge of this sub-process. The main feature of the technical system impacting this sub-process is the availability (or not) of a secure electronic information exchange system linking the hospital with outside healthcare professionals to allow sending the letter in electronic format. When such a secure system does not exist, paper letters are sent by snail-mail, and/or handed to the patient on the day of discharge (if the letter is ready).

3.5. Identification of Key Variables Potentially Impacting Performance or Quality

A number of variables of the work system described above are likely to impact performance or quality indicators of the DL process. It is not possible here to present the entire list of suspected variables and their hypothesized relation with indicators, but Table 3 provides a few examples of such variables and of the indicators on which they might have an impact.

4. Discussion/Conclusion

There are some limitations to the present study, essentially in terms of generalization, as observations and analyses were performed in only one academic hospital. Therefore, complementary observations and interviews have been carried out in two smaller hospitals (650 bed CH Denain and 578 bed CH Roubaix). Additionally, three other academic hospitals participating in the national evaluation project compared the data collected in Lille University Hospital with their own DL process and technical systems. The analysis of these additional data did not identify new types of work system or new key explanatory variables. Nevertheless, it is still necessary to extend the observations to private hospitals that may operate differently than public hospitals.

The overall goal of the national project is to design a methodology to evaluate the impact of the technical system (including HIT) and of the work system it is embedded in, on the performance and quality of the DL process and content. The next phase of the research consists in designing a method to collect data on the key variables identified in the present study which are likely to impact performance and quality indicators of the DL. Some data may be collected semi-automatically but most of them require qualitative investigation. These data will be collected through a questionnaire.

We expect interesting results regarding co-variations between work systems characteristics and DL indicators. That will allow us to measure realistically the impact of the IS used for the DL process. International collaborations will be required to cross-check these results with the many international studies that have been carried out on the subject. Such collaborations with more advanced countries regarding automation of the DL process (e.g. Australia and Denmark) are under exploration.

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Understanding Different Contexts Using Theory

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Context Sensitive Health Informatics: Many Places, Many Users, Many Contexts, Many Uses
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The Question Concerning Narration of Self in Health Informatics

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Abstract. Narration is central, even crucial, when it comes to embracing the whole individual, continuity of care, and responsible (ethical) handling of the technological construction of the self that takes place in health informatics. This paper will deal with the role of narratives in the construction of health informatics platforms and how different voices should have space for speech on these platforms. Theoretically the paper takes an outset in the actant model for narratives by the French-Lithuanian theorist of linguistics and literature A.-J. Greimas and post-phenomenological readings of human-technology interactions. The main assumption is that certain interactions and voices are absent from the construction of health informatics platforms, because regarded as outside the text of computational and medical practice and expertise. This has implications for what concerns meaning and understanding regarding both the actual users (physicians and medical staff) and excluded users (patients and citizens).

Keywords. Narratives, self, health informatics, value sensitive design

Introduction

This paper will deal with the importance of narratives and the understanding of narratives in relation to construction of meaningful continuity of care and how selves are co-constructed through language embedded in technologies. This is made in order to discuss 'how can the role of the citizen and the patients be enhanced in complex health IT contexts'? It is the assumption that meaningful continuity of care is hindered and to some degree even prevented by the lack of different narratives in health informatics, and it is not considered how we co-construct ourselves together with technology. This means that we are and remain unaware and unconscious of the role played by technology in moulding ourselves in its picture. The French philosopher Jacques Ellul was of the opinion that technology determines our beings, feelings and behaviours and there is no escape from this reality. He writes: "The new man being created before our very eyes, correctly tailored to enter into the artificial paradise, the detailed and necessary product of means which he ordains for himself – that man is I" [1]. We have become perfectly tailored components that as means fit neatly into the technical system that has a determined end, e.g. the artificial paradise.

This paper is not a technological determinist or dystopian contribution to already existing dystopias' of the 20th century like Oswald Spengler [2], Jacques Ellul [1], Martin Heidegger [3] among many, but rather an attempt to describe the overall inappropriate handling of language and language-systems in health informatics. The language-system in health informatics is characterized by a one-dimensional focus on standards [4], which certainly is needed in order for systems and people to interact, but

as if one-dimensional on the premises of technology, then we lose the full body of the patient/citizen and that of the professional herself. It is important to notice that it is not only the patient/citizen who is moulded, but also the actual user of the technology, e.g. physicians and medical staff who are transformed into 'one dimensional man' [5].

Technology is not vicious, anti-human or intentional on its own, but integrated part of the construction. Our selves are co-constructed with technology, where a certain kind of symmetry in between humans and technology are at stake and performed [6]. Intentionality resides in both humans and technologies and we should be careful when dealing with the intentionality of health informatics, because, as it is for now, striving towards *efficiency, efficacy* and *effectiveness* controlled by instrumental and mechanical rationality. Ellul saw this determination layered within technology and could not find any escape from final 'technification' of humans and society, where humans are treated as means to an end in a chain production perspective.

On the other hand the American feminist and STS researcher Donna J. Haraway wrote the Cyborg Manifesto in 1991 and in it she foresaw quite a lot of what has happened within information and communication technology, and even though that the following quote might seem gloomy then Haraway actually greeted the coming of a new post-human age wherein a new type of humanity would prosper thanks to our interactions with machines and technologies: "Communication sciences and modern biologies are constructed by a common move – the translation of the world into a problem of coding, a search for a common language in which all the resistance to the instrumental control disappears and all heterogeneity can be submitted to disassembly, reassembly, investment and exchange…The world is subdivided by boundaries differentially permeable to information. Information is just that kind of quantifiable element (unit, basis of unity) which allows universal translation, and so unhindered instrumental power" [7]. It is inevitable that technology will have an increasing and decisive importance in relation to how we as humans become, but this constant and dynamic becoming is not determinate and final. It is unpredictable and beyond our imagination, which means that we have to construct meaningful and responsible frameworks for handling human-technology interactions and associations where values and norms for what is means to be in these interactions and associations are explicated and activated.

In this perspective it seems as if health informatics is 'one dimensional' in its mechanical and instrumental rationality. Health informatics should be efficient, effective and effectual, but also embracing other *'e's* like *engagement, enactment, embodiment, empowerment, emancipation, empathy* and *enhancement* [8] in order for it to become multi-dimensional and *truly* representative for both medical staff and patient/citizen. In the following I shall address how the narration of the technological self can be constructed in health informatics and furthermore how context sensitive design based on values, norms and design criterions is possible in the construction of multi-dimensional man.

1. The Self and Health Informatics

Health informatics is ontologically and epistemologically tied to what it is made of, i.e. health and informatics. Health is in this perspective human matter and informatics technological matter. Health is subjective, emotional and bodily, whereas informatics is objective, mechanical and cognitive. This might seem as a dichotomy, but of course there are innumerable overlaps, connections and dialectics. We cannot separate subject

from object, emotions from mechanics and/or bodily perception from mental cognition. Nevertheless there is a tendency of such distinctions, which is certainly not new – it has been going on ever since René Descartes separated the body from the mind in the 17th century – and despite courageous attempts in the 19th and 20th century to reunite body and mind then the distinction is still at hand. Medical staff is torn in between the two world-views (ontologies) as it is supposed to care for the health of the individual and maintain the authenticity of the self, and at the other hand account for the efficacy of cure, and maintenance and efficiency of the system. The latter mainly made through proper information systems. I shall return to the inappropriate focus on optimization of efficiency, mainly in a economical perspective, later in this paper.

For now I shall introduce to an actant/communication model, which could serve as exemplary sample of current problems in health informatics platforms that seems to prioritize, in an asymmetrical and inappropriate way, the objective, mechanical and cognitive on behalf of subject, emotion and body.

The French-Lithuanian theorist on linguistics and literature A.-J. Greimas' dualist actant model [9] concerning the construction and dynamics of a narrative, provides us with an understanding of current problems for what concerns communication and interaction in between doctors and patients.

Sender *Health care system*		Object *Cure/Care*		Receiver *Patient/Citizen*
Assistant *Medical staff*		Subject *Citizen/Patient*		Opponent *Health Informatics (?)*

Figure 1. Actant model. After Greimas; 1966/1990

The 'assistant', who is supposedly, medical staff, have a certain picture of the individual that sits or lies in the clinic. They see her as a patient with a record related to sickness or/and injury. This record is told in objective medical language and layered within ontology and a system, which is literally and linguistically closed to the 'subject' and the 'receiver', e.g. the individual. The 'subject' as a citizen has a different narrative and wording, and the story often begins well before showing up in the clinic and/or the hospital. The perception and conception of the situation is often filled with doubts and worries that remains inaccessible to the narrative of the doctor, at least if we consider how ontology of health informatics is considered through SNOMED or similar tools for handling the complexity of health informatics in hospitals on a global level. The 'sender' and the 'assistant' may have all good intentions (and they have) to produce cure and care to the 'citizen/patient', but the problem is that technology may show as mediator of friction and opposition. The reason why is that it does not manage to cope with the lifeworld of the 'citizen/patient' and furthermore seems to hinder acts of empathy, empowerment and emancipation in relation to the medical staffs itself.

Of course this need not be the case, and health informatics is not in a position of friction and opposition per se. Actually it is often the physical and/or mental condition of the citizen herself, which causes friction and opposition. In other cases it may be the physician that changes role in the model and through a paternalist and commanding attitude becomes the opponent to the autonomy of the citizen. This possible paternalist and commanding attitude of medical staff and of the health care system is readily supported by the health informatics platforms that are constructed in order to facilitate exactly this attitude. The autonomy and authenticity of the citizen/patient is not safeguarded in this regard, and if the individual is considered then it is overly in regard to safety of data in relation to integrity of privacy. It is obvious that health informatics as

a tool should support practices of medical staff for what concerns cure, administration, workflow, safety and alike, but it is as well needed that information systems are considered as health and care technologies that assures/cuddles the maintenance of self and authenticity. In order for this to occur there is a need for a complimentary approach to health informatics and communication, wherein is present possibilities and potentials for authentication of selves, both that of the medical staff and the citizen/patient. In this way health informatics would escape the classification of opponent/alien to the self of the citizen/patient. The question is how this could be made?

According to the Greek philosopher Aristotle a narrative consists of a beginning, middle and an ending [10]. It is that simple, or seemingly it is. Because where do things begin, where is the substance (the corpse) and when and where does it end? It is beyond doubt that narratives are interpreted in very different ways by citizens/patients and medical staff/health care systems. Life itself and the life of the self begins, it evolves and it ends. Birth, lived life and death. This is also in the numbers of medical records, but exactly numbers. When we meet the health care system we carry our narratives, which is made out of myriads of folds [11, 12] and stretched out in between life and death [13]. Lying on the couch we re not a 'case' or a symptom, that is just part of us in the given situation, but rather the occasional and situational carrier of something. It is this something, which is recorded in the system and what is left out is the core or the actual 'thing' – the person/human. What is layered in the system and in the narrative of the system is a bunch of 'somethings' that do not necessarily depicts or tells the story of the person, or make a representation of the self of the individual lying on the couch. At the same time it is obvious that these 'somethings' are co- constitutional of our beings and necessary elements in the narratives of our selves.

2. Context Sensitive Design in Health Informatics

There is no existential essence of the self, as continental existential philosophy would have it, but rather a multi-facetted crystal, where planes and sections are broken in different ways, and representations and meanings change as we turn the crystal. Currently health informatics is in search for the essential technical core of the citizen/patient as opponent to the impossible search of the individual for an essential human core. Both searches are out of line with the actual reality, which consists of a myriad of folds [11, 12] and thousands of plateaus [12]. This is the actual context (reality) of which citizens/patients and medical staff is integrated part together with technologies. In order to arrange and manage folds and plateaus we have to address the design process with sensitivity, which according to the Dutch philosopher of technology I. Van de Poel should be layered within values and norms, e.g. value sensitive design [14].

Value sensitive design (VSD) has been around for the past ten years and mainly in a Northern European context. VSD takes an outset in ethics and morals wherein we ask ourselves what it means to be human and how we should interact with each other and the world. Technology is, as we have seen, integrated part of this interaction and not an isolated object without any sort of intentionality. This means that the norms that can be explicated are not exclusively human in a conventional sense, but co-constructed and constituted with technology.

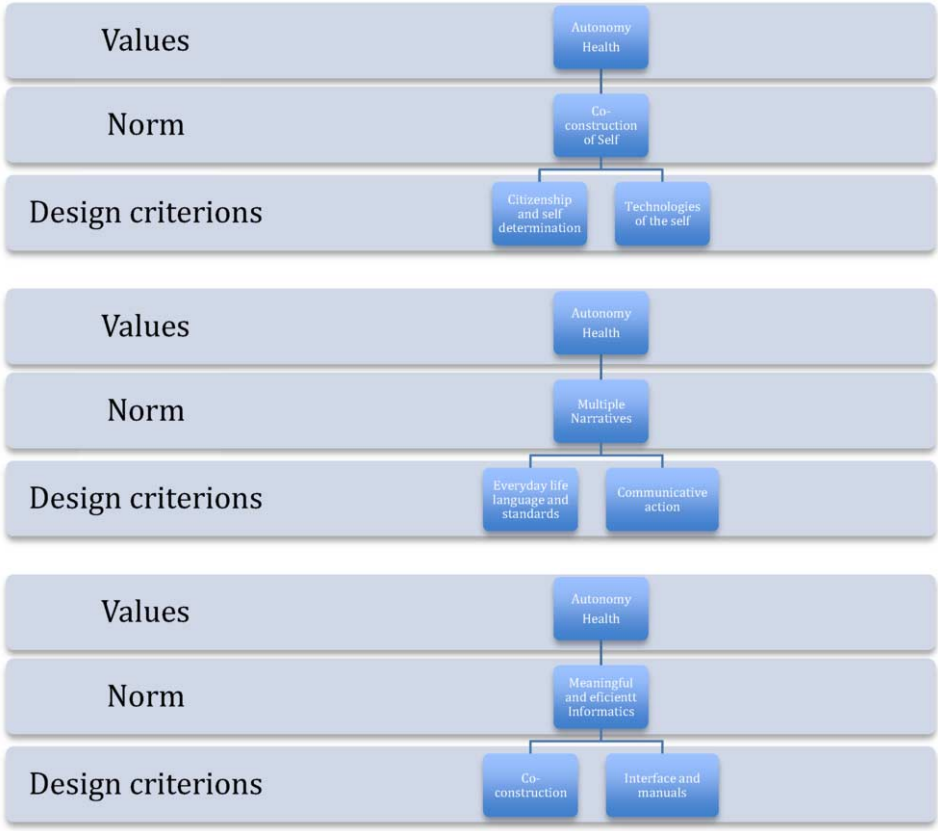

Figure 2. Value sensitive design. After Van de Poel; forthcoming

In the hierarchical tables above, which are exemplary, I have addressed autonomy and health as values. Other values, like utility, precaution, justice, inclusion, are as relevant and could be applied in the analysis of value sensitive design. The same thing goes for norms, but in this case they are closely tied to the main discussion of the paper: narration and self in health informatics. The design-criterions are requirements for guidelines that should direct construction of health informatics, i.e. have direct impact on ontology and architecture of the actual design.

3. Perspectives

One possible way to escape alienation and exclusion is to educate the medical staff to see health informatics as constituent for construction of self, and again, both that of themselves and of the citizen/patient. A close look at the medical curricula in a Danish context (4 medical educations) shows an alarming absence of training and education in health informatics, and very little reflection on self and the importance of narratives and language. The recommendations of this paper is to create platforms for health informatics in medical educations, and furthermore to address the importance of language, self and narration in the construction of health informatics. This means that medical staff should receive adequate and appropriate training and education in health informat-

ics. Not in order for them to be able to program and develop technological platforms and solutions, but in order for them to be on a level to understand the architecture of health informatics (ontology, terminology, content, construction, format and outline) in order to interact on both an operational level and on a design level. The latter because their experience and training in the *art of medicine* [4] is needed, in order to assure axiology in the architecture (ethics, aesthetics and thought collectives/paradigms). In the perspective of this paper this means that the *e's* of effectiveness, efficacy and efficiency has to be complemented by engagement, enactment, embodiment, enhancement, emancipation, empowerment and empathy, which are all *e's* that take their rationale in axiology [8].

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Understanding the Context of Patient Safety Through The Lenses of Three IMIA Working Groups

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Abstract. Delivering safe patient centered care remains an important yet elusive goal across healthcare systems worldwide. The complexity of healthcare delivery and the unique contexts where it is delivered necessitates patient safety solutions that go beyond individual perspectives. This paper articulates the current state of patient safety research and HIT from the perspective of three International Medical Informatics Association (IMIA) working groups. Each WG will describe patient safety issues within their domain. We then integrate the three WG perspectives into an integrated model to support research, education and policy development for patient safety where HIT is concerned.

Keywords. Sociotechnical, human factors, patient safety, technology induced errors, context, health information technology

Introduction

Delivering safe, patient centered care remains an important goal across healthcare systems worldwide. Despite the attention to medical errors and patient safety raised by reports such as 'To Error is Human' [1], it is still suggested that medical errors are a significant cause of patient death [2]. More significant is that many of the health information technologies (HIT) we design to improve care delivery such as electronic medical/health record systems or computer physician order entry may actually lead to new types of errors (i.e., technology induced errors) [3,4]. Today, the health informatics industry has recognized that HIT exist on a continuum, from safe to unsafe systems, with some HIT having features and functions that may improve while others detract from patient safety. With this awareness there has emerged an impetus towards designing HIT that prevent traditional medical errors and are considered safe technologies [5].

To address these patient safety issues academics, HIT industry leaders, and governments at all levels have called for studies that look at the multiple dimensions that contribute to medical errors including technical, human factors, organizational, and cognitive dimensions [6-9]. However, while research has looked at these issues it has

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tended to do so in an isolated manner (i.e. considering the HIT independently from its context of use). HIT is used within a healthcare ecosystem that is influenced by all of the above dimensions depending on the specific context of use [10]. While sociotechnical frameworks have been developed to provide insight on HIT elements and patient safety, a shortcoming of these frameworks is that they often look at the various components as isolated entities, rather than as a set of integrated components.

Information about occurred errors are usually recorded in a database. For example, in Denmark errors are reported by health professionals but since 2010 patients and their relatives have also been able to report experienced errors. Approximately 50.000 errors are reported annually from hospitals. While the largest category are medication errors (23% in 2014), other categories - communication and other administrative procedures referrals, admission/discharge etc. - exceeds the number of medication errors. These type of errors happens in transitions between sectors, departments, staff groups, and between patients and professionals. These categories of errors usually involves the use of HIT, but the technology involved in the error is only occasionally mentioned in the reports. A content analysis of 17, 000 reports from the capital region of Denmark found 448 reports explicitly mentioning a specific HIT system. However, very few usability errors were reported – the staff tended to blame themselves for not using the system correctly [26]. Every system breakdown was reported and many errors were reported when systems were replaced or upgraded to newer versions.

Self-reporting systems are meant to improve patient safety by establishing a closed loop learning cycle. However, self-reporting systems have shown to be inadequate as they are difficult to code for data entry – the reports are mainly free text. They are incomplete as they contain sparse information to identify IT induced errors, and they are also found ineffective as the reporting culture is changing over time [11].

A more viable alternative to register errors that has happened will be to prevent them by applying a multi perspective on technology induced errors. We need to look beyond any one perspective to devise multi-perspective, context sensitive solutions. This paper addresses that need by developing a multi-dimensional perspective on patient safety from the perspectives of three International Medical Informatics Association (IMIA) Working Groups: Organizational and Social Issues (OSI), Health Informatics for Patient Safety and Human Factors Engineering for Health Informatics.

1. A Multi-Perspective Panel on Patient Safety

Each of the authors represents an IMIA working group. In the sections below patient safety is discussed from the perspective of three working groups followed by the development of an integrated model of patient safety. We also discuss the implications of the model on the design and evaluation of HIT.

1.1. Organizational and Social Issues

We cannot manage safety per se but rather we need to manage the clinical behaviors that lead to patient safety issues. From an Organizational and Social Issues (OSI) perspective, one of the challenges is that while patient safety initiatives start at the macro level, they are integrated at the micro level. And at times there are gaps between the two levels that may lead to patient safety issues. One such gap is at the system design level. In a study of a perioperative information system [12], an anesthetist commented

about the security feature that automatically logs out a user after 5 minutes of inactivity. It was designed for security reasons to prevent people from walking away from the system and someone else gaining inappropriate access to data. However, surgeries are typically longer than 5 minutes and have periods without data entry but where the anesthetist will have the system contextually configured for the next data entry point. If they are logged out they will have to reconfigure the setup and may miss something. One anesthetist commented 'I realize it [automatic logout] is a security feature but it creates a patient safety issue'.

Collaborative rules of engagement are another issue. While HIT may be designed to facilitate integration across areas as a building block of patient safety, practice variations of individual users can limit the effectiveness of these safety initiatives, or even create new unsafe practices. In the perioperative study there were instances where an anesthetist would put a memo in the HIT to guide patient care. For example, when a patient transfers from the operating room to post-anesthesia care unit a memo might be created saying the patient's blood pressure is prone to spikes or their O2 de-saturates quickly. However, because there was no organizational protocol on memos, nurses in PACU may not know where to look for it and therefore may not see it [12].

How people interact with HIT at the micro level can also create unsafe conditions. One OSI perspective is how people actually use HIT in context compared to how it was designed. One such theory is prospect theory that attempts to predict how people will make decisions during uncertainty [13]. It also states that people who perceive something as a loss will be enticed to engage in more risky behavior to accommodate for their loss [13]. Implications of HIT implementation such as paper persistence or workarounds can be seen as people taking risks to accommodate perceived loses from HIT. Both anesthetists and nurses commented that while the benefits of the electronic system were well conveyed pre-implementation, the benefits they would lose from the paper system were not communicated nearly as well and were only truly understood once the HIT had been implemented. At an OSI level, people often perceive HIT as a loss, or at least an obstacle to doing day-to-day tasks, and as a result may create shortcuts or workarounds to minimize their perceived losses. However, these workarounds may create unsafe situations. If we can position HIT from the perspective of gains, by openly discussing trade-offs between paper and electronic systems and how clinical routines will be impacted by HIT, it may help people understand the changes from HIT implementation and how to accommodate such changes.

1.2. Health Informatics for Patient Safety: Improving the Quality and Safety of HIT

HIT safety should be everyone's concern in the healthcare industry. Around the world governments, vendors, healthcare organizations and health professionals have identified the presence of technology-induced errors and they have a desire to address this growing issue. This represents a significant shift from 11 years ago when the first publications emerged identifying technology-induced errors as an important safety issue [6, 14]. Today, we have governments, healthcare organizations and researchers who are monitoring for technology-induced errors and discovering new ones [15, 16, 23] – as new technologies are introduced so are new types of technology-induced errors [4, 5]. Organizations are innovating and exchanging ideas about how best to improve the safety of HIT by improving its quality [17].

Health informatics researchers have developed and proven the usefulness of several methodologies in identifying and addressing these types of errors before systems are

implemented (e.g. heuristic evaluation, usability testing, clinical simulations, rapid and traditional ethnographic approaches and case studies) [3, 6, 8,14,18,20,21]. In addition to this, we have models (i.e. human factors, sociotechnical, organizational behavior and software engineering models) [17, 19] that can be used to understand and develop strategies that allow for technology-induced errors to perpetuate and propagate over health care systems and across organizations (i.e. differing vendor and healthcare organizations) [19] and across health care contexts (e.g. physician offices, regional health authorities, home care agencies) [4,6,8,10].

To date we have also seen professional organizations and governments step forward with new regulations for software testing such as the work by Health Canada [15], new policies and programs (see the work of the Office of the National Coordinator in the United States and Canada's Health Informatics Association [24,25], a new culture of HIT safety [25], and organizational strategies for moving towards great utilization and improvement of HIT safety attributes [17,24,25]. This is exemplified by the report published by the Institute of Medicine on Health Information Technology Safety [22].

Even so, there is much work that continues to needs to be done to improve the safety of HIT as many safety issues still exist. There is a need to continue to extend human factors, socio-technical and HIT safety research [3,6,12,17,19,23]. To date we have seen a significant shift from documenting the value of HIT to reducing errors and moving towards improving the overall quality and safety of HIT [3,5,22,17]. In a span of 11 years technology safety has moved to the forefront of health informatics research and professional practice.

1.3. Human Factors Approaches to Improving Healthcare Safety

Over the past decade methods from usability engineering and human factors have been used proactively to identify and mitigate technology-induced errors in healthcare IT. This work ranges from usability testing to use of clinical simulations conducted in situ in real settings where health information technology will be deployed. The IMIA human factors working group has identified an approach to ensuring system safety that argues for an initial phase of usability inspection and usability testing for detecting surface level usability errors that might lead to technology-induced error (e.g. screen layouts that are confusing, inability for users to navigate to patient allergy information etc.) [3]. In addition, the working group has recommended that such evaluation lead to iterative cycles of system and user interface refinement to ensure system safety at the level of surface level usability. After detection and correction of such usability problems, a system safety approach to IT testing goes on to recommend application of clinical simulations to test the system/user interface under close to real conditions that can be artificially controlled (in order to explore certain aspects of interest of the user-system interaction in depth). Feedback from this stage of evaluation can again be input into system refinement and redesign [3]. Finally, the working group has identified a final layer of evaluation involving testing of systems in-situ under near-live and then live conditions. It is argued that such testing is also required to identify issues and problems related to impact of systems on workflow and problems that would occur during use of the system in real clinical practice [3].

In summary, the human factors working group recommends a layered approach to testing and evaluating systems that ranges from the individual interacting with the system in isolation (the level of user-computer interaction) to testing of systems under

realistic technical and social conditions. Finally, no matter how much testing is done prior to system release, a small scale pilot release with continuation of data collection (using unobtrusive data collection methods) is recommended prior to widespread release to identify and mitigate the potential negative impact of technology-induced error and lead to increased system safety.

2. An Integrated Model of Patient Safety

Fig.1 shows our integrated model of patient safety. The integrated model is intended to guide how patient safety and HIT are studied from multi-disciplinary perspective. The figure illustrates how each of the three WGs study patient safety from the perspective of HIT-provider interactions and the 'undesirable' adverse events (AEs) and 'desirable' care outcomes that emerge from the interactions. Fig. 1 highlights that while the focus of study for the three dimensions is different, that patient safety cannot be studied in isolation, but rather it requires an integrated effort to identify adverse events as well as the people and HIT issues that lead to them. The model emphasizes that it is the behavior and interactions between people, processes and technology that we need to be most interested in.

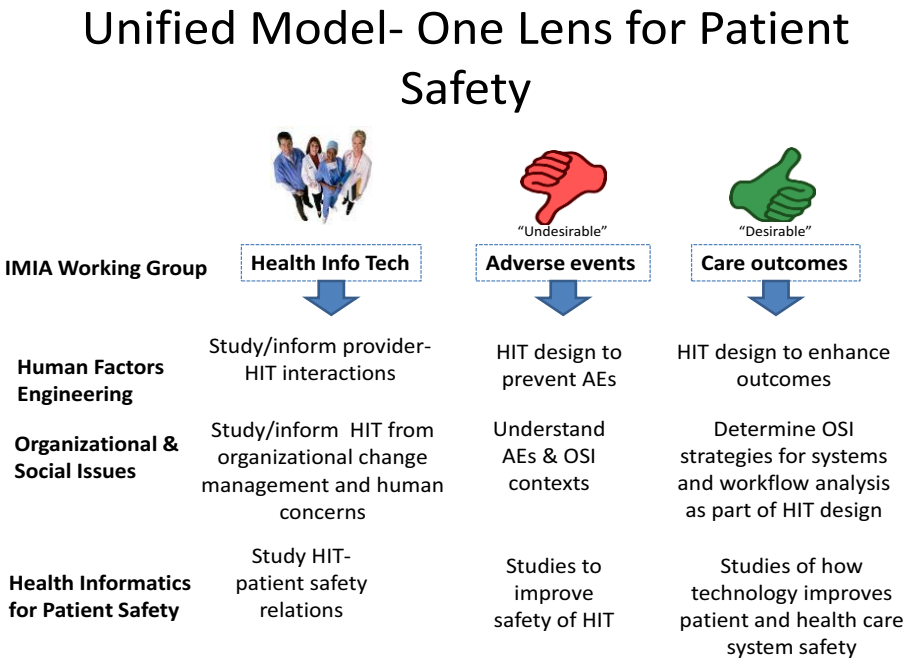

Figure 1. Integrated model of patient safety

As shown in Fig.1, while adverse events are undesired outcomes of how users and HIT interact, understanding the errors requires us to understand contexts of how people and HIT interact (OSI WG). Once we have understood the relationship between AEs

and contexts we can then identify AEs (Patient Safety WG) and inform HIT design to prevent AEs (Human Factors WG).

For example, in section 1.3 we described how usability testing needs to be used in all phases of HIT design including testing that incorporates social and technical contexts. The OSI working group complements that work by identifying contexts such as the rules of engagement for how collaboration works to enable usability testing to incorporate those contexts. Simulation is another method used by the human factors WG as it allows us to test context. However, the specific contexts that we need to consider may not be defined and the identification and understanding of different contexts is a large part of the work of the OSI WG.

3. Discussion

In this paper we discussed patient safety from the perspective of three IMIA WGs and provided an integrated model of patient safety and HIT. Our overarching message is that patient safety cannot be studied in isolation but rather it requires collaboration across WGs such as the three described in this paper. The integrated model of patient safety presented in this paper is meant to provide the starting point for studying, and understanding medical errors and adverse events as part of the design and evaluation of HIT to prevent errors. Our quest to identify patient safety issues and then to develop human factors strategies to prevent the issues will need to be shaped by the organizational and social contexts where healthcare delivery is provided. Complementary methods to study patient safety issues are also needed. One such example being Activity Theory to identify contextual factors related to activities which can then be used to inform clinical simulation studies. Overall, we need to move away from studies that simply describe unsafe practices or adverse events and conduct more research that explains *why* these unsafe situations occur. Research that provides explanations would enable us to better predict patient safety issues to allow us to then inform HIT design and evaluation to prevent them.

Understanding and managing patient safety is an ongoing task. While HIT has helped reduce 'classic' errors it has also created a new category of technology induced errors. It stands to reason that as we solve those errors new ones will arise. Our quest to reduce patient safety issues needs to be viewed as an ongoing journey and not a destination.

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Context Sensitive Health Informatics: Many Places, Many Users, Many Contexts, Many Uses
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The Contextualization of Archetypes: Clinical Template Governance

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Abstract. This paper is a status report from a large-scale openEHR-based EPR project from the North Norway Regional Health Authority. It concerns the standardization of a regional ICT portfolio and the ongoing development of a new process oriented EPR systems encouraged by the unfolding of a national repository for openEHR archetypes. Subject of interest; the contextualization of clinical templates is governed over multiple national boundaries which is complex due to the dependency of clinical resources. From the outset of this, we are interested in how local, regional, and national organizers maneuver to standardize while applying OpenEHR technology.

Keywords. Electronic patient record, interoperability, semantics, integrated care, OpenEHR

Introduction

Large and complex health care organizations globally fight to achieve seamless integration and standardization across professional, departmental and institutional boundaries. In Norwegian healthcare, existing Electronic Patient Record (EPR) systems provide an inadequate basis for such a workflow, and even quite modern EPRs are still considered systems of documentation rather than systems of process and decision support. Shared care and integrated care has over a decade been a focus area for the health authorities in Norway and more recently, which particularly emphasises the need for EPR systems to be organized in a more structured manner and for such systems to be more interoperable in order to communicate information across heterogeneous practices [1, 2]. The reason for this is an increasing demand for rapid feedback on results, and an urge to compare organizational or clinical data internally, regionally, or nationally. Structured EPR data will make it possible for clinicians to categorize variables in order to build meaningful reports, to extract data for quality registers, and for clinical research. Structured data elements will also make it possible to organize information that supports process support- and decision support inside an integrated EPR portfolio with focus on patient pathways.

A national initiative to deal with this has gradually gained foothold in Norwegian healthcare. Initiatives using an openEHR architecture have been established both for the purpose of building a national repository (a so-called Clinical Knowledge Manager) of common semantic data elements for collaborative EPR systems, and large EPR ven-

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dors are building their system portfolio around the OpenEHR technology. Archetypes are information elements of clinical concepts, where observations, options, instructions, and actions form the iterative process of treatment and care [3]. By using OpenEHR, it is possible to make EPR content structured in a multilevel modeling approach that includes templates, archetypes, and a reference model intended to improve semantic interoperability and the reuse of data [4]. Archetypes are re-usable structured models of clinical concepts and knowledge made to standardize the content of EPRs. How do different pieces of software know what the data means, is give an increased opportunity for interoperability. "How to build a patient –centric longitudinal EPR across enterprises" and how to secure sharing of data among stakeholders in different areas of healthcare includes a focus on semantics with a standardized language for EPR variables. For example, a study by Garde et al. [5] concerns the modeling of clinical content of EPR systems that could become available internationally. The study shows how clinical content can be made available using archetypes and templates from OpenEHR and ISO 13606. Through this, the OpenEHR platform could become the foundation for safe sharing of the information the clinicians need as tool for decision support inside the EPR system (ibid). The Clinical Knowledge Manager for archetypes is planned to contain between 1000 and 2000 archetypes, archiving information about how new archetypes are translated, modeled, and shared. A precondition for success is that clinicians agree on the content of each archetype in the consensus process. In turn this will secure a common understanding of the clinical content of EPR systems over regional and national boundaries. Information based on archetypes will in the future form the content of any given EPR system that supports the sharing of OpenEHR technology. Clinical data (archetypes) will be contextualized through the use of templates. In turn, all schemes included reports, clinical processes, and clinical or organizational decision support are planned and organized by using different templates.

This paper concerns the three layers of organization, local, regional, and national that embodies the contextualization of structured data using archetypes. While earlier research on OpenEHR archetypes has demonstrated success on clinical process- and decision support on a local level [3], this paper focuses on the effect a national repository for archetypes has for the interoperability of a local, regional and national organized template production. Based on this we present the following research questions: What advantages does a national repository of consensus made archetypes bring, and what are the pitfalls?

1. Methods

This research use qualitative methods, interpretive, and ethnographically oriented, grounded in the action research tradition through the first and second author participation and contribution in the work accomplished [6].

Analysis of longitudinal research is a continuous and iterative process with an ever-changing intensity. As Klein and Myers [7] suggest, it can be understood as a hermeneutic circle that refers to relating the whole to the part, and the part to the whole. The part is not a fixed unit, but flexible, that is allowing changes to the unit of analysis for a given purpose. However, ethnography may also prove efficient in identifying, analyzing, and evaluating changes in practices that emerge from using the IT system as part of the design and implementation of this system. My background as a clinical nurse, ten years of working with clinical cancer research, and almost six years at NST

as an advisor, PhD student, and project manager has shaped my competence to include action research to the methodology of this research. I will do this by including the results from the national initiatives through the projects, and by inviting board members to participate and bring the regional archetype development into the research as important field experiences. Accordingly, action research is a framework for inquiry that seeks to bring together action and reflection, theory and practice, in participation with others, in the pursuit of practical solutions to issues of pressing concern to people. Six interviews has been added (first author), and ten interviews (second author) to the numerous of meetings, documents, and texts written for the project lasting for an average of 1 hour.

2. Results

2.1. The Archetype Governance

The National Administration Office of Archetypes (NRUA) was established in 2013 by National ICT with the goal to produce high quality archetypes. The NRUA employs three people whereof two in full positions and one in a part-time position. Two new employees are suggested to start working specifically with modeling of archetypes and templates. NRUA further includes representatives from each of the four Regional Health Authorities. There are between two and three members from each of the four health regions. As an example, there were three members from the North Norwegian Health Authority, one physician with special interest in health informatics, one nurse with a PhD in information Systems, and one project manager from the regional ICT development program were the new process oriented EPR is developed.

The overall goal with NRUA is to coordinate the development and use of archetypes on a national level, both handling translations of international archetypes as well as handling local initiatives. It is called "Do-ocracy" where doers make the decisions, but where the reviews are initiated by the Editorial Group which also covers the recruitment of the reviewers to the national Clinical Knowledge Manager. If requirements are met, the further approval is done by the Editorial Group. The requirements are factors such as having the right number of clinical specialists for the right archetype (national level) where all four health regions are included.

Since the beginning in January 2014 NRUA has focused on the translation of already existing observation-archetypes like blood pressure, body weight, nutritional risk, height, and temperature. Clinicians have been invited to participate through the national Clinical Knowledge Manager after coordination between the regional groups and the secretariat at NRUA. Other archetypes are also considered, all based on regional programs or initiatives such as a specific nursing registration scheme in the West Norway Regional Health authority, archetypes for national clinical registers, archetypes ordered by clinical work-groups with focus on the development of the new EPR system, and a number of archetypes ordered by cooperating vendors on a global level. In this face the focus was on the translation of existing archetypes from the global Clinical Knowledge Manager. In CKM the specialist only need to adapt to what is clinically relevant. Specialists from all of Norway discuss the clinical content of variables that are important for clinical processes. An increasing problem has been late coming requests for structural changes which so far have led to several review-rounds that in turn can lead to an increased drop-out rate. However, there have not yet been disagreements of severe

character. Even so, there are always questions and skeptical engagement when it comes to tools like the Clinical Knowledge manager both towards usability and log-in errors: "*In both our experience, and based on feedback from newly recruited users, the CKM has an intuitive user interface making it easy to understand how comments are entered and saved. Some users experience problems with error pop-ups during login, but this seem to be related to older versions of Internet Explorer." (Member of NRUA)*

On the regional level the project has invited 90 clinicians, nurses, nutrition specialists, and doctors. The clinicians chosen were based on the "have to" and "should" lists, and the most of them had earlier relations to regional ICT projects. In present time the project have 40 activated clinicians and approximately 10 members from the regional NRUA group and National Centre for Telemedicine that also include researchers with technological background. This group has gathered once every fourth week to discuss and coordinate with the national development. For the six archetypes now in the loop of getting consensus (Body-weight, Pulse, Respiration, Boy-Temperature, Height-Length, and MEWS-score which is a modified early warning score to detect the degree of illness) and with several more in the loop, the portfolio has increased to a number possible to start produce template of different character.

2.2. Clinical ICT Governance

Based on the two-layered model of the new EPR it became obvious that the regional health authority needed a new regional administration with focus on the clinical content of EPR systems independent of systems vendors. The production of template based schemes and reports, process- and decision support (contextualization) are processes that include initiative and dedication from a large number of clinical resources that needs to adapt to the process. Based on the ongoing regional project where the new EPR already was tested a clinical governance should be in place: *"Regional decisions have already been effectuated and there is a risk of them dissolving without necessary regional governance in place." (Leader of the "standardization-of-practice" project).* In the beginning of 2013 the local ICT department at the University hospital started to plan the archetype governance, and the general governance of clinical EPR content on a regional level (modeling of clinical content). The first version of a mandate was planned and written by the local ICT department at the University Hospital as host for the EPR development process in cooperation with the large regional ICT project. The result was a "breakdown" where the focus was "which health trusts became responsible for what". In more previous time new efforts has been done, and a regional model for radiology governance has been established in one of the health trusts as a pilot project. The project manager was asked where the bottle-neck towards success was situated, with the following answer: *"Except from the fact that there are political issues to the case…..new organizational functions require our department to "grow"* into a new role. As of this the future is uncertain, it is impossible to adapt to new technology that not yet has been installed". In addition to this, the processes towards national consensus on archetypes have struggled due to the lack of clinicians and specialists needed to gain consensus which also have resulted in less activity with the development of the EPR and the following tests of the product. The interruptions caused by this has been several; 1) The national repository of archetypes is a slow developing process, but an increasing number of archetypes makes it possible for the vendor and clinical environment to start the production of clinical content. 2) The vendor has not yet installed all the tools needed for the clinicians to integrate clinical content. 3) The hospitals and

their ICT administration has not been organized (the regional administration) to agree on a standardized portfolio of schemes, process- and decision support, but has the technical installations and organizational standards in process.

2.3. Regional ICT Administration, Former Clinical and Technical

The existing regional ICT organization has since 2005 supported and managed all the hospitals' ICT systems which include clinical governance (in a cooperative sense), and all technical parts of the ICT portfolio. In 2013, the Health Region decided to reduce the number of ICT installations connected to the EPR from nine to one, creating a more efficient and cost saving centralized ICT portfolio. This was an important step towards a more regionalized and standardized EPR. The regional ICT organized and owned the project that was conducted in close collaboration with the EPR vendor, the regional ICT project and the four health trusts. This centralization is bounded to reduce technical maintenance and the organizational workload on the regional ICT organization, having just one centralized installation. The installation and the backup installation are both situated close to the University hospital. The regional ICT is responsible for governance of a regional system portfolio including the New EPR.

In addition to a centralized ICT portfolio, the actual *use* of the ERP systems has been evaluated. The regional ICT project established in 2012 a sub-project focusing on standardizing work routines for using EPR in the region. More than 500 users from the four Health Trusts participated in the process. The goals of standardizing were to increase quality and safety in patient treatment and establish a basis for sharing patient information across the region and former health trust boundaries. This project was also a required standardization effort needed for using a more process oriented and open EPR portfolio. Since the new EPR is based on structured information, process and decision support, and aims to underline patient pathways from beginning to the end across the region and different levels of healthcare, it is important to use the EPR in a streamlined way. This is a user-controlled system that needs to be founded on already established regional standards and new local/regional/national standards for process and decision support. The contextualization of archetypes depends on a standardized and integrated ICT portfolio where systems with different reference models for structured information needs to be mapped for integration. To achieve this a more nuanced governance is applicable: *"My guess is regional functional governance is placed in the biggest health trust, they already have an established organization for governing both the new and the old EPR, One alternative is that this is run from the health trust, another one is that this organization is moved to a regional level" (Leader BigProject).*

3. Discussion

3.1. The Contextualization of Archetypes

By using OpenEHR the clinicians will be supported with a more open, adaptive, and collaborative system which enables modeling of clinical content owned and made by the clinicians environment on local/regional/national levels. The modeling of clinical content, and the following contextualization into reports, schemes, process- and decision support will consist of variables from different applicable systems such as for

instance the EPR, Radiology (RIS/PACS) and laboratory to mention a few. The answer to succeed with standardization through context based archetypes is to build a "Do-ocracy" of determined clinicians. This "concept of speak" taken from the leader of the secretariat of NRUA pinpoint the challenges for organizers, which theoretically calls for coordination of work to make clinicians proud owners of clinical content. To achieve this, archetypes for structured data and sharing of information has to become more visible for the clinicians through a more targeted information practice. So far, the national consensus processes for archetypes show that dedicated clinicians are hard to obtain because of much pressure in everyday work. Therefore the vision of the project needs a strong anchorage both top- down and bottom- up in the clinical organizations. It is important that the clinicians are presented for some effects of what this new EPR can give them. In particular, the role of the governance structure implicates a shift from an organization that serves clinical practice to an organization that exercises authority over it to ensure that every practice followed the work-standards.

In the bigger perspective, the governance of a new standardized portfolio of structured data in multiple systems is three-folded. The contextualization of clinical variables into meaningful clinical decision support includes the involvement of clinical resources on a local, regional, and national level. Hence, this also includes three layers of organization needed to be involved. NRUA is a national decision maker that organizes the regional groups, vendors, and ICT projects. The regional governance or clinical modeling group place orders, coordinate regional projects, and contributes to national consensus. Both organizations are built on and dependent of clinicians and their contribution which primarily is based on interest and overtime in practice. On the contrary we have the regional ICT which is contributing by standardizing the ICT portfolio, securing the integration, and mapping the reference models. In all, the regional ICT needs to be coordinated with the clinical groups in this complex governance model to be.

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Health Informatics Can Avoid Committing Symbolic Violence by Recognizing and Supporting Generic Decision-making Competencies

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Abstract. 'Symbolic violence' is committed, however well-intentionally, by the imposition of particular conceptualizations of what information, in what form and quality, is needed in order to make an 'informed choice' and hence – by questionable segue - a high quality decision. The social and cultural forms of relevant cognitive capital possessed by those who fail, because of their low general literacy, professionally-set knowledge tests of functional health literacy, are being ignored. Failing to recognise and exploit a particular form of *functional* decision literacy, in fact leads to symbolic violence being experienced by individuals at *any and all* levels of general literacy. It leads many to adopt the same range of avoidant and other undesirable strategies within healthcare situations observed in those of low basic literacy. The alternative response we propose exploits the alternative generic decision literacy which comes in the form of the ability to access and use the decision-relevant resources provided for many consumer services and products on comparison websites and magazines. The methodology is the simple form of multi-criteria analysis in which the products' ratings on multiple criteria are combined with criterion weights (supplied by the site) to produce scores and 'best buys' and 'good value for money' verdicts. Our alternative approach extends this approach to healthcare options and permits the incorporation of personal criterion weights in furtherance of person-centred care. Health informaticians, especially those in the decision support field, should build on this widespread generic competence. The fact that it is generic, far from implying context insensitivity, can be seen as a necessary basis for achieving context-sensitivity and sensitivisation at the level of the individual person as they experience a lifelong sequence of healthcare decisions.

Keywords. Informed choice; health literacy; person-centred care; empowerment

Introduction

A recent paper questions the focus on *functional* literacy in attempts to encourage and support the making of 'informed' healthcare choices [1]. Drawing on the work of Bourdieu, Adkins and Corus see 'symbolic violence' being committed, however well-intentionally, by the imposition of particular conceptualizations of what information, in what form and quality, is needed in order to make an 'informed choice' and hence – by questionable segue - a high quality decision. These conceptions are built into the definitions of health literacy by WHO and the EU and have major policy and resourcing

implications[2]. The social and cultural forms of capital possessed by those who fail, because of their low general literacy, to pass professionally-set knowledge tests of functional health literacy, are being ignored, say Adkins and Corus. These individuals are being characterised, however implicitly and politely, as having deficiencies that need eliminating or at least reducing. 'A substantial amount of research concludes low literate individuals are incapable of taking on the tasks associated with healthcare and such disempowering depictions of low literates propagate stereotypes and biases toward the undereducated and perpetuate disparities and gross inequities in healthcare services…Those who fall short of standard expectations experience denigration, leaving them with no command for social respect.' The experiences of symbolic violence create concerns of being ridiculed and these manifest themselves in avoidance and other strategies inimical to optimal healthcare decision making, producing consequences such as non-adherence.

In this paper we accept the validity of this argument, but move away from its concern with low general literacy to argue that failing to recognise and exploit a particular form of functional *decision* literacy, in fact leads to symbolic violence being experienced by individuals at *any and all* levels of general literacy. It leads many to adopt the same range of avoidant and other undesirable strategies within healthcare situations observed in those of low basic literacy. Our alternative response exploits that form of generic decision literacy. It offers support that does not imply that only an 'informed choice' can be a good decision, with 'being informed' defined professionally. It focuses on the vacuum left at the Point of Decision in the formal definitions.

The argument is most effectively made with reference to what we see as the current orthodoxy within the decision-aiding branch of health informatics. This orthodoxy is grounded in the IPDASi guidelines [3], but encompasses the specific interpretations in publications that proclaim their adherence to them. We can also endorse the conclusion of Joseph-Williams, Elwyn and Edwards, reviewing research into the patient experience, that knowledge is not power, and that information is not in itself empowering unless deployed (deployable) within a more equal clinical power relationship [4]. But we disagree with their assumption that knowledge in the conventional form is to be regarded as a necessary condition, albeit now one of two. We argue that supplying the information in a particular 'unconventional' form and integrating it with the best available estimates, will enable the patient to arrive at an informed decision, even if they know nothing about its content in the sense the orthodoxy seeks. Some patients will wish to engage in the orthodox way. We are concerned with those who will experience this requirement as symbolic violence, as a result of which they will adopt attitudes and behaviours not conducive to optimal health, self-defined. The relative numbers are not known, but may be large.

Our case for a generic approach may appear to endorse or encourage context-insensitivity. Almost the opposite. The argument is that a generic and widely available 'decision language' is essential if context-sensitivity is to be successfully achieved by the individual patient/person in their lifelong sequence of healthcare decisions. To seek to achieve context-sensitivity without such a generic grounding can lead to the detrimental consequences of the 'symbolic violence' inflicted when it is implied that every decision has to be treated on a one-off basis; that (e.g.) a prostate cancer screening decision has no connection with an atrial fibrillation treatment one; and that general decisional empowerment is not possible.

1. The Orthodox Approach to Decision Aiding and Evaluation of Decision Quality

We can make this point in a specific way by referring to the evaluation of the aids being produced by Karen Sepucha and colleagues. While these aids contain both knowledge and goals/values components, only the knowledge score is available at an individual level, since the values component of quality is addressed only *ex post*, at a group level, and in terms of the relationship between goals and eventual actions (group level concordance). The recent herniated disk decision aid study provides a good example of what is advanced as a decision quality instrument, but at the individual level reduces to a measure of the knowledge possessed by the patient - after administration of the aid [5]. This is naturally the knowledge in the aid necessary for the choice to be regarded as 'informed'. The mean knowledge score from the patients who viewed the decision aid was used to set a 55% threshold for 'informed'.

The argument is essentially circular, but the issue for us is not whether a patient's information is incorrect, while being perceived to be correct. The issue is whether showing that it is incorrect and attempting to correct the misperception by providing the correct information will constitute symbolic violence, without leading to a *better* decision, as opposed to (possibly) an 'informed decision' according to the orthodoxy.

It is important to make clear immediately that we are not arguing against this sort of condition-specific information being made available in a decision aid and making it available in the form it is usually provided. Indeed we are in favour of making it available on an opt-in basis, probably via links, and possibly even with some weak nudging towards consulting it. We embed our decision aid, based on Multi-Criteria Decision Analysis, (MCDA) in a wider program, MyDecisionSuite, which offers many opt-in customisation possibilities as well as the personalisation for the aid itself [6,7]. We are arguing against any implication that consulting information, retaining it, and attempting to synthesise it with personal preferences, are *necessary* conditions of a good decision, let alone the sufficient conditions implied by prominent decision quality measures.

In our alternative, information essential to a good decision *is* present in the aid, but it is present in a matrix of option performance rates on multiple criteria. This matrix format is familiar to all those possessing the generic decision literacy that enables them to engage with product and service comparison websites. Even then the information matrix is made available only on an opt-in basis, because we do not want to imply that consulting it, and processing it in a way usually referred to as 'making up one's mind', will lead to a better decision. We remain largely agnostic on that, in the same way we remain agnostic whether a decision informed in the orthodox way will produce a better decision – unless it is assessed by a tautologous outcome measure, that is, one using an individual's score on a knowledge/information test as the measure of decision quality. In order to avoid abdicating from the challenge of measuring decision quality within person-centred care we have offered MyDecisionQuality as a self-reported dually-personalised measure [8].

2. Recognising and Supporting Generic Decision Literacy

This generic decision literacy comes in the form of the ability to access and use the decision-relevant resources provided for many consumer services and products on comparison websites and magazines. The methodology on these sites is almost always the simple form of multi criteria/attribute analysis in which the product's ratings on

multiple criteria are combined with criterion weights (supplied by the site) to produce scores and 'best buys' and 'good value for money' verdicts. A large proportion of the population is familiar with this framework and language, its widespread commercial use and popularity of associated sites (e.g. comparethemeerkat.com) providing the most convincing evidence of this. Over 80% of consumers are reported to have consulted a comparison website in 2010, so the number is likely to be even higher now [9].

In Figure 1 (bottom panel) we enter the ratings for three anonymised free standing washer-dryers that appeared in a recent Which (UK) consumer magazine report on 16 such appliances. Five criteria were rated and weighted to arrive at the overall score. Price was listed separately and not weighted, leaving that trade-off to the consumer.

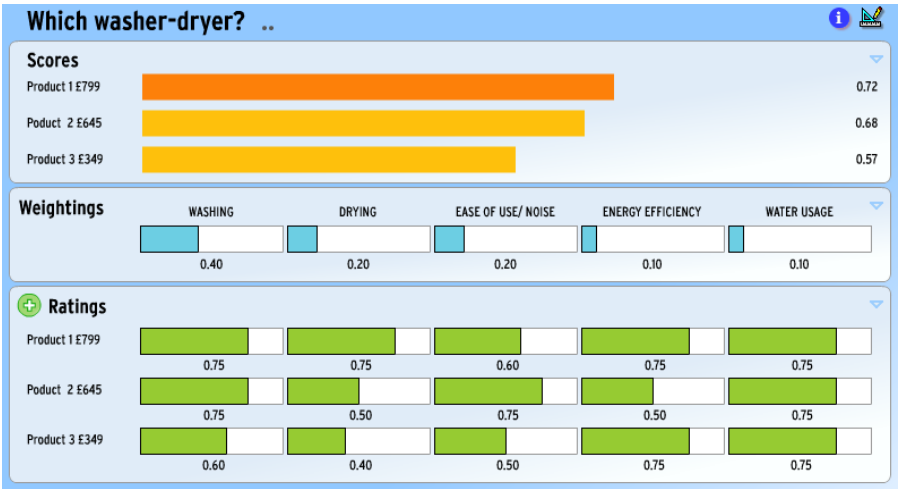

Figure 1. Ratings, Weightings, and Scores for three anonymised Washer-Dryers from a consumer magazine report re-presented in MCDA format

We do not endorse the particular framing (criterion selection and weightings) and use it only as an example of the sort of content presented in such comparative reports.

The Scores are the expected value of the Ratings and Weightings. Amid all the attempts to improve decision making and information communication, a central concept - expected value - has not received the attention needed even if the objective is to argue against it. We attribute this to the overarching reluctance to address the question of how information should be synthesised with preferences in any explicit way. Such an approach represents a form of reverse symbolic violence, implying that a proper person possesses high quality synthesising ability as an intuitive competence.

While these comparison sites increasingly include ratings and scores for medical devices and health products apps, they avoid evaluations of healthcare options that would involve weightings for criteria such as length of life. That is what our alternative approach, where the options become ones such as lifestyle change, medications and surgery and the attributes ones such an quantity and quality of life and treatment burden. While suggesting that health care decisions may be appropriately approached in the same way as buying a washer-dryer will be surprising if not appalling to some, there are three very good reasons for this extension to healthcare. (It is hopefully clear why the example must not be a healthcare one.)

Since it recognises and exploits a widely possessed type of generic literacy, the alternative not only has less potential to produce symbolic violence but simultaneously greater potential to empower the person. Such empowerment is a precondition of the person owning the decision (whether or not it is in some way shared), which increases the likelihood that the option decided upon will be adhered to subsequently. Whether there is greater concordance in relation to that chosen option is an open question. This will be determined by many things including the clinician's attitude and commitment to person-centred care, as well as quality of both the aid and the discourse surrounding it.

The orthodox approach cannot deliver person-centred care. In person-centred healthcare the relative importance of the considerations that matter to the person in their life is elicited and combined, at the point of decision, with the best estimates available on the performance of the available options on those criteria. This integration is performed in an explicit way which can be communicated to the person. Any prior comparative option evaluations, such as those that constitute the conventional 'evidence base' cannot be part of this process. The ethics of transparent person-centred care require 'evidence base' to be reconceptualised as the unsynthesised matrix of option performance rates for the person-important criteria mapped against the person's criterion preferences [10]. Our approach is therefore not only compatible with person-centred healthcare, it is actually the only way we can see transparent and direct decision support for it being delivered.

Emphasising the generic character of all healthcare decisions enables the individual to visualise any healthcare decision, whatever the condition (or set of conditions) in the same way, rather than it being implied that they need to know a lot about their breast or prostate cancer or whatever. They can then exploit their social and cultural capital which exists because their friends and contacts 'speak the same language' at a decision level. Irrespective of the biological specifics. And that generic competence extend through the life course, so that a sequence of decisions about contraception, birthing technique, and menopause management, as well as any morbidities that arise in the life course, can all be thought of and discussed socially within the same graphic structure.

Professionals already possess this generic decision literacy, so the task should be the simple one of recognising that it should be applied to their area of professional expertise, not just in their domestic life as a consumer. This does not mean writing off their other 'knowledge capital', but it does mean complementing it in order to engage with persons who do not possess it and are at risk of symbolic violence.

3. Reflections

While our focus is on the micro and meso levels, we can speculate about the wider systemic origins of the focus on this particular type of functional health literacy, rather than generic decision literacy. Among the most important macro origins would seem to be the demands for methodological rigour in studies used to justify policy level decisions with financial implications, such as on drug reimbursement or decision aid provision. The dually-personalised measures appropriate for person-centred care do not provide 'hard' criteria, able to be aggregated for groups. Possession, or not, of a proposed set of essential facts, especially about the improvements offered by a new drug or device, is eminently fit for purpose, *given this purpose*. But we question who should define what and how much information is important in person-centred care [11] and sug-

gest reconceptualising the person - previously known as patient [12] - as a researcher engaged in an n-of-1 study for optimal health behaviour choices [10].

Health informaticians interested in supporting person-centred decision making and care at all points in patient pathways, including health records and decision aids, need to acknowledge, accept, accommodate, and adopt MCDA-based approaches to transparently document, support, and evaluate healthcare decisions.

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