Driving Quality in Informatics: Fulfilling the Promise

Editors: Karen L. Courtney
       Alex Kuo
       Omid Shabestari

IOS Press
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Preface

“If you build it, they will come.”

In the past, this seemed to be the dominant paradigm for technology development and implementation in healthcare. This initial paradigm often led to poor user satisfaction and failed implementations of healthcare information technology. In the last few decades, informatics has embraced user-centered design principles to improve both the design and adoption of information and communication technologies. However, frequently the end-user is perceived to only be the clinician.

Although the data in healthcare are about and are received from patients, patients are not usually perceived of as end-users of health information or health information technology. In the popular press, we are seeing a grass-roots effort from patients to change their role in their own health management. A change to a more dynamic partnership with clinicians means we need tools that are able to support patients as well as clinicians in this partnership. New online tools and mobile applications are sprouting up to fill the demand, but rigorous evaluation of these tools can be lacking; leading to questionable quality and concerns for patient safety. The informatics field has the expertise to provide critical leadership in this area.

The call for this year’s conference asked for authors to consider the role and voice of the patient. Patients themselves were invited to contribute papers describing their experiences in healthcare and their use of their own data. The papers here reflect not only the informatics innovations in the field, but also explore how to include the patients when considering design, implementation and long-term adoption of health information systems.

We hope that the knowledge shared between ITCH 2015 participants will generate further discussions and collaborations and lead to breakthroughs in delivering effective and inclusive healthcare worldwide.

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The Impact of University Provided Nurse Electronic Medical Record Training on Health Care Organizations: An Exploratory Simulation Approach

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Abstract. Training providers appropriately, particularly early in their caregiving careers, is an important aspect of electronic medical record (EMR) implementation. Considerable time and resources are needed to bring the newly hired providers ‘up to speed’ with the actual use practices of the organization. Similarly, universities lose valuable clinical training hours when students are required to spend those hours learning organization-specific EMR systems in order to participate in care during clinical rotations. Although there are multiple real-world barriers to university/health care organization training partnerships, the investment these entities share in training care providers, specifically nurses, to use and understand EMR technology encourages a question: What would be the cumulative effect of integrating a mutually agreed upon EMR system training program in to nursing classroom training on downstream hospital costs in terms of hours of direct caregiving lost, and benefits in terms of number of overall EMR trained nurses hired? In order to inform the development of a large scale study, we employed a dynamic systems modeling approach to simulate the theoretical relationships between key model variables and determine the possible effect of integrating EMR training into nursing classrooms on hospital outcomes. The analysis indicated that integrating EMR training into the nursing classroom curriculum results in more available time for nurse bedside care. Also, the simulation suggests that efficiency of clinical training can be potentially improved by centralizing EMR training within the nursing curriculum.

Keywords. Nursing, EMR, training, curriculum, informatics, education

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Introduction

Electronic medical records (EMR) are increasingly prevalent on the health care delivery landscape, both in North America and globally. EMR technology has been shown to increase organizational efficiency, promote patient safety, increase consumer access to personal health information, and provide support for provider to provider communication, as well as patient to provider interaction [1]. Use of EMRs has been accelerated by the Health Information Technology for Economic and Clinical Health Act of 2009 in the United States which allocated $27 billion dollars to help doctors transition from paper medical records to electronic medical records (EMR) systems or electronic health records (EHR) systems. Physicians must show meaningful use of these systems and will be assessed penalties for not adopting an EMR system by 2015 [2].

Corporate and consumer interest in increasing productivity, improving outcomes, and enhancing marketplace competitiveness has also provided an impetus to EMR adoption. However, there is also evidence that implementation of EMR systems is a complex process involving multiple stakeholders, and that when EMR systems are not effectively designed or integrated into workflow the results can be negative [3-4]. Collectively, the literature surrounding EMR use and implementation clearly indicates that human factors such as provider training, experience and interaction with technology influences the safety and effectiveness of these systems.

Training providers appropriately, particularly early in their caregiving careers, is an important aspect of EMR implementation. The wide variability in existing systems and stages of use adds an element of complexity to the EMR training process. Organizations may hire experienced clinicians who have years of experience with EMR technology, but the system they have been trained to use may differ considerably from the system used by the current employer. Conversely, organizations may hire new graduates who have received training in EMR use during their educational careers that does not mimic current real-time technology. In either case, considerable time and resources are needed to bring the newly hired providers ‘up to speed’ with the actual use practices of the organization.

Similarly, universities lose valuable clinical training hours when students are required to spend those hours learning organization-specific EMR systems in order to participate in care during clinical rotations. University systems are charged with training future clinicians in EMR use in order to prepare them to thrive in the current practice environment, as well as allow them to provide safe care within the organizations that participate in clinical training programs. Nursing students, for example, participate for short periods of time in numerous clinical settings (hospitals, nursing homes, community clinics), each of which may have different EMR systems and requirements. Universities can provide students with generalized informatics training, but the training may not be entirely consistent with the systems used in each clinical training site.

Health care organizations are responsible to orient care providers to effectively use their currently implemented system, and must expend valuable resources and productivity hours when nurses and other clinicians are removed from the direct caregiving role to attend necessary training. Universities are responsible for providing students with generalized informatics knowledge, but lose valuable resources and clinical training time when students are removed from bedside experiences to attend organization-specific EMR training. Although there are multiple real-world barriers to
university/health care organization training partnerships, the investment these entities share in training care providers [7,8], specifically nurses, to use and understand EMR technology encourages a question: What would be the cumulative effect of integrating a mutually agreed upon EMR system training program in to nursing classroom training on downstream hospital costs in terms of hours of direct caregiving lost, and benefits in terms of number of overall EMR trained nurses hired?

Ideally, this question would be tested using a multi-site intervention-based trial, with a study design that controls for the variability between organizations while also assuring some uniformity of resources between study sites. The study would require a training partnership between health care organizations, universities, and the nurses in training. Numerous barriers exist to studying this question using a prospective, intervention based research trial design. First, implementation of EMR’s into curriculum is costly. Faculty would need to be trained, computing program access would need to be assured, and well-developed curriculums would need to be modified for short term evaluation of the model. Resources vary between universities, and the cost of creating a minimal level of uniformity would be high and potentially disruptive. Nursing faculty are currently in short supply, and taking time to conduct such a study may not be feasible. Second, given the variability in the United States (US) health care system, the benefit for health care organizations may be minimized by students not choosing to enter the organization as employees post-graduation. Similarly, students may not be interested in participating in such partnerships, and seek employment elsewhere once the training has been completed.

Despite these barriers, this question of mutual benefit through partnership in EMR training is worthwhile. Students could potentially achieve seamless integration into employer EMR systems, faculty time up-front may increase but over time may decrease as student clinical orientation time is streamlined, and health care organization may develop a pool of future nurse hires that are not in need of costly, time consuming EMR training. An identified, published account of the experiences surrounding training nursing students at a single university in the US on the EMR system for a single hospital demonstrate that such a curricular partnership is possible [5]. However, a hypothesis-driven evaluation was not included in the program design, and study outcomes were not clearly measured. The cumulative effects of such a partnership represent a gap in current knowledge.

1. Methods

In order to inform the development of a large scale study, we employed a dynamic systems modeling approach to simulate the theoretical relationships between key model variables and determine the possible effect of integrating EMR training into nursing classrooms on hospital outcomes. The computer simulation model was specified using the STELLA program package. Simulation modeling involves the development of model that represents important aspects of the system under evaluation. Once validated, the model can be used to study the effects of changes in inputs to the system or modifications to its structure. Simulation is particularly useful in situations where the system or process being studied is too complex to be evaluated with traditional analytical techniques [6].

The model (see Figure 1) was designed to estimate the number of EMR trained nurses that are newly hired by the hospital, and the subsequent time away from
Caregiving activities that will be required to train newly hired nurses. It was hypothesized that as more nurses enter practice who have experienced the integrated university curriculum, less training time would be required from the organization to train new hires. While the hypothesis may seem intuitive, the simulation approach allows us to go beyond determining if EMR integration has an effect on hospital outcomes, and allows for a mathematical understanding of the rate and cumulative effects of systems changes over time. Model specification included rate of new students enrolled and graduating over 4 years, accounting for student attrition, hires that may come from outside of the proposed university curriculum, and post-hire nurse attrition. For the purposes of this exploratory study, numbers were imputed to allow for relationship to be assessed. Subsequent to the development of this base model, future models can be developed using input from real-world university data. Figure 1 visually displays the simulation model, specified to demonstrate the flow of students into the hospital and IT training system.

2. Findings

The model simulated once a year hiring of nurses over a four year period for a total of 500 new hires, the number of new hires that have already been trained by the university, and the time away from caregiving required to train new hires. Results are shown in Figure 2. Figure 3 indicates how much time off the floor for IT Training could be reduced if more nurses were hired who had received IT training at the university. The analysis indicates that integrating EMR training into the nursing classroom curriculum results in more available time for nurse bedside care. Also, the simulation suggests that efficiency of clinical training can be potentially improved by centralizing EMR training within the nursing curriculum.
Figure 2. Results of simulation model demonstrating cumulative influence of integrated IT training

Figure 3. Cumulative time away from caregiving after IT integration (line 2)

3. Conclusions

As EMR technology becomes more widely implemented in healthcare settings, there is a need to develop educational programs that allow students access to a wide range of information technology. Efforts are underway to modernize integration of technologies such as EMRs into health professional education. Our work using simulation has shown that a wide range of factors need to be considered in making decisions about how to effectively integrate EMRs and other information technology into health professional education. These issues range from logistical factors to cost factors to factors related to resources. This work is limited by the inability to address real-world adaptations to training challenges, such as alternative methods of training that do not result in time away from caregiving. Our model was exploratory, and further research is needed. However, simulation provides a powerful tool to help in decision making about how to best integrate health information technologies such as EMRs into professional education and practice settings.

References


The Importance of Telehealth for Directors and Other Decision Makers

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Abstract. Innovation in healthcare services and clinical service redesign is a must because currently gaps exist between the care that people should receive for disease management and the actual care they receive. Directors and other decision makers should be aware of key challenges in the design, implementation and deployment of telehealth. In this paper, we discuss how telehealth enable chronic disease management, population health management and patient engagement, and what are the biggest challenges with getting value out of telehealth.

Keywords. Telehealth, chronic disease management, decision makers.

Background

In England, it is estimated that more than 15 million people live with a long term condition [1]. This group, roughly account for 50% of all GP appointments, 64% of outpatient appointments and 70% of all inpatient bed days [2]. In total, 30% of the population account for 70% of the total healthcare spent (£7 out of every £10). Figures in the rest of the world are similar. For instance, in the USA, chronic diseases cause 7 in 10 deaths every year, nearly 1 in 2 adults live with at least one chronic illness, and more than 75% of health care costs ($3 of every $4 spent on healthcare) are due to these conditions [3]. Furthermore, estimations predicted that in 2020, 66.7% of all deaths (7.63 million) in India would be as a consequence of chronic diseases [4].

By introducing telehealth services, it is expected that healthcare systems will become more efficient through better use of the existing workforce and other resources [5][6][7]. In fact, telehealth services can be used to provide remote support and patient education. Decreasing referral waiting times and costs [8] are expected as a result of relocating patients from secondary and tertiary care to primary care and home settings. Moreover, the Veterans Health Administration (VHA) indicated that telehealth cannot only significantly reduce costs, but also can reduce hospital bed stay and admission rates [9].

Currently, telehealth is acknowledged to have the potential of being adopted by a significant number of healthcare systems across the world. For instance, by 2010, Canada reported 5,710 telehealth systems in place which serviced the 21% of the Canadian population who lived in rural or remote areas [10]. Other countries such as Australia [11], England [12], Norway [13], Scotland [14], and USA [15] among others,
have also contemplated different forms of telehealth at local or national level for service modernization and research.

1. How can telehealth enable chronic disease management, population health management and patient engagement?

The ageing population, especially the subgroup with multiple chronic conditions, is highly resource-intensive due to increased hospitalizations, longer length of hospital stays and the requirement for increased attention and monitoring [16]. As an innovative intervention, telehealth can be applied outside of healthcare facilities where home environment becomes the usual care scenario. On such settings, telehealth is distinguished by the need of active commitment of patients (or people to be supported) in the adoption of telehealth technology, and in handling self-management for their own care.

Innovation in healthcare services and clinical service redesign is a must because currently gaps exist between the care that people should receive for the management of chronic conditions, and the actual care they receive. Ways in which telehealth systems can support and improve the patient’s care are mentioned below.

1.1. Changing attitudes to and of patients within health care

This can be done by transforming the classic models of doctor-patient relationship described by [17], from activity-passivity to guidance-cooperation and to the ultimate model, mutual participation. This requires that doctors or other health professionals inform, educate, support and help patients themselves to play the main role in day-to-day monitoring and management of symptoms resulting from chronic diseases. An example of sharing doctors’ notes with patients (enabling patient communications and education) using telehealth can be consulted in www.myopennotes.org.

1.2. Providing information needs and building health literacy

This can be achieved by ensuring what patients really understand, tailoring and personalizing information, and by providing the right formats and technology that support simple and easy-to-read health information (see http://www.optiongrid.org as an example).

1.3. Assessing patients for health confidence and health activation as well as significant emotional problems

This should be a starting point for disease management. Telehealth can incorporate such assessments into an efficient and well integrated information system tailored to the specific needs of chronic disease treatment programs.

1.4. Supporting self-monitoring

Self-monitoring “provides the foundation for self-management” [18]. Systematic recording of information (for example physiological measures) can be used to increase
patients’ awareness of their measures, and how these can change over time. It can also be used for identifying other problems that affect the medical condition being monitored, and for helping patients to recognize whether they are reaching their goals.

1.5. **Supporting self-management programs**

There is a growing potential for provision of self-management in both via the internet and the telephone. Healthcare providers can Assess, Advice, Assist, Arrange and Agree with their patients a systematic medical plan (the 5As approach) [19]. This can be done by increasing healthcare access to patients with long term conditions, especially in rural and remote areas without clinical or community settings available.

1.6. **Engaging and empowering patients and their relatives**

This can be done by directly connecting patients to care givers, and personalizing services in response to the unique needs and preferences of patients. Helius is an interesting telehealth example (see http://www.proteus.com), which supports care delivery throughout the treatment cycle by enabling real-time information about medication-taking, rest and activity of patients.

1.7. **Giving access to EHR and PHR**

This can make patients feel more prepared for clinical encounters, ask more relevant questions, know more about their health care, and more likely to take further steps to improve their health. For this reason, telehealth applications should be integrated into an Electronic Health Record (EHR) or a Personal Health Record (PHR). A robust and trustable application that gives access to personal health information from EHR is the Veterans Affairs Blue Button (http://www.va.gov/bluebutton).

1.8. **Supporting Population Health Management**

This helps to detect inappropriate resource utilization, to identify patients at risk, and to avoid delay in access to care services. This can be done by integrating telehealth as part of the model for clinical information exchange which can help to evaluate patient data, send alerts to case managers or care coordinators, provide feedback reports to clinicians, and to send reminders to patients or their carers.

2. **What are the biggest challenges with getting value out of telehealth?**

Directors must be aware that the design, implementation and deployment of telehealth is not straightforward. Moreover, “the evidence base for the value of telehealth in managing chronic diseases is on the whole weak and contradictory” [20]. From a research based on the context of an EU Framework project – REALITY (Representative evaluation of evolving remote home-based patient monitoring delivery – QLG7-2002-02657) – it is concluded some key challenges in the development and implementation of telehealth:
2.1. **Staff training**

Doctors may resist ICT adoption if they perceive any loss of autonomy, status, or change in their role as practitioners. Training and early user inclusion is definitely a key factor in the success of telehealth.

2.2. **Project management**

Implementing change is hard. Values, norms, and roles are involved in the change, which is seen as an expression of interactions, conflicts and relationships among health care professionals. A dedicated project manager with good leadership skills needs to be identified and proper assessment of the amount of staff time to carry out telehealth work should be estimated.

2.3. **Patient and provision of support**

Patients’ expectations about living independently are high and make telehealth very attractive. Individual requirements such as disease conditions, demographics including socio-economic status, comorbidities, and any other impairment should be considered in the design of a telehealth intervention and to support personalization. Patients should receive training and be evaluated on regular basis in order to become more competent in using telehealth technology.

2.4. **Technology**

Purchasing of compatible hardware, software and IT equipment, as well as choosing appropriate IT vendors are some of the most challenging issues. In order for telehealth to perform well, it is required to adopt a need driven approach rather than an approach being driven by technology. IT vendors should be chosen on their ability to provide maintenance, replacement, interoperability, accountability and training. In addition, the technology should be safe, easy to use, secure, accessible, and be able to integrate patient data into the Electronic Patient Record (EPR) so an accurate clinical decision and treatment tailored according to the needs of patients can be made from the EPR.

2.5. **Risk analysis**

The risk in telehealth systems depends on a combination of type of users, circumstances of use, type of use, and nature of the system. There is not a specific clinical risk guideline for telehealth, but the former NHS Connecting for Health published a guidance (DSCN 18/2009) related to the deployment and use of health software that can be used for identifying clinical hazards and controlling the risks of new systems.

2.6. **Funding**

Telehealth projects are usually supported by short-term (non-recurrent) funding. Reimbursement policies are yet on debate. It may be the case that IT in healthcare does
not provide direct business performance (no return on investment), but may enable other parts of the healthcare system that generate other benefits [21].

3. Conclusions

Those responsible for commissioning and running hospitals can make a difference to the health and wellbeing of the most vulnerable and at-risk populations; in particularly for patients with long term conditions. Telehealth is a rapidly evolving and growing field, however adoption should be taken with caution as evidence for telehealth, in terms of cost-effectiveness and quality of life improving, is yet to be determined.

References

Using a Digital Marketing Platform for the Promotion of an Internet Based Health Encyclopedia in Saudi Arabia

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Abstract. The objective of this paper is to investigate the experiences of using a digital marketing platform to promote the use of an internet based health encyclopedia in Saudi Arabia. Key informant interviews, meeting documentation, and Google Analytics were the data collection sources used in the study. Findings show that using a digital marketing platform led to a significant increase in the number of visitors to the health encyclopedia. The results demonstrate that digital marketing platforms are effective tools to be used for promoting internet based health education interventions. Future work will examine long-term educational impacts and costs in using digital marketing platforms to promote online healthcare sites in Saudi Arabia.

Keywords. Digital marketing, health encyclopedia, health education

Introduction

Digital marketing platforms offer organizations the opportunity to expand their consumer base. There are a number of different companies that provide digital marketing services. For example, the Google digital marketing platform provides DoubleClick Digital Marketing (DDM), which is an “integrated ad-technology platform that enables agencies and advertisers to more effectively create, manage and grow high-impact digital marketing campaigns [1]”. Other digital marketing platform...
companies also provide similar services such as Hub-spot, Exact-target, Marketo, Marin Software, and Vocus [2]. There are also digital marketing companies that provide services to healthcare providers such as BrightWhistle which is a digital marketing platform provider that focuses on providing digital marketing services to healthcare providers. Their services focus on increasing the number of patients to private for-profit hospitals through the use of digital marketing platforms [3].

For years, the development of websites with trustworthy health information in the Arab world has been neglected. Much of the available Arabic health information has focused on a particular healthcare organization’s goals, services, and policies [4]. A study conducted by Al-Tuwaijri determined that, of the 122 Arab health websites evaluated in terms of providing high quality health information, only five provided trustworthy health information to the Arab consumer [4]. As a result of this research, various healthcare organizations within the Arab world began to develop health information websites that are trustworthy and credible to improve health literacy and empower patients. A study conducted in 2012 on how Saudis use online health information found that 58% of those surveyed used the internet to search for health information [5]. In the study, most patients discussed the health information found online with their physician and believed that sharing such information improved patient-physician relationships.

With the proliferation of Arabic Health websites catering to the growing need of Arabic health information, there is a need for trustworthy and credible health information in Saudi Arabia. A major issue with these health websites, especially in Saudi Arabia, is attracting enough visitors to the website to justify their presence. The objective of this paper is to investigate the experiences of using a digital marketing platform to promote the use of a web-based health encyclopedia in Saudi Arabia.

1. Background

King Abdullah Arabic Health Encyclopedia (KAAHE) is an online health portal that delivers trusted health information for Arab speakers throughout the world [6,7]. The King Abdullah Arabic Health Encyclopedia (KAAHE) portal includes thousands of pages of textual and interactive content. Those pages are written in plain language that is easy to understand by different community groups and can be browsed on computers, tablets and mobile phones. King Abdullah Arabic Health Encyclopedia (KAAHE) is organized in different interactive sections such as: Symptom checker, Health Calculators, high quality 3D Human body and several medical topics relating to diseases, healthy life style, diagnosis and treatment, news and events [6,7]. KAAHE addresses the general population, professionals, as well as students. It serves more than 300 million Arabic speakers in all parts of the world with an interactive electronic portal, promoting health through a simpler language using evidence based information to serve Arab citizens around the world [6, 7].

In 2010, the idea of the project was presented to His Royal Highness Prince Muqrin bin Abdul Aziz, honorary president of the Saudi Association for health informatics, who in turn presented it to the Custodian of the Two Holy Mosques King Abdullah bin Abdul Aziz, who approved the project and gave his directions to allocate a budget for it. The Ministry of National Guard Health Affairs (MNG-HA) was to administer the project in cooperation with the Saudi Association for Health Informatics. In order to ensure that the encyclopedia follows the best international
quality standards, a variety of agreements with different international organizations (e.g., Health on the Net Foundation, Geneva University, and the Patient Education Institute) were signed. KAAHE’s website was launched during the Saudi E-Health Conference held in Riyadh 11th of March 2012 [6, 7].

In the first three months of its launch the number of users remained low at 5000 users a week. This was due to the fact that users can only benefit from King Abdullah Arabic Health Encyclopedia (KAAHE) services if they knew the exact URL address. During this period, the project team relied on conventional promotional campaigns including Ads, brochures, and visits to hospitals and clinics. In order to improve the visibility of KAAHE, the project team realized the need for developing a promotion strategy that would use a digital platform. Three months after the launch date, the project team identified the following issues: 1) Limited number of website users; 2) Lack knowledge about the website; 3) Limited website content; and 4) Not meeting the objective of being the most trusted Arabic health resource on the internet.

2. Methodology

The study used a case study approach while collecting data from a variety of sources including two key informant interviews, KAAHE project documentation, experiences of the researcher in working with KAAHE, and Google Analytics. The data was collected between February 1 and March 30, 2014.

3. Results

3.1 Committee Formation for Marketing Plan

In June of 2012, a committee was formed to suggest ways to increase the number of visitors to the site. Although there was some level of awareness through traditional methods such as press coverage, brochures, and information booths, more work was needed for promoting KAAHE. The committee conducted a SWOT Analysis and agreed on several steps to take: 1) Establish a KAAHE promotion team; 2) Set up a promotion strategy plan to guide the promotion team; and 3) Use digital marketing platforms to promote KAAHE in the Arab world.

A team of four KAAHE employees were tasked with the duties of creating a digital marketing platform using social media (Twitter, Facebook, Google+, and YouTube Channels). The group developed a plan to use social media to develop different types of posts relating to male health, women’s health, child health, and to provide announcements on KAAHE events that were taken place in Saudi Arabia.

Second, the team agreed to develop a KAAHE mHealth application that could be downloaded through the iPhone and Android platforms, which will improve the accessibility of KAAHE to the public. Third, the promotion team contracted with Google Ads to give priority to KAAHE when users were searching for medical information in Arabic. Fourth, an e-mail address for users to ask health related questions answered by healthcare professionals was created. Fifth, active e-mailing groups were solicited to share information about KAAHE.
3.2 Increases in the Number of Users

Using a digital marketing platform solution for health promotion showed a significant increase in the number of users to KAAHE subsequent to the digital promotion campaign. Figure 1 shows the September, 2012 to October, 2012 time period which indicates the number of users prior to the implementation of the digital marketing campaign. In this period, there were a limited number of visitors to KAAHE. After implementing the digital marketing platform, there was a significant rise in the number of user between November, 2012 and December, 2012, with fluctuating peaks. Ninety percent of the increase in visits was attributed to Google Ads. Today, there are over 50,000 daily visitors to KAAHE from across the Arab world, where the highest number of users come from Saudi Arabia and Egypt. The implications of having increased users to KAAHE are: 1) increased health awareness in the Arab world; 2) raised health literacy in the Arab world; and 3) the discussion of health issues that were considered sensitive in the Arab world.

![Figure 1: Weekly Visits to KAAHE, Before and After.](image)

4. Discussion

Based on our study, results show that the use of digital marketing platforms can increase the number of visitors. Our study showed a significant increase in the number of users to KAAHE when using multiple digital marketing strategies such as social media, e-mail lists, Google Ads, optimized search strategy, and Mobile Apps. Today, KAAHE is the leading and most credible health information source in the Arab world. This work adds to the growing body of research in the area that looks at using social media and mHealth technologies in healthcare [8-14].

Future work will provide analysis of the most effective digital marketing strategy that generated the largest number of visitors to KAAHE. Furthermore, more detailed analysis of the number of visitors for the 2013 and 2014 years are being analyzed. Future work will also include other information relating to the costs associated with the use of digital marketing platforms to promote health websites [15].

There are also several limitations to this research. First, generalizing the study findings to other healthcare platforms in the Arab world or elsewhere should be conducted with caution. Second, the primary researcher of this study is also part of the KAAHE digital platform promotion team, which subjects this work to researcher bias.
Third, more data collection is needed to further substantiate the findings suggested in this paper. Future studies will address the above mentioned limitations of this research by expanding the number of data collection sources which will further validate the findings.

5. Conclusion

Utilizing technology to advertise and conduct digital promotional campaigns has dramatically increased the number of users to the KAAHE website. The use of digital marketing platforms is leading to increased health awareness and literacy in the Arab world, and specifically, Saudi Arabia.

References

A Pharmacy Inventory Management System in Saudi Arabia: A Case Study

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\textbf{Abstract.} The objective of this paper is to report preliminary findings of the implementation process of a pharmacy inventory management system at a local Saudi hospital. Meeting documents, key informant interviews, and experience of the researcher were part of the data collection sources used in the study. A thematic analysis of the data was conducted. Preliminary findings show that the implementation process of the pharmacy inventory management system needs the involvement and support of senior management and experienced technical expertise. Future research will focus on investigating the impacts of the pharmacy inventory management system on workflow and medication errors.

\textbf{Keywords.} Stock management, pharmacy, information system, Saudi Arabia

\textbf{Introduction}

Pharmacy systems need to monitor medications inventory levels and predict future order and reorder intervals. The daily consumption of medications needs to be tracked by a Pharmacy department to evaluate the future demand for prescription drugs. Gebicki et al, evaluated hospital medication inventory policies and found that pharmacy departments which incorporate drug characteristics when ordering pharmaceutical drugs can address the compromise between patient safety and cost [1]. Wilson, in 1992, presents a case study on the two-year goals of the department of pharmaceutical services at Sioux Valley Hospital to reduce costs through improved prescription drug inventory management. By using the available computer technology at the time, the hospital was able to decrease inventory by 10 percent while maintaining high quality services [2]. This paper reports on the implementation process of a pharmacy inventory management system at a local hospital in Saudi Arabia.

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1. Background

The pharmacy department is one of the departments under Prince Sultan Medical Military City (PSMMC). There are four main pharmacies and six satellite pharmacies under PSMMC open during the weekdays for 9 hours a day. The main pharmacies are responsible for providing inpatient pharmaceutical services within PSMMC sites during the weekends and night-shift as well as providing medication supply to other departments (ward stock) within the hospital.

The pharmacy department manually monitors medication inventory levels within the hospital pharmacies. The pharmacy department requests medication inventories from the logistical department based on average monthly usage, inventory control recommendations, and medication availability on pharmacy shelves through paper and a computer system. This system was done through a combination of several procedures including paper-based forms and manual entry of pharmacy information through a standalone in-house application that is not integrated with the main pharmacy system [2, 3].

2. Study Design

2.1 Study Setting

Prince Sultan Medical Military City (PSMMC) is a tertiary hospital with a 1200 bed capacity. PSMMC is the main military hospital in Riyadh, Saudi Arabia providing healthcare services to the Ministry of Defense employees and their dependents. PSMMC is funded and directed by the Medical Services Department (MSD), Ministry of Defense (MOD). The study was conducted at the PSMMC pharmacy department.

2.2 The Technology

Pharmacy Stock Management System (PSMS) is a software application that monitors and controls hospital drugs and medication stock levels. Applications are installed on pharmacy staff computers in order to distribute a concurrent access to the PSMS.

2.3 Methodology

A case study approach was used in this study. Case study research appears in the social sciences, health informatics, and the ICT literature. A widely accepted research methodology, it serves to describe the real-life context in which an intervention has occurred and demonstrates the details of participant viewpoints through the use of multiple data sources [5].

2.4 Data Collection and Analysis

Pharmacy management inventory system documentation data, key informant interviews, and meeting documentation were the data collection sources used in the study. Three key informants were interviewed: a pharmacy manager, a pharmacy stock coordinator, and a pharmacy informatics coordinator. A thematic analysis of the data was conducted. The data was collected between September 2013 and October 2013.
3. Results

3.1 Issues Prior To PSMS Implementation

Prior to the implementation of the pharmacy inventory management system, there were a number of issues that were causing delays in service such as:

- Stock management business process is not easy to understand and design.
- Lack of stock management knowledge and needed expert staff.
- Miscommunication due to the number of departments involved in the business process.
- Military Management, routine paperwork and slow workflow due to inflexible centralized management.
- Delayed Pharmacy store and stock control staff training.
- Staff resistance to change.
- Network infrastructure and lack of IT support and cooperation.

3.2 PSMS Implementation

Pressure from the medical administration as well as patient complaints pushed management to look for an urgent solution. Disruption of both work flow and patient’s lives were the motivating factors for the Directors of Pharmacy and Logistics departments to raise and escalate the issue to higher management. At that time, Pharmacy managers were assigned to find a proper intervention as everybody was affected including Director of Pharmacy, Director of Logistics, physicians, patients and top management.

The design of the pharmacy inventory management, based on the requirements of the users had to meet a certain conditions, including:

1. Adaptation to user needs.
2. Support and backup the system at remote sites
4. Provide real-time overview of stock reports at all sites.

Furthermore, there were six main stages that occurred during the implementation process: 1) User Requirement Phase; 2) Technical Requirement phase; 3) Testing and Validation Phase; 4) Pharmacy/Logistic staff and training; 5) “Go-Live”; 6) Certificate of completion phase.

4. Lessons Learned

4.1 Improve organization workflow

Implementing a Pharmacy Inventory Management System led PSMMC to improve the monitoring of pharmaceutical supplies and minimize supply shortages. Early indications show improved workflow throughout the pharmaceutical department as a result of the new system. More work is needed to improve the workflow department with the addition of new systems to improve pharmaceutical services within PSMMC.
4.2 Involve senior management to impose new regulations

User acceptance of workflow changes was difficult. Official letters were distributed to all departments forcing them to comply with the new regulations. Management had instructed all staff encountering difficulties to manage their time between training and work duties and to report their individual issues to the department for further assistance. Involving senior management helped improve the uptake of the system by users.

4.3 Utilize technology resources to provide a better service to your patients

Monitoring the pharmacy drug supply through a manual process was a challenge due to the difficulty of efficient inventory monitoring. With the implementation of the new technology, pharmacy managers were able to monitor medication inventory levels and plan for replenishments of supplies accordingly. At PSMMC, the Pharmacy inventory management system alerted pharmacists about expired medications and drug recalls. Utilizing technology enhanced patient services provided through the pharmacy department.

5. Discussion

This case study investigated the experiences of implementing a pharmacy inventory management system at a local hospital in Saudi Arabia. The work presented the stages undertaken throughout the implementation process. Lessons learned were also discussed. Although the implementation process was challenging, the Pharmacy Inventory Management System helped improve the management of drug inventory levels thus improving pharmaceutical services. This work adds to the current literature on the evaluation of health information systems in Saudi Arabia [6-14].

There are also several limitations about this research. First, generalizing the study findings to other pharmaceutical departments in Saudi Arabia should be conducted with caution. Second, the primary researcher of this study is also part of the implementation team, which subjects this work to researcher bias. Third, more data collection is needed to further substantiate the findings suggested in this paper. Future studies will address the above mentioned limitations of this research by expanding the number of data collection sources which will further validate the findings.

6. Conclusion

The case study examined the implementation experiences of the Pharmacy Inventory Management System at Prince Sultan Medical Military City (PSMMC). It provided information on the stages, steps and process that were followed during each phase of the project. Although there were several challenges during the implementation process, preliminary results show improvements in the management of pharmaceutical inventory levels and improved pharmaceutical services. Where the case study provided an overview of the implementation experiences, there are several limitations to the generalizability of the findings to other settings.
Acknowledgement

The authors would like to thank Dr. Omar Da’ar of the College of Public Health and Health Informatics for his editorial comments and feedback.

References

The Implementation Experiences of a Pharmacy Automation Drug Dispensing System in Saudi Arabia

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Abstract. The objective of this paper is to investigate the experience of implementing a pharmacy automation drug dispensing system in Saudi Arabia. Key informant interviews, meeting documents, and experience of the researcher were the data collection sources used in the study. A thematic analysis of the data was conducted. Study results discuss the organizational challenges prior to implementation as well as details of the implementation process. Preliminary results show improvements in the services provided by the pharmaceutical department. Lessons learned are also discussed. The work presented in this paper is preliminary and more research is needed to evaluate the overall impact of the new pharmacy automation system on services provided by the pharmaceutical department.

Keywords. Drug dispensing, pharmacy workflow, Saudi Arabia

Introduction

Much has been written in both the academic and non-academic literature about hospital pharmacy department automation systems. Within Saudi Arabia, more research is needed to assess hospital pharmacy practice [1]. In 2012, Alsultan et al, conducted a study on the hospital pharmacy practice in Saudi Arabia. Twenty-nine hospitals in the Riyadh region participated in the survey and results showed that pharmacies were improving their dispensing services. The authors also recommended further improvement to hospital pharmacy systems by introducing more technologies such as barcoding systems, smart infusion pumps, and automated mediation distribution. Automating hospital pharmacies can lead to a reduction in medication errors and improve worker productivity by helping pharmacist focus on the treatment of patients and improving health outcomes [2]. The objective of this paper is to present the experiences of a local Saudi hospital in the implementation of a Pharmacy Automation System (PAS).

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1. Background

Prince Sultan Cardiac Center (PSCC) is a cardiac specialized center with 200 bed capacity providing health care services to Ministry of Defense (MOD) patients. Usually, this center is operated with full staffing and bed occupancy. The center is served by one main inpatient pharmacy that operates 24 hours and seven days a week with two satellite pharmacies covering critical care units during workdays (8:00 am – 5:00 pm). Dispensing medications for admitted patients and distribution of these medications is based on a very common pharmaceutical dispensing system called the Unit Dose System (UDS). Moreover, ongoing orders delivered during nightshifts are dispensed done as soon as the pharmacist receives the prescription.

The Pharmacist receives prescription and reviews it for any drug to drug interaction, medication errors, and side effects that might exist. Next, the pharmacist will enter the prescription in the pharmacy system. Third, the pharmacy technician prepares the drugs depending on the labels given by the pharmacist. Fourth, another pharmacist will double check the drug prepared by the pharmacy technician. Finally, the pharmacy porter will deliver the drugs to requesting wards and the nurse will collect it (Figure 1).

2. Study Design

2.1 Study Setting

PSCC in Riyadh, Saudi Arabia, is part of Prince Sultan Medical Military City (PSMMC), which is one of the leading healthcare organizations in the Kingdom. The Pharmacy services department has for years been recognized as a leader in the use of technology to improve pharmacy services within the Kingdom.

2.2 The Technology

System components are made up of hardware and software that are interfaced with pharmacy system. On a hardware level, the system consists of many dispensing stand-alone cabinets distributed among all wards at PSCC. Each stand-alone cabinet contains...
medications where the dispensing processes are controlled and monitored by the system.

2.3 Methodology

A case study approach was used in this study. Case study research appears in the social sciences, health informatics, and the ICT literature. A widely accepted research methodology, it serves to describe the real-life context in which an intervention has occurred and demonstrates the details of participant viewpoints through the use of multiple data sources [3].

2.4 Data Collection and Analysis

PAS documentation data, key informant interviews, and meeting documentation were the data collection sources used in the study. Three key informants were interviewed: a Pharmacy Manager, a Senior Pharmacist and a Pharmacy Informatics coordinator. A thematic analysis of the data was conducted. Data was collected between September 2013 and December 2013.

3. Results

3.1 Issues Prior To Implementation

Prior to the implementation of the PAS, there were a number of issues that were causing delays in the pharmaceutical department, which included:

1. High workload and overworked staff
2. Time delays in dispensing medication
3. Medication Errors
4. Routine paperwork and slow workflow
5. Nurses and Physicians complaining about order delays
6. Pharmaceutical drugs unaccounted for or missing

3.2 Organizational Factors

Pharmacy managers decided to introduce a Pharmacy Automation Drug Dispensing System to improve the pharmaceutical services on both the administrative and medication services levels. On the administrative level, the department was seeking to achieve high standardization levels and Joint Commission International (JCI) certification. On the medication service level, assuring patient safety and clinical data quality was considered to be the most important aspect in pharmaceutical services. Therefore, applying automated system at the center and across all departments was essential to improve the image and services of the pharmaceutical department.

3.1 PAS Implementation

As the healthcare domain is complicated and Health Information Technology (HIT) projects are expensive, pre-implementation costs had been calculated as well as system
customization and service contracts. These were calculated to assure system durability and service continuity with the highest quality at a minimum cost. This project was implemented as a collaboration among pharmacy, nursing, and IT departments. The committee consisted of representatives from the three departments in addition to the pharmacy informatics coordinator.

The project implementation was conducted in the following manner:

- **Kick-off meeting:** The pharmacy department held a meeting with the nursing and IT departments to discuss workflow, design and system requirements.

- **Vendor technical requirements:** Discussions occurred to figure out database configuration, interface requirements, pharmacy systems current situation and locations of network/power outlets.

- **Testing and validation:** After implementation, super users made the demonstration of the implemented system to the end-users. At this stage, pharmacy department submitted desired changes to the system configurations.

- **Pharmacy/Nursing training:** Vendor conducts training for all end-users divided into sessions and groups in addition to self-tutorial training programs installed in each vendor stand-alone station.

- **Go-live:** specified time table and date for go-live and all staff involved in the process were informed officially.

- **Certificate of completion:** Pharmacy department, as a project owner, signed the completion certificate upon project commissioning and once the system requirements were fulfilled.

4. Lessons Learned

4.1 Improved Pharmacy Workflow

Implementing the pharmacy automation system led to an improvement in dispensing and workflow. Other healthcare organizations in Saudi Arabia should explore the implementation of similar systems to eliminate medication errors, missing doses, orders delays, and drug-drug interaction which all impact the quality of patient care.

4.2 Ensure that Informatician has both Health and IT Backgrounds

The implementation of pharmacy automation needs trained health information technology staff that understands both the healthcare setting and the technology. Health information technology staff are able to understand the needs of the users and communicate them to the information technology staff. Selecting people with health informatics background will lead to higher acceptance of the new technology by users.

5. Discussion

This paper describes the experiences of implementing a pharmacy automation system at a local Saudi hospital. Although the findings of this study are preliminary, more work is needed to evaluate the overall impact of the pharmacy automation system on workflow and prescription dispensing time, especially in Saudi Arabia, where more
research evaluation is needed [4-12]. Several limitations exist with such a study conducted at a preliminary stage and a larger study is needed to validate the preliminary findings reported in this paper.

6. Conclusion

The Pharmacy Automation System is a required system to minimize medication errors which exist with non-automated drug dispensing systems. The experience of this implementation has improved pharmaceutical services at PSCC. Although there are limitations to this study, future work will include more data sources to validate the research findings.

Acknowledgement

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References

Project ALIVE: An Action-Research Exploration of EMR Value in Primary Care

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Abstract. This paper outlines a quality assurance (QA) process and a multiple case, explorative, electronic medical records (EMRs) project in Ontario. The project, dedicated to Advancing and Leveraging the Investment Value of EMRs (ALIVE) was an eight-month investigation of improvements to EMRs in terms of the technical elements of patient records that could be optimized through data standardization and the social elements needed to integrate value into the everyday functioning of primary care (PC) organizations. We argue that standardized and structured data offer substantial clinical value in PC insofar as it enables more proactive chronic disease prevention and management (CDPM). While PC clinicians may have had the opportunity to look the other way with respect to enabling technologies in the past, imminent health system reforms demand more meaningful use of EMRs moving forward.

Keywords. Electronic medical record, data standardization, clinical value, chronic disease prevention and management, primary care, action research, quality assurance

1. Theoretical and practical context

The Province of Ontario recognizes the need to change the way it delivers healthcare to its residents. This realization is magnified by the considerable demographic challenge of providing care to an aging populous in a fiscal situation that does not afford continued increases in health spending [1]. Answering the question of how government can contain health spending starts with existing cost structures. Hospital costs are 28.7% of total provincial health cost and when combined with the expense for physician compensation the proportion rises to about 45% [2]. This current reality means any significant plan to address health costs has to address how the health system delivers care across the primary/community care to acute care continuum.

Changes related to the care for difficult to diagnose, difficult to treat chronic diseases are important places to improve across the care continuum. Achieving the triple aim (higher quality patient-centred care, improving population health, and
moderating per capita costs) as it relates to CDPM will be asked of PC clinicians in the coming years [3, 4]. The role PC organizations will play in this necessary transformation has not been fully explained but there is emerging recognition and clarification of the central responsibility they have in providing quality care early in chronic disease progressions to avoid escalating system costs. Ontario’s Action Plan puts PC at the centre as “it’s better for patients, supports a better quality of practice for our doctors and reduces the likelihood that patients will be admitted, or readmitted to hospital” [5]. While health sector planners have suggested the patient needs to reside at the centre of care planning for some time, the message from Ontario leaders is that they will continue to reform payment mechanisms to ensure they are purchasing best-practice care and better outcomes for patients.

Achieving the triple aim requires a strong focus on quality. In 2010, Health Quality Ontario’s (HQO) mandate was expanded in the Excellent Care for All Act to include a responsibility to report on system outcomes, to support continuous quality improvement, and to make “recommendations to health care organizations and other entities on standards of care in the health system, based on or respecting clinical practice guidelines and protocols” [6]. In line with their expanded mandate, HQO published attributes of a high quality health system (access, integration, efficiency, effectiveness, focus on population health, safety, patient-centredness, appropriate resources), and a PC performance measurement framework was developed to guide measured quality improvement based on those attributes [7]. HQO’s direction on performance management outcomes was a signal to consider the new role that health informatics can and will play in improving health delivery in Ontario, and a signal to engage in investigations of more meaningful EMR use as have been developed in other Canadian jurisdictions [8, 9]. For our project, Advancing and Leveraging the Investment Value of EMRs (Project ALIVE), the opportunity was to demonstrate improvements that exist for PC organizations who invest in enhancement and change using intelligence generated from their EMR. Project ALIVE explored clinical value opportunities and efficiencies through more meaningful use of EMRs to show how PC is contributing to a more efficient health system in terms of per-capita cost and a more effective system in terms of how chronic diseases are managed.

2. Project ALIVE

Project ALIVE was an exploratory project that aimed to strengthen connections between improved patient-level health data in EMRs and better clinical outcomes. Working with two Ontario Family Health Teams (FHTs), the project deployed clinical (physicians, registered nurses), change management (registered nurse with change management experience and certification), project management (PMP), technical (long-time EMR developer and data analysts) and research resources to: i) increase the clinical value of EMRs for PC practitioners to enable them to deliver quality care to their patients; ii) understand and enhance the maturity level of EMR use; iii) mobilize data in a standardized/structured format. This paper concentrates on ALIVE’s process and examples that suggest how PC organizations can use developed health informatics to deliver better care and pursue organizational maturity in the face of health system reform.

During the eight-month project funded by eHealth Ontario, the two participating FHTs identified chronic diseases they wished to standardize in their EMR to improve
clinical effectiveness (Table 1). ALIVE was guided by a steering committee governance structure that included representation from clinicians, community support organizations, health system managers (i.e. eHealth Ontario; Local Health Integration Network; OntarioMD) and physician groups (Ontario Medical Association).

Table 1. Descriptive information for Ontario Family Health Teams (FHTs) participating as Project ALIVE.

<table>
<thead>
<tr>
<th>Case Study Information Categories</th>
<th>FHT 1</th>
<th>FHT 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Physicians (Nurse Practitioners)</td>
<td>14 (4)</td>
<td>18 (3)</td>
</tr>
<tr>
<td>Number of Rostered Patients</td>
<td>25,648</td>
<td>24,642</td>
</tr>
<tr>
<td>Number of Conditions for Standardization</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Conditions</td>
<td>CHF-Congestive heart failure</td>
<td>CHF- Congestive Heart Failure</td>
</tr>
<tr>
<td>GDM-Gestational Diabetes mellitus</td>
<td>GDM-Gestational Diabetes mellitus</td>
<td></td>
</tr>
<tr>
<td>Type 1 Diabetes mellitus</td>
<td>Type 1 Diabetes mellitus</td>
<td></td>
</tr>
<tr>
<td>Type 2 diabetes mellitus</td>
<td>Type 2 diabetes mellitus</td>
<td></td>
</tr>
<tr>
<td>Dementia</td>
<td>Dementia</td>
<td></td>
</tr>
<tr>
<td>Mild cognitive disorder</td>
<td>Mild Cognitive Impairment</td>
<td></td>
</tr>
<tr>
<td>Asthma</td>
<td>Asthma</td>
<td></td>
</tr>
<tr>
<td>COPD-Chronic Obstructive Pulmonary Disease</td>
<td>COPD-Chronic Obstructive</td>
<td></td>
</tr>
<tr>
<td>Hypertension</td>
<td>Hypertension</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td>Depression</td>
<td></td>
</tr>
<tr>
<td>Anxiety disorder</td>
<td>Anxiety Disorder</td>
<td></td>
</tr>
<tr>
<td>Prediabetes</td>
<td>CAD-Coronary Artery Disease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Atrial Fibrillation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Cerebrovascular Accident</td>
<td></td>
</tr>
<tr>
<td></td>
<td>MS-Multiple Sclerosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Osteoporosis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parkinson Disease</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Spinal Cord Injury</td>
<td></td>
</tr>
<tr>
<td>EMR Vendor</td>
<td>PS Suite (Telus)</td>
<td>PS Suite (Telus)</td>
</tr>
</tbody>
</table>

3. Method

ALIVE was a short-term project involving two cases and a compressed change management schedule. Understanding the constraints that project timing puts on research inquiry, project researchers employed an action research (AR) perspective to quality assurance (QA) whose method mirrored project management protocols [10]. Specifically, we reviewed an organizational-change AR cycle and ascertained that key similarities between this approach and our project existed. The AR cycle identified eight stages: diagnosis, data collection, data analysis, feedback, action, reflection/evaluation, dissemination, and planning further action. The ALIVE implementation model was based on project and change management approaches [11], and included 11 steps over four stages: benefits realization awareness, data standardization, clinical process adoption and training, and ongoing sustainability and support (Figure 1).

Our approach to implementing ALIVE constitutes a form of AR because of the similar methodical processes used to produce shared meaning through clinician implementation from the participating FHTs. For example, the diagnosis stage in AR
and benefits realization awareness stages both included processes of problem identification, environmental and literature scans, clarification of problems with key stakeholders, and pilot studies to determine a deeper understanding of identified potential solutions. The data collection, data analysis and feedback stages of AR aligned with ALIVE’s data standardization stage. It focused on listening to clinician input through one on one interviews, data collection, collaborative analysis, validation of data standardization techniques, and informing potential solutions for action and change. Action and reflection/evaluation stages of AR were similar to clinical process adoption and training that deployed key interventions (using standardized EMR data), that evaluated project value to clinicians, and collected critical reflections of limitations. Finally, dissemination and planning further action was part of the ongoing sustainability and support stage of ALIVE, where project staff developed handoffs for continuing operation of EMR improvements and distributed findings through health system and research partners.

4. Findings

The following sections outline some of the benefits developed in each of the four stages of the ALIVE implementation (Figure 1). The selected benefits lead to a discussion of a PC organization’s potential to deliver better CDPM care. The creative process related to these benefits is cause for further discussion on AR and project management as an approach to inquiry, and EMR and system benefits development moving forward.

4.1. Benefits Realization Awareness

The initial stage of ALIVE was dedicated to understanding the context for achieving better clinical value for PC in EMRs. A review of the Canadian Institute for Health
Information (CIHI) documents substantiated the potential for creating clinical value, specifically related to improving CDPM [12]. In contrast, the literature revealed instances of physician reluctance to include performance management information from the EMR because of data quality concerns and the opportunity to diminish the art and nuance of practicing medicine [13].

As a result of these perspectives, ALIVE pursued meetings and interviews with clinicians across the two FHTs in order to understand the local environment and their opinion regarding chronic disease standardization. Our data generally supported the findings in the literature, that clinicians are receptive to the potential that standardized data offers to their practice, but not in all cases. We found as a general rule physicians who were directly involved in providing care to a specific population with a chronic disease, i.e. through managing a specialty clinic, seemed more responsive to the idea of standardizing data and improving EMR use moving forward.

4.2. Data Standardization

The next stage of ALIVE involved coding historical data in the EMR. The process of standardizing diagnoses (using SNOMED-CT and ICD-9 codes) involved a data analyst conducting an initial search for patients diagnosed with chronic diseases in a pilot physician’s EMR. The utilized search was one the physicians would typically use to identify patients with chronic diseases, and had undergone multiple iterations. After some initial validation, the analyst produced a list of patients for review and the physician eliminated patients who did not have the conditions. For some conditions the number of false positive diagnoses eliminated from the EMR was more than 25% of the search. The analyst then went back through the physician’s full patient roster using a different search to find other patients who may have the chronic diseases of interest but who were not correctly identified, i.e. locate patients prescribed antihyperglycemics, but were not diagnosed as diabetic in the patient record. The analyst presented these additional patient records to the physician for validation and they acknowledged these patients who had chronic diseases and were not identified in the patient record (false negatives).

Table 2 shows the results of this process for a subset of the conditions standardized across both participant FHTs for Chronic Obstructive Pulmonary Disease (COPD), Dementia and Mild Cognitive Impairment (MCI). Across these conditions the historical coding identified 70 more valid diagnoses, a 7.6% increase. These 70 people are now more easily identified as having a chronic disease and therefore have a greater likelihood of being provided more timely and effective care.

<table>
<thead>
<tr>
<th>Chronic Disease</th>
<th>Total Number of Diagnoses</th>
<th>Number of Project ALIVE requests for clinician clarification</th>
<th>Added Number of Valid Diagnoses (% increase)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic Obstructive Pulmonary Disease (COPD)</td>
<td>697</td>
<td>136</td>
<td>36 (5.2)</td>
</tr>
<tr>
<td>Dementia</td>
<td>176</td>
<td>33</td>
<td>21 (11.9)</td>
</tr>
<tr>
<td>Mild Cognitive Impairment</td>
<td>51</td>
<td>21</td>
<td>13 (25.5)</td>
</tr>
<tr>
<td>Totals</td>
<td>924</td>
<td>190</td>
<td>70 (7.6)</td>
</tr>
</tbody>
</table>
It is important to note that these physicians may, in fact, be providing appropriate care and referrals to these patients. There is however, an acknowledged risk associated with the lack of appropriate documentation and in turn, the potential to miss opportunities to provide these patients with proactive and appropriate care for their chronic disease.

4.3. Clinical Process Adoption & Training

Project ALIVE shared these findings with clinician participants as part of workflow studies to learn more about how the project could design better ways to enter, mobilize and use information in the EMR. ALIVE created and tested a customized toolbar with clinicians that improved their ability to enter relevant information into the patient record. The toolbar allowed for the input of chronic disease flow sheets into the record and also launched the billing process for incentive payments directly from the same flow sheet.

Another process initiated and enabled for the FHTs was the development of more sophisticated reports. One type of report created from the more robust EMR data showed missed eligible incentive billings. The benefit associated with this development was two-fold: i) unrealized revenues that clinicians could achieve in the future; ii) a new time saving search protocol which would enable the redeployment of resources away from the previous time consuming verification processes.

Another report enabled through ALIVE (MediDash [14]) was the use of better data to drive disease-specific dashboards related to the treatment of chronic diseases. The project worked to introduce several options available to the FHTs that used standardized EMR data to show powerful comparative pictures. This was able to drive more proactive questioning by clinicians for the benefit of patients.

A final example of the benefits developed through the adoption and training phase was the improvement of clinical EMR reminders. ALIVE worked with clinicians to understand how to insert questions into the clinician-patient interaction that would lead to better outcomes. For example, improved standardized data for congestive heart failure (CHF) patients allowed connections to best practice related to vaccinations that could help avoid decompensation and serious complications if the patient was admitted to the hospital. In one FHT fifteen patients diagnosed with CHF were identified as having visited their physician within the past year, but not being vaccinated for influenza or pneumonia. The project worked with clinicians to improve the EMR prompts with consideration of existing workflows.

4.4. Sustainability and Support

ALIVE also engaged with the participating FHTs to better understand how the work and associated benefits would be sustained once the project ended. There is a chasm that has been identified in the way PC organizations are funded and how that relates to their ability to pursue developments in decision support. In addition, the project uncovered some existing gaps in organizational protocols that required development in advance of deploying additional investments to improve clinical value through EMR data. In developing options for PC organizations moving forward, Project ALIVE recognized the need for a differentiated/custom service to support meaningful use, recognizing
different organizational starting positions on what researchers have referred to as the long process developing (pre)conditions for meaningful use [9].

5. Discussion and Conclusion

There is little trouble substantiating the claim that standardized and structured data in EMRs delivers several possibilities for innovation and better care [15]. Easier searches can identify patients with specific disease conditions or comorbidities for more proactive care, and can help screen the broader patient population. There is little debate in the potential that exists for PC organizations to become more efficient contributors to the health system by measuring and reporting on their contributions with higher quality data.

There remain several unanswered questions about how well equipped PC organizations are to make the changes necessary to embrace new information into their practice. Specifically: i) are clinicians prepared to complete the additional work needed to standardize patient records and enable more reliable CDPM?; ii) are there mechanisms in place in PC organizations to ensure data quality?; iii) is there ongoing clinical leadership, organizational development, change management resources and collaborative interest in place to support these improvements?; iv) Is it possible to sustainably apply this model of implementation in a broader PC context?

It appears that PC clinicians have had the opportunity to choose to look the other way on the clinical value available through more meaningful use of EMRs. Perhaps it simply has not been an informed choice; clinicians have not been empowered with the appropriate knowledge and resources to embrace and pursue clinical value. Regardless, the current EMR proficiency within PC organizations may not be easy to maintain in the near future. The recent Canadian Foundation for Healthcare Improvement (CFHI) paper outlines a challenge of realizing system-wide cost savings from improved quality in our current health environment [1]. Historically the system costs and potential solutions have been spread across time in the patient journey and across the organizations who deliver care in different places of the continuum. Accountable care organizations provide a structure that enables better reporting on existing practice and a more direct structure that incents quality improvements and shared financial savings. Health system reform will demand that PC organizations learn to mobilize and take advantage of all available resources (including EMRs) to deliver higher quality CDPM care. In an environment with many constraints, the improved identification and management of patients with chronic disease is a significant step forward with the potential to achieve cost savings and improve the quality of care.

For project managers and researchers working in rapid implementation environments that require organizational change and systems improvement, the AR method used in a QA study offers a potential methodological approach for research that appropriately mirrors project management protocols. This allows for the development and use of knowledge in a real time manner that achieves project deliverables and yields research outcomes.
Acknowledgment

The authors would like to acknowledge the dedicated work of the entire Project ALIVE team and thank eHealth Ontario for project funding and support.

References


[14] MediDash is an EMR tool developed by East Wellington Family Health Team, Erin Ontario. For further information please contact Dr. Kevin Samson, kevin.samson@ewfht.ca.

Nurses: Extending Care Through Telehealth

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\textsuperscript{b}University of Victoria, Victoria, BC, Canada

Abstract. Nurses have an immense impact on the growth and scope of Telehealth as they embrace diverse roles. TeleNursing introduces transformational change which positively impacts both clients and providers, increasing access to care and reducing the time and costs associated with traveling for health care. Integration of clinical support and remote diagnostic tools inspire new uses of Telehealth, thus enabling care previously only possible in person to be delivered virtually. Nurses currently leverage Telehealth to deliver care and education, monitor clients remotely and support medical consultations. Over 90\% of Island Health nurses surveyed recommend Telehealth as a care modality to clients and 100\% support Telehealth as a means to increase care to vulnerable communities. Programs wish to increase uptake of TeleNursing but face numerous challenges regarding funding, resourcing, scheduling and geographical ownership. TeleNursing goes beyond clinical support and has the potential to exponentially expand Telehealth services, normalizing Telehealth as a care modality. Nurses look to Telehealth to improve their ability to partner with clients over distance, providing surgical care, maternal/pediatric care and group education

Keywords. Telehealth, TeleMedicine, Care Modality, Healthcare, Island Health, TeleNursing, Clinical Support, Remote Diagnostic Devices

Introduction

Telehealth refers to the use of communications and information technology to deliver healthcare services and information over distances [1]. Telehealth is a common modality to provide care at Island Health, an authority responsible for providing health services to over 760,000 people on the west coast of British Columbia.

Since implementation in 2007, Island Health Telehealth has grown exponentially and is embedded within many clinical programs. Technological advances, such as digital stethoscopes and exam cameras, have pushed Telehealth to a new paradigm where providers can physically assess their clients over distance. Nurses are often required at the client site to facilitate medical assessments, thus enabling remote consultations. In addition to providing clinical support, nurses are beginning to use Telehealth to provide distant client care and education (often referred to as TeleNursing) [9]. Professional bodies, such as the Canadian Nurses Association, support Telehealth in nursing practice and its

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potential to enhance healthcare services [2]. This paper addresses TeleNursing impacts, insights and challenges while examining additional ways nurses can incorporate Telehealth into clinical practice.

1. Telehealth and Nursing at Island Health

At Island Health, nurses use Telehealth to monitor clients remotely, deliver care and education and provide clinical support during medical consultations. There are several Island Health programs that routinely use clinical support during their Telehealth sessions: Cardiology, Renal, Speech Language Pathology and Geriatrics. TeleNursing is expanding through Home Health Monitoring and Wound Care, by providing distant client care and education. The number of Telehealth consultations with clinical support has grown dramatically (Table 1), expanding more than 300% last year [3].

1.1. Monitoring Clients Remotely

Home Health Monitoring (HHM) is an initiative that supports clients in monitoring chronic conditions. Nurses provide heart failure education and partner with clients to improve self-management skills and track symptoms. The HHM program empowers clients to improve management of their heart health. Clients take their own vital signs and self-assess their wellbeing using a remote and wireless tablet with ancillary biometric capturing tools that transmits a daily care plan to the nurse. Home and Community Care nurses monitor the clients’ results remotely and help clients gain a better understanding of heart conditions and early detection of health changes to prevent hospitalization. HHM has a significant impact on outcomes, resulting in 67% reduction in hospital admissions, 75% reduction in length of hospital stay, and 65% reduction in emergency room visits at Island Health (2014).

1.2 Delivering Care and Education via Telehealth

Nurses regularly use Telehealth to provide care remotely to clients. For example, Island Health Kidney Care Clinic nurses deliver client education and services via Telehealth, allowing them to connect to multiple communities simultaneously. Kiyomi Renville, a renal nurse and Telehealth advocate, states that “Telehealth has increased access to education for clients and has had a positive impact on overall health and quality of care”. Similarly, cardiology nurses use Telehealth to deliver education sessions to clients living with atrial fibrillation.

Table 1. Growth of Telehealth consultations within Island Health.

<table>
<thead>
<tr>
<th>Fiscal year</th>
<th>Total Telehealth consultations</th>
<th>Telehealth consultations using clinical support</th>
</tr>
</thead>
<tbody>
<tr>
<td>2011/2012</td>
<td>2,042</td>
<td>3</td>
</tr>
<tr>
<td>2012/2013</td>
<td>2,522</td>
<td>133</td>
</tr>
<tr>
<td>2013/2014</td>
<td>3,648</td>
<td>343</td>
</tr>
</tbody>
</table>
1.3 Supporting Medical Consultations

Many Island Health programs require clinical support at the client site to assess vital signs, perform physical assessments, and operate Telehealth diagnostic devices. Consultations take place in designated Telehealth rooms located in health care facilities leveraging locally available nurses.

For example, the Heart Health program relies on nurses at the client site to take vital signs and use a digital stethoscope which transmits heart and lung sounds. During the appointment, the remote specialist collaborates with the nurse in real-time, guiding optimal placement of the stethoscope. More than 270 cardiology sessions have successfully been delivered via Telehealth to Island Health clients.

Seniors Outpatient Clinic nurses use Telehealth to collaborate with geriatricians remotely while conducting cognitive assessments, strength tests, and physical assessments. As elderly clients generally have a variety of mental and physical conditions, strong communication between local nurses and the geriatrician is essential for client care. With dementia being a possible barrier to Telehealth, nurses assess the suitability of Telehealth for each client and advise the geriatrician of additional observations during sessions [4].

Requests for consultations requiring client site clinical support is increasing, both within and outside of Island Health. If client site clinical support were always available, more programs would employ Telehealth as a modality, helping equalize access to care in vulnerable communities.

2. Nursing Impact on Telehealth

The inclusion of clinical support during Telehealth consultations has had an immense impact at Island Health. Without Telehealth clinical support, more clients would be without specialty care or required to travel. Before Telehealth, the only options for remote clients to receive clinical education were via mail, telephone, or to travel [5]. Additional programs, such as multiple sclerosis and rehabilitation, are beginning to explore Telehealth as a viable care modality option given the availability of client site clinical support.

3. The Impact of Telehealth on Nursing Practice

Nurses experience multiple benefits from Telehealth, including decreased clinical isolation, reduced patient transfers, education opportunities and ability to further support community based care. Nurses working remotely can connect with physicians, colleagues, and access unique education opportunities, linking them to clinical networks otherwise inaccessible. In both remote and central facilities, nurses can use Telehealth to discuss clients’ health plans, procedures and general medical conditions with physicians and other care-team members.

Telehealth reduces patient transfers and associated nursing tasks: preparing and accompanying the patient, completing paperwork, booking the ambulance, and communicating with the family [6][7]. Instead of transfers disrupting client care and nursing workflow, nurses can facilitate specialty consultations via Telehealth.
4. Island Health Nurses Perspective on Telehealth

Island Health Telehealth surveyed 53 nurses to better understand their opinion of Telehealth. Of those surveyed, 40% had direct Telehealth experience. Survey responses were positive with more than 90% of nurses stating they would recommend Telehealth to clients and providers. All nurses surveyed agreed that Telehealth increases access to specialist care. One nurse commented that “What I like most about Telehealth is the improvement in the ‘patient journey’ across the Island. It [Telehealth] saves our complex, chronically ill patients a lot of travel time, money and energy to be able to access specialty care in their own community” [8]. Of surveyed nurses not currently using Telehealth, 66% see opportunity to use it within their practice and 90% foresee potential to improve client continuity of care.

5. Challenges

Some challenges have surfaced with increased use and adoption of Telehealth at Island Health: emphasized need for clinical support at the client site, scarcity of resources, scheduling, funding, and geographic ownership. Providing support for Telehealth consultations is a relatively new clinical task and creates additions to daily workflows. Programs are requesting remote clinical support in cases where nursing would not normally have been part of the client’s care. Clinical shortages and budget restrictions make it difficult for managers to find nursing hours for Telehealth. Local client care often conflicts with Telehealth consultations, necessitating rescheduling of the consultation.

The funding and ownership of Telehealth clinical support is a grey area within Island Health. For example, one community hospital advocates for local care and therefore delivers clinical support by adding Telehealth consultations to their ambulatory slate. Others look to Telehealth for funding of clinical support or struggle to find available nursing hours.

6. Opportunities for Expansion in Nursing Practice

Nurses view Telehealth as a tool to better serve clients and wish to integrate Telehealth into their practice. Surveyed Island Health nurses recommend Telehealth be adopted into the following programs: pre and post-operative consultations, breast feeding assessments, maternal care, pediatric consultations, diabetes group meetings, and respiratory care.

As health authorities focus on primary care and clients as partners, there is opportunity to extend Telehealth into client homes. For example, Community Health Workers (CHW) currently observe medication adherence by visiting clients in their homes. Nurses are required to confirm sliding scale insulin dosages, as this falls outside the scope of CHWs. Telehealth in the home allows nurses to remotely verify correct dosages of insulin injections, increasing efficiency and eliminating time lost to travel.

Island Health Telehealth is actively strategizing to address the above challenges, with the intention to create seamless transition of embedding Telehealth into nursing practice. Current restructuring of Island Health into new geographic areas will
encourage local ownership of client care, hopefully increasing access to Telehealth clinical support.

**Conclusion**

Clinical support and remote diagnostic technologies create a paradigm shift where Telehealth is embedded in our health care system. Remote physical examinations are enabled, preventing countless kilometers of travel for both clients and providers. Support from leadership and clinical champions are essential in supporting this transformational change. Care providers have the option of using Telehealth to expand delivery of services and work with clients remotely. With the increasing interest and desire to incorporate Telehealth in nursing practice, there will be an exponential growth in the utilization of Telehealth technology.

**References**


Using Community Based Participatory Research as a Method for Investigating Electronic Health Records

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Abstract. One information source for the Personally Controlled Electronic Health Record is the consumer repository. This paper reports on the use of community based participatory research, as a project method, derived from an initiative where people with complex chronic conditions and their carers attended a rural health promotion and lifestyle modification program. Through co-operative inquiry embedded in the research approach, health promotion workers and their clients were actively supported to adopt and use the PCEHR as an intervention. Simultaneously they were encouraged to reflect on its design, mechanisms for its implementation and their perceptions of its overall impact on consumer’s ability to self-manage complex conditions.

Keywords. Personally Controlled Electronic Health Record, Community Based Participatory Research, Complex Chronic Diseases, Health Promotion and Lifestyle Modification Program.

Introduction

Australia’s development and rollout of the personally controlled electronic health record (PCEHR) commenced in 2012. It continues to struggle with adoption and utilisation. Despite expenditure of more than $1billion only 7.8% of the Australian population has registered for a PCEHR. Part of the problem has been a lack of transparency, inadequate community facilitation compounded by poorly articulated implementation and evaluation frameworks [1]. These problems have been particularly evident amongst communities serving vulnerable populations including those people with complex chronic conditions (CCCs). There is a genuine concern that widening disparities in the quality and efficacy of services may become embedded by an eHealth divide. Meaningful adoption and use of the PCEHR clearly relies on all stakeholders being involved and all aspects of a health care record being usable, safe and useful [2]. Unfortunately few complete PCEHR systems are currently in routine use, making evaluation and assessment of their effectiveness, in real settings, extremely challenging. This situation does however, present an opportunity to investigate and evaluate the...
current systems in actual use providing insights that might support improved roll-out towards general implementation [3].

Given the high costs associated with CCCs it is clearly in the interest of the wider community to support patients and their carers to remain as healthy as possible [4-6]. Australian Governments already support programs focusing on CCCs including in rural areas [7, 8]. Initiatives involve health promotion workers assisting communities through health promotion and lifestyle modification programs to providing safe environments for socialisation, recreation, physical and cognitive stimulation. For people with CCCs maintenance of these functions assists them to remain active community members [9]. However, at local level, there is a reluctance of consumers to contribute and an ineffectiveness of staff to consult with consumers in service design, implementation and evaluation [10]. In rural communities, many with distinctive and unique histories and values, mainstream services may also be inappropriate for people living with CCCs. Rural health promotion and lifestyle modification programs provide care and stimulus for consumers but unless the programs are compatible with the desired needs of these people, services are under utilised [9].

In this context, the paper discusses the use of a community based participatory research (CBPR) as a method to actively engage people with CCCs, their carers and health promotion workers as participants in research on PCEHRs. This approach demonstrates how rural community involvement in health service design and delivery can be achieved effectively. Iterative cycles of doing, observing and reflecting on the dynamics involved in planning, implementing and evaluating a PCEHR can deliver outcomes perceived as positive by the community. At individual level too positive outcomes can be evidenced, as health professionals are able to implement a self-management approach to care more easily where clients were engaged through CBPR.

1. Community Based Participatory Research

Participatory research is a qualitative methodology. In health care and eHealth research forums it is considered democratic, equitable, liberating, and life-enhancing qualitative inquiry [11-13]. Distinct from action research that pursues change, CBPR requires active involvement by all participants, ensuring their experiences and understandings are directly involved in shaping research that describes and affects their lives. Indeed, it can be argued from a methodological perspective that: "... knowledge constructed without the active participation of practitioners can only be partial knowledge" [14, 15]. CBPR proposes a set of principles based on assumptions that: (a) genuine partnership means co-learning i.e. academic and community partners learning from each other, (b) research efforts include capacity building, in addition to conducting the research i.e. that there is a commitment to training community members, (c) findings and knowledge should benefit all partners, and (d) CBPR involves long-term commitments to effectively reduce disparities [16].

Within healthcare CBPR encourages meaningful and relevant evidence about practices in communities. The approach attempts to balance academic research with valuing the contribution that community groups make in the development of knowledge about community practice. It promotes collaborations between health care researchers and communities in the design and implementation of research projects. The goal is to foster sustainable efforts at a local level that facilitate the translation of research advances into improved health for all [15, 17].
This paper reports on research that used a CBPR approach to support participants engaging in self-management through the use of the PCEHR; and to evaluate the process taken by the study participants in implementing the use and subsequent impact of the PCEHR as an electronic health management tool. The CPBR approach encouraged health promotion workers and consumers to participate equitably in the research process, enhancing participant responsiveness with each stage of the research, in order to move forward to self identified actions and facilitate learning opportunities for participants through reflection on the processes and outcomes.

2. Method

The qualitative research was conducted over a 12 month period in Tasmanian rural primary health care settings. The participants were 22 people involved in health promotion and lifestyle modification programs, including people with a diagnosis of two or more CCCs, their carers and their health promotion workers. The research acquired social sciences HREC full committee ethical approval (H0013781).

3. Research Strategy and Design

Three groups were convened by the health promotion workers with the researcher focusing on facilitation of: issues confronting participants dealing with CCCs, rural health promotion and lifestyle modification programs, the concept of the PCEHR as a health promotion and lifestyle modification intervention and commitment to future approaches. The research was designed to respond to the emerging needs of the participants in relation to their PCEHR arising from the changing situations experienced over the research period. The research involved implementing the CBPR approach in six stages,

- Stage 1 Project set up and recruitment
- Stage 2 Baseline data collection and analysis
- Stage 3 Intervention
- Stage 4 Post intervention data collection and iterative analysis
- Stage 5 Data Interpretation
- Stage 6 Contribution to knowledge

The research design used a range of data collection tools including voice recorded, focus groups and memos, in-depth semi-structured interviews as well as individual PCEHRs and researcher field notes. To validate the research a checklist [17] was reaffirmed at each stage. The checklist ensured group consensus, fully informed participation and upheld ethical integrity.

4. Data Analysis

Data analysis was conducted simultaneous with the iterative cycles of data collection. Where low literacy level, or physical incapacity was identified amongst some
participants, these individuals were encouraged to connect with another participant, to provide support [18]. However, analysis described in this paper is limited to evaluation of the CBPR process. The data analysis involved sharing with and by all participants their ongoing observations, discussions and reflections leading to group clarification, decision-making and action. Using qualitative techniques [19] transcripts of all voice recordings and text arising from each data source, were coded to identify core themes. This iterative process continued until ‘thematic saturation’ was achieved, no further codes were identified and a complete and coherent analysis of the data set developed.

5. Discussion

The CBPR approach has engaged users that are traditionally invisible or hard to engage and whose opinions in health and eHealth debates have been marginalised or worse ignored to the detriment of solutions [13]. The outcomes of this study indicate people with CCCs and the community have the capacity to determine, collaborate and communicate their health care needs, deriving both empowerment and satisfaction in doing so.

A key component to the methodological approach was the researcher situated as a facilitator, rather than a change agent, being well trusted and embedded in local knowledge and politics. Involving the people with CCCs in rural communities in CBPR not only supports individual and community development in terms of knowledge, confidence and interest but also contributes to the research. Bringing individuals together in like situations encourages and empowers them to discuss the ways in which they experience and understand their CCCs, build self efficacy and grapple with new technology. By doing CBPR the individual experiences the feeling of not being alone, realises that their difficulties are shared, understands and hears the frustration that they have are not their inadequacy but an identification of poorly design systems. Collectively there is a mutual, self reinforcing experience and as a community they are empowered to articulate to the health service and to the PCEHR their challenges and potentially develop a new and better process.

Using CBPR recognised the value of the knowledge that the community contributed to the co-creation of new knowledge. Its focus on practical issues, problem solving and change provided evidence for practice that is immediately useful and relevant to the community. By engaging the community in the research process it has not left to chance the usefulness of the outcomes of the research. With the full involvement of community groups and in the future, policy makers, decisions can be made about how to use the information to bring about change.

Whilst the methodological approach is largely applicable, generalisability of the current research may be limited to similar situations. There is always the potential for community based research to prove challenging; engaging participants fully in the process can mitigate this. The unpredictability of CCCs, was considered early in the study design. The research process was not dependent on large numbers of participants.

6. Conclusion and implication for practice.

There is a requirement for the creation of a national meaningful [2] PCEHR implementation and evaluation framework. The CBPR approach accommodated social,
cultural, organisational, and emergent change [3]. It promoted the PCEHR as engaging and empowering equally for all participants. Based on the premise, all stakeholders can help to promote better understanding, reducing the negativity to the PCEHR, the participatory paradigm can assist in developing PCEHR knowledge for communities and policy makers.

References


[16] Field PA, Morse HM. Nursing Research: The application of qualitative approaches Cheltenham, United Kingdom: Nelson Tomes Ltd; 2002.
Bridging a Divide: Architecture for a Joint Hospital-Primary Care Data Warehouse

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Abstract. Healthcare costs are driven by a surprisingly small number of patients. Predicting who is likely to require care in the near future could help reduce costs by pre-empting use of expensive health care resources such as emergency departments and hospitals. We describe the design of an architecture for a joint hospital-primary care data warehouse (JDW) that can monitor the effectiveness of in-hospital interventions in reducing readmissions and predict which patients are most likely to be admitted to hospital in the near future. The design identifies the key governance elements, the architectural principles, the business case, the privacy architecture, future work flows, the IT infrastructure, the data analytics and the high level implementation plan for realization of the JDW. This architecture fills a gap in bridging data from two separate hospital and primary care organizations, not a single managed care entity with multiple locations. The JDW architecture design was well received by the stakeholders engaged and by senior leadership at the hospital and the primary care organization. Future plans include creating a demonstration system and conducting a pilot study.

Keywords. Data warehouse, primary care.

1. Introduction

In Ontario, the top 5% of complex patients (i.e. patients with multiple co-morbidities) account for over two-thirds of healthcare costs [1], while over one-third of patients discharged from internal medicine wards are readmitted to the hospital within 90 days, costing over $700 million per year [2]. There is a need for a means to identify high-risk patients before they are admitted or readmitted to the hospital. Data warehousing, a technology that integrates data from separate information systems, is one solution that could aid healthcare professionals in identifying high-risk patients. By generating reports from an integrated repository of primary care and hospital data, a data warehouse could allow for identification of important trends in patient data, and provide evidence for interventions that decrease the likelihood of hospital admission or readmission. Such an application of data warehousing technology holds much analytical potential, as primary care data (i.e. last family doctor visit, medications prescribed, lab results) could complement hospital data (i.e. medication reconciliation done, patient education provided) in data discovery. However, even though data warehousing is not a novel technology in the healthcare sector [3,4,5,6], the potential

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for constructing a data warehouse to specifically lower admission/readmission rates has not been thoroughly explored. Past studies into integrating data from primary care and hospitals have typically only gathered data for research purposes [7,8,9] or have been done within a single institution that controls both the hospital and the primary care clinics [10,11]. The barriers to implementation of a data warehouse that extracts data from separately managed organizations are therefore not well documented. Thus, while addressing many of those barriers, as well as other aspects of implementation such as cost and value, this paper investigates the potential of developing a scalable data warehousing system to lower admission/readmission rates across multiple hospital-primary care systems, using data from two distinct healthcare organizations that closely collaborate with each other to provide care to patients. For an initial design study, North York General Hospital (NYGH) and North York Family Health Team (NYFHT) agreed to collectively develop such a system.

2. Methods

We undertook a two-stage stakeholder consultation process. In the first round, key informants are asked to identify problems they faced that could be solved by having access to primary care data and to better analytics from the hospital. An initial proposed architectural solution was developed, addressing the major issues identified by initial informants. This proposed architecture was subsequently presented to a second round of stakeholders, gathering additional design recommendations and validating the design. Overall, a total of 36 key informants from NYGH, the North York Family Health Team (similar to a patient centered medical home), the Local Health Integration Network (similar to a District Health Authority), the Ministry of Health, and the eHealth sector participated in semi-structured, individual 1-2 hour-long interviews. Their opinions shed light on the following topic areas: 1) governance, 2) business case, 3) workflows and clinical goals, 4) technical requirements, 5) data needed 6) privacy, and 7) high level deployment and implementation.

Findings from the interviews were collated into a report and presented to senior leadership for support and implementation. We also conducted a patient matching study to ensure that patients identified in the primary care database could indeed be matched to patients in the hospital database.

3. Results from Interviews

3.1. Purpose of Data Warehouse

Stakeholders presented two conflicting views about the purpose of the data warehouse. 1) Management saw the data warehouse as tool to allow health care providers to measure and better understand processes of care. 2) Front-line clinical personnel felt the data warehouse should serve as a shared clinical data repository, to improve communication between the hospital and primary care, reduce redundancy (e.g., ER doctors would know what the family doctor had tried in the past and failed), and make accessing important results (i.e. CT scans) easier for clinical personnel. This difference in needs can be resolved by first establishing a simpler management system and then
later moving to a more complex clinical care system as the organizations gain more experience and are able to secure additional funding.

3.2. Value of the Data Warehouse

There is good evidence to suggest that medication reconciliation, patient education, follow-up with family physician within 7 days of discharge and a few other interventions can reduce the likelihood of hospital readmissions. A JDW could potentially help track the efficiency of existing processes in providing these interventions. Even more valuable was the potential for using predictive algorithms to identify patients in the primary care system that were more likely to be admitted to hospital in the future. These types of algorithms have been used successfully in a variety of settings [12,13].

A business case was developed to identify the cost savings that could accrue based on reducing readmissions for 2 diseases that see high readmissions. Assuming a 20% reduction in readmissions and approximately $8200 per readmission episode and an annual cost of managing a simple data warehouse of $250,000, a medium-sized hospital could potentially save over $1M per year. The payback period is less than one year, more than justifying the costs of building and maintaining a data warehouse.

3.3. Barriers and Risks of Implementation

Interviewees identified several barriers and risks of implementing a data warehouse:

How will privacy be maintained? A data sharing agreement between the hospital and primary care institution was seen to be necessary to ensure all parties understood the risks and their obligations. Encrypting all health card numbers and maintaining data in an anonymized fashion were also seen to be important.

Financial Disincentives: Many quality improvement projects fail because of unforeseen financial disincentives. For example, decreased readmissions could lead to fewer ER visits that lead to lower revenues and an inability to retain emergency physicians. Since NYGH has a very busy ER, this was not seen to be an issue. Another example was that the hospital (NYGH) might experience decreased bed utilization, thereby lowering revenues. The recent move to capitation based funding removes this potential threat.

Competing priorities. Due to the large number of existing initiatives at NYGH, one of only 4 HIMSS Level 6 hospitals in Canada, discussants felt that competing priorities might pose a barrier to implementation. It is possible that different stakeholders will want to steer the data warehouse in different directions; e.g., by adding different metrics to the reports. To balance the wishes and needs of all stakeholders, a governance structure was developed and presented to interviewees for validation.

3.4. Proposed Governance

Discussants agreed that a data warehouse would need oversight from primary care and the hospital so that the data warehouse met the goals of all stakeholders and the risks associated with warehouse were mitigated. The governance structure proposed included two committees overseen by an Executive sponsor, who ensures the committees have the resources they need and helps overcome bureaucratic obstacles: 1) The Data Warehouse Steering Committee oversees IT infrastructure and data warehouse
operation, and is primarily responsible for privacy, security, data extraction and cleaning, report development, and dashboard development. 2) The Clinical Steering Committee reviews the work of the clinical and administrative staff, and is tasked with identifying new data or report needs that are communicated to the Data Warehouse Steering Committee. Other interviewees validated this structure, and also suggested that the Clinical Steering Committee should have cross membership with the Data Warehouse Steering Committee to improve cohesion and collaboration.

3.5. Architectural Goals and Principles

Architectural goals (key attributes of the warehouse system that support business goals) and principles (i.e., decision criteria used in constructing and maintaining the system) were identified. The key architectural goals validated with IS (information services) and IT stakeholders include: 1) Be scalable to multiple health care organizations and settings. 2) Be scalable to health care organizations in other communities. 3) Be simple to implement. 4) Be easy to maintain. 5) Decrease costs over time.

Six architectural principles were developed to guide development and maintenance of the data warehouse: 1) Use best practices in privacy and confidentiality. 2) Design for flexibility and growth. 3) Design for scalability and integration. 4) Convey maximum benefit to patients. 5) Meet capacity needs. 6) Design for pragmatism.

3.6. IT Architecture

Data from the hospital will come from two systems (Cerner, Med2020) while primary care data will come from the North York FHT EMR, which is a network in CPCSSN, Canada’s national surveillance network for chronic illnesses. When patients visit either the hospital or primary care, the JDW will be updated with data about the patient’s visit. Cerner records patient characteristics (e.g. ID, sex, caregiver) and admission/discharge information (e.g. date, part of hospital admitted to), and Med2020 lists diseases of interest (e.g. COPD) and their ICD-10 code and date of onset. On the primary care-side, CPCSSN records data about patients with chronic illnesses such as COPD and CHF (e.g. visits to primary care, time of last visit, physician’s prognosis, etc.). CPCSS currently collects data on over 840,000 patients from the practices of over 585 physicians who use one of 12 different EMR systems across Canada [14].

These systems together capture the key data that is required to monitor the complex clinical workflows pertinent to patient care. Data from the JDW will be made available for analytics and business intelligence, to identify important trends in the data that may assist healthcare professionals in delivering better quality of care. Overall, the IT architecture validated by informants provides a reliable and secure means to integrate data relevant to patient care in NYGH and NYFHT.

3.7. Feasibility Study

An initial feasibility study was undertaken, with the assistance of both primary care and hospital-based data analysts. A list of patients from primary care having either Chronic Obstructive Pulmonary Disease (COPD), Congestive Heart Failure (CHF) or both, was generated. 1,650 patients met these criteria and their records were linked with the Cerner database. 1274 patients had had at least one interaction with the hospital in the previous 3 years.
4. Discussion

A JDW has potential utility in decreasing admissions/readmissions. Several organizations have developed proprietary systems and have used them to good effect [10,11]. However, there have been no descriptions for the architecture of this type of system for management purpose in the literature. We present here an architectural design for a JDW that has good face validity and strong buy-in from key hospital and primary care stakeholders. There is also very good overlap in patients across the two organizations. A demonstration version of the JDW is currently being constructed and will be undergoing further testing and research once funding for a pilot project is secured. A data sharing agreement is currently being negotiated for production level sharing of data between the hospital and primary care clinics.

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References

Supporting Dementia in the Community:  
A Human Factors Perspective

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Abstract. There is a knowledge gap regarding the human factors that can lead to successful implementation and adoption of health technologies specific for supporting people with dementia (PD) and their spousal caregivers (SC). This paper extends and applies a community-based framework to review some recent examples of technologies and studies that have targeted this population. Examined characteristics include: the people, environment, task management, technology implementation and design, and the ethical and socio-technical considerations associated with technologies used to support PD in the community.

Keywords. Dementia, Alzheimer’s Disease, Caregiver, Aging, Human Factors, Community Care, Health Information Technology, Health Technology

Introduction

Globally it is estimated that 35.6 million people are living with dementia [1], and the total health care costs for people with dementia in 2010 was more than 1% of the global gross domestic product [2]. In Canada, informal caregivers and spouses spend the greatest amount of their time in the caregiving role. 31% of spouses provide more than 30 hours of support a week [3]. 45% of spousal caregivers (SC) report multiple signs of psychological distress, and 33% of these individuals had consulted with a health practitioner due to concerns directly related to their caregiving role [4]. As more people with dementia (PD) are aging-in-place, there is a greater need for research in the implementation and adoption of health technologies that support this population. This paper will extend and apply an analytical framework in answering two questions specific to PD living in the community: 1) the human factors for PDs in designing health technologies that alleviate the burden of stress on the SC, and 2) age-specific human factors for the SC.

1.0 Dementia and Aging

Dementia is a blanket term used to describe a range of illnesses associated with cognitive decline [3]. In Canada, 14.9% of people over the age of 65 have a cognitive impairment [3] and when looking at the age of SC, 21.5% are between the ages of 65 and 74 and 41.1% are over 75 [4]. Alzheimer’s disease (AD) is the most common form of dementia, accounting for 64% of the cases of dementia in Canada [5]. Characteristics of the disease include loss of memory, intellect, judgment and reasoning,
and a change in normal moods and reactions. The health information technologies (HIT) that are being introduced to the community to support PD are commonly managed by the SC. The SC is most commonly an age-peer to the person with dementia. Therefore, it is critical to examine the effects of age-related human factors for both PDs and SCs.

2.0 Extension and Application of a Framework for People with Dementia and Spousal Caregivers

Or et al. [6] provide a rare example of the human factor considerations for community health settings. The authors apply the University of Wisconsin-Madison-System Engineering Initiative in Patient Safety (SEIPS) model in evaluating HIT that specifically address the increase in care demands and unpredictability of home care settings for health practitioners. The framework consists of five elements: the people, the tasks, the technology, the environment and the organization [7]. Extending the framework to HIT being used to support PD and SC in the community, it is proposed in this paper that the characteristics for each of these considerations include: 1) the people–PD and SC; 2) the environment specific to PD; 3) the tasks–task management for PD; 4) technology– design and implementation considerations for the PD and SC; and 5) organization–ethical and socio-technical factors that impact HIT applications for PD. The human factor considerations for the environment, tasks and technology that are specific to PD, translate to a greater understanding in developing supportive technologies that reduce the stress associated with informal caregiving. Table 1 considers each of these categories in analyzing the human factors that impact HIT for PD and SC living in the community.

Table 1. Five characteristics were extended and applied from Or, et al. [6] application of the SEIPS model [7] to analyze the specific human factor considerations for designing and implementing health information technologies that support individuals with dementia and their spousal caregiver living in the community.

<table>
<thead>
<tr>
<th>Consideration</th>
<th>Summary</th>
</tr>
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<tbody>
<tr>
<td><strong>Changes in Memory Processes Due to Dementia</strong></td>
<td>- Initial stages of AD often result in anterograde amnesia, resulting in decreased ability to record new information [8]. As AD progresses, the memory failure can evolve into forgetting long term events and familiar settings and faces[8]. The indirect route in accessing memory can be more resilient for recovering memory [8].</td>
</tr>
<tr>
<td><strong>Changes due to Aging that Impact the Spousal Caregiver</strong></td>
<td>- Older adults take double the time than younger adults to complete complex tasks [9]. Level of functioning in older adults is more heterogeneous in comparison to a younger cohort, resulting in more diverse changes in physical, sensory and cognitive [10]. Decline in performance of executive functions such as planning, monitoring and coordinating ongoing activities [10]. Areas that require more complex controlled processing or motor control are also the areas that show the greatest dual task impairment [10].</td>
</tr>
<tr>
<td><strong>Spatial</strong></td>
<td>- Creating a predictable and familiar environment accesses the less impaired implicit memory [11]. A range of spatial recognition tools can provide systematic clues to indicate specific locations within the home [12]. Reducing the clutter within a home, can decrease distractions and confusion [13].</td>
</tr>
</tbody>
</table>
| **Sensory** | - When night sets in, a PD may demonstrate agitation and aggression due to the change in light conditions, resulting in "sundowning". Excessive wandering of PD results in interruption of sleep patterns for both the SC and individual [5]. Evening wandering can be alleviated by providing overhead, blue lighting throughout the day [14]. The use of high CCT blue lighting over yellow lighting may improve circadian
rhythms, thereby decreasing stress and agitation for PD [14]. Sensory changes as one ages include a decreased tolerance for the amount of glare and direction of lighting and a reduction in the visible colour spectrum [14]. As one ages, there is decreased ability to hear higher frequencies [15].

**Physical**

-as Minimal research has examined the physical changes to a PD. The result is that HIT are being created with little understanding on the specific anthropometric considerations for PD [8].

### 3) Task Management for PD

<table>
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<th>Consideration</th>
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<tr>
<td><strong>Sequencing and Prompting</strong></td>
<td>-Errors can occur due to sequencing of steps, omissions, additions and the inability in balancing two tasks [12]. There is a lack of recognition in initiating actions and/or remembering to utilize the device. This necessitates creating strategies around triggering the first step of the sequence - prompting the person to utilize the device [12] [16]. When a person becomes caught within a sequence of events, success can come by distracting the person from the task and tapping into more subconscious processes [17].</td>
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</table>

| **Error Detection and Reduction** | -Although efficiency may be important for the caregiver and family, it may not be critical or even possible when a PD is performing a task [8]. Accuracy should be prioritized over speed; avoidance of all errors may be unlikely, but it is more critical to reduce the potential harm that can come from these errors [9]. PD tend to have a low rate of detection of errors, but when they do detect the errors they have a high probability of correcting the errors. These perceived errors tend are often microslips, rather than delayed corrections [18]. Automatic rapid detection of errors may be preserved in PD, but that there needs to be further emphasis on creating systems to correct errors that have already been produced [18]. |

### 4) Technology - Design and Implementation for the PD and the SC

<table>
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<tr>
<th>Consideration</th>
<th>Summary</th>
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<tbody>
<tr>
<td><strong>Training and Instruction</strong></td>
<td>-Training becomes less effective as dementia progresses, but greater success may come from implementing the indirect route for memory [8]. Successful adoption requires training for the SC, in order to create reassurance that the HIT will not be an added burden [8]. Specific types of training can be effective during any stages of the disease. Reality orientation therapy combines training with prompts, where the intent is to minimize spatial-temporal disorientation [12] in [19]. -PD frequently request and have positive reactions to the presence of written instructions. It has been found that the instructions are rarely referenced and there can be extensive difficulties in using them [20]. PD often have difficulties interpreting and understanding verbal instructions, and voice concerns over the instructions being too fast [20].</td>
</tr>
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</table>

| **Design Considerations** | -Successful operation of a HIT occurred when the subconscious was used for problem solving [17]. -For those technologies where recognition is desired, voice-cueing is an application being developed, where the recording of a familiar voice was found to be more successful. However, a challenge has been that a familiar voice may trigger the patient to search for the person, rather than recognize that the voice is coming from the device [16]. -A failure of systems to blend into the environment may result in the person fiddling with the device, external cables and buttons could be pulled and damaged [16], thereby increasing caregiver stress and workload. - A study designed to prompt hand-washing had greater success with unfamiliar motion-sensor taps than traditional turn style [21]. Touch screens have been found to be readily understood and accessed by people with cognitive decline [22]. Navigation on a touch screen was more successful when a series of arrows were utilized versus dragging a finger across the screen [22]. |
Minimizing Confusion

- The introduction of novel steps can cause severe impairment in the attentional processes for PD [12].
- Rather than accessing cognitive processes that demand the learning of a new task, systems should be designed around procedural memory that prompts the person through a series of tasks [8].
- Systems should prevent false feedback, and thereby cause a person to misunderstand why a device is not working. The default should always be reset to the baseline to ensure the same pathway is required each time [16].

Presentation and Design

- The order of options can impact a decision. Randomly shuffling and presenting options may address this [22]. Consider the changes due to the normal aging process and utilize the skills that have not been impacted by dementia [23].

5) The Organization - Ethical and Socio-technical Considerations

Ethical

- User-centred approach may not be appropriate, as trialing technology during the initial stages of development may lead to added frustration if the system does not work fully. This may cause the subsequent refusal of any new technology. Involvement of the caregiver may address this, but this then introduces the challenge of the needs of the caregiver being prioritized over the PD [16].
- When involving caregivers in evaluations, there are concerns that data may be skewed since caregivers may only report the memory lapses and overlook the successes [18].

Socio-technical

- When examining health informatics and aging, there is a lack of knowledge as to what technologies are required for the aging population as well as limited cross-disciplinary research [24]. There are a few studies that examine quality of life, economics, gender differences for HIT older adults [24] and meaningful impact in relation to technologies that focus on cognitive decline [25]. Kitwood (1990, 1998) warns against labeling a person with dementia as being incapable, as this ‘malignant social psychology’ can damage a person’s self esteem and ultimately lead to loss of selfhood [26].
- Usability research and development has been limited, due to the current perception that the age of SC prevents them from learning and adopting a new technology [20]. Seniors avoid trialing devices, believing it will be a futile effort and will only create added stress [20]. When technologies have been unsuccessful, seniors are less likely than other age groups to recognize that the failure may be due to design and not due to their inability to learn a new system [20].

Conclusion

Although there are examples of promising developments in the field of HIT for PD, few of these are currently being utilized in practice. This includes limited availability of frameworks and models that can be applied to evaluating HIT in the community. Originally designed to reveal potential medical errors and employee outcomes in more traditional healthcare settings, the SEIPS model translates well to a community setting. It recognizes the additional stresses that can be introduced to the healthcare provider (in this case the SC) and potential impacts on patient safety for PD.

In applying the SEIPS model to HIT for PD, it revealed that there are many barriers and challenges that need to be overcome before these technologies can translate to a population level. Considerations include applying a user-centred approach in research and development that does not introduce more stress and frustration for the PD or SC. Similar to the findings by Or et al.[6], the authors of this paper found that a knowledge gap continues to exist in understanding the cognitive, physical and sensory changes that are specific to PD and the aging SC and how to translate this into practical applications. To ensure PD and SC are sufficiently supported in the community, there needs to be a greater understanding on the human
factors that are specific to dementia, and how to maximize the areas of cognition that are less affected and more dependable.

References

Patient Narratives Representing Patient Voices to Inform Research: A Pilot Qualitative Study

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Abstract. We are investigating the feasibility and effectiveness of establishing a library of patient narratives to inform patient-centered research in the U.S. Veterans Affairs organization. Using qualitative methods, we conducted a needs assessment of 15 researchers and then interviewed and videotaped 11 veterans with traumatic brain injury or diabetes. We developed a method for displaying the narratives to researchers modeled after a UK initiative called DIPEx and then performed preliminary usability testing. We found that it is not only feasible to provide researchers with patient narratives that could help guide their research, but that similar narratives might be useful to practitioners, health system decision makers, and other patients as well.

Keywords. Consumer health, patient narratives, research design, usability

Introduction

Patient-centeredness is now considered an essential component of a broader range of clinical and health services research, but researchers frequently find it difficult to incorporate patient perspectives, values and preferences into projects in a meaningful way. [1] Furthermore, few approaches to patient engagement or incorporation of patient perspectives in research are evidence-based. Researchers and clinicians will increasingly want and need access to the voice of patients and their families as well as models for how to effectively integrate this information into research.

We believe that creating, cataloging and maintaining a collection of narratives could make patient voices available to researchers when they are developing and conducting studies and incorporating results into care. Creating such a library could increase efficiencies and eliminate barriers to patient-centered systematic reviews, clinical research, and health services research. Allowing narratives to inform multiple studies could be more efficient than obtaining patient input de novo for each new review or study and the availability of narratives may also reduce the time needed to obtain results if new interviews and focus groups are not required before the start of a study. Patient narratives, defined as stories told by health care consumers about health

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issues, have been useful for educating health care professionals, [2] and for their understanding patient views, especially when collected as meta-narratives into libraries and the text analyzed. [3] Research about the use of narratives to inform research is largely limited to improving narrative research, not health services or clinical research. [4-5] The Department of Veterans Affairs is especially interested in incorporating the patient voice into research. Two conditions that are especially prevalent among veterans are diabetes and traumatic brain injury (TBI). Nearly 25% of veterans in the Veterans Health Affairs program have diabetes [6] and 15% of those who served in active combat in Afghanistan and Iraq have mild TBI. [7] These areas seem ripe for stories because both diagnoses are life changing. Our aim was to investigate the feasibility of collecting patient narratives from TBI and diabetes patients and organizing and disseminating them so that they are useful to researchers.

1. Methods

Because our goal was to help inform research, we first conducted a needs assessment using qualitative interviewing to ask researchers how stories might be useful, at what point in the research process they might be used, what we should ask patient interviewees, and what form the library should take. We then conducted semi-structured interviews with patients to gather narratives, analyzed the results using both deductive and inductive methods, and experimented with different formats for dissemination. The study received human subjects approval from the joint Institutional Review Board for Oregon Health & Science University (OHSU) and the Portland VA.

1.1. Subject recruitment and selection

For the needs assessment, we purposively selected VA and OHSU researchers who worked with TBI and diabetes patients. For patients, we used multiple recruitment methods to distribute flyers and announcements within the VA hospital itself and outside the VA through veterans’ organizations. Potential subjects were screened by phone so that we could be sure to include a gender, age, and severity of condition mix. Subjects provided written consent.

1.2. Data collection and analysis and format development and usability testing

We interviewed researchers using a semi-structured interview guide and analyzed transcripts using a template method. [8] With patients, we conducted 1-2 hour semi-structured interviews asking about the onset of their condition, early symptoms, their experience with their condition and how it changed their lives, their care, coping mechanisms, challenges their involvement in research studies, recommendations about research areas, and advice for other patients. The interviews, conducted jointly by two researchers and observed by a third, took place in a conference room in the VA hospital and were audio recorded and transcribed as well as videotaped. During this pilot phase, recordings were only read and viewed by the research team, so anonymity was not an issue. We used QSR NVivo to assist with analysis of the transcripts. All were coded in two ways. First, we coded according to predetermined codes that followed our interview topics, a template method. [8] Then we used a grounded theory approach [9] to develop themes, with two investigators coding each and reaching agreement and a
third researcher verifying those results after reading the transcripts. The entire team of five researchers discussed and agreed on interpretations during weekly meetings over a six-month period. We developed two types of dissemination vehicles and, with the help of a panel of researcher experts, performed preliminary usability testing.

2. Results

2.1. Needs assessment results

We interviewed 15 health services or clinical researchers affiliated with the Portland VA or OHSU about the usefulness of a library of patient narratives. They thought that increasing their understanding of patient priorities, justifying research in targeted areas, and referencing the library in background sections of grant proposals would be helpful. They might use narratives to inform planning for projects, gain ideas about recruitment, present research results in context, and justify additional research funding. They suggested provision of different formats (text, audio, and video), detailed indexing, summaries and distillations, and a guide for use of the library.

2.2. TBI interview results

We interviewed five TBI patients and six diabetes patients, all from the Portland area. Analysis of the diabetes interviews is in process. Preliminary results from analysis of the TBI interviews include the following themes.

- Diagnosis/nature of the injury/early signs: again, there was variation here in that some were officially diagnosed and others not, some had more than one injury, some were in combat and others received their injuries in other ways. Early signs varied in some ways and were alike in others.
- Ongoing symptoms/comorbidities: TBI and PTSD often occur together, as do depression, anger, cognitive impairment, suicidal ideation, and addictive behavior.
- Challenges/impact on daily life: interviewees described their invisible disability, being “damaged goods”, challenges of cognitive impairment, and impact on relationships, as well as special challenges of reintegrating into society both after the military and after their injuries.
- Coping mechanisms and support: these included internal strategies in addition to external sources of support, including family and friends and formal services inside and outside of the VA.
- Reintegration into society: the journey was difficult for all of our subjects, both because of the TBI and also because leaving the military presented challenges as well.
- Research role: suggestions for areas of research were more about health care services than they were about TBI. Interviewees offered insight into recruiting strategies.
### Table 1. Themes and representative quotes

<table>
<thead>
<tr>
<th>Themes</th>
<th>Quotes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diagnosis/early signs/nature of injury</td>
<td>“But initially, it’s the fact that you feel like an idiot, because you can’t remember your family’s name, you can’t remember what you did fifteen minutes ago, and words escape you, words you know, and you’re like and you can’t bring a word up, and then you lose it entirely.”</td>
</tr>
</tbody>
</table>
| Ongoing symptoms/co-morbidities | “My diagnosis was hypomania, which is some people consider bipolar, others don’t… I didn’t get the good stuff. I didn’t get the nice mania, but I got the negative, and since I already have—was predisposed to depression, dysthymia, well, this kicked in another one because I was damaged goods.”  
“TBI, PTSD—actually, then they called it adjustment disorder. You can’t have PTSD in the service.”  
“The computer screens, I always have to have a different color set, because if I didn’t it would—everybody’s like, “Why are you changing the screens?” “Because I can’t see it otherwise.” “Why are you changing it to large font?” “Because I can’t see it otherwise.” |
| Challenges/impact on daily life | “Well, yes. Well, my face was destroyed, so my older daughter, she stopped talking…my ex, it shook her up really badly, and she ended up with the brunt of dealing with health insurance companies, and doctors, and stuff, demanding money and calling the insurance company, it basically drove her over the edge. She fell apart.”  
“But I don’t drive anymore. I do okay as long as I’m driving forward. Backward, backing out I can’t, I just can’t do it.” |
| Coping mechanisms            | “Drinking. Drinking went way up…”  
“I’ve found either distractions have been good, deep breathing, sitting down, laying down and writing things down, just writing down the problem itself so you can—what’s the word—sort of deconstruct because it’s big.” |
| Sources of support           | “Because she’s actually my caregiver…She’s my memory. When I go to a medical appointment, I know I’m not going to remember any of it, so she does…It’s a huge impact having somebody you can count on, and can help you get to these medical appointments”  
“I feel a lot of veterans, especially the older ones, are not in the system, but even the younger guys coming back the hoops you have to jump through … I think a lot of people get frustrated, and they just give up, and they just don’t want to deal with all the red tape.” |
| Reintegration into society   | “You know, depression, suicidal ideation, occupational impairment, social impairment.”  
“They always told me I should never work more than part-time. And you try to explain to them that you have to work or you can’t live. Because you’re not going to get assistance.” |

2.3. Dissemination module development and indexing of transcripts

The needs assessment suggested that researchers would like to see a variety of formats, so we used two strategies: first, we experimented with indexing the text of the transcripts, which would be relatively inexpensive; second, we developed a more time consuming but potentially very effective format using video clips and summaries of
qualitative research results accessible on the web (rather than using our video, to protect the anonymity of subjects). The indexing was relatively straightforward, with an alphabetical index developed by human indexers to provide access to portions of the transcripts on topics of interest to researchers.

The module development was modeled after that designed by DIPEx, a UK project that produces Healthtalk (www.healthtalk.org) using rigorous qualitative methods. [10] Ours was geared towards an audience of researchers. A home page devoted to TBI offers a summary describing TBI and links to headings, which are our themes described above. If the user clicks on a theme, a description of the theme and links to video clips appear.

2.4. Usability assessment and feasibility estimate

We gathered a panel of ten experts who regularly attend a monthly health services research conference and held a focus group for assessing the indexed transcript format and the module format. The researchers had suggestions for improvement, agreed that they would find either format useful, and urged us to consider a broader audience for the module. While it would be feasible to develop a narrative library of indexed transcripts or carefully organized videos, researchers would prefer the latter, which would involve far greater expense.

3. Discussion and conclusion

While it was possible for us to recruit, interview, analyze, and present our findings in different formats, we did meet challenges and learned several lessons from this study. It was more difficult recruiting TBI patients than diabetes patients, possibly because they were hesitant to tell their stories even though as part of a research project, they were promised confidentiality. When we piloted the module with researchers, we learned that the interviews would likely be as interesting to other audiences, such as patients, clinicians, and health system decision makers, as to researchers. Producing a full module similar to those that are part of Healthtalk.org for TBI would be possible given funding and the possibility of recruiting from a broader population of TBI patients.

Acknowledgements

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References


Awareness of Technology-Induced Errors and Processes for Identifying and Preventing Such Errors

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Abstract. There is a need to determine if organizations working with health information technology are aware of technology-induced errors and how they are addressing and preventing them. The purpose of this study was to: a) determine the degree of technology-induced error awareness in various Canadian healthcare organizations, and b) identify those processes and procedures that are currently in place to help address, manage, and prevent technology-induced errors. We identified a lack of technology-induced error awareness among participants. Participants identified there was a lack of well-defined procedures in place for reporting technology-induced errors, addressing them when they arise, and preventing them.

Keywords. technology induced error, awareness, identification, prevention

Introduction

Information Technology (IT) is a big driver of industries, markets, and organizations worldwide. With health IT becoming more complex, pervasive, and susceptible to errors [1], health IT administrators and professionals have viewed these technologies as both “an essential organizational prerequisite for the delivery of safe, reliable, and cost-effective health services” and “a disruptive innovation for health services organizations [that] remains an overlooked organizational development concern” [2, p. 287]. This has resulted in a need to determine if organizations working with health IT are aware of technology-induced errors and how they are addressing and preventing them. To date, little research has focused on the level of awareness among healthcare managers, administrators, and IT professionals and the processes and procedures that are used to address technology-induced errors in organizations.

1. Background

1.1. Technology-Induced Errors and Awareness of Such Errors

Health IT can be viewed both as a solution to medical errors [3-7] and an opportunity to inadvertently introduce new kinds of errors [8-16]. There is evidence in the literature...
showing how IT may actually facilitate / induce errors [11, 12]. As a result, a new type of error in healthcare that arises from the use of technology has been identified [14]. Technology-induced errors can be defined as errors “that inadvertently occur as a result of using a technology” [13, p. 54], and “arise from: a) the design and development of technology, b) the implementation and customization of a technology, and c) the interactions between the operation of a technology and the new work processes that arise from a technology’s use” [14, p. 154]. Internationally and nationally, there is a need for more effective error reporting systems that allow for submission of information about near-misses and actual errors resulting from health IT and medical device use [15, 16]. Such work is important as it will prevent underreporting and will lead to the “development of new error reporting approaches and mechanisms focused around health IT problems” [16, p. 4].

2. Methods

2.1. Participants and Recruitment

We used a combination of convenience and snowball sampling [17, 19]. Invitations were first sent to participants via mailing lists at the University of Victoria. Individuals who participated in the study were asked to forward the invitation letter to their colleagues and peers who might be interested in participating in the study. Individuals participated in the study if they had direct experience in working with issues related to technology-induced errors. Participants were health IT specialists and / or clinicians. Participants were, therefore, able to provide insights into the occurrence of technology-induced errors [18].

2.2. Data Collection and Analysis

Interview questions focused on defining technology-induced errors, describing current processes aimed at reducing the risk of such errors, and identifying factors that may contribute to these types of errors. A conventional content analysis approach was used to analyze and code the interview data [20]. The codes were categorized into broader concepts and themes [21]. Ethics approval for this study was obtained from the University of Victoria Human Research Ethics Board.

3. Results

3.1. Demographic Data

Seventeen individuals participated in the study. Participants included physicians (n=4), nurses (n=6), analysts (n=2), consultants (2), and managers (n=8). Participants had experience in healthcare, IT privacy, security, delivery, informatics services, and / or various combinations of these areas.
3.2. Semi-structured Interview Data

Three major topics were explored through this research: the definition of technology-induced error, possible solutions for identifying, addressing, and preventing technology-induced errors, and current practices for reducing the risk of technology-induced error. General concepts related to technology-induced errors were identified: eight general concepts related to the definition of technology-induced error; seven general concepts related to possible management of technology-induced errors, and six general concepts related to strategies for addressing technology-induced errors. Four overarching themes related to the factors that contribute to technology-induced errors were identified as well.

3.2.1. Technology-Induced Error Definition

All participants were asked to indicate their awareness of technology-induced error and to define the concept in their terms. The goal of this study was not only to determine whether there was a consensus among the participants on the definition of technology-induced error, but also to identify factors that, according to the participants, contribute to technology-induced errors. Participants’ definitions included various factors, some of which were related to information access, interpretation, reliability, and validity.

Seventy six percent (n=13) of participants indicated they heard of the term and provided in-depth definitions. 6% (n=1) of participants were not aware of the concept, and 18% (n=3) of participants did not know the term but were aware of the concept. Participants suggested that technology-induced errors can be defined as health IT errors that result from an interplay of issues in the systems development life cycle (SDLC), knowledge / training, workflow, human-computer interaction, configuration / compatibility, policy, data access, and content. For example, one of the participants defined technology-induced error as “a faulty operational decision made by the technology user, facilitated by a flaw in the system’s design”. Participants also suggested that this interplay might occur at four different levels (i.e., four overarching themes): individual (i.e., user interacting with the technology), vendor (i.e., meeting design requirements of the organization), organizational, and governmental (i.e., contradicting policies or lack of system-workflow fit). For example, one of the participants suggested that technology-induced errors might arise as a result of “inaccuracies when implementing and deploying technologies in healthcare” and “policies and regulations that govern the introduction of technology into healthcare”.

3.2.2. Suggested Solutions for Identifying, Addressing, and Preventing Technology-Induced Errors in Healthcare

Participants suggested that there were seven areas where technology-induced errors could be managed. Technology-induced errors could be managed in the context of the SDLC, knowledge / training, workflow, human-computer interaction, configuration / compatibility, policy, and user engagement. Most participants believed that the phases of the SDLC and user knowledge / training were the main areas where factors that contribute to technology-induced errors could be addressed: “Well, I guess there’s the two main aspects to trying to reduce it. On the user side, the training process or the method in which you keep everyone up to date so that they don’t create the errors, and also how the reporting of the errors is done. Similar with a lot of the incident reporting. It’s very very difficult to get an organization to report on the incidents that they feel
make them look bad”. When describing how technology-induced errors could be reduced or prevented, each participant focused on sources of technology-induced errors. While some participants felt strongly about addressing potential causes of technology-induced errors in SDLC processes, others focused on improving training/education as a preventative strategy so that individuals would be more aware of technology-induced errors: “Terminology, training, I think, is definitely something that people need to look at. Not just the initial training, but also the refresher training after the first week of implementation. And you have trainers on site”.

3.2.3. Current Practices for Reducing the Risk of Technology-Induced Error and Responsibility for Addressing Technology-Induced Errors

Eighteen percent of participants (n=3) stated that there were no processes in place at the time of the study to reduce and prevent technology-induced errors in their organizations. Other participants talked about processes that were in place that could, potentially, aid in reduction and prevention of technology-induced errors: “most of the work that we do is based around implementing products as well as having procedures involved on the operational side of things, so having a strong project management process, user requirements, and having the checkpoints within the project”. It must be noted that the processes described by participants were not specifically aimed at technology-induced error reduction and prevention. Participants identified six main areas where their organizations could use strategies to address technology-induced errors: the SDLC, user knowledge/training, workflow, policy, content, and user engagement. As illustrated earlier, most participants talked about the SDLC process and training when asked about the processes and procedures in their organizations that might reduce or prevent technology-induced errors.

4. Discussion and Conclusion

Information about technology-induced errors in healthcare is lacking. According to this research, there is a need to fully define the problem of technology-induced errors and to make health professionals and organizations aware of it. The results of this study show that many individuals have heard of the “technology-induced error” concept or have encountered such errors in their practice. However, none of the participants were aware of the number of technology-induced errors that occur in their respective organizations. This suggests a lack of reporting mechanisms in place for monitoring the frequency of such errors. This lack of reporting, in turn, inhibits not only the appropriate level of awareness, but the ability to address and prevent these errors.

Participants were unable to fully describe having or knowing of processes or procedures at their healthcare organizations specifically aimed at identifying, addressing, or preventing technology-induced errors. Participants noted that while some organizations have certain processes in place, such as training and paying close attention to SDLC phases, there were no clear-cut, policy-driven procedures in place for: (a) reporting technology-induced errors, (b) addressing these issues when they arise, or (c) preventing such errors from happening in the first place. A lack of reporting mechanisms for addressing technology-induced errors may contribute to low awareness of such errors and in turn fewer processes to address them. Future research will need to focus on implementing and closely monitoring the effect of reporting
systems aimed specifically at technology-induced error reporting (including reporting system impacts on patient safety).

References

Designing Electronic Medication
Reconciliation for Patients: The Lead User
Method

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b Department of Family Practice, University of British Columbia, Vancouver, BC, Canada

Abstract. There is a potential to reduce medication errors by supporting the use of
medication reconciliation through electronic Personal Health Records. The lead
user method was used to identify specific goals and activities that are required to
have in an electronic medication reconciliation tool and to provide a synthesized
visual design that would reflect these requirements. Lead users identified two
major functionalities of a proposed medication reconciliation tool: ability to view
and edit certain medication information when reconciling medication lists and
share most current, reconciled medication lists with selected providers.

Keywords. Medication Reconciliation, Personal Health Record, Lead User
Method

Introduction

In the United States, between 380,000 and 450,000 preventable Adverse Drug Events
(ADEs) occur annually [1]. In Canada, approximately 70,000 potentially preventable
Adverse Events occur annually, 24% of which (approximately 16,800) are related to
medication errors [2]. One potential way of reducing medication errors is to support
people with Personal Health Records (PHRs) that can help them reconcile their own
medications into a comprehensive, up-to-date list [3]. Despite promise, PHRs have not
yet been heavily adopted [4]. One reason for low adoption and use could be the design
of the tools in the PHRs. The lead user method is an approach that has been used to
generate new and innovative product ideas. The purpose of this study was to apply the
lead user method and explore designs for a patient-initiated electronic medication
reconciliation tool that could be incorporated into an electronic PHR.

1. Background

Medication reconciliation aims to reduce the likelihood of ADEs through a formal,
systematic, and comprehensive review of patient’s medications to ensure that any
medication changes that occur across transitions of care are communicated to the

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Improvements in medication management may reduce hospitalization and re-hospitalization rates associated with ambulatory care sensitive conditions [5].

A patient-initiated medication reconciliation system may be more accurate than a provider-initiated system [7]. Using a PHR with medication reconciliation enables patients to be more involved in their own care and could help meet developing reconciliation requirements [8].

Alberta Health is currently implementing a province-wide PHR through MyHealth.Alberta.ca. It will offer its users access to their medication dispensing history through the Alberta Pharmaceutical Information Network (PIN) [9]. The users of this PHR can add medications and manage their own medication lists. Thus, all the major technical components will be in place for patient-initiated medication reconciliation in Alberta.

2. Methods

The lead user method is a user-centered design research method [10, 11] that has been used to develop product breakthroughs in other domains [12, 14] and in healthcare [15]. The goal of this method is to select highly motivated users who are ahead in their field of expertise, expect high benefits, and display extreme user needs [10, 14]. This kind of user selection is intentional. Working with lead users has been shown to generate more innovative ideas for products. The method was adapted for this study to inform the design of a PHR Medication Reconciliation tool aimed at supporting patients in reconciling their own medication lists across the continuum of care.

2.1. Participants

Three lead users were recruited for this study from a convenience sample of collaborators in health informatics. The inclusion criteria for selecting lead users incorporated experience with designing, developing, or evaluating clinical information systems, focusing on medications, PHRs, or both. The lead users were experts in medication management, health information systems design, evaluation and management, as well as prescribing and dispensing.

2.2. Data Collection and Analysis

Lead users were invited to participate in up to three generative design sessions held individually with each lead user. These sessions elicited design ideas from each lead user and moved from elicitation to validation through user interface (UI) visualizations. Between sessions, the research team analyzed the verbalized requirements and translated them into visual designs using a rapid visualization tool, and applied UI patterns and best practice principles for user interface design. We collected each user’s key goals for medication reconciliation and reflected them in each mockup design, which we then used in follow-up discussions with the lead users.

After each UI mockup was individually validated, a synthesis review occurred with the research team to create three synthesized models: a goal model, an activity model, and a visual model. The synthesized goal model summarized the key goals for medication reconciliation using the i* goal modeling language [16]. The model is used...
to highlight the simple care system and goals linked between roles. Based on the combined requirements and goals from the lead users, we developed a primary medication reconciliation flow. We used an activity diagram to depict an expected flow of activities when using a medication reconciliation tool. The synthesized visual mockup was aimed to include all activities identified as necessary by the lead users. Where there were variations, the researchers compared options to the goal and activity models and to general UI patterns, deciding on a preferred option.

3. Results

Three lead users were engaged for 2-3 sessions that took between 30 and 60 minutes each. The users had experience in: being a patient with medications (3), evaluation of health information systems (3), health information system design (3), medication management (3), and medication communication (1). The requirements and functionality proposed by the lead users led to the design of three individually validated medication reconciliation visual mockups. The individual requirements were compared and synthesized into a common goal model, an activity model, and a visual mockup of a medication reconciliation tool.

3.1. Lead Users’ (Combined) Goals: Synthesized Goal Model

The synthesized goal model summarizes the key goals for medication reconciliation from the lead users (Figure 1). The patient has five main goals: know when to reconcile medications with the help of regular reminders from the PHR, have accurate best possible medication history (BPMHx) in their record, know that the circle of care has access to that BPMHx, access various sources of personal medication information through the PHR (i.e., currently prescribed medications), and, overall, ensure that the medications are being managed safely as a result of their healthcare provider being aware of the updated list of medications that the patient takes. The key common goals in the model relate to appropriate and timely sharing of information to ensure safe medication management.
3.1.1. Synthesized Activity Diagram

The synthesized activity diagram (Figure 2) is focused on two main workflows:
1. Reviewing and editing the list of medications
2. Sharing that list with members of the patient’s circle of care.

Figure 1. Synthesized goal model (simplified model is shown). More detailed model freely available at: http://ehealth.uvic.ca/initiatives/projects/Synthesized%20Goal%20Model.pdf

Figure 2. Synthesized activity diagram shows the primary medication reconciliation flow displaying activities associated with medication reconciliation through a PHR (simplified diagram is shown). More detailed figure freely available online: http://ehealth.uvic.ca/initiatives/projects/Synthesized%20Activity%20Diagram.pdf
3.2. Synthesized Visual Model and Functional Description

The synthesized visual model includes activities that were identified as necessary by the lead users. Elements of the independent designs were considered individually and then holistically to ensure that the synthesized visual mockup was consistent while meeting the expressed needs from the goal and activity models. The activities and functionalities identified through the synthesis include: displaying un-reconciled medication list, adding new medications, reviewing medication discrepancies, discontinuing or archiving medications, and sharing reconciled medication list. All mockups may be accessed online on the eHealth Observatory website: http://ehealth.uvic.ca/initiatives/projects/Synthesized%20Mockup.pdf

4. Discussion

The goal of this study was to identify functional requirements of an electronic medication reconciliation tool that would be available through a PHR system. The approach also supported the development of a synthesized visual design that would reflect these requirements. These requirements and designs have been shared with Alberta Health.

The lead user method enabled our team to identify specific goals and activities that are required to have in a medication reconciliation tool from users who have spent time considering the problem space from different angles. As a result of this method, the lead users were able to both provide their own perspective and see how their ideas and suggestions translated into visual designs. This allowed for more detailed validation and further refinement than we expected. This study was limited to the requirements and design portion of the lifecycle. Future work will consider end-user testing and evaluation of impact of including medication reconciliation in PHRs.

The lead users identified two major functionalities of a proposed medication reconciliation tool: ability to view and edit certain medication information when reconciling medications lists and share most current, reconciled medication lists with selected providers. It is our hope that the findings from this study will aid in further PHR design and development as well as help researchers in considering how to evaluate effectiveness of PHR-supported medication reconciliation.

Acknowledgements

We would like to thank Alberta Health for supporting this project as part of the overall Personal Health Record development and deployment in Alberta. We would also like to thank our contributors for taking the time to share their knowledge and experience: Nicole Kitson, MSc, PhD; Jeff Barnett, MSc, FCSHP; and David Chan, MD, MSc.

References


Patient Perspectives on Patient Participation – Results From a Workshop with a Patient Council in a General Practice

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Abstract. The paper presents results from a workshop with a group of patients in a Danish General Practice (GP). The workshop facilitated a dialogue on patients’ roles and activities in daily health care by using a participatory design inspired method and pointed towards a pluralistic view on patients’ participation represented by the terms ‘mixed’, ‘social’ and ‘fluent participation’. The results challenge future research on Information and Communication Technology to support patient participation in health promoting activities by questioning how to embrace pluralistic opportunities for patient participation, which is especially important to GPs treating a broad group of patients.

Keywords. Patient participation, participatory design, empowerment, General Practice

1. Introduction

Patients’ active participation in health care has received increased attention in Denmark. The health care system is under pressure caused by an aging workforce, financial strain and increase of patients (demography, chronic illness, comorbidity, etc.). The Danish health care sector is witnessing a structural change where responsibility for medical service to an even larger extent is being allocated to the primary sector. Investments in advanced health care technology make the hospitals provide treatment that is more specialised, leaving the primary sector (Municipalities and General Practitioners) to be responsible for care and medical follow-up. Technology-mediated treatment has, to a large extent, given a better quality and also a faster turnover of patients in hospitals. In Denmark, the number of days a patient is admitted to a hospital has decreased from an average of seven days in 1990 to 3–6 days in 2013 [1]. From 2005 to 2010, the number of outpatient visits increased by 32% [2]. Thus, Information and Communication Technology (ICT) has played a pivotal role in facilitating patients’ roles and active participation.

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participation in daily health care. ICT can support treatment from the home of the patient [3], patients’ rehabilitation or health promoting training at home [4] and patients’ motivation, and can provide emotional support [5]. A central question in the research and development of ICT support for patients is: what are patients’ perspectives on these ambitions and strategies? Research on patients’ use of telemedicine has emphasised the invisible work that patients do [6] and, thus, the important role patients have in making technology-mediated health care work. Hence, patients’ perspectives are important to investigate. In this paper, we report from a workshop facilitating a discussion among patients about their roles and activities in daily health care.

2. Methods

The workshop was initiated by cooperation with a Danish General Practice (GP) (staff: four doctors and five nurses). The clinic formed a patient council as a step towards enhancing their understanding of patients’ needs and perspectives. It is its ambition to improve the cooperation between the clinic and its patients [7]. An initial concern for the clinic has been to develop flexible types of patient communication and patient consultation. They have developed a principle called ‘open door’, which includes the introduction of a web-based system facilitating patients’ communication with the clinic directly before consultations, thereby allowing the clinic to plan their interventions. The result is an open door to patients (i.e., no pre-booking of consultations), five days a week from 8 am to 15 pm. A second ambition of the clinic is to take the ‘open door’ policy further by introducing services that move beyond the short medical consultations (a maximum of 15 minutes per consultation) to support increased compliance and health promotion, in general, among its patients. These ambitions correspond well with national strategies calling for facilitated patient empowerment [8, 9]. However, it is uncertain, in the strategies and to this clinic, how best to use ICT to support patients in active daily health care. Therefore, the patients’ perspectives on this matter are important.

We were invited to facilitate a workshop with the clinic’s patient council (which has 10 members) with the purpose to obtain insights on patients’ perspectives on their roles and activities in daily health care. Participants were a broad and representative group of patients from the clinic: young and elderly patients, patients with chronic illness, parents, and patients with different cultural and national backgrounds.

The workshop (n=6) was held in a meeting room at the clinic on a scheduled meeting day for the patient council. We were given 90 minutes to conduct the workshop. To ground the discussion, we developed two fictive patients (Table 1).

Table 1. Two fictive patients presented to the patient council

<table>
<thead>
<tr>
<th></th>
<th>John</th>
<th>Jasmine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>55 years old</td>
<td>24 years old</td>
</tr>
<tr>
<td>Diagnosis</td>
<td>Newly diagnosed with type 2 diabetes</td>
<td>Gave birth to a baby one month ago</td>
</tr>
</tbody>
</table>

John and Jasmine are regular patients at the clinic. In addition to regular consultations, the clinic now offers facilitated cooperation on daily health care. How does this work?
To facilitate the discussion, we developed a set of situation cards for the participants to discuss based on methods inspired by Participatory Design and Information System theories. The materials and structure of the workshop guided the patient council through a reflective conversation about people, activities, technologies, locations, and resources. We asked (Table 2): Who do patients want to cooperate with in health care? What do patients want to cooperate about? How do patients want to cooperate in health care? Where do patients want to cooperate in health care? When do patients want to cooperate in health care? Activity cards were developed to support inspiration and force answers (Table 2). The cards showed a series of ideas, and, to force answers, participants were requested to prioritise among these and select one idea/answer. The cards were printed and laminated i.e. questions and activities were made into visual, tangible artefacts [10] facilitating participants in the process of organising and prioritising opportunities for health care cooperation.

Step one in the workshop introduced the two fictive patients. In step two, the activity cards were presented and distributed to the participants, one card with a question at a time, i.e. first the participants discussed the question: “Who do patients want to cooperate with? Second, “What do patients want to cooperate about?”, etc. The participants reflected and discussed each set of activity cards in pairs for five minutes, picked their personal preference card and then shared their priorities with the whole group. The workshop materials and instructions worked well – we had to stop discussions several times to move the agenda forward. The workshop was recorded on video and analysed by listening to the patients’ talk several times, transcribing patients’ discussions, and searching for patterns in the discussion by clustering core themes.

Table 2. Printed text on the activity cards for patients to prioritise when reflecting on patients’ roles and activities in daily health care. In each column are the situation (A, B, C, D, and E) and activities related to each situation (A1, A2, A3, etc.)

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<tbody>
<tr>
<td>A1. Equal patients. John is in a group for T2D patients, and Jasmine is in a group for new parents.</td>
<td>B1. Health promotion. The clinic facilitates cooperation among patients on health promotion themes (diet, exercise, and quitting smoking and drinking alcohol).</td>
<td>C1. Sharing. John and Jasmine share health activities and knowledge with others. Fx diet, exercise, etc.</td>
<td>D1. In the clinic John and Jasmine meet and cooperate in the clinic.</td>
<td>E1. Every day. John and Jasmine cooperate with others on a daily basis.</td>
</tr>
</tbody>
</table>
form a patient network and support each other to John and Jasmine, the most important thing is to be part of a network (vs. being alone with daily health care). in groups that do healthy things together. John meets twice a week with his group for a joint three kilometre walk, and Jasmine meets with her group at the playground once a week. with health care networks in various places. cooperate with others every second week.

<table>
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<tbody>
<tr>
<td>Patients living close form groups and support each other.</td>
<td>John and Jasmine are encouraged and challenged through cooperation with others. It keeps them motivated.</td>
<td></td>
</tr>
</tbody>
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Other ideas? Other ideas? Other ideas? Other ideas? E5. Ad hoc. John and Jasmine cooperate with others when they feel like meeting.

### 3. Results – Patients’ perspectives on health cooperation

The results from the workshop, not surprisingly, show that patients have disparate perspectives on patients’ roles and activities in daily health care. Some patients called for broad cooperation while others called for small and specific cooperation. Some patients regarded health cooperation as a minor activity in their daily living while others called for a lot of cooperation, etc. However, an analysis of the patients’ conversations revealed a pattern of three themes. Patients emphasised the importance of i) mixed cooperation balancing medical ideals and instructions with everyday life and experiences, ii) social relationships facilitating not only health promoting issues but also relationships, and iii) fluent (vs. static) cooperation facilitating variation and various opportunities for cooperation. Figure 1 below elaborates these three themes with quotes from the patients’ talk.
Mixed cooperation includes a mix of competencies (1), a mix of instructions and experiences (2), and a mix of specialized and local knowledge (3)

“Cooperation with others in the same situation is good but needs and experiences must be mixed. Experienced and newly diagnosed patients can learn from each other”

“Cooperation must be a mix of medical advice and personal experiences and needs. It must not be too instructive but give room for people to participate with their needs and knowledge”

“It is nice to meet with people with experience and knowledge but it is also nice to share everyday issues with people living close to you”

Social cooperation includes activities that support relationships (4), closeness (5), and joint health activities (6)

“It is just about being in a network. Sometimes it is just nice that you have someone to talk to. It does not have to be a person in the same situation or someone with the same illness just someone that can listen”

“I know that you can read and connect a lot on Facebook where there is a lot of groups but it takes away the closeness between people when you write someone that is not part of your everyday life”

“You need to do something together. It is not that interesting to have an illness. You need to engage in shared health activities like exercise or cooking, not just meet for lectures”

Fluent cooperation facilitates various opportunities for cooperation (7) and changing health issues/motivations for cooperation (8)

“You need the opportunity to cooperate on a daily basis virtually but and to meet physically when you feel like it and have time for it”

“Themes can change and must change. If you only meet about grocery shopping you will have nothing to meet for when that issue has been dealt with”

Figure 1. Identified themes and quotes from patient conversations at the workshop

4. Concluding remarks

With the objective to point at possible ICT-mediated health promoting activities to enhance daily health care outside the clinic, the method gave plenty of input for the clinical staff to consider. Despite the limited number of participants at the 90 minute workshop, the participatory design inspired method provided insights to directions for ICT-supported future patient cooperation and emphasised how valuable patients perspectives are for ICT designers. The method disclosed valuable insights into patient’s perspectives on who, what, how, where, and when, which the clinic and its staff can use to extend their cooperation with their patients. Using the two personas ‘John’ and ‘Jasmine’ as the focal points for the questions and answers made the participants feel free to draw on their own experiences with people or situations alike, as well as indirectly draw on their own experiences and preferences.

It is important to seek structured and innovative advice from patients, as they have precise but not homogeneous views on what may and may not work for them when it comes to health cooperation. Most ICT to support patient participation in daily health
care is centred on similarity with respect to the disease (e.g., diabetics co-operating with other diabetics). The workshop at the GP reviled a pluralistic view on patients’ requirements for participation represented by the terms ‘mixed’, ‘social’ and ‘fluent participation’. Thus, the results challenge our future research on ICT-supported patient participation by questioning how to embrace pluralistic opportunities in developing ICT-mediated patient participation, which is especially important to GPs treating a broad group of patients and who are obligated to deliver broad services.

References

Danish Citizens’ Expectations to the Use of eHealth

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Abstract. Danish citizens’ attitudes and expectations to eHealth is being investigated in this paper with the aim is to explore how the Danish citizens perceive eHealth. Data has been collected through a national survey with 1,058 respondents (80% participated by e-mail, 20% by telephone). We found that the majority of the Danish citizens had experience with use of eHealth and a positive view on eHealth’s impact on future healthcare. However, the citizens neither using nor trusting eHealth, belong to the socio-economic weak population with no or very little education suggesting a need for the designers and planners to revisit their patient empowerment strategies.

Keywords. eHealth, national survey, citizens, empowerment.

Introduction

Denmark has an international reputation of being a country of fast adopters of eHealth technology [1]. An International survey in the 2010 Commonwealth Fund International Health Policy Survey found that <10% of adults in the 11 countries that participated in the survey had used email to pose a medical question to their regular doctor or place of care in the latest 2 year [2]. In contrast the 2013 survey (n=1058) of Danish citizens’ use of eHealth from which we report in this paper, disclosed that 65% of the respondents or their closest relatives had used ICT to communicate with their GP [3].

For all stakeholders within Danish healthcare the pervasive role of the citizens in eHealth is a hot issue; healthcare managers, healthcare professionals, citizens, patient associations, system developers, vendors and politicians, all advocate that eHealth enhances patients position in treatment and care. The 2011 and 2013 Danish National and Regional eHealth strategies supports this potential of using eHealth technologies as the means to involve and empower the citizens in healthcare [4, 5].

Thus, the public health strategies leave the offices with patient/citizens empowerment as one of their strong objectives. However, when it comes to stating why empowerment is important and how empowerment is achieved, the intentions are rather fuzzy and not based on research data on e.g. Danish citizens’ eHealth readiness or eHealth literacy.

The citizens are end-users when it comes to designing, developing and implementing eHealth, and therefore, their perceptions and expectations are crucial pointers for politicians, planners and developers in relation to possible outcomes of eHealth; including empowerment.

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It is therefore of our concern to advocate research based evaluation and monitoring of eHealth initiatives and support developers ability to access data and use these to develop eHealth that do not leave citizens weak and manipulated as it is the case in several ongoing National, Regional and Municipal eHealth initiatives in Denmark [6].

In 2013, inspired by Canadian and Australian studies of consumer experience with eHealth, the Danish Center for Health Informatics (DaCHI), commissioned MEGAFON to carry out the first National survey on Danish citizen's expectations and perspectives on eHealth with a population sample of (n=1058) [7, 8] DaCHI has many years of experience in monitoring eHealth implementation in Denmark e.g. the National implementation of the Electronic Health Record (EHR), as well as more reason experience with a National monitoring of Health care professionals use of health informatics in their daily clinical practice [9][10]. This paper reports on selected findings from this survey [3] being the answers to the following questions:

- Have you by any means used IT in connection with your healthcare?
- Generally speaking, are you then in favour of or against the development of ICT to be used in healthcare?
- Do you expect use of eHealth to improve or impair the quality of the healthcare that you will receive within the next three years?

### 1. Methods

The outset was a questionnaire survey, drafted with inspiration from the Canadian consumer survey [7]. The number of children in the household, educational level, access to Internet (both in private and at work/education), mobile phone and smartphone, as well as chronic diseases was collected as baseline data. For those questions inquiring about citizens’ views and attitudes, it was possible to elaborate the answers.

Twice in minor pilot studies we tested the questionnaire by both asking the respondents to fill in the questionnaire and give feedback on the design of the questions, as well as adding issues they experienced were need to elaborate their views. Then, the refined survey was handed over to MEGAFON, a Danish market research agency. They again tested the survey and some questions were reformulated. The enumeration was designed as a combinational survey where both e-mail and telephone were used to question respondents from their citizen panel. In total the survey had 1,058 respondents, equivalent to the needed number of respondents for a country the size of Denmark. 80% of the respondents participated by e-mail, 20% by telephone.

In addition to general baseline data and subjects concerning use of eHealth, the respondents were questioned about their expectations for eHealth, including whether they saw themselves as having a positive or negative attitude, towards eHealths ability to improve quality of healthcare. Therefore, the question concerning this issue was split in two. After the respondent had stated whether he/she had positive or negative expectations towards eHealths influence on quality in healthcare, an elaboration of the answer was asked for. [3]
The unit of analysis comprised of people who were already part of the MEGAFON citizen panel. 2,100 e-mails were sent and 500 phone numbers were called. The selected respondents reflected the Danish adult population with respect to age, education and geographic distribution. 51% of the 1,058 respondents were female, 49% male. The population age was between 18 and 70+ with a distribution of 15 to 19% of the respondents in the 6 age groups.

The data was sampled over a period of one week in October 2013 and sorted into tables frequency tables and cross tables, for further analysis.

2. Results

60% (n=634) of the respondents had been using IT in connection with their healthcare. 56% were women and 44% men. 48% (n=305) of those holding a medium and higher educational background had been using IT, while 17% (n=107) of those with no professional education had used IT in connections with their healthcare. Out of the 60%, 78% (n=522) have not experienced any problems doing so. 37% (n=390) have had no experience with the use of IT for their healthcare. Of citizens with one or more chronic diseases 68% (n=238) had been using IT in connection with their own health, while 28% (n=99) had not.

78% of the respondents (n=823) were in favour of eHealth being used in healthcare. They valued availability of personal health data whenever these were needed and gave special importance to being able to follow previous and on-going treatments. They emphasised that eHealth was timesaving as treatments no longer depended on time and place. Furthermore, some respondents claimed that the development of eHealth would increase the efficiency of the Health Care Sector, result in economic savings and reduce the waiting time. 8% were against the use of eHealth in Healthcare (n=85). Of the reasons they mentioned were that the personal meeting could not be replaced by technology as well as not feeling that the treatment is proper, if the clinic is not visited.

There was only a minor difference between age groups. 82% of respondents between 19 and 29 were in favour of eHealth, 78% in the age group of 70+. As for those not in favours we found 10% from the age group between 19-29 and 9% from the age group 70+.

59% (n=627) of the respondents expected eHealth to improve the quality of care, within the next three years. Of these were 54% female (n=292) and 64% male (n=335). Crossed with educational background 17% (n=105) of respondents with no professional educational background expected eHealth to improve with in the next 3 years. For those with medium to long professional education it was 49%. 59% of the respondents having one/more chronic diseases (n=206) expected eHealth to improve the quality in care, compared to 60% of the non-chronic citizens (n=408).

Ten percent (n=103) of the respondents expected eHealth to impair the quality of healthcare with in the next three years. 37% (n=38) of those had a medium to long professional educational background where as 22% had no education.

Thirty-one percent (n=329) of the respondents did not know what to answer.
3. **Discussion**

The majority of the Danish adult citizens share the government’s enthusiasm for eHealth, being expressed in the public strategies. More that half of the Danish citizens (60%) have a personal experience with eHealth and 59% expected the use of eHealth to improve the quality of healthcare with in the next three years. Thus, it may be concluded that the Danish citizens are adapting well to the use of eHealth.

Our data support the assumption that the higher the education the more likely the citizens are to use eHealth and to have a positive view for the future of eHealth. Knowing that in Denmark the severe healthcare problems – followed by high public expenditures – are to be found among citizens with no or very low educational background and hence a low socioeconomic status, [11] it must be considered alarming for the patient empowerment agenda that the number of citizens from with these attributes are still relatively high.

The high educational level among the citizens may give an explanation as to why we found that 78% of those having used eHealth, expressed that they have had no problem doing so, as these eHealth applications on the whole are developed by people like themselves [12].

When eHealth, by the different Danish stakeholders is being directly assigned the role to empower the citizens in healthcare (and indirectly help to reduce public health care expenditure), our findings raises a flag and points at a need for specific attention to designing eHealth that attracts socioeconomic weak citizens with limited educational background.

Two thirds of the citizens with one or more chronic disease had used IT in connection with their healthcare. This supports the assumptions that citizens with chronic diseases are motivated to use eHealth and add to the need to involve these in participatory design processes [13].

A very high percentage of the Danish citizens express a positive view on the future use of eHealth in healthcare. Younger people, who are known for being more familiar with using ICT, are not in more favour since there is no significant difference between age groups. This is also the case for those not in favours of development of ICT to be used in healthcare.

4. **Concluding remarks**

A majority of the Danish adult citizens have, according to their self-assessment in our national survey, experience with the use of eHealth to their healthcare. They share a positive view to how eHealth may influence future healthcare. However, there is a need for the stakeholders, public as well as NGOs to be attentive to which groups of citizens that are being empowered. Citizens not using eHealth and have no experience with eHealth belong to a large extend to the group of citizens known to have the least resources but the largest health problems in society. This group of citizens needs to be involve not only in the designing appropriate eHealth technology but also defining exactly what kind of eHealth support they need to improve their livelihood and healthcare.
References

Development of a Flexible and Extensible Computer-based Simulation Platform for Healthcare Students

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Abstract. Accessing appropriate clinical placement positions for all health profession students can be expensive and challenging. Increasingly simulation, in a range of modes, is being used to enhance student learning and prepare them for clinical placement. Commonly these simulations are focused on the use of simulated patient mannequins which typically presented as single-event scenarios, difficult to organise, and usually scenarios include only a single healthcare profession. Computer based simulation is relatively under-researched and under-utilised but is beginning to demonstrate potential benefits. This paper describes the development and trialling of an entirely virtual 3D simulated environment for inter-professional student education.

Keywords. Computer-based simulation, healthcare student learning, inter-professional training

Introduction

Undergraduate students studying professional degrees in the health disciplines are required to gain professional practice experience, usually delivered through student placements. This is important in all health professions, but is particularly important for those working in the hospital setting, where students and professionals are routinely expected to work synergistically with a range of health practitioners possessing wide and disparate sets of training, skills and experiences [1, 2].

A recent report prepared for the Health Workforce of Australia (HWA) highlighted that students undertaking clinical placements experience a significant amount of occupational stress, which negatively impacts upon their ability to learn and perform. One of the most commonly cited stressors is a lack of adequate preparation for their placement. Students were also concerned about the amount of knowledge they were required to learn and the speed in which they had to do so, and reported a fear of making mistakes [3].

Fortunately, there is an educational solution that can help resolve these issues in the form of simulation [3]. Through simulated exercises students can gain an understanding of their role and responsibilities in patient care, making them better
prepared for their placements. As an additional benefit, educators can be certain that students who have participated in simulated activities will have specific skills and experiences prior to graduation. The recent study by Hayden et al. [4] acknowledged the difficulty that exists in accessing sufficient appropriate workplace placement positions for undergraduate nursing students in the USA. The researchers substituted up to 50% of practical hours with simulation hours and found there was no discernable difference in the quality of these students compared to those with the normal number of placement hours.

There is a range of existing simulation activities occurring throughout the national and international community. Commonly these are focused on the use of simulated patient mannequins. These high fidelity simulators enable students to practice a range of procedures and skills, and are considered to be an excellent teaching tool for health professionals [5]. However, simulation programs such as this are typically presented as single-event scenarios, without the context of the true work environment and the rest of the patient’s admission history [6]. They are also logistically difficult to organise, particularly when there is an inter-professional focus, and it is challenging to incorporate all professions equally into the same patient care event [7]. Furthermore, they are expensive to operate and lack accessibility, with mannequins being costly and heavy pieces of technology that require trained operators, skilled demonstrators and a suitable physical space in which to practice [5].

These simulated exercises are generally well received and provide good learning outcomes. However, due to logistical and cost pressures, they are only sparingly applied, and are often dependent on external funding for their continuation. As such, there is a real need for a more cost-effective, easier to organise, and time-efficient approach to healthcare training simulations.

This research in progress paper describes the development and planned trialling of an entirely virtual 3D simulated environment for inter-professional student education. This type of simulation is relatively under-researched and under-utilised, but is a field which has seen significant recent advances. It is becoming increasingly accepted as an effective educational tool [3, 8, 9]. In comparison with the mannequin approach, this style of simulation has many benefits to offer, and has the potential to solve both the cost and logistical issues that can undermine typical simulation programs. For example: the simulations can be more complex and detailed, not being limited by the mechanical capabilities of the mannequin; the learning environment can be simulated cheaply and quickly, with few on-going costs; they can be updated and extended easily; and they are very accessible. Most standard desktop computers, laptops, and now tablet devices are capable of running a quality 3D simulation to an acceptable standard, allowing students to access the simulations on demand through the web, and connect and collaborate online, without needing to share a physical space.

1. Background

To date, much of the computer simulation work has been done using Second Life (Linden Research, San Francisco), a multiplayer, persistent virtual world in which users can create and share content, using online creation tools. Researchers and educators working on healthcare simulations in this space have been able to produce some useful outcomes, leveraging the relatively accessible online world creation tools and the built-in network support to make collaborative simulated learning
environments [6, 10]. However, Second Life as a platform for healthcare simulation has many drawbacks. It can only run on high end computers with Windows, OSX or Linux operating systems – not mobile devices. Quality is not assured, with poor performance being a common complaint. It is very expensive, with a $1000USD set-up fee and a $295USD monthly rental fee to run just one simulation. Finally, only one simulation can be run at a time, which must be shared by all users.

A potentially more effective approach to the development of healthcare training simulations is to use a modern game engine, which allows developers to avoid the limitations noted above. The development project team had previously been successful in building simulators in this style, with the development of a comprehensive simulation of a community pharmacy environment. The community pharmacy simulator has proven to be effective in a randomised controlled trial [11]. The results indicate that the simulation performed as well as, or better than, a traditional pharmacy practice tutorial in all measured aspects when given to third-year pharmacy students. Results measured include student satisfaction, confidence to practice, and clinical knowledge. These results were achieved even though students in the traditional tutorial group of the trial had access to two clinically trained demonstrators, whereas students in the computer-based simulation group did not. In light of this success, the community pharmacy simulator has been integrated into the pharmacy degree at the University of Tasmania, and is now also being evaluated for use at the University of Newcastle.

The natural evolution of this concept is the development of a flexible and extensible simulation platform in which students can practice either singly or in teams to address patient-centred scenarios in a chosen healthcare setting.

2. Method

This project uses the Unity3D game development engine, which is free for non-commercial use, extremely powerful, and very accessible. Unity3D also allows developers to build versions for a wide range of both PC and tablet devices, making the resultant software extremely accessible to students at any time or place.

The initial focus of the development is on modelling the basic roles of doctors, nurses and pharmacists in a hospital setting. Students using this simulation will be able to practice not only their own roles and duties in a safe and feedback-rich environment, but will be able to work collaboratively on multiplayer inter-professional scenarios where their ability to communicate will influence patient care. Students can even undertake other professional roles to provide experience from a range of perspectives.

The system enables students to follow the patient’s hospital inpatient journey from admission through to discharge. It includes interactions such as: initial systems review and diagnosis; medication history and reconciliation; inpatient medication prescribing, review of inpatient orders and medication administration; patient observations, response to patient monitoring/MET calls; through to discharge planning, discharge counselling and multidisciplinary meetings. Successful negotiation of the scenarios requires students to gather and interpret data as in real world practice, communicate effectively with other members of the virtual healthcare team and act appropriately for the given situation.

The development also provides a scenario-building tool which allows educators to craft their own scenarios to fit their teaching needs. Most users will be satisfied with this, but if they have particular needs that are not accommodated within our provided
platform, future developers will be able to easily extend it. For instance, including different professional roles and alternate healthcare settings, or modifying existing work to better suit their particular educational needs, perhaps by adding localisation elements for different local hospital environments.

3. Evaluation Plan

Evaluation will involve a small pilot with volunteer students from the three disciplines undertaking a basic collaborative scenario, outside of normal class hours. Researchers will measure pre- and post-scenario values for students’ confidence to practice, enthusiasm and engagement, attitudes towards their colleagues, and clinical knowledge. This style of evaluation has been successfully used previously for the community pharmacy simulator. This will be followed by focus groups as part of the debriefing which will provide further qualitative assessment of the student experience. Interviews will also be conducted with the hospital preceptors and students after their placements to determine if there has been any apparent change in preparedness and ability to work collaboratively with other students and staff.

After the initial evaluation, it is intended that this should be used as a teaching tool in some of the classes as a method of achieving the learning objectives.

4. Discussion

This approach fills the identified need for current students to be assisted in developing appropriate expectations in relation to the placement experience. Some students have difficulty adjusting to professional placements and this is frequently due to a mismatch between student and placement facilitator expectations. It is possible for students to continue practicing, using computer based scenarios, until they are confident with issues such as inter-professional communication, patient interactions, ward orientation, professional expectations, and understanding and navigating professional boundaries. All these skills and experiences can be introduced earlier in the curriculum, without negatively impacting on the healthcare experience of real patients.

As evidenced by the previous trial, computer based simulation can provide consolidation of knowledge, improved self-confidence in relation to knowledge, communication ability, teamwork and a greater appreciation of the roles of other healthcare professional groups [11]. Students can undertake elements of the simulation as many times as they want, and thereby gain confidence and familiarity with hospital activities in a non-threatening and risk-free environment. The outcome is the improved readiness for optimal real world clinical placement, which is expensive, resource intensive, and scarce.

The availability of an easy to use scenario builder has the potential to enable educators to mirror a wide range of health professional and patient experiences for different health professional groups and students at different levels of their degrees. It can also be used for continuing professional development scenarios to refresh or enhance the skills of trained healthcare professionals. This scenario building can occur quickly, easily, dynamically and cheaply to reflect changes in clinical practice.
5. Conclusion

Computer based simulation using a flexible and extensible platform is an appropriate method to extend and support undergraduate healthcare student learning. In particular it is a viable method to reduce placement costs, stress, and improve student and patient outcomes. It is possible to use this method to provide inter-professional learning scenarios that can be conducted either in real time or asynchronously, thereby enhancing students’ preparation for placements and clinical practice.

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References

Integration of Electronic Health Records into Nursing Education: Issues, Challenges and Limitations

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Abstract. In this paper we describe our integration of teaching about the use of electronic health records into a fourth year undergraduate nursing course. We report on our method of integration and issues, challenges and limitations of the approach. We present our findings using a case study approach that includes a description of the context and EHR software used.

Keywords. Electronic health record, nursing, informatics, education

Introduction

Undergraduate nursing students represent a significant proportion of health professionals who need to develop electronic health record (EHR) competencies as regional health authorities are rapidly implementing the technology. Nurses are one of the highest users of such records in their everyday work, making this an essential competency for their practice. EHRs are systems that allow health professionals to enter and retrieve patient data electronically. Although some studies have been published about nursing informatics competency development [1-3] and the impact of introducing a EHR into a nursing course to achieve competency [8], few studies have discussed the instructional and technical issues that arise from integrating EHRs into nursing courses and programs. The purpose of this paper will be to discuss the introduction of an EHR into an undergraduate nursing course from an instructional and technical perspective.

1. Review of the Literature

EHRs are an important technology because they are the terminological, informational and workflow interface between nurse decision-making and actual patient care. As such today, EHRs are a primary and critical resource technology in healthcare for health professionals where patient care is concerned, yet there are few schools of

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nursing where the technology is fully integrated into undergraduate nursing curricula internationally [1]. There are a number of reasons for this. Some countries have just developed or are in the process of developing nursing informatics competencies [1-4]. In other countries, there is a lack of opportunity to access a variety of EHRs typically used in healthcare settings for educational purposes in an educational context (e.g. as part of a college or university nursing program) [1]. There are a number of reasons for this, namely: (a) an inability to acquire multiple EHRs for educational purposes due to the high cost of purchasing and maintaining such systems, (b) a lack of health informatics expertise to implement and maintain an EHR in an educational setting, (c) a lack financial resources to implement and maintain such systems [4,5,7], and (d) a lack of nurse educator competencies in teaching students how to use the technology [6]. Few studies have described how to overcome these issues. Instead, the research has focused upon describing the impact of introducing EHRs into a nursing course at the undergraduate level in terms of: (a) developing nursing informatics competencies, improving student confidence in using the technology, and developing EHR knowledge and skills [3,7-10]. There is a need for more documented examples of EHR integration into an undergraduate nursing program, including published works that describe the issues and challenges encountered by educators. These are important concerns as some jurisdictions are now requiring entry-level Registered Nurses to develop nursing informatics competencies and understand how to use information and communication technologies in health care [11].

2. Method

2.1. Case Study

The work will be presented using a case study format to describe the issues and challenges experienced by educators associated with EHR integration in an undergraduate nursing course. A case study format will be used as it allows for a full description of the setting, context, materials and educator experiences [12].

2.2. Setting and Context

Researchers at the University of Victoria created an EHR portal that allowed for easy access to several open source EHRs records via the WWW by several hundred students at the same time [see 1]. Prior work involving the portal involved integrating the EHR into the University of British Columbia medical program. In this work medical students accessed an EHR over the WWW from three geographically distributed sites and worked through a patient case in a course [see 1,4,5,13 for more publications on differing aspects of this work]. In this paper we extended our work integrating EHRs within a nursing course: Nurses Influencing Change. The course was selected for a number of reasons: (a) the course is structured to promote discussion about innovations, changes, and issues in health care and their implications for nurses, (b) many regional health authorities in Canada are currently implementing EHRs, (c) there was an identified need for nursing students to be able to learn about and critically evaluate the technology for its ability to support nurses, and (d) this would offer students an opportunity to learn about the EHR in a classroom context for the purpose of preparing for actual use in clinical settings.
2.3. Participants

Nursing and health informatics professors collaborated to create this opportunity for approximately 170 4th year undergraduate nursing students.

2.4. Materials

The portal provided students with access to several open access and private EHRs [see 1,5,13]. The Veteran’s Affairs Computer Patient Record System (CPRS) was selected as the EHR for the course as it is considered the gold standard in the healthcare industry with research supporting its use as a tool that can improve the quality of patient care [14], and because it has an open source platform [1,5,13,14].

2.5. Procedure

Each student was given their own user name and password to access the portal and CPRS. The week before the class where EHRs would be discussed, students were emailed the manual, asked to log on to the portal and EHR, and were instructed to explore the EHR prior to attending a lecture in the Nursing Trends course. As part of pre-classroom work, students were asked to answer a set series of questions about the ability of the technology to support: (1) nursing practice, and (2) the strengths and weaknesses of the technology from a nursing perspective. The students then attended a three hour classroom session where they were presented with a short lecture by the researchers, who set up the experience, on the underlying conceptual and theoretical aspects of EHRs, followed by group work where students were asked to critique the technology from a nursing perspective and present their analyses of the technology to each other. Professors facilitated student discussions and presentations.

3. Results

The approach taken to integration of an EHR into the course entitled Nurses Influencing Change to lead to intense student discussion. A number of findings and observations can be made from this experience described below.

3.1. Experience with Using EHRs and EHR Portals

The professors realized that not all students or faculty were technically savvy where full EHRs and EHR portals were concerned nor were they familiar with all types of hardware and software (such as decision support systems). As well, most students and faculty had had only limited experiences in working with hybrid EHRs (i.e. where part of the patient record was electronic and the other part was paper-based) during practica and in working with Internet based portals (such as the one at the university). These experiences did not afford individuals with a full understanding of the conceptual and theoretical aspects of the EHR. For example, students and faculty indicated they liked the opportunity to work with a full EHR (as clinical practice settings were not fully electronic) and to learn about how to use a system using simulated patients to fully understand system features and functions. Students commented that prior to this
opportunity they had very little experience with specific to EHR functions (e.g. vital signs documentation, laboratory results review). Production EHRs, implemented in regional health authorities do not allow for “hands on” experimentation with system features and functions as real patients are involved. Typically, individuals learn to use software through experimentation and “hands on use”. This work also afforded students and professors with opportunity to discuss patient privacy and confidentiality with regards to the EHR. Our work points to the need to integrate the technology into undergraduate nursing courses or programs at various times during the program so students can learn incrementally and incorporate their EHR knowledge into their practice as they gain overall nursing competence over time.

3.2. Use of Personal Hardware and Software in an Educational Context

Students and faculty used their own computers, web browsers and wireless internet connections to access the portal (e.g. on the university campus, at home). There were a wide range of computer hardware, software and wireless internet networks being used by students and this sometimes affected the quality of the experience. Students and faculty were asked to use their own computers to reduce the cost associated with using the portal and the EHR and to reflect the current academic educational environment where software and hardware used by students and faculty is selected by individuals to support individual educational needs. As well, an easy to use manual was developed to introduce students to the EHR portal and software supplemented by help desk support. Help desk support was important because it was able to determine the root causes of some of the students being unable to logon or use the technologies (i.e. some students’ required support to overcome problems with wireless access, while others who used Mac computers required a windows desktop emulator) [1].

3.3. Need to Access Software in Real-time to Support Student Discussion

During classroom exercises, it was noted that it was very useful for the students to be able to view the EHR and at the same time receive group facilitated support from professors. Here, professors did not expect that students would need to access the technology during discussions to help with identifying specific features and functions of the system that did not support nurses’ work and how this might lead to workarounds. Professors talked about the need for nursing students to point out these issues to improve EHR designs into the future. Students found it helpful to access the technology during group discussions and critically evaluate the EHR in the classroom.

3.4. Limitations, Issues and Challenges

Students noted the technology could significantly improve the quality of patient care once a full EHR was deployed because it offered ways to be more efficient in their nursing practice without compromising time spent with patients. Nursing students believed the technology did not fully support nurses’ work. Some students noted that nursing terminology was not present in the EHR and how this could lead to the invisibility of nursing. During student discussions, questions also arose as to why health care organizations did not have fully functional EHRs and why data did not include nursing and allied health contributions to care. Students suggested that nursing content and interprofessional terminologies, features, functions and content be added.
4. Discussion and Conclusions

Integrating EHRs into nursing programs requires a holistic approach that considers more than the impact of the technology on nursing informatics competency development. A holistic approach considers instructional, technical issues and nursing practice issues. If technical issues are not addressed in advance, students will not be able to use the EHR and/or will use it ineffectively. If instructional and nursing issues are not considered that bridge the translation from theory into practice the development of competencies that can be effective or useful in practice will be compromised. Presenting students with the issues and challenges of using a technology helps educators to create an environment that is open to students being willing to experiment and work through the difficulties when learning the complexities of EHRs and its use by nurses. This increases the likelihood students will engage with the materials in a pragmatic and open-minded way that leads to greater mastery of necessary skills and competencies in health informatics and electronic documentation systems as required in nursing practice. Research, however, is needed to understand not only how technologies improve competencies, but how to construct classroom activities that truly engage students to help them learn how to use technology effectively and ensure their EHR competency. This has included identifying how EHRs can be designed with nursing terminologies and to reflect real world nursing activities.

References


Know Me – A Journey In Creating A Personal Electronic Health Record

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Abstract. KnowMe is a patient created personal story of key life events both medical and non-medical that enables clinicians to understand what matters to the patient, not what’s the matter with them. By shifting the Electronic Health Record (EHR) focus to knowing when a patient was at their best, what’s important to them, their personal health goals, and care preferences, clinicians and patients can collaboratively work together in creating a treatment plan that aligns resources tailored to their needs.

Keywords. Patients, Personal Health Record

Introduction

Personalization is becoming more and more apparent in many aspects of modern day life and we believe it is most important in health care. While many personalized medicine efforts focus on what is in a person’s DNA, the Know Me project focuses on what is in a person’s heart and mind that a lab test cannot uncover.

In order for clinicians to better care for patients they should know what matters to the patient, not just what is the matter with the patient. The health care team must also be able to see what is important to the patient and what his/her goals for health are. What was the person like at their best, before they became a patient? Clinicians must be able to see the patient’s health care team as he/she defines it. That team may be a spouse and children for one person and a neighbor or friend from church for another. People are unique and the information their clinician sees should be too. That’s why Cerner and Island Health are creating “Know Me.”

Know Me consists of and brings together common demographics (address, next of kin, etc.) in a more patient-centered way to tell a person’s story. It also allows for patient entered data so the patient’s voice is part of that story. Finally, Know Me allows clinicians to enter both clinical and non-clinical data to document and help fellow clinicians understand a patient better. “Patients are the ultimate stakeholders. They have the most at stake, and can contribute real value in new ways.” [1] Dave deBronkart

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1. Island Health and Cerner’s Journey to Know Me

This project can trace its roots back to the story of one of Island Health’s patients. Mrs. G. was a healthy and active woman in her community, on Vancouver Island. She fell and broke her wrist. What followed was a tragic series of events where Mrs. G. was transitioned from place to place and her health slowly declined until she was confined to a wheelchair in a residential care facility, where she ultimately passed away. In reviewing the case, it was determined that each caregiver along the way generally provided good care. However, the system itself created an environment where transitions, discontinuous planning, and a lack of understanding of Mrs. G. as a person (her status, and history, and recent abilities) resulting in this rapid decline.

With the permission of Mrs. G’s daughter, Island Health documented the story in great detail. Because the most tragic part of Mrs. G.’s story was that it was happening to other elderly people under the care of the Health Authority. The leadership decided that telling Mrs. G.’s story might help to deepen the understanding of caregivers and help them improve process to ensure the story would not happen in the future.

Through documenting the story, her daughter described a better future state where, if caregivers really knew what her mother was like, at her best, they might have been able to set higher goals and different plans to return her to that state of health.

2. Early work on Know Me

Cerner employs a User Centered Design and Agile methodology to develop software. These methodologies value individuals, interactions, and their goals over processes and tools. Working software demonstrated early and often is more important than comprehensive documentation. Responding to change is valued over following a plan that doesn’t deliver value each release. And, most importantly for this project, end user collaboration is at the centre of all the work. In the case of Know Me, there are several end user groups. Of course, clinicians are expected to benefit from a deeper understanding of a patient’s story. But we also expect that patients themselves will be ‘end users’ by giving them the ability to contribute to their story, in their own words, through the use of a patient portal or some other means.

In the early days of the Know Me observation research, involved extensive interviewing of clinicians, physicians, and patients. Patients were determined to be the primary focus of end-user interviews and they came first. Island Health had already established a Patient Voices Network, where citizens could volunteer to participate in Island Health projects or committees. Patients were invited to participate based upon their interests and the amount of time they wanted to commit. Fifteen patient advisors were invited to participate and subsequently interviewed. They represented a broad cross-section of demographic groups and experiences. These 15 individuals had 350 health care experiences over the preceding 12 months, across five different communities on Vancouver Island. The patient interviews provided a rich starting point about how the EHR might support a better experience.

“"The more information I’m able to provide about “who” I am and what I hope for in terms of health results, the easier it is for ALL medical professionals to be on the same page, whether I’ve seen them before or not. I think this will also help them see me more as

"
a “person” and not just another “patient”: Pamela, Patient Advisor

The team then proceeded to interview physicians and the interdisciplinary care team to observe their current workflow and coordination of care. In all, 55 clinicians were interviewed and/or observed, across 25 different specialties in 7 communities across Vancouver Island. The goal was to understand what information or details they felt were missing from what they know about a given patient that might help them provide better care. If patients were able to better ‘tell their story,’ how might the plan or treatment change? The innovation team discovered that there were a lot of gaps in the story that were filled in through a series of notes and whiteboards and that the multi-disciplinary care team had been cobbled together their patients’ stories and were excited about the prospect of the EHR facilitating better communication.

“Getting back to the basics of meeting together, as a team to go over relevant information pertaining to our patients, assigning jobs, and daily follow-ups is an efficient way to maintain and maximize team based care. We are living our values of being better together.” Dr. Sam Williams, Chief of Staff- West Coast General Hospital

Overall, the investigation process told us that patients want clinicians to see them as a person and not just another patient. They want clinicians to know about their family, values, daily living, fears, triggers, and hobbies. In turn, clinicians want to really understand their patients so they can provide better care.

3. Getting to Know a Patient Advisor

Mrs. E is one of our patient advisors that has shared her story and provided feedback on KnowMe. This is her story, in her own words:

My name is Mrs. E. I live in Victoria, and I’m a retired teacher and school administrator (I’ve been retired for four years). I live with my husband, Chris, and I have two children, Scott and Amber who are in their twenties, and live in Vancouver. My mother, Barb, is 89 and living in Ottawa. We all consult and support one another about anything healthcare related.

My health started to decline about 8 years ago, mainly due to bilateral hip replacement and chronic Urinary Tract Infections. I am in constant pain and it is affecting all parts of my live. I used to love yoga and hiking, and I just can’t do those things anymore. I have had frequent referrals and frequent medical appointments due to my conditions, and I am often asked to “start from scratch” with each new doctor. I know that files are sent electronically from doctor to doctor, so why should I start from scratch? I think it would be helpful for both patient and health care provider to have a short summary of key points for easy reference prior to the beginning of the appointment.
**My Bio as I want it stated to my health care team in the EHR:**
Health and wellness are very important to me. I like to be physically active, vital person who wants to do everything she can from a self-management perspective to enhance health in her life. I prefer to manage the use of medications, knowing they are necessary treatments for some of my illnesses and conditions. Mrs. E

**4. Current State**
As of September, 2014 Know Me is in its early design and development iterations. The first phase of the project is to leverage data that already exist in the EHR. Through the normal registration, scheduling, and assessment processes at Island Health, information is captured that can start to tell someone’s story. Today the data is collated in a clinical manner, but we are challenging the status quo to aggregate the data from the patient’s perspective. This creates a medium in which the person can tell their story and provide what is important for a clinician to know, a paradigm shift. The Agile methodology calls for iterative design and development with end users (in this case, both patients and clinicians) involved throughout the process. We expect the design will evolve and change based upon use in real time and in different venues of care. The first release of Know Me is scheduled for May, 2015.

![Early stage Know Me design](image)

**Figure 1.** Early stage Know Me design

Privacy and security are important considerations in the Know Me project. EHR’s have robust controls over which clinicians have access to different types of information. The literature to date does not really address the blend of clinician and patient inputs
and access by patients to edit their own record. As of the writing of this paper, a grant is being written to fund the study of that work and to organize a research study to create a new access control model that will sufficiently deal with this dramatically different approach to patient and their personal care team involvement in their care.

The overall objective of the research project is to research the Circle of Care-based access control system for Know Me. According to Price, the Circle of Care (CoC) is a system that is centered on a patient and contains the providers, information and activities related to that patient’s care [2]. Relationships between patients and actors in their individual and evolving “circles of care” (CoC) are ephemeral and depend on changing conditions and healthcare contexts. Moreover, Price points out that providers in the CoC includes not only physicians, nurses, other formal providers, but also informal providers (lay people providing care, such as family members or friends).

5. The Future of Know Me

Ms. G and Mrs. E’s story are just two of thousands, which is why Cerner and Island Health are working together to create a “Know Me” view of the patient. The view will allow patients to update his/her information, provide clinicians a mechanism to update the view and give health coaches and clinicians the ability to access the information. Island Health will be deploying a patient portal to further facilitate the Know Me approach. Through the patient portal, patients and/or their personal care team will be able to document and edit their goals, their living situation, and their care team as they perceive it and as their story unfolds.

As Island Health continues to evolve to a model of integrated primary and community care, new roles will emerge that will enhance the Know Me process and will benefit from its potential. Health coaches will proactively work with patients to document their goals and track progress in real time. Know Me will become a regular part of how patients actively engage in their care throughout their journey of health, as well as through episodic moments of care.

“My doctor is a diabetes expert, but I am the leading expert in my diabetes. My opinion and preferences are just as important as those of my health care team, and working together with my doctor to create a personalized approach in managing my Type 1 diabetes has earned me the best health outcomes.” [3] Kerri Sparling

References

Integrating Clinical Decision Support into EMR and PHR: a Case Study Using Anticoagulation

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Abstract. Clinical decision support (CDS) for atrial fibrillation is expected to ease the implementation of often-complex guidelines for atrial fibrillation and anticoagulation. Most clinical decision support systems (CDSS) for anticoagulation are stand-alone systems that do not integrate with electronic medical records (EMR). We have developed an architecture that consists of a computerized CDS that can integrate with multiple EMRs and multiple patient health records (PHRs). The design process revealed some significant issues that were resolved through systematic business/clinical analysis and creative clinical design in the diagnostic and treatment domains. Key issues identified and resolved include: 1) how to correctly allocate existing patients into various CDSS states (e.g., MAINTENANCE, HOLD, DISCONTINUE, etc), 2) identify when a patient becomes eligible for CDSS guidance over time, 3) how the CDSS maintains information about the patient’s anticoagulation state and 4) how to transform vague human-readable concepts to explicit computable concepts. The management of anticoagulation for atrial fibrillation is no easy task and we believe our architecture will improve patient care at all levels and ultimately better balance the reduction of stroke risk while minimizing harms from major bleeding. In addition, the architecture presented is scalable to other treatment guidelines and is scalable to multiple EMRs and PHRs, making it suitable for use in a platform approach.


Introduction

It is estimated that about 350,000 Canadians live with atrial fibrillation (AF) \cite{1}. Of these, roughly 35\% (or 120,000) will go on to have a stroke during their lifetime \cite{2}. With proper anticoagulation (AC) therapy such as warfarin or one of the new oral anticoagulants, the risk of AF related stroke can be reduced by over 60\%, saving more than 70,000 people from having a stroke \cite{3}. It has been found that as many as 28\% (~100,000) of patients with AF are undertreated, leaving 35,000 patients at virtual certainty of having a stroke \cite{4}. The treatment of AF frequently requires AC, which

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can potentially harm the patient by causing bleeds. Selecting the appropriate treatment for AF requires careful balancing of benefits and harm. Fortunately the CHA₂DS₂-VASc tool, which quantifies the risk of stroke and the HAS-BLED tool, which quantifies the risk of bleeding allows clinicians and patients to balance the potential benefit versus harm of AC.

There are many benefits that are expected from using CDSS for anticoagulating patients who have AF. These benefits include increasing the number of people with AF who are treated appropriately with AC and reducing the number of people that are at higher risk of harms than benefits [5]. A comparison of AC guidelines for AF and real-world warfarin prescription has shown that there is a high discrepancy between actual warfarin use and guideline recommendations [6]. This suggests that AC decisions are not being based on systematic evaluation of stroke and bleeding risk [6]. A clinical decision support system may improve AC by analyzing stroke and bleeding risk, providing AC information so that clinician and patient can have an informed discussion on therapy choices [6]. It has been shown that computerized CDS does lead to AC improvement in the number of patients that were able to achieve therapeutic AC [7].

There are several standalone Anticoagulation CDSSs in use or in testing [8] [9]. In an era of increasing EMR use, physicians find standalone solutions to be cumbersome and difficult to integrate into practice. We have developed an architecture for integrating CDSS into EMRs and PHRs using anticoagulation as a case study.

The aim of this design project was to investigate how to integrate clinical decision support (CDS) for AF into electronic medical records (EMR) and patient health records (PHR).

1. Methods

We used standard business analysis and architecture development tools for the design process [10]. The design team included a business analyst, a clinical subject matter expert, a project manager and a clinical informatics expert. A literature search in Medline using the search terms “atrial fibrillation”, “anticoagulant”, “clinical decision support”, and “computerized guidelines” was conducted to identify use of CDSS for AF.

Six key business analysis artifacts were developed: 1) Work flow analysis, 2) CDS anticoagulation guideline algorithm (including Triggers Document and Data Dictionary), 3) Object-oriented domain analysis, 4) Requirements specification document, 5) Graphical user interface mockups and 6) Application Programming Interface requirements. We used an iterative process to develop the artifacts and obtained external feedback from an anticoagulation clinical expert on a periodic basis.

2. Results

Our initial plan was to develop a state-less CDSS; i.e., one where the patient’s anticoagulation state would be determined in real-time, based on clinical criteria in the medical record. It turned out that this was not possible because some patient states are indistinguishable from others using just clinical data in the medical record.
Our analysis identified several issues that need to be solved when integrating a CDSS into an EMR and PHR. These include: 1) Correctly allocating patients already on treatment to the right state in the CDSS (see Initializing the CDSS); 2) Knowing when a patient has become eligible for CDSS during an encounter (see Determining Eligibility below); 3) Keeping up with and managing the changing patient states during the course of treatment. Patients do and will change states and those states need to be explicit and transparent; e.g., patient’s anticoagulant being put on HOLD and then re-initiated. (See Managing State Transitions below) Using clinical data alone to determine patient state is not possible and could expose the patient to harm that would be difficult to monitor; and, 4) Making vague terms and statements explicit. Human-readable guidelines are peppered with terms such as ‘when stable’ and ‘increase frequency of monitoring’, which don’t have an operational definition that can be computed.

2.1. Initializing the CDSS

When the CDSS is initialized (i.e. used for the first time on patients who have not been allocated to a specific “state”) there are already many patients in the EMR database who would be eligible for CDSS recommendations. There are two main categories of patients that are detected: 1) ‘Orphan’ patients (called “Null – Pre-CDSS” in Figure 1)—those with the diagnosis of interest (AF in this case) but not currently on treatment or patients on treatment, but without a diagnosis on record and 2) ‘Maintenance’ patients—those already on treatment. Orphan patients fall into one of 4 categories (‘fell through the cracks’, ‘refused treatment’, ‘harms outweigh benefits’ and ‘false positive’) that are not distinguishable using only clinical data. Maintenance patients are easy to categorize, but those on HOLD cannot be easily distinguished using clinical data.

![State Transition Diagram](image-url)

**Figure 1** State Transition Diagram

To solve these issues of poor categorization, we designed a Patient Initialization Dashboard that creates a registry of patients that are most likely to be eligible for the CDSS. Physicians can manually (re)categorize their patients according to their anticoagulation status (aka ‘initialize’) and ensure that the CDSS provides the appropriate recommendations for each patient. The patient registry has the secondary benefit of allowing the physician to get a list of all of their AF patients and ensure that no one is falling through the cracks.
2.2. Determining Ongoing Eligibility for CDSS

Patients who are newly diagnosed after initialization of the CDSS need to be detected in a different way. This requires a more sophisticated integration with the EMR. The EMR needs to pass Event information to the CDSS when new information is added to the chart (e.g., OnNewProblemListEntry). For example, upon entry of a new Problem List Diagnosis or a new Encounter Diagnosis, the CDSS needs to be informed that a new diagnosis has been added and needs to make a determination of CDSS eligibility based on the new information.

To solve the problem of on-going eligibility checking, the EMR needs to provide the CDSS with a minimal dataset of information when a diagnosis is added to the problems list (OnNewProblemList) and when a diagnosis is added to an encounter (OnNewEncounterDiagnosis). The CDSS can then determine whether the patient is eligible for CDSS recommendations.

2.3. Managing State Transitions

Once a patient’s state is determined, either through direct physician categorization in the Patient Initialization Dashboard or through the eligibility determination during the visit, the CDSS needs to be able to persist the information about the patient’s current state. This information may not be able to be stored by the CDSS for privacy or efficiency reasons. We thus propose installation of a ‘cookie’ in each EMR with the relevant information about the patient and require the EMR to provide it back to the CDSS within the same package of clinical information or minimal dataset that it sends to the CDSS when the CDSS is called.

State transition diagrams place patients into explicit AC states (see Figure 1): 1) NULL, 2) PRE-INITIATION, 3) MAINTENANCE, 4) HOLD and 5) DISCONTINUE. Switching is handled as a DISCONTINUE and PRE-INITIATION sequence.

This same system can be used to safely put a patient’s AC on HOLD for a short period of time (e.g., for surgery or other invasive procedure). In this case, the CDSS would replace the HOLD cookie with a MAINTENANCE cookie, once the HOLD expired. This also solves an important clinical problem where patients who are put on HOLD fall through the cracks and are not re-initiated after their procedure.

2.4. Making vague terms explicit

The AC guidelines do have several vague terms. The most difficult to operationalize was one called ‘stable’ INR (International Normalized Ratio—a measure of the level of AC). When does an INR result become stable? After 2 or 3 or 4 results that are within the appropriate range? The answer is, ‘it depends’. Even if INR has been stable, if a patient gets sick or is hospitalized, then the INR is not considered to be stable and needs to be monitored more frequently.

This problem was solved by creating an operational definition that included additional pieces of information that could be obtained through the PHR or a patient interactive system.
2.5. The business analysis artifacts

We have created an EMR and PHR implementation guide that explains to EMR vendors how to integrate the CDSS into their EMR and tethered PHR applications. Lastly, we have developed a web-based tool for testing and demonstration purposes. The artifacts are EMR and PHR agnostic and will allow any EMR vendor to integrate their EMR and PHR products with the CDSS engine.

3. Discussion

Anticoagulation in CDSS systems is already successfully being used as standalone systems in specialized clinics. There is a need for them in general practice, but they need to be integrated into EMRs and PHRs. We have developed an architecture that describes how to integrate an AC CDSS into multiple EMRs and PHRs. The architecture and design are intended to be generic and work for multiple treatment guidelines. However, the specifications do need further prototyping and testing. This integrated CDSS will undergo clinical trials in the near future. A demonstration system that can be integrated into EMRs and PHRs has been developed and is awaiting integrations and further testing.

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References


Patient Access to Their Health Record Using Open Source EHR

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Abstract. In both Europe and North America, patients are beginning to gain access to their health records in electronic form. Using the open source cityEHR as an example, we have focussed on the needs of clinical users to gather requirements for patient access and have implemented these requirements in a new application called cityEHR-PA. The development of a separate application for patient access was necessary to address requirements for security and ease of use. The use of open standards throughout the design of the EHR allows the possibility of third parties to develop applications for patient access, consuming the individual patient record extracted from the full EHR.

Keywords: Electronic Health Records, EHR, Open Standards, Open Source, Patient Access, cityEHR

Introduction

The implementation of widespread access to electronic health records is beginning to gather pace in some parts of Europe and North America. In England, all patients are due to have access to their primary care record by April 2015 [1]; in the US the 'Blue Button' was introduced in 2010 to provide patient access to records through the Department of Veterans Affairs portal [2, 3]; in Canada the MyOSCAR open source personal health record system has started to provide patient access to records [4].

The focus of many early implementations of patient access, or Personal Health Records (PHR) has been on the ability to view, download and transmit the full record, as defined by the Meaningful Use rules of the Office of the National Coordinator for Health Information Technology in the US [5].

In contrast, the focus of our study has been the requirements for patient access, as expressed by professional, clinical users of an Electronic Health Record (EHR) and the implementation of those requirements in the open source cityEHR health records system.

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Requirements

We gathered requirements for patient access to the EHR from current and prospective clinical users of the cityEHR system in secondary care (in-patients and out-patients). The purpose was to determine how clinical users viewed the potential benefits and barriers in patient access to their own record.

From this process, the key requirements chosen for first implementation were:

- safe and secure access to the record
- access control to data determined by clinical users
- usable on any client device, particularly mobile and/or handheld devices
- browse and view the full record (subject to access control permissions)
- annotate existing documents in the record
- add new documents to the record, particularly for completing assessment forms
- send/receive notifications to/from clinical users

The main Use Case considered in our requirements gathering was access to the record by users waiting in out-patients clinics or at home prior to admission as an in-patient. In both of these cases, an important benefit to clinical users is the ability for patients to complete assessment forms before the clinical encounter; in the case of patients awaiting admission, a review of those assessments may mean that the planned admission is postponed or cancelled, with significant benefit for both the patient and care provider.

Implementation Using cityEHR

The cityEHR is an open source health records system deployed in several sites in the NHS in England. It stores all clinical data as XML documents, in a native XML database, using the HL7 CDA standard [6]. Patients are identified in the system using a unique identifier; in the NHS is usually the NHS Number, issued and maintained on a national basis and proven to be a reliable identifier for patients [7].

The main objectives in implementing patient access were to:

- provide a safe and secure technical foundation for patient access
- implement the key functional requirements identified by clinical users
- make the record accessible and usable across a range of user devices

Patient access to cityEHR is implemented in a separate system called cityEHR-PA, using the same open source, technology platform as cityEHR - the eXist native XML database and Orbeon forms X-Forms engine, running in an Enterprise Java application server (Apache Tomcat, or similar).

The first key design decision in implementing cityEHR-PA was to encapsulate the patient's own record so that there is no possibility of patients gaining access to the wider range of information available to clinical users of the EHR.

Periodically (once every 24 hours, for example) the database is replicated for use in the patient-access system. A separate, standalone database holds the credentials used for user authentication. Once authenticated, the full record for the patient is extracted from the replicated cityEHR database and is held as a single XML document within the session running for the authenticated user. All access to the record is then made through
this session-based document; there is no further interaction with the database until the session terminates.

Any new content created by the patient (saved forms, forms to be published in the record, annotations or notifications) is held in the server session until that session is terminated (user logs off or it times out).

On termination of the session, the replicated database is updated and this is then periodically synchronised with the cityEHR database.

A sequence diagram of the interaction with the database is shown in Figure 1.

The extracted record used in the patient access session is a single XML document which mirrors the structure of the XML database used in cityEHR. This database organises records by the unique patient identifier, with the set of HL7 CDA documents that comprise the patient record being held in a database collection specific to that patient. Similar database collections are used to hold transient data for 'work in progress' and notifications Figure 2 shows the top-levels of the XML document used to hold the patient record extract.

The user interface for cityEHR-PA is much simpler than the interface for the full cityEHR system. This reflects the relative simplicity of the functions available to the user and is also a requirement to make the system easy to use on mobile devices. Like cityEHR, each page view uses an identical layout and each area of the page is reserved for a single functional purpose; there are three such functional areas in cityEHR-PA, compared with nine in cityEHR.
Figure 3 shows a comparison of the two user interfaces. In addition to the implementation of cityEHR-PA, it was necessary to create some new functionality on cityEHR itself in order to support patient access. The key capabilities added were to:

- designate the type of clinical documents that can be accessed by patients (created or read)
target notifications to patient users and view notifications from patients

see patient annotations made against clinical documents in the record

view clinical documents created by patients

Within cityEHR, patient created content is stored and handled in exactly the same way as content created by clinical users, but the provenance of that content (as stored in the HL7 CDA header) allows the clinical user to identify and filter appropriately. For example, cohort searches used for clinical studies can exclude patient created data

Conclusions

Our implementation of patient access to clinical records in the cityEHR system has highlighted the need to take account of the needs of both clinical and patient users of the EHR. Our focus in this instance was on the needs of clinical users: what functionality do patients need in terms of access to their own record which would enhance the clinician-patient interaction, in the opinion of clinicians.

Key to implementing secure access to the same information used in the full clinical record is to separate the data accessed by the patient and restrict access to the full EHR to the minimum required to extract and update the record of each individual patient. Using open standards in the implementation of the cityEHR has made the implementation of the basic view-download-transmit features quite straightforward, with the use of HL7 CDA similar to the approach taken in implementation of the Blue Button functionality in the US.

The user interface of the cityEHR-PA allows for the more interactive use of the patient’s own record and the use of the record as a communication tool, in the manner envisaged by other studies [8, 9].

Finally, the approach to extracting the patient’s record and implementing a separate application for patient interaction lends itself to the development of third-party tools and applications for patient access.

References


Usability Testing of a Prototype Multi-User Telehealth Kiosk

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Abstract. The overall purpose of this study was to learn how community-dwelling older adults would interact with our prototype multi-user telehealth kiosk and their views about its usability. Seven subjects participated in laboratory-based usability sessions to evaluate the physical design, appearance, functionality and perceived ease of use of a multi-user telehealth kiosk prototype. During usability testing participants recommended 18 new features (29% of comments), identified 15 software errors (23% of comments) and 29 user interface errors (47% of comments).

Keywords. Telemedicine; Aging; Usability; Informatics

Introduction

New solutions for maintaining or improving health and improving health resource utilization are needed so that aging populations may continue living independently. Though access to information and monitoring can be addressed through telehealth interventions, placing single-user telehealth devices in individual older adults’ home is financially unrealistic for both individuals and for their health care system payers. One solution may be multi-user telehealth “kiosks”, interactive, multi-function devices that monitor vital signs and other health parameters and facilitate virtual visits between users and their health care providers.

Three recent studies have addressed the feasibility of using multi-user telehealth kiosks for health management activities. Each of these studies has provided preliminary evidence that implementing these devices for self-monitoring in community contexts is feasible.

However, this early work also raised usability concerns about existing multi-user telehealth kiosks. Commercially available kiosks were limited in function, expensive, non-customizable for individual needs, and unreliable. As a result, we have developed a next generation, multi-user telehealth kiosk. The design and development of the kiosk is detailed elsewhere. Because the physical design and software interface of our prototype kiosk differ substantially from commercially available devices, we needed to assess older adults’ opinions of the physical design, and the appearance, functionality and perceived ease of use of the software interface.

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1. Methods

The overall purpose of this study was to learn how older adults would interact with our prototype multi-user telehealth kiosk and their views about its usability. Following approval from the Institutional Review Boards at the University of Pittsburgh (PRO09100293) and Carnegie Mellon University (HS10-083), we conducted laboratory-based usability testing of the multi-user health kiosk. These subjects were: 65 years of age or older, lived independently in the community, had sufficient vision to see images on a television screen and adequate hearing to carry on a telephone conversation, and had the ability to read and speak English. As a rule of thumb, it is estimated that five subjects can identify approximately 80% of all usability problems.

1.1. Testing Protocol:

Upon completion of informed consent procedures, each subject participated in a single, individual usability testing session with our prototype multi-user telehealth kiosk, lasting approximately two hours. After collecting baseline measures, a member of our research team provided each subject with a brief orientation to the kiosk, explaining its purpose and features and demonstrating how it works. The subject was then asked to perform a series of tasks, such as logging on to the kiosk; locating information; obtaining various physiologic, physical, and self-report measures and reports; and using the message function. When a subject was unable to complete a task, the research team member noted it and provided verbal or physical assistance to complete the task before moving on to the next task. Subjects were asked to "think aloud" their thoughts and feelings about what they were doing as they performed each task, thereby providing us with additional insight into their reaction to the physical and graphical user interface design elements of the kiosk. After completing all tasks, each subject was interviewed regarding the appearance, ease of use, and perceived usefulness of our prototype kiosk and suggestions for improvement. Using an iterative approach, we reviewed the data and modified the software or hardware interface, if indicated, following each test session.

1.2. Analysis:

Summary descriptive statistics including frequencies, ranges, and measures of central tendency were computed for all quantitative data. Content analysis of the qualitative data from videotaped usability testing and verbatim transcripts of the end-of-session interviews was performed by members of the research team to identify recurring themes. Findings were then peer-reviewed by a multi-disciplinary team of researchers specializing in quality of life technology research.

2. Results

2.1. Subjects

Seven subjects (5 male, 2 female) participated in individual usability testing sessions. Their average age was 76.85 years (range 69 – 86). All subjects had been retired
between four and 29 years (M = 15.86 years). Two subjects had annual incomes less than $30,000 USD and five subjects had annual incomes of at least $60,000 USD. Five subjects reported their general health as “good” and two subjects reported their general health as “very good.” Responses to “how often health problems stand in the way of doing things you want to do” included “never” (n = 2), “seldom” (n = 4) and “often” (n = 1). The number of current chronic health conditions reported by subjects ranged from zero to five (M = 2.14). No subject indicated needing help from another person on a daily basis because of a health problem.

2.2. Technology Attitudes

Subjects were asked to rate their attitudes towards technology in general and their perceptions of the health kiosk specifically on a scale from 1 = “not accurate at all” to 10 = “extremely accurate.” They had strong favorable beliefs about technology (see Table 1), but they also recognized potential negative effects.

Table 1 Beliefs about technology (1 = not at all, 10 = completely)

<table>
<thead>
<tr>
<th>Technology Attitude</th>
<th>Mean Agreement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technology makes life easy and convenient</td>
<td>9.00</td>
</tr>
<tr>
<td>Technology increases personal safety and security</td>
<td>8.57</td>
</tr>
<tr>
<td>Technology makes life comfortable</td>
<td>8.43</td>
</tr>
<tr>
<td>Technology brings people together</td>
<td>6.86</td>
</tr>
<tr>
<td>Technology reduces privacy</td>
<td>6.71</td>
</tr>
<tr>
<td>Technology gives people control over their daily lives</td>
<td>6.57</td>
</tr>
<tr>
<td>Technology makes people dependent</td>
<td>6.14</td>
</tr>
<tr>
<td>Technology makes people isolated</td>
<td>6.14</td>
</tr>
<tr>
<td>Technology makes life complicated</td>
<td>6.00</td>
</tr>
<tr>
<td>Technology makes life stressful</td>
<td>5.43</td>
</tr>
</tbody>
</table>

When asked about factors that may influence the decision to use technology in general to assist in performing daily tasks, subjects indicated that safety was most important whereas attractiveness was least important (see Table 2).

Table 2. Importance in deciding to use technology for daily tasks (1 = not important at all, 10 = extremely important)

<table>
<thead>
<tr>
<th>Decision Factor</th>
<th>Mean Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>How safe is it to use</td>
<td>8.57</td>
</tr>
<tr>
<td>How well it meets your needs</td>
<td>7.86</td>
</tr>
<tr>
<td>Ease of use</td>
<td>7.71</td>
</tr>
<tr>
<td>How it affects your privacy</td>
<td>7.00</td>
</tr>
<tr>
<td>Cost</td>
<td>5.57</td>
</tr>
<tr>
<td>How visible is it to others</td>
<td>4.14</td>
</tr>
<tr>
<td>The way it looks (attractiveness)</td>
<td>3.29</td>
</tr>
</tbody>
</table>

Subjects were asked their attitudes toward the kiosk both before and after the usability testing (not accurate at all to extremely accurate). In most areas, positive statements were viewed as more accurate or the same after using the kiosk, while negative statements were viewed as less accurate after use (see Table 3).

After using the kiosk, subjects indicated that they did not feel the statement “the health kiosk seems too flimsy, like it might break” was accurate (M = 4.86). Their response was either positive or neutral when asked whether “the health kiosk would
make life…” easier” (n = 3), “worse” (n = 0), or “no different” (n = 4). In regards to the
tfactors the users rated as important to decisions to use a technology (Table 2), users
positively rated items related to both ease of use and usefulness of the technology
(Table 3).

Table 3 Kiosk specific attitudes before and after use (1 = not accurate at all, 10 = extremely accurate)

<table>
<thead>
<tr>
<th>Kiosk Specific Attitudes</th>
<th>Mean Before Use</th>
<th>Mean After Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning to use the kiosk will be/was easy for me</td>
<td>8.43</td>
<td>8.71</td>
</tr>
<tr>
<td>It will be/was easy to get the health kiosk to do what I want it to do</td>
<td>7.00</td>
<td>9.00</td>
</tr>
<tr>
<td>The health kiosk is/was attractive from a physical standpoint</td>
<td>6.71</td>
<td>6.71</td>
</tr>
<tr>
<td>The benefits that the health kiosk will provide are worth the cost of the device</td>
<td>6.71</td>
<td>7.14</td>
</tr>
<tr>
<td>Using the health kiosk will help me to achieve important goals</td>
<td>6.43</td>
<td>6.57</td>
</tr>
<tr>
<td>Using the health kiosk will make my life easier</td>
<td>6.29</td>
<td>7.14</td>
</tr>
<tr>
<td>I am/was anxious about using the health kiosk</td>
<td>4.71</td>
<td>5.71</td>
</tr>
<tr>
<td>It would be easier to just get another person to help rather than using the health kiosk</td>
<td>2.86</td>
<td>3.29</td>
</tr>
<tr>
<td>Using the health kiosk will be an invasion of my privacy</td>
<td>2.86</td>
<td>2.29</td>
</tr>
<tr>
<td>It will be/was confusing for me to use the health kiosk correctly</td>
<td>2.71</td>
<td>2.29</td>
</tr>
<tr>
<td>It will be embarrassing to be seen using the health kiosk</td>
<td>2.14</td>
<td>1.14</td>
</tr>
</tbody>
</table>

2.3. Usability

The research team took notes of specific recommendations and questions expressed by
the subjects during the testing session. Users recommended 18 new features (29% of
comments), identified 15 software errors (23% of comments) and 29 user interface
erors (47% of comments). Issues regarding the user interface included hardware as
well as software. An example of a hardware error was “RFID not working on repeated
login/logout,” and a hardware suggestion was “Can you round the corners on the desk,
to minimize injury if someone bumps into the kiosk?” The majority of user interface
comments were requests for clearer instructions for individual measurements, such as
“tell me when to remove the pulse oximeter.” Other user interface comments related to
appearance such as “change drop down menu to buttons instead” and “add more space
between questions.” New feature requests included items such as “customizable font
sizes” and “ability to print material.” Modifications based on the recommendations
were made following each testing session.

Figure 1 illustrates how users influenced the look of the interface as well as the
functionality. The first version of the screen appears on the left and the final, modified
version appears on the right. Colors for the measurement buttons in the final version
are bright and offer high contrast to the background color when those measurements
are available to the user. Measurements that are unavailable appear “washed out”. In
Figure 1, the eye exam is unavailable and therefore appears substantially lighter in
color than the other icons. Icons in the final version were simplified and made more
uniform in appearance. On screen buttons were made larger to accommodate users
with limited vision or diminished fine motor skills.
3. Discussion

Current telehealth studies have focused on single-user devices. Further emphasis on individual, single-user devices may only widen existing disparities in care. Multi-user devices have the potential to offer similar benefits while expanding the number of users, particularly among older adults in congregate living situations who have little, if any, access to on-site health care or novel technologies for self-management of health and wellness. Foundational to this current and future work in multi-user telehealth is the effective engagement of both patients and health care practitioners. As a first step in engagement, we have involved potential users in the usability evaluation of the kiosk. Feedback from users proved invaluable in making revisions to the design. This study is limited as it was tested in a controlled environment with users without notable vision or hearing difficulties.

Building on this work, we have implemented a second round of usability testing in four different community settings, such as community centers, senior day centers and residences, to explore how diversity of setting and socio-demographic characteristics among older adults may affect users’ perceptions of the kiosk and its utility in helping them to manage their health.

References

Trialling an Electronic Decision Aid for Policy Developers to Support Ageing Well

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Abstract. The complex process of developing policies and planning services requires the compilation and collation of evidence from multiple sources. With the increasing numbers of people living longer there will be a high demand for a wide range of aged care services to support people in ageing well. The premise of ageing well is based on providing an ageing population with quality care and resources that support their ongoing needs. These include affordable healthcare, end of life care improvement, mental health services improvement, care and support improvement for people with dementia, and support for healthy ageing. The National Health and Medical Research Council funded a research project to develop a policy tool to provide a framework to assist policy makers and service planners in the area of ageing well in rural and regional Australia. It was identified that development of an electronic version of the policy tool could be useful resulting in a small pilot development being undertaken and tested with policy makers and service planners. This paper describes the development and trialling of a tablet based application used to assess the acceptability of computerised forms for participants actively involved in policy development. It reports on the policy developer’s experience of the electronic tool to support ageing well policy making based on evidence.

Keywords. Policy development, healthy ageing, e-policy tool, focus groups, mobile technology, ageing well

Introduction

Policy development and service planning are complex endeavours that occur at many different levels, from small organizational units to major government departments. Policy developers and service planners need to have sufficient information to prioritise issues; this is particularly important as they work towards building a society that will support healthy ageing of the population in the coming decades. In 2013 the Council of the Ageing Australia reported five key priorities for policy actions to improve the lives of older Australians. These include affordable healthcare, end of life care improvement, mental health services improvement, care and support improvement for people with dementia, and support for healthy ageing\cite{1}.

Development of policies and planning of services requires the compilation and collation of evidence from multiple sources. This can result in policy developers...
investigating the same evidence multiple times, or many developers investigating and developing similar policies for the same purpose without knowledge being shared. To ameliorate this the Australian National Health and Medical Research Council funded a research project to develop a policy tool to provide a framework to assist policy makers and service planners in the area of ageing well in rural and regional Australia. During this project it was identified that development of an electronic tool could be useful and so a small pilot development was undertaken and tested with policy makers and service planners. This paper describes research that developed and trialled a tablet based application, which has assessed the acceptance of computerised forms for participants actively involved in policy development. It reports on the policy developer’s experience of the electronic tool to support ageing well policy making based on evidence.

1. Background

There is increasing concern that older Australians are being disadvantaged in relation to service delivery, particularly in rural and regional areas. This is particularly evident in relation to the activities surrounding healthy ageing. It is the responsibility of service providers and policy developers to determine what services are available and where. Research shows that when decisions are complex people need realistic expectations, knowledge, clarity about values, and a sense of efficacy to make appropriate decisions [2]. When these elements are deficient, people may experience decisional conflict and lack of clarity about which option to choose. This can result in delayed decisions, decision regret, or quickly discontinued decisions [3].

Importantly, it has been estimated that by 2050 there will be 1.8 million Australians aged 85 and over [4], demonstrating there will be a high demand for a wide range of aged care services. The premise of ageing well is based on providing an ageing population with quality care and resources that support their ongoing needs. Decisions are difficult especially when there is lack of clarity and knowledge around all the issues relating to ageing well. According to Simonen et al. [5], knowledge comes from research, evaluation, recommendations, experience, and education. The problem that many policy developers face is identifying and prioritising the issues to be addressed. This can then impact upon the effectiveness of policies being developed for users such as aged care service providers.

Whilst it is not the sole determinant of service provision, organisations and policy makers are paying more attention to cost-effectiveness of interventions or services to the ageing population. According to Walker [6], cost-effectiveness requires the assessment of relative costs and consequences of different interventions to assist with prioritising. Policy developers acquire knowledge and use this knowledge to assist them in policy development. Technology may assist the decision making process by exposing decision makers to knowledge based systems that assist in the selection criteria process, improve effectiveness in decision making and provide time savings [7].

2. Method

The research used a case study methodology conducted over two phases; the tool development phase, and tool evaluation phase.
2.1. Phase 1 Tool development phase

Initially a paper-based decision-tree was developed as part of the broader research project. A section of this was then used to develop electronic tool to represent the procedures and rules used in the paper-based tool. The survey was developed using Lime Survey as this had the functionality to meet the requirements necessary for building the electronic tool whilst remaining relatively simple to use. The required functionalities included comprehensive logic flows and the ability to embed web links within the application.

2.2. Phase 2 Evaluation of the paper-based and electronic pilot tools

Phase two evaluated the electronic tool using focus group consisting of policy developers and service planners involved in the area of ageing well. Focus group participants used a scenario-based three-phase evaluation method to evaluate the tool. Focus group participants documented comments on cards, which were the collectively analysed by the group. The data collection included participants’ expectations of the tool, benefits of the tool and issues concerning the use of the tool.

The two scenarios that guided the focus group evaluation of the tool were:

- **Scenario 1:** You have been requested to prepare a brief on a possible policy response to rising public concern about elder abuse.
- **Scenario 2:** You are tasked with developing a policy outline to address concerns that patient controlled budgets might lead to inappropriate patterns of service access.

Bradshaw's [8] taxonomy of need describes four types of social need: normative need, felt need, comparative need and expressed need. The scenarios were designed to include specific aspects of these needs in relation to aged care in different settings. For example, scenario one asked policy developer to provide a possible policy response to rising public concern about elder abuse. Using this first scenario, a policy developer could try to understand and measure the needs of elder using both the electronic tool and paper-based tool. The second scenario had a different focus by asked policy developers to develop a policy outline to address concerns that patient controlled budgets might lead to inappropriate patterns of service access. Focus group participants came to consider the scenarios from differing perspectives and understandings.

3. Discussion

Developing policies using paper-based tools allowed policy makers to document decision making while accessing needs from older people. The four types of needs were assessed in both electronic tool and paper-based tool. However, the paper-based tool assumed policy developers had existing knowledge or had obtained it from external resources prior to using the tool. The electronic tool was designed to allow policy developers to directly access external resources within the application. If policy developers did not have evidence, they could search for evidence using the electronic tool. The questionnaire imbedded in the tools required policy developers to research for evidence prior to answering any questions. This required extensive research skills to fully conduct the search. As evidenced by a participants card below, the search for...
Evidence could go forever. Both tools provided evidence capture during policy development. They did not replace the standards of policy development. Policy developers must themselves decide if they have enough evidence to develop their policy.

"Electronic tool is great, but need to be able to access the information."

Policy process model proposed by Lasswell [9] comprised of seven stages that include intelligence, promotion, prescription, invocation, application, termination, and appraisal. The first stage of the policy cycle discussed in Fischer and Miller [10] involves setting agenda for problem recognition and issue selection. The tools were designed to address the initial stage of policy cycle and in particular to identify the needs in aged care. Because the electronic tool was developed from a small section of the policy tool, it only provided guidance to the initial stage of needs assessment. The participants suggested that the whole program logic that guides the tool would need to be transformed into an electronic form if further stages of policy development are required. Although policy developers were familiar with stages in the policy cycle and keen to explore further stages, the pilot tools were designed to only address the initial stage of policy development.

4. Conclusions

The main purpose of the pilot was to see whether the electronic tool enhanced the potential for policy makers and service planners to access and use evidence in decision-making by making research evidence more accessible. Policy developers need evidence they could gather from research but there is no straightforward evidence [13]. This electronic tool provided an interface where policy developers could access the information or evidence via a web link. Google Scholar was the only web link embedded in the electronic tool. Accessing the right information on the Internet requires good knowledge of sources of information. According to the feedback cards, Google Scholar did not seem to provide access to the information required by policy developers. The quality of information or evidence will be based on its source. More open access to general searching was required. However there was a distinct difference in the searching ability of the Policy developers compared to the Practitioners involved in Policy Development. Policy developers had more advance searching skills.

The ability to capture, search, and document evidence was provided within the tool itself. The inbuilt functionalities give policy developers an opportunity to evidence their knowledge with the latest research during the decision making process. This ensures that they look at all aspects of the problem at hand and consider all available evidence at that point in time. However, the paper-based tool did not offer these functionalities. The limitations of a paper-based tool could restrict accessing and documentation of evidence, if it had been sought, at the time the decision is being made.

The electronic tool has a major challenge by providing access to so much information. The user can become easily lost with information overload. Limiting access to Google Scholar was initially designed to overcome the problem of information overload. The question then becomes one of ensuring that the user has the required research skills or restrict the access to information to ensure the user is not exposed to information overload. In contrast, the paper-based tool was straightforward and offered a structure on how to ensure users were ‘thinking’ about the evidence while
making policy decisions. The electronic tool has embedded functionalities to generate advice as outputs to the users at the end. At the completion of the task users were offered advice on the action that should be taken regarding policy development. The pilot provided advice based on a simple decision tree model and was reasonable generic in nature while still providing and outcome. On the other hand, the paper-based tool was more tick and flip, and then filed in a drawer for possible future reference. The electronic tool could be designed to complement effective research activities for policy developers to gather quality evidence for their policy development. This research project was based on only a small section of the policy tool. A separate research project should be conducted to cover the whole policy tool development.

Acknowledgements

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References

Beyond Effectiveness: A Pragmatic Evaluation Framework for Learning and Continuous Quality Improvement of e-Learning Interventions in Healthcare

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Abstract: A pragmatic evaluation framework for evaluating the usability and usefulness of an e-learning intervention for a patient clinical information scheduling system is presented in this paper. The framework was conceptualized based on two different but related concepts (usability and usefulness) and selection of appropriate and valid methods of data collection and analysis that included: (1) Low-Cost Rapid Usability Engineering (LCRUE), (2) Cognitive Task Analysis (CTA), (3) Heuristic Evaluation (HE) criteria for web-based learning, and (4) Software Usability Measurement Inventory (SUMI). The results of the analysis showed some areas where usability that were related to General Interface Usability (GIU), instructional design and content was problematic; some of which might account for the poorly rated aspects of usability when subjectively measured. This paper shows that using a pragmatic framework can be a useful way, not only for measuring the usability and usefulness, but also for providing a practical objective evidences for learning and continuous quality improvement of e-learning systems. The findings should be of interest to educators, developers, designers, researchers, and usability practitioners involved in the development of e-learning systems in healthcare. This framework could be an appropriate method for assessing the usability, usefulness and safety of health information systems both in the laboratory and in the clinical context.

Keywords: Evaluation, pragmatic evaluation, usability, usefulness, user satisfaction, e-health, e-learning, Low-cost Rapid Usability Engineering, Heuristic evaluation, Cognitive Task Analysis, SUMI, health informatics, intervention, quality improvement

Introduction and Purpose

E-learning is defined at a practical level as the delivery of instructional content or learning experiences facilitated by electronic technology [1]. Today, E-learning
interventions are widely adopted by many companies to reduce training time and cost. Therefore, an effective pragmatic approach for evaluation should be considered to avoid costly implementation failures. The purpose of this article is to demonstrate how effective a pragmatic framework was in evaluating the usability and usefulness of an e-learning intervention for a patient clinical information scheduling system and in providing practical evidence for learning and continuous improvement of e-learning systems in healthcare. A pragmatic evaluation is designed as a process of selecting appropriate mixed-methods that combine different tools and techniques at a practical level [2]. Pragmatic evaluations are aimed at: planning interventions, learning and continuous improvement of interventions, programming policies, and transformation of society [3]. The dimensions of this approach to evaluation include: quality, net benefits and system usage [2]. The dimensions of system usage (use and user satisfaction) are discussed under two different but related concepts, usefulness and usability [4].

The concept of usefulness is defined as the degree to which a specific information item will serve the information needs of the users [4]. Usability is the capacity of a system to allow users to accomplish their tasks safely, effectively, efficiently, and enjoyably [5]. Relevant to e-learning, usability relates to the development of interactive products that are easy to learn, effective to use, and enjoyable to work with [6]. Usability is assessed through different subjective quality components including: learnability, efficiency of use, ease of recall or memorability, low error generation and subjective pleasure [7, 8]. Usability is subjectively measured in terms of satisfaction and objectively in terms of effectiveness and efficiency [6]. Usability evaluation methods (UEMs) are used for improving system development based on user’s feedback [8]. UEMs are grouped broadly into inspection and testing methods [9, 10]. Inspection methods include: heuristic evaluation (HE), cognitive walkthrough (CW), and action analysis [9]. Inspection methods are used for identifying usability problems and improving the usability of an interface design by comparing it to established standards [9]. These methods can be used alone or in combination with usability testing methods [11]. Usability testing methods involve testing of participants who represent the target user population as they perform representative tasks using an information technology [8]. The usability testing methods include video recording of user interactions; think-aloud protocol analysis, field observation, and questionnaires [8, 9].

The Software Usability Measurement Inventory (SUMI) questionnaire is cited in the ISO 9241 standard as a recognized way of testing user satisfaction [9]. The Human Factors Research Group (HFRG) at the University College Cork in the United Kingdom (UK) hosts the central database for the SUMI questionnaire [12]. The data collected using the SUMI questionnaire is analyzed with SUMISCO software. This software calculates the mean score and the standard deviation of the scores and compares them to a standardized mean and standard deviation of 50 and 10 respectively [9]. This method is conductive for testing as it is fast and does not require a large number of end users (minimum ten users required) [7,13]. The dimensions of the SUMI inventory are composed of: efficiency, affect, helpfulness, control and learnability [7]. The SUMI questionnaire has been found useful for assessing the usability of e-learning systems [7, 14]. However, using the questionnaire alone is insufficient. Additional methods of usability evaluation are required to augment it [8, 14].

The Low-Cost Rapid Usability Engineering (LCRUE) technique was developed to rapidly evaluate the usability and safety of healthcare information systems both in laboratory and clinical context [10]. The technique was developed by researchers at the University of Victoria to quickly answer the question “How can we ensure the
healthcare information systems that we develop are suitable, meet information and workflow needs, and are safe [10]?

This technique involves observing a smaller number of representative end users (minimum three to four users are required) of a specific system as they carry out representative tasks and think aloud [15]. Equipment for data collection during usability testing included: a video camera, microphone, screen cam, and screenshot software [10]. The LCRUE is found to be an appropriate technique and it was used to identify problems related to the user interface [10].

The Cognitive Task Analysis (CTA) approach is used to evaluate the impact of system applications on human reasoning and decision-making processes to help identify characteristics of the system prior to implementation [5]. The CTA approach includes development of a task hierarchy for individual activities and observation of subjects with different levels of expertise while performing tasks [5]. Three major CTA techniques are identified: an observation and interview technique, a process tracing technique using a think-aloud protocol or subsequent recall, and a conceptual technique [16]. The CTA approach is used to develop expert systems, clarify job or task competence, and attain performance goals [15]. The CTA approach involves video recording and includes a number of defined steps [16]. This approach is used to provide the producers, developers, and the designers with feedback and guidance to produce a usable system [6]. For the purpose of the evaluation, HE criteria customized specifically for web-based learning were selected to aid the process of CTA. HE is defined as “a usability inspection method in which the system is evaluated on the basis of well-tested design principles known as heuristics” [5]. HE is found to be a fast, inexpensive and easy to perform method for identifying 65% - 75% of the usability problems that, when fixed, can result in major improvements to user interfaces [8]. HE is conducted in a series of phases including: preparing a list of heuristics, stepping through or inspecting the user interface or system for heuristic violations, independent evaluation of the user interface and generation of a list of heuristic violations along with recommendations to the design team [5]. The severity of the usability problems is rated based on using the Nielsen’s severity scale [5].

Relevant to e-learning, many evaluation frameworks and models are proposed in the literature including using specific criteria for pedagogical evaluation of virtual learning environment (VLE); using subjective methods such as completing questionnaires; or elaborating on comparison grids for evaluation against specific selected criteria [17]. The methods of e-learning evaluation are grouped based on types of evaluation (formative, summative, integrative and quality assurance), types of experiment test or case studies, etc.) and criteria for evaluation – evaluation is performed against specific criteria (usability or learning effectiveness evaluation) [18]. Usability heuristics, frequency of interactions or learning outcomes are added to the frameworks and models [17]. The evaluation of e-learning platforms requires a thorough consideration of function and usability of the overall learning system in the context of human, social and cultural aspects of the organization [19]. Some researchers focused on the technology-based components of e-learning systems [20]. Other researchers studied the human factors of e-learning systems and user satisfaction [21]. Few studies were found in health informatics where the researchers evaluated the usability and usefulness of e-learning systems [22]. Thus, a pragmatic framework was considered for evaluation of e-Learning interventions in healthcare.
1. Methodology

Evaluations were conducted by recruiting frontline users (n=14) and Informatics Consultants (n=5). Participants in each group were asked to complete an e-learning module for a patient clinical information system scheduling system, a core competency assessment, user demographic questionnaire and SUMI electronic or paper questionnaire. Additionally, all Informatics Consultants were observed and asked to think aloud while interacting with the content of the module that carried in a Web-Based Training Manager for e-learning. Their verbalizations and physical behaviours were audio-recorded and video-taped. Usability was subjectively measured in terms of a global scale and five sub-scales (efficiency, affect, helpfulness, control and learnability). Thematic analysis was conducted for the SUMI open-ended questions and interviews. Themes were coded based on the usefulness of information (relevance of use, format, reliability, level of use and timeliness) and the usability of the system (ease of use, aesthetic, navigation, terminology, learnability and response time) [4]. Audio-recorded and video-taped data were analyzed using CTA aided with HE criteria. E-learning Web Site user interface usability heuristics were based on a list customized specifically for web-based learning [8]. In general, all participants were satisfied with the usability and usefulness of the e-learning system used (Figure 1, Table 1). The results of CTA indicated some areas where usability was problematic (Figure 3, 4, 5) and were related to GIU, instructional design and content, some of which might account for the poorly rated aspects of usability when subjectively measured by SUMI (Figure 1). These findings were supported by the participant’s comments (Table 2). Learning outcomes and efficiency of the system used were objectively measured too (Figure 2).

![Figure 1. SUMI, Subjective Usability Evaluation](image1)

![Figure 2. Learning Outcomes and System Efficiency](image2)

![Figure 3. Overall Usability Problematic Area](image3)
Table 1. Thematic Analysis of the SUMI Open-Ended Questions

<table>
<thead>
<tr>
<th>Usability of the e-Learning System</th>
<th>Usefulness of the e-Learning System</th>
</tr>
</thead>
<tbody>
<tr>
<td>“Easy to use and understand”… “User friendly prompt when necessary”… “It is friendly and offers option to move back for refresh”… “Icons are unclear”… “Error messages”</td>
<td>“I appreciate that, as a user, I could return and review when additional learning was needed”… “Checking patient information is important”… “More hand on exercises” “instructions on how to view the video, it doesn’t indicate you can pause if the screens are changing faster than you can read”</td>
</tr>
</tbody>
</table>

Table 2. Cognitive Task Analysis Aided by Heuristic Evaluation Criteria for e-Learning

<table>
<thead>
<tr>
<th>Recognition Rather than Recall Problem</th>
<th>Site Navigation Problem</th>
</tr>
</thead>
<tbody>
<tr>
<td>“You have to remember all little icons and what they mean as you are going through, so, remembering to click view to identify the core mandatory data.”</td>
<td>“I think this the way the screen is set up here. It asks me to continue, but, there is no button that says Next, I am assuming the arrow pointing right but it doesn’t fit the screen, I am assuming that Next, but, may get stuck for some people”</td>
</tr>
</tbody>
</table>

Figure 4: Recognition Rather Than Recall Problem.  
Figure 5: Site Navigation Problem.

2. Discussion and Conclusion

The framework applied for evaluation of e-learning intervention for a patient clinical information scheduling application described in this paper is useful, not only for measuring the usability and usefulness, but also for providing practical objective evidence about learning and continuous quality improvement for e-learning systems. The framework was conceptualized based on two different but related concepts (usability and usefulness) and selection of appropriate and valid methods for data collection and analysis that included LCRUE, CTA, HE criteria for web-based learning, and the SUMI questionnaire. This mixed-method approach combines different tools and technique not only to gather quantitative and qualitative information, but also to structure, analyze and judge the information. The results of the analysis showed many areas where usability was problematic, related to GIU, instructional design and content, which might account for the poorly rated aspects of usability. These findings should be of interest to developers, designers, researchers, and usability practitioners involved in development of e-learning systems in healthcare. For some e-health applications, this framework could be a suitable method for assessing the usability, usefulness and safety of health information systems in both laboratory and clinical contexts.
References


SmartMed: A Medication Management System to Improve Adherence

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Abstract. Adherence is the degree to which patients comply with their caregivers prescribed treatments. Lack of adherence due to various causes negatively affects health objectives. Prior work in the field of medication management has indicated the usefulness of IT as a possible aid for those who have difficulty adhering to prescribed medication regimes. In this paper we present a medication management system (SmartMed) that has been designed to monitor and increase adherence. The SmartMed system consists of a portable pill bottle device, a local base station, and a cloud data service. It reminds users when it is time to take their medications, and acquires adherence data which is accessible for applications that query the data service. The project was undertaken as an undergraduate engineering design project. This paper describes the design and prototype implementation of this system and provides direction for future work.

Keywords. Medication adherence, smart devices, smart systems, SmartMed

Introduction

Adherence to medications is a multidisciplinary research topic that has been described by many as a key factor in improving healthcare outcomes [1,2,3]. In 2003, the World Health Organization estimated average medication adherence was 50%. The same report hypothesized that promotion of medication adherence is potentially more beneficial to global health care outcomes than the development of specific treatments and therapies [1]. A recurring theme in the current literature is that medication nonadherence is a non-trivial problem that will require an array of interventions/solutions [3]. The three pillar approach to medication adherence summarized by Vlasnik et. al [2,1] describes improvement to adherence as a multifaceted process involving interplay between patient information, motivation, and learned behaviours.

Methods to foster medication adherence should impact all three of these factors. Recent trends in technology and mHealth (mobile health), have seen a number of solutions to help address the nonadherence problem ranging from software applications to devices the size conventional microwaves [4,5]. These technologies have seen some success and further work is required before a consensus on a technological solution is reached [3]. This uncertainty is in part due to the difficulty of measuring adherence to
prescribed medication regimes [6] as most large scale studies rely on self-reporting by patients. More concrete data can be provided by solutions that remove human bias. Systems that use patient-centeric reminders, involve healthcare professionals, and integrate well into patient lifestyles have shown promise for improvement of adherence [3,7]. The SmartMed: Medication Management System provides a means of addressing many of the concerns highlighted above. Though developed independently, SmartMed’s design coincides with a recent description of a conceptual system by Varshney [8]. Thus, SmartMed can be used as a prototype implementation of the hypothetical model. The SmartMed system consists of a pill bottle device equipped with audio/visual alarms, a local base station, and a cloud data service. The remainder of this paper briefly summarizes the design and implementation of the SmartMed system, discusses the implications of the system, and suggests future work.

1. Design

The SmartMed system was designed to meet requirements that are loosely tied to current issues regarding medication adherence, they are as follows:

I. The system shall provide a portable method for storing medications.
II. The system shall notify the patient when to take their medication.
III. The system shall log whenever a dose of medication is taken.
IV. The system shall provide a data service to store medication and adherence data.
V. The system shall provide an interface from which users can update their medication profile and view their personal adherence record.
VI. The system shall provide an interface from which care providers or family can access and assist with the patients medications.

Examining these requirements, it is clear that they address the concerns outlined by Vlasniks three pillar approach to medication adherence. Specifically, requirements III, IV, and V support patient information as they facilitate the capture and reflection of information regarding patient adherence. Requirements I and II support learned behaviours by providing a flexible system which assists in conformance to desired behaviour. Requirements IV, V, and VI support motivation indirectly by allowing those in the circle of care of the primary user to become more actively engaged in the care process. These requirements also coincide with many of the requirements outlined by Varshneys hypothetical medication management system and adherence model.

1.1. System Components

The SmartMed system consists of five components: a pill bottle device, a local base station, a cloud data service, an end user or patient, and a care provider. See Figure 1.

The pill bottle device provides users with a method for storing pills and notifies them via audio and visual cues when it is time to take their next dose. The device communicates wirelessly with the local base station component to acquire new prescription instructions and report adherence data. The device detects when it is
opened and logs each occurrence. There is also a snooze button which allows users to delay the alarm, similar to an alarm clock snooze.

![High-level system diagram describing interactions between system components.](image)

Figure 1. High-level system diagram describing interactions between system components.

The base station communicates wirelessly with the pill bottle device(s) and relays information to and from the cloud data service component. This component allows a more verbose and structured protocol to be implemented between the cloud data service and the base station. It also facilitates a simplified protocol for communication to the pill bottle device. It also provides a critical security buffer between the pill bottle device(s) and the Internet, on which robust security measures can be built, e.g. firewalls and information encryption.

The cloud data service component acts primarily as a data repository. It manages all the pill bottle devices and associated users. An Application Programming Interface (API) was defined to allow the local base stations and clients to push and pull data from the data service. Significant thought during design was given to security/verification protocols to protect user data. The design protocol uses a multi-step exchange of certificates/keys between clients, the local base station, and the data service to validate users.

There are two client types within the system, the end users (patient) and care providers. The end user is the individual who is receiving medication management assistance from the system. Care providers represent all those individuals who are able to supervise or assist the patient with their medications; this includes family members, physicians, nurses, and pharmacists. In some cases the patient may not require any input from a care provider, in others it may be critical that care providers assist with setup and management of the system. Both patients and care providers are able to view and update information accessible through the cloud data service. Patients or family members can do this via a web client. Health care professionals may wish to access patient data through clinical systems.

2. Implementation

The current implementation of the system is a prototype which achieves most of the functionality described in the previous section. Due to the timeline of undergraduate
projects (3 months) not all designed features could be completed; their completion is ongoing via an NSERC funded follow up project. An image of the current implementation of the pill bottle device can be seen in Figure 2A.

![Image of pill bottle device]

**Figure 2.** A. Current pill bottle device. B. Visualization of adherence data.

The pill bottle device is custom 3D printed with two enclosures. The first has space for approximately one month of pills, the second contains a battery, ePaper screen, and circuit board. The cloud data service is backed by a relational database and serves a web application that uses a Model-View-Controller paradigm to present information to the users, see Figure 2B. The local base station is currently a software service that can be run on a user’s Bluetooth enabled personal computer.

The following provides a use case for the current implementation of the system. While this use case takes some liberties with the level of integration into current health information technology infrastructure it is possible given the current implementation. The use case assumes the patient is receiving assistance managing medications from their pharmacist:

1. Patient receives a new prescription from their physician and brings their pill bottle device to the pharmacy to be filled.
2. The pharmacist fills the pill bottle and enters the prescription information into the SmartMed cloud data service via the web interface.
3. Next time the pill bottle is brought within its base station (in the home of the patient) it will download the new prescription and begin reminders and adherence tracking.
4. The patient goes about their daily routines for several weeks receiving reminders to take their medication, ensuring the battery is charged and brought within range of the base station on a regular basis.
5. When the patient requires a refill on their prescription they return to the pharmacist. The pharmacist reviews the adherence data collected by the pill bottle and finds that the patient is having trouble taking their evening medication dose.
6. The pharmacist and patient discuss ways to adjust the medication regime to better accommodate the patients lifestyle.
7. During the next visit to the pharmacy the pharmacist noticed the improved adherence and commends the patient on the outcome.

3. Discussion

The SmartMed system fulfills requirements that support patient information, motivation, and learned behaviours; which have been identified as key factors for adherence. Thus, it is a solution to a portion of the medication nonadherence problem. While the current implementation is a prototype, it is representative of a system which has the potential to become a production ready product.

This system has clinical implications for medication management. Specifically, a care provider would be able to view patient adherence and reach out to motivate adherent behaviours. The system has implications for research, particularly in the case of randomized control trials. Stated previously, obtaining reliable adherence rates is difficult, the SmartMed system could provide significantly more reliable data when testing the effect of interventions. There were three critical assumptions that contributed to defining the project scope:

I. Patients/users are willing to take their medications as prescribed.
II. Once pills are removed from the bottle they are taken as directed.
III. When the bottle is opened the correct dose of medication is removed.

These assumptions represent weaknesses in the current design, the project team is actively working on ways to relax these assumptions. Possible solutions are changing the dose taken detection method and using context aware notifications/cues.

Before the system is market ready or becomes a research tool, significant revision is required. Current work focuses on the pill bottle electrical systems and integration with existing clinical information system, namely OSCAR EMR. Future work will focus on usability studies, safety and security evaluations, and user trials.

This project was undertaken as a 4th year undergraduate capstone design project. The SmartMed team would like to thank the University of Victoria’s Department of Electrical and Computer Engineering for providing initial funding and support, and NSERC for ongoing support via an Undergraduate Student Research Award.

References


Health Informatics-Enabled Workflow Redesign and Evaluation

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Abstract. Although health information technologies frequently serve as critical workflow components, we currently lack validated methods for identifying how health informatics can support workflow redesign and for evaluating redesign results. In this study, we describe how a previously developed business process redesign framework was adapted for health informatics-enabled workflow redesign and evaluation. We then demonstrate our methods using an emergency medicine case study.

Keywords. Health informatics, workflow redesign, evaluation

Introduction

Chuck Friedman famously said the fundamental theorem of biomedical informatics is that, “a person working in partnership with an information resource is somehow ‘better’ than that same person unassisted (1).” Friedman’s definitions of ‘person’ and ‘information resource’ are important for health informatics-enabled workflow redesign and evaluation as ‘person’ is depicted from a socio-technical system perspective (to potentially include a team, group, or an entire organization) and ‘information resource’ is seen as facilitating the person’s completion of their tasks. However, Friedman leaves his theorem’s key term, ‘better,’ undefined, implicitly recognizing that potential improvements or declines associated with information resources are myriad and context dependent. Researchers at Eindhoven University of Technology developed a general framework for business process redesign, identified generic workflow metrics, synthesized redesign best practices (heuristics), validated these best practices in qualitative and quantitative analyses, and adapted them to the healthcare setting (2-8). We adapted this framework for use in health informatics-enabled workflow redesign and evaluation by using components from existing health informatics evaluation frameworks. We then tested our methods using a case study from emergency medicine.

1 Eric Eisenstein, Duke Clinical Research Institute, Durham, NC.
1. Workflow Concepts

A Workflow is comprised of a set of interrelated activities that collectively produce a primary product or service for customers external to the workflow (Figure 1). A workflow also may produce secondary products or services for customers in that or other workflows. Although most of these products or services are intended, others may be unintended (9). Changes to healthcare workflow activities may impact patient care safety, efficacy, and efficiency. However, these relationships are complex and involve contextual factors (associated with the patient, their environment or their broader health care system) that are external to the workflow itself. Thus, while patient outcome changes may provide general assessments of workflow success, the relationship between workflow change and patient outcomes typically is that of a necessary but not sufficient condition. For this reason, we recommend a combined approach to healthcare workflow redesign that uses traditional clinical studies to identify situations in which improvements in workflow metrics are associated with improvements in patient morbidity, mortality, and quality of life. Once these health improvement opportunities are identified, a set of four metrics described below can be used to quantitatively evaluate specific workflow redesign implementations.

![Healthcare Workflow Framework](image)

**Figure 1.** Healthcare Workflow Redesign Framework.

2. Workflow Metrics

The four evaluation metrics are: time, cost, quality (internal and external), and flexibility (4). Collectively, these dimensions form what is called the ‘devil’s quadrangle’ because improvements in one dimension (e.g., reduced time) frequently are associated with declines in other dimensions (e.g., increased cost or reduced flexibility). Because of potential performance tradeoffs, a workflow redesign or
evaluation needs to consider all of these metrics simultaneously. Each metric provides a set of general performance measurements that serve as a starting point for quantitatively evaluating workflow redesign changes.

The *Time* metric is represented by two summary measurements that may be further divided into components. *Lead time* is the time it takes to produce one product or service, and *throughput time* is the elapsed time between the completion of two activities (e.g., from the end of activity 1 to the end of activity 2). This distinction is important because it recognizes that a reduction in lead time does not necessarily translate into a reduction in throughput time as other factors may be preventing workflow activity completion.

The *Cost* metric is the sum of all direct costs associated with an activity. These may include: running costs (labor, machinery, and training), inventory costs, transport costs, administrative costs, and resource utilization costs. Indirect costs typically do not change when workflows are redesigned and can be omitted from most evaluations. However, there may be situations in which indirect costs are altered and need to be included. An example is when a redesign involves the outsourcing of sufficient work that general management functions can be eliminated.

The *Quality* metric can be evaluated from two perspectives: external and internal to the workflow. *External quality* is the customer’s perspective and includes both satisfaction with the workflow’s products and its processes (the way the workflow is executed). Because healthcare workflows frequently have multiple external customers for their primary and secondary products, it is important to identify all external customers and obtain some indication of their relative importance to the workflow’s success. *Internal quality* is the worker’s perspective and includes the assessment of job characteristics that are satisfying and motivating. While these may be very important in workflow redesigns, they are difficult to measure.

The *Flexibility* metric relates to the workflow’s ability to react to changes and is measured in terms of specific resources, individual activities, and the entire workflow. Flexibility impacts the workflow’s ability to create different combinations of products or services, perform different tasks with the same personnel, change the sequence of activities, handle different volumes of inputs and outputs, and, modify the process.

In summary, all workflows face constraints of time, costs, quality (internal and external), and flexibility during their operations. Workflow redesigns seek to alter these relationships and improve one or more workflow metrics.

### 3. Workflow Framework

The objective of the Eindhoven University of Technology’s business process redesign framework is to assist developers and implementers in identifying alternative business process configurations (Figure 1). The framework is not intended to serve as a model for business processes; rather, it is a tool for developing redesign alternatives. The framework consists of six business process elements and the external environment. These elements are the business process’s: (1) *customers* (both external and internal), (2) *products and services* (primary and secondary, intended and unintended), (3) *views* (both the *operation view* detailing the process’s anatomy, e.g., number and type of tasks, and the *behavior view* detailing the process’s physiology, e.g., task sequencing and scheduling), (4) *participants* (the organization’s structure, e.g., departments, groups, users, and roles, and *population*, e.g., individuals and their relationships), (5)
information used and created, (6) technologies used, and (7) external environment (other than customers).

4. Best Practices

Business process redesign best practices are intended to be general and applicable to different workflow types that create different product and service sets. Best practices are associated with each business process framework element except for products. A complete list of best practices is provided in Riejers (2) and Netjes (8). Generally, customer best practices seek to improve customer contacts; operation view best practices deal with workflow implementation; behavior view best practices address when the workflow is executed; organization best practices are concerned with which resources are involved and how they are allocated; information best practices relate to how information is or may be created, processed or used; technology best practices concern technologies that are or may be used; and external environment best practices seek to improve communication and collaboration with externalities.

5. Health Information Technology Mechanisms

Stead and Lin identified four health care information technology mechanisms (10). These include: (1) automation: the ability to perform an activity with little modification, (2) connectivity: connecting systems and individuals, (3) decision support: facilitating or improving decision making, and (4) data-mining capabilities: creating new knowledge by recognizing relationships. These four mechanisms describe the ways in which health information technologies can be used in the previously described business process redesign best practices. The next section is an example of how this may occur.

6. Workflow Redesign an Evaluation Example

Previous research has shown that reducing the time between a heart attack’s occurrence and the opening of blocked coronary arteries significantly improves patient survival prospects. For this reason, hospitals treating patients with severe heart attacks (ST-elevation myocardial infarction, STEMI) are evaluated using the door-to-open-artery metric that assesses the elapsed time between a patient reporting to the hospital and the time their blocked artery is opened. Typically, patients suspected of having a heart attack arrive at the emergency department, register at the main desk, wait to be seen by healthcare professionals, and undergo a series of electrocardiogram and other testing before a STEMI diagnosis can be made. When this diagnosis is made, the patient must wait additional time until an interventional cardiology suite and associated staff members are available to treat them. During off-hours when staffing is low, this wait time may become excessive. The business process redesign best practices introduced above suggest several methods whereby a hospital might reduce their STEMI patient door-to-open-artery metric.
Task elimination (Operations view) might allow STEMI patients to bypass the emergency room and proceed directly to the interventional suite. However, hospitals are hesitant to begin preparations for emergency cardiac procedures without having prior physician determination that the patient actually has a STEMI. An option would be to create separate Order types (Operation view) for STEMI and non-STEMI patients that would allow STEMI-diagnosed patients to proceed directly to the interventional suite. This could be accomplished by Resequencing (Behavior view) tasks so that the STEMI diagnosis is made before the patient reaches the hospital. In this arrangement, emergency medical technicians (EMT) would use 12-lead electrocardiograms, an Integral technology (Technology), to collect and send ECG data to a cardiologist’s cell phone, via Task automation (Technology). The collecting and sending of ECG data are examples of health information technology automation and connectivity mechanisms. Lastly, the hospital would Empower (Organization: population) the cardiologist to determine whether the patient had a STEMI and to activate the interventional cardiology suite and staff so that they would be ready when the patient arrived.

Previous research suggests that these hospital workflow redesign best practices will reduce door-to-open artery time and emergency department care costs (11). In contrast, metric changes for non-hospital workflows are less favorable. EMT personal now have addition tasks related to the collecting and transmitting of ECG data. This will increase their time with patients suspected of having a heart attack and have a negative impact on their primary metric, home-to-hospital transportation time, and their overall care costs. This is because of the requirement for increased EMT time per suspected STEMI case and the added cost for new ECG data collecting and sending equipment. Additional costs will be incurred to pay cardiologists for being on-call and for reading cell phone ECG data. Thus, while the overall impact upon patient care is expected to be positive, only the hospital will reap these benefits.

7. Conclusion

We introduced a framework for health informatics-enabled workflow redesign and evaluation and demonstrated its use in an emergency medicine case study. We believe these methods will be useful for health informaticians involved with workflow redesign.

Acknowledgement

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References


Abstract. Heart rate monitoring is being used to estimate activity of autonomous nervous system by analysing heart rate variability (HRV). HRV has been recently shown to be effective means to monitor efficacy of exercise in patients with cardiovascular conditions and older adults. Whether HRV can be used to identify exercise exertion levels is unknown. There are multiple approaches to analyse HRV however it is not clear which approach is optimal in assessing cycling exercise. Previous studies demonstrated potential of analysis of short-term sequences of beat-by-beat heart rate data in a time domain for continuous monitoring of levels of physiological stress. The goal of this study was to assess the potential value of short-term HRV analysis during cycling exercise for automated identification of exercise exertion level. HRV indices were compared during rest, height of exercise exertion, and exercise recovery. Comparative analysis of HRV during cycling exercise demonstrated responsiveness of time-domain indices to different phases of an exercise program. Using discriminant analysis, canonical discriminant functions were built which correctly identified 100% of ‘highest level of exertion’ and 80.0% of ‘rest’ episodes. HRV demonstrated high potential in monitoring autonomic balance and exercise exertion during cycling exercise program.

Keywords. Personal health systems, heart rate variability, signal processing, exercise, telerehabilitation

Introduction

Home-based cycling exercise programs have been shown to positively affect clinical outcomes and quality of life. To ensure exercise safety and efficacy, cardiovascular monitoring is required during exercise for people with cardiovascular conditions and older adults. Heart rate monitoring can potentially help both in estimating activity of autonomous nervous system and level of exertion by analysing heart rate variability (HRV) [1-5]. HRV has been recently shown to be effective means to monitor efficacy of exercise in patients with cardiovascular conditions [6] and older adults [7]. There are multiple approaches to analyse HRV however it is not clear which approach is optimal in assessing cycling exercise. Previous studies demonstrated potential of analysis of short-term sequences of beat-by-beat heart rate data in a time domain [8] for continuous monitoring of levels of physiological stress. The goal of this study was to
assess the potential value of short-term HRV analysis in time-domain for automated identification of exercise exertion level during cycling exercise.

1. Methods

1.1. System and Data Acquisition

A 13-minute exercise that included two 5-minute periods with different leg exercise levels (1.5 and 2.5 miles/hour leg cycling) was offered to 5 healthy volunteers. Before, between and after these two exercises, volunteers took each 1-minute rest. This approach allowed investigation of three typical exertion levels in a usual exercise routine: rest, height of exercise exertion and recovery. Corresponding exercise episodes were used for building a classifier: 1) the first minute of exercise procedure which did not include cycling was selected for the rest condition called 'Rest,' 2) the last minute of exercise (the 11th to 12th minute of exercise procedure) that represented the height of exertion was selected for the exercise condition called 'Highest of exertion,' and 3) the 12th to 13th minute of exercise procedure which represented exercise recovery after cycling exercise was selected for the recovery condition called 'Recovery'. The 13-minutes exercise procedure was repeated at three separate days for each volunteer.

Volunteers used the interactive Biking Exercise (iBikE) system that was previously described [9]. Before beginning of the experimental procedure, participants wore a wireless electrocardiogram (ECG) device (BN-RSPE, BIOPAC Systems, Inc., USA) on their chest with pre-gelled/disposable ECG electrodes (LL Electrode Series, Lead-Lok®, Inc., USA) leads connected to the subject to obtain a Lead II trace. At the beginning, the subjects were asked to rest for 5 minutes for cardio-stabilization. During the experimental procedure, 1 kHz ECG was continuously sampled by a data acquisition system (MP150, Biopac Systems, Inc., USA) that was connected to a laptop. Raw data from ECG were band-limited from 0.05 Hz to 150 Hz.

1.2. Analysis

For each subject, a total of 9 sets of ECG signal (3 sets of ‘rest,’ 3 sets of ‘highest of exertion’ and 3 sets of ‘recovery’) were extracted from each of 3 completed visits using data acquisition software (AcuKnowledges 4.2, BIOPAC Systems, Inc., USA). Extracted ECG datasets were analyzed by HRV analysis software (Kubios HR, University of Eastern Finland) [10] which produced all time-domain HRV variables.

All statistical analyses were performed using IBM SPSS Statistics 21 (IBM, USA). First, paired t-tests were conducted to identify whether HRV variables differed significantly depending on exercise exertion category. A set of HRV time-domain variables produced by 5 volunteers were analyzed after each of them completed 3 visits resulting in 15 episodes for exercise exertion category.

Second, bivariate correlation analyses for 9 sets of 7 HRV variables from each of 5 volunteers were conducted to investigate the degree of relationship between the time-domain variables. The correlation coefficients for each of 5 volunteers were individually calculated to find out whether the correlation coefficients differ among volunteers. The ranges between maximum and minimum of correlation, and mean of correlation coefficient for each correlation pair were analyzed.
Third, the discriminant function analysis was conducted to investigate a potential value of discrimination among groups. Optimal predictors were selected based on the results the first step of paired t-tests and the second step of the bivariate correlations, and used for independent variables in the discriminant function analysis. Eigenvalues and canonical correlations for all functions were investigated. Canonical discriminant function coefficients were also calculated. Finally, the classification results were assessed by matching between the original status and the predicted status.

2. Results

Paired sample t-tests for all 7 time domain variables of HRV were conducted to find significant changes between each exercise condition among ‘rest,’ ‘highest of exertion’ and ‘recovery’ (Table 1). Significant changes between ‘rest’ and ‘highest of exertion’ were found for: Mean RR, SD RR, RMSSD, and RR tri. Between ‘highest of exertion’ and ‘recovery’, significant changes were found for: Mean RR, SD RR, RR tri, and TINN. From ‘rest’ and ‘recovery’ comparison, significant changes were found for: Mean RR, SD RR, and RR tri.

Using values for each time-domain HRV variable from each individual volunteer, the relationship between each two variables was studied to check the possibility of reduction of the time-domain variables in a predictive model. The results of bivariate correlation analyses were based on individual datasets. Between two variables, significant correlations were found between various HRV parameter combinations when we investigated correlations for each 5 volunteers. However only two combinations (SD RR and TINN; NN50 and pNN50) were found to have significant correlations across all 5 volunteers. The mean correlation between SD RR and TINN was 95.8% for all 5 volunteers with 93.5% minimum and 98.6% maximum correlations within all 5 volunteers. The mean correlation between NN50 and pNN50 was 99.0% for all 5 volunteers with 97.0% minimum and 100.0% maximum correlations within all 5 volunteers.

All 45 values of Mean RR, SD RR and RR tri were used to compose discriminant functions based on linear parameter combinations, and to build a predictive model for discrimination among 3 exertion categories. In the analysis, the independent variable entry method was performed to calculate canonical discriminate function coefficients, eigenvalues, and canonical correlations. Two canonical discriminant functions were calculated. The eigenvalue of first function (Function 1) was 2.353, and the canonical correlation of Function 1 was 0.838. In case of the second function (Function 2), the eigenvalue was 1.531 and the canonical correlation was 0.778. The proportion of discriminating abilities of Function 1 and Function 2 were 60.6% and 39.4% respectively. Total 45 sets including 15 sets of ‘rest,’ 15 sets of ‘highest of exertion’ and 15 sets of ‘recovery’ were assessed with the classification results. When classifying the study sample with a model derived from the whole sample, ‘Original,’ 80.0% of ‘rest,’ 100.0% of ‘highest of exertion’ and 86.7% of ‘recovery’ were classified correctly, so overall 88.9% of original grouped cases were correctly classified with 2 developed canonical discriminate functions. When ‘Cross-validated’ classification was performed that was using the leave-one-out method, 80.0% of ‘rest,’ 100.0% of ‘highest of exertion’ and 80.0% of ‘recovery’ cases were classified correctly, resulting in overall 86.7% of original grouped cases correctly classified (Figure 1).
3. Discussion

Comparative analysis of HRV during cycling exercises demonstrated responsiveness of time-domain indices to different levels of an exercise exertion and their potential in monitoring autonomic balance and stress levels during home-based exercise program. HRV indices with highest levels of responsiveness to different exertion levels were

Table 1. Paired samples t-test

<table>
<thead>
<tr>
<th></th>
<th>Paired Differences</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>Mean RR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rest - highest of exertion</td>
<td>336.26</td>
<td>103.36</td>
</tr>
<tr>
<td>highest of exertion - recovery</td>
<td>-91.56</td>
<td>47.53</td>
</tr>
<tr>
<td>rest - recovery</td>
<td>244.70</td>
<td>72.87</td>
</tr>
<tr>
<td>SD RR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rest - highest of exertion</td>
<td>22.28</td>
<td>17.28</td>
</tr>
<tr>
<td>highest of exertion - recovery</td>
<td>-54.81</td>
<td>24.78</td>
</tr>
<tr>
<td>rest - recovery</td>
<td>-32.53</td>
<td>36.09</td>
</tr>
<tr>
<td>RMSSD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rest - highest of exertion</td>
<td>10.68</td>
<td>16.81</td>
</tr>
<tr>
<td>highest of exertion - recovery</td>
<td>-22.71</td>
<td>44.27</td>
</tr>
<tr>
<td>rest - recovery</td>
<td>-12.03</td>
<td>55.70</td>
</tr>
<tr>
<td>NN50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rest - highest of exertion</td>
<td>1.80</td>
<td>6.41</td>
</tr>
<tr>
<td>highest of exertion - recovery</td>
<td>-1.93</td>
<td>3.63</td>
</tr>
<tr>
<td>rest - recovery</td>
<td>-0.13</td>
<td>7.85</td>
</tr>
<tr>
<td>pNN50</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rest - highest of exertion</td>
<td>2.51</td>
<td>6.94</td>
</tr>
<tr>
<td>highest of exertion - recovery</td>
<td>-2.03</td>
<td>3.96</td>
</tr>
<tr>
<td>rest - recovery</td>
<td>0.48</td>
<td>8.58</td>
</tr>
<tr>
<td>RR tri</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rest - highest of exertion</td>
<td>4.26</td>
<td>1.81</td>
</tr>
<tr>
<td>highest of exertion - recovery</td>
<td>-6.79</td>
<td>3.85</td>
</tr>
<tr>
<td>rest - recovery</td>
<td>-2.53</td>
<td>4.16</td>
</tr>
<tr>
<td>TINN</td>
<td></td>
<td></td>
</tr>
<tr>
<td>rest - highest of exertion</td>
<td>75.33</td>
<td>139.28</td>
</tr>
<tr>
<td>highest of exertion - recovery</td>
<td>-190.33</td>
<td>113.24</td>
</tr>
<tr>
<td>rest - recovery</td>
<td>-115.00</td>
<td>209.27</td>
</tr>
</tbody>
</table>

Mean RR: the mean of RR intervals, SD RR: standard deviation of RR intervals, RMSSD: square root of the mean squared difference between successive RR intervals, NN50: number of successive RR interval pairs that differ more than 50 ms, pNN50: NN50 divided by the total number of RR intervals, RR tri: the integral of the RR interval histogram divided by the height of the histogram, TINN: baseline width of the RR interval histogram, SD: standard deviation, SE: standard error of mean, Sig (2-tailed): two tailed probability, units are msec for Mean RR, SD RR, RMSSD and TINN, % for pNN50, and normalized unit (n.u.) for the others, * p < 0.05, ** P < 0.01. All mean values were averaged for N=15.

![Figure 1. Classification status graph](image-url)
identified. From the paired t-tests, HRV parameters with highest differences were identified in the first analysis phase. As a result, Mean RR, SD RR and RR tri were selected by \( p < 0.05 \) and \( |t| > 2 \) for the prediction indices, and then included TINN with \( p \approx 0.05 \) and \( |t| > 2 \). Correlation analyses between different time-domain indices allowed minimize number of independent variables for future prediction model because higher correlation meant significant correspondence between two variables but lower correlation meant their potential uniqueness. 95.8% mean correlation for all 5 volunteers between SD RR and TINN indicated their similarity and dependency, so TINN was excluded by less significant paired t-test results. Therefore, final Mean RR, SD RR and RR tri were set for predictors of canonical discriminant analysis to classify 3 exertion levels that were rest, highest of exertion and recovery.

Function 1 and Function 2 equations were calculated based on 3 exertion levels and 3 predictive variables. These two functions projected the location (Function 1, Function 2) on the territorial map as shown in Figure 1 to distinguish the exertion levels. Eigenvalues, % of variance, % cumulative % and canonical correlation were related each other and these parameters confirmed how well the functions classify the exercise exertion. The resulting functions correctly predicted 100% of ‘highest of exertion’ and 80.0% of ‘rest’ episodes in both original and cross validation experiments with overall 86.7% classification accuracy for all three exercise exertion levels. Thus, the results from this present study demonstrate a significant potential in using the short-term time-domain HRV for classifying exercise exertion level during cycling. Further validation studies are warranted with higher sample sizes, more detailed exercise exertion level classifications, and subjects with different clinical conditions.

References

A Platform to Collect Structured Data from Multiple EMRs

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Abstract. Adoption and use of Electronic Medical Records (EMRs) is continuing to rise across Canada, leading to more data being generated. These data, however, are not being captured in a standardized manner, they are not available for research, surveillance or health system management, and they are not having a real-time impact on healthcare providers at the point of care. Multiple stakeholders, including researchers and system evaluators, require easy access to high quality, structured data. As current EMRs are not able to effectively meet their needs, we engaged multiple stakeholders to assist in designing a solution. A total of 90 stakeholders from various backgrounds participated in an iterative joint design process. After incorporating the feedback of all stakeholders, we developed the design for a scalable platform for capturing structured, evidence-based data from all EMRs in Canada for research, health system management, clinical decision support and other purposes. We discuss the design specification for our proposed solution and explain how, using clinical forms, we can not only capture structured, high quality data from multiple EMRs, but also provide real-time guideline advice to providers at the point of care. The scalability of this proposed solution across multiple diseases and multiple EMRs is also explained. We further discuss the benefits and limitations of this proposed solution to several key stakeholder groups and address issues of privacy and security.

Keywords. Electronic Medical Record, Clinical Decision Support, Clinical Decision Support Systems, Computerized Guidelines

Introduction

Electronic medical record (EMR) usage is continuing to rise in Canada [1]. Nationally, more than 64% of primary care physicians use EMRs [2]. One of the benefits of having electronic data is that multiple stakeholders could make use of that data to, for example, conduct research or surveillance. Although the amount of electronic data being entered into EMRs is increasing, current EMRs lack several key capabilities that prevent their full benefits from being attained. First, current EMRs cannot capture standardized data that are comparable across multiple EMRs. Second, EMRs cannot transmit data to a central repository; each EMR vendor maintains its own database, resulting in multiple data silos for the same population. Third, EMRs are not able to present real-time guideline recommendations to physicians at the point of care; standalone guideline systems are of little value to physicians if not integrated into the EMR.

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There is increasing demand for structured data from EMRs from key stakeholders. These stakeholders require high quality data for research, quality indicators for policy analysis and program evaluation, and clinical decision support and guideline implementation. Since EMR vendors are not able to effectively meet the needs of these stakeholders, there is a need for a more scalable and effective solution. Our objective was to design a scalable platform for capturing structured, evidence-based data from all EMRs across Canada for research and other purposes.

1. Methods

We identified key stakeholders through a brainstorming approach. Stakeholders represented 9 key categories, including: Healthcare Providers, Patients, Researchers and Academics, the Ontario Ministry of Health, eHealth Ontario, OntarioMD, EMR Vendors, the Privacy Commissioner’s Office, Guideline Implementers, and Non-Governmental Organizations and Associations. We engaged a total of 90 stakeholders using a purposive and snowball sampling approach.

We developed a design brief and a conceptual model displaying the basic architecture of how structured data could be captured and used. We used a Collaborative Interviewing approach to design the system. Each stakeholder was asked to validate findings identified by previous stakeholders and told about what other stakeholders desired. The system design was iteratively modified to take into consideration each stakeholders’ concerns and suggestions. There were no mutually exclusive needs identified. The following section describes the final system design.

2. The Design Process

2.1. The design brief

The design brief, validated by all stakeholders, for the data collection platform included the ability to: 1) Collect structured, evidence-based data on multiple diseases from all EMRs across Canada, 2) Send the data to a repository in real- or quasi-real-time, 3) Provide real-time guideline advice to practitioners, patients and families, 4) Allow for standardized calculation of quality indicators, including patient experience indicators, 5) Provide rapid updates to forms as new evidence becomes available, 6) Provide the ability to monitor effectiveness of knowledge translation efforts and to make course corrections in response to data from the field, 7) Support new models of care and the Chronic Care Model, 8) Develop faster and less expensive ways of updating forms and guideline knowledge across all EMRs in Canada.

2.2. The Initial Solution Description

We proposed working with all EMR vendors to incorporate an “HTML window” into their application. This window is part of the EMR and will display data entry forms in the context of the EMR and will co-exist with forms in the EMR. Users will select forms from within their EMRs as they currently do. Whenever a web form is available, the EMR sends a request to a Forms Server, which displays the latest version of the
form available (Figure 1). A standard core data set file, such as a form could be pre-populated with demographic data and other data that was already available in the EMR.

Figure 1. Scalable Structured Data Collection Architecture

Once the user completes data entry, they submit the form data to the Forms Server. The data is packaged by the Forms Server into a standard format and returned to the EMR, where it is stored in the local EMR database. This ensures that data required for medico-legal purposes is available when required and does not have to be retrieved from the Forms Server later. The collected data can now be used for multiple purposes.

2.3. Design and development of forms

Researchers and other stakeholders can author forms using a Forms Authoring System. Any EMR can access the Forms Server via the web browser in the EMR, making this solution scalable. Using the web browser in their respective EMRs, providers can select the form(s) they are interested in using in their practice.

The Forms Authoring System defines forms using ‘formlets’—similar to the OpenEHR archetypes. Designing a form by using formlets, allows the Forms Server to render a completely customized form for any patient, based on their history of diseases. Since the EMR is already sending a CCD at the time of the form request, it is possible to produce the customized form in real-time [3]. This is particularly attractive in primary care where patients typically have multiple diseases.

As new evidence becomes available, the platform allows for this evidence to be rapidly incorporated into existing guidelines/forms or for new guidelines/forms to be developed. The result is a faster and less expensive method of updating guideline knowledge and forms across all EMRs in Canada.

2.4. Further elaboration of the Solution

The data, once collected, can be used for multiple other purposes. Guideline advice to practitioners, patients and families can be made available in real-time. Data can be processed through clinical decision support (CDS) algorithms and recommendations
can be incorporated into the forms that are being served by the Forms Server. This can be done in real-time, while the patient is still being seen by the provider [4].

Standardized calculation of quality indicators, including patient experience indicators becomes easier. Any advice or metrics that are calculated can be incorporated into the Forms that are used by end-users. The data can be reused for research [5], surveillance, health system management and other routine secondary uses.

The platform also makes it possible to monitor the effectiveness of knowledge translation using CDS. By analyzing incoming data, it is possible to know whether CDS recommendations are being followed. If not, it is possible to change the recommendations to see if they are more effective than previous ones. By using more advanced tools, it is even possible to conduct A/B testing of forms and guideline recommendations. A/B testing of forms could allow faster iteration of usability and help achieve truly intuitive user interfaces, which is difficult to do with current community-based EMRs and the long feedback cycles necessitated by today’s software architectures. A/B testing of guideline recommendations could lead to faster impact of CDS and guideline recommendations, as implementers react to users responses to their recommendations and make changes on an on-going basis.

The platform can also enable patients and families to have access to information about their condition in a format that is easy to read and understand, as structured data in their record will allow them to connect to patient-friendly, high quality data that can automatically be linked directly from their record.

2.5. Privacy and security considerations

Clearly, the platform described is likely to surface key issues of privacy and security. We propose 3 privacy preserving mechanisms to be built-in to the platform: 1) Patient consent model. This would be for collecting data for evaluating the impact of interventions or for collecting data not usually collected as part of routine medical care. 2) Agency model. In cases where vendors or academics are providing clinical decision support for routine medical care and where they need access to clinical data for analysis and improvement of their decision support tools, an agency agreement is an excellent solution. 3) Anonymized data model. Where researchers or health system managers need specific data that is normally collected during routine patient care, getting an anonymized data set is an acceptable approach. All 3 mechanisms are well entrenched in current privacy legislation and make for a robust set of privacy protections.

Ensuring the security of patient data will require standard privacy and security practices such as regular privacy impact assessments (PIAs), threat risk assessments (TRAs) and audit log reviews; training on privacy and security for all staff; encrypted databases –there are good solutions that allow for real-time access to data while still maintaining encryption. All users should be authenticated and have role-based access. The Ontario Information Privacy Commissioner’s office validated the privacy design.

3. The Design Outcome

The benefits of this new platform are significant. Clinicians would be able to participate in world-class research through their EMRs more easily than ever. They would have access to the latest versions of high quality, evidence-based data collection templates. Integrating EMR data collection into clinical practice at the point of care
has been shown to be feasible [6]. Clinicians could also access practice-based quality measures as well as peer comparison metrics. Finally, physicians would have access to the latest guideline recommendations at the point of care.

Researchers would also benefit from our proposed solution. Researchers would finally have access to structured data for research. They could assess the effectiveness of guideline recommendations at the point of care and also capture Quality Indicators. Clinical forms could easily be updated whenever new evidence is found. Researchers could also easily scale to multiple diseases without having to involve the EMR vendor. Finally, researchers could easily add consent management into the system.

The health sector would benefit by having an exportable technology for enhanced primary and secondary uses of data. This solution would also provide the evidence-based leadership in Canada a platform to engage in with the eHealth future. EMR vendors would benefit by being able to refer researchers and other data collectors to a third party for forms development –most vendors are not structured to provide custom forms development to researchers. This solution would also decrease the cost and effort involved in EMR vendors serving the needs of researchers for forms. eHealth Ontario and the Ontario Ministry of Health would benefit by being able to implement guideline and Quality Indicators as well as evaluate the impact of policies and investments. This solution would allow them to leverage the investments that have already been made into EMRs. Finally, they would now have an environment to test innovations before rolling them out to other physicians and have the ability to scale up deployment across the Province as soon as projects are found to be successful.

Limitations include issues of sustainability and lack of an identified roadmap to realize the design. Getting funder buy-in to build such a system will be required.

Acknowledgements

We thank the Ontario Best Practices Research Institute (Dr. Claire Bombardier and Sandra Couto) and the Ontario Rheumatology Association (Dr. Vandana Ahluwalia) for their support and encouragement in pursuing this project.

References


The Role of Technology in Reducing Unnecessary Duplicate Diagnostic Imaging Examinations

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Abstract. Unnecessarily repeating diagnostic imaging (DI) examinations can expose patients to additional radiation and place pressures on human and financial resources in healthcare. Through a qualitative study, non-radiologist physicians were interviewed about their ordering practices. This included questioning participants about how they would determine if a DI examination had already been performed or scheduled to take place. Participants described how they asked their patients about whether prior testing had been done or if future tests were scheduled. Participants also indicated that they consulted electronic systems to determine if prior DI examinations occurred. However, other research suggested that patients may not accurately recall their DI history. Meanwhile, using electronic systems such as decision support or computerized provider order entry could help to reduce duplicate ordering, although more research is necessary.

Keywords. Duplicate ordering, decision support systems, diagnostic imaging, medical imaging, patient safety

Introduction

The Canadian Association of Radiologists (CAR) suggested that up to 30% of diagnostic imaging (DI) tests in Canada could be inappropriate [1, 2]. Examples of inappropriate DI examinations include cases where: (a) the most ideal imaging modality is not selected, (b) imaging results would not change or support a patients’ management, (c) imaging tests are performed too early to obtain a diagnosis, and (d) duplicate imaging examinations are performed [3]. In some cases, duplicate DI examinations are necessary, for example, to evaluate the progression of a disease. This paper focuses on unnecessary duplicate ordering and presents data collected from a qualitative study investigating this issue. For the purpose of this paper, unnecessary duplicate ordering refers to cases where DI examinations are repeated without a clinical need. As some DI modalities expose patients to additional radiation (for example, x-ray, computed tomography [CT], and positron emission tomography [PET]) [3], receiving an inappropriate examination can raise patient safety concerns [4]. For example, a chest x-ray can expose a patient to approximately the equivalent of three days of background
radiation; a CT scan of the abdomen or pelvis can expose a patient to approximately 4.5 years of background radiation [3]. The lifetime estimate of developing cancer associated with an abdominal CT scan for a 25 year old would be approximately 0.05% [5]. Although the risk is low for individuals who require DI services, unnecessary exposure to radiation from DI examinations is concerning on a population level [4].

In addition to posing threats to patient safety, inappropriate DI can place strains on human and financial resources in healthcare. For example, CAR expressed concern about having enough radiologists and technicians to manage the increasing number of scanners being used across Canada [6]. As well, approximately $2.2 billion were spent on DI services in Canadian hospitals in the 2005-6 fiscal year [7]. The use of DI services have also increased [8]. For example, in Canada, CT use has increased by 58% (2,767,849 to 4,377,919 scans) between the fiscal years of 2003/4 and 2011/12 [8]. Thus, promoting more appropriate ordering could help to reduce these stresses on resources in healthcare.

1. Methods

This paper focuses on the duplication of DI services, one of several themes that emerged from a larger study which explored the DI ordering practices of referring physicians in Canada. One of the main research questions focused on how physicians determine if a DI examination had already been performed or was scheduled to take place and how they decide on ordering. To address this research question, a semi-structured interview study was conducted with non-radiologist physician participants who were able to order DI services in their Canadian jurisdiction.

2. Results

2.1. Participant Demographics

Twelve non-radiologist physicians participated in this study. Recruitment occurred until saturation was reached [9, 10]. Saturation was reached after four general practitioners, two geriatricians, two neurologists, one rheumatologist, one respirologist, one hepatologist, and one emergency physician participated. The years of experience of these participants ranged from 4.5 and 35 years (mean = 20.33). The majority of participants had over 15 years of experience (9/12; 75%) and were mostly educated in Canada (58%) and the United Kingdom (25%).

2.2. Semi-Structured Interview Results

Several themes emerged from the interview data, including duplicate ordering management. This theme will be described in more detail below.

2.2.1. Ordering Practices

Participants indicated that they typically ordered several differing types of DI: x-rays (9/12; 75%), CT scans (9/12; 75%), ultrasounds (7/12; 58%), magnetic resonance imaging (MRI) tests (6/12; 50%), and PET (1/12; 8%) scans. Participants would order
between approximately 1.5 and 80 requisitions per week (mean = 23.58). As well, participants were asked to ascribe a percentage to how many DI requisitions were placed in a week that were routine in nature (i.e. non-challenging from a clinical perspective) and their responses ranged from 0 to 80% (mean = 48.83%) of all requisitions.

2.2.2 Duplicate Ordering Management

As mentioned, participants were asked how they would determine if a DI examination had already been performed or was scheduled to take place. Interestingly, the majority of participants (8/12; 67%) noted that they would ask the patient directly about their DI history (i.e. the type of DI examination the patient received and when it had taken place). The following interview excerpts illustrate this finding:

The easiest way is to actually ask the patient, you know, “has someone else ordered this test?” And they may or may not know. (Participant 06, Line 92-93)

The most reliable thing is probably still asking the patient. (Participant 07, Line 56)

That’s a very good question, and it’s almost impossible. The flow of information between doctors or between institutions like hospitals and physicians and between specialists and GPs is almost non-existent. A lot of the time, the only thing you have—most of the time, you wouldn’t have anything and you wouldn’t know if something has been done, other than just by asking the patient...so really, the patient would be the number one source of information. (Participant 10, Line 50-56)

These interview excerpts highlight how participants would ask the patient to recall their DI history.

Other participants indicated they used electronic resources to determine if a patient had prior testing done. Specifically, participants who did not ask the patient directly accessed health information systems to determine if the patient had a recent DI examination. These participants (4/12; 33%) described using a Picture Archiving and Communications System (PACS) or other electronic systems to determine whether a DI examination had been performed in the past or were scheduled to take place. The following interview excerpts illustrate this finding:

So, if it’s happened before, and it’s in our health district, it will show up on our diagnostic imaging database. (Participant 03, Line 60-61)

If it’s already been performed, I can find out because I can log into our electronic system...It has everything from within the Province. (Participant 09, Line 41-42)

These interview excerpts demonstrate how some participants would use their jurisdiction’s PACS or other electronic system to determine if a DI examination had been performed or was scheduled to occur. Overall, participants would either ask the
patient directly or consult their jurisdiction’s PACS or other electronic system to determine if a DI examination had been performed or scheduled.

3. Discussion

The majority of participants would ask their patient directly to determine the patient’s DI history, a view supported by another group of researchers. For example, Hendee et al. (2010) stated that “physicians should encourage patients to describe the imaging examinations they have undergone previously to help ensure that duplicate studies are not performed” [11, p. 244].

However, another study asked patient participants to recall whether they had received a CT scan in the past 5 years [12]. Overall, 31% of participants (365/1168) stated that they had not had a CT scan in the past 5 years. Comparing these responses to the hospital’s electronic health record system revealed that 39% of participants (142/365) had, in fact, undergone a CT scan in the previous 5 years [12]. Thus, relying on the patient to recall their DI history may not be sufficient to determine if a diagnostic imaging test is needed.

3.1. Decision Support Systems as Solutions to Duplicate Ordering

Decision support systems (DSS) or computer provider order entry systems (CPOE) could help to reduce duplicate ordering. This could be done by alerting the clinician of a similar examination that was already performed recently or one that is scheduled to take place. For example, a study conducted in Massachusetts found that a DSS alerting ordering physicians of potential duplicate imaging orders resulted in a reduction in orders placed [13]. Specifically, 6% (661/11074) of orders were cancelled when the DSS alerted the physician of a potential duplicate order (i.e. an imaging examination performed on the same body part within the past 90 days) [13]. This was compared to 0.9% (194/22281) of orders cancelled in the control group, which did not employ the DSS alert [13].

Similarly, in 2007 a pilot project was conducted in Manitoba, investigating a CPOE and DSS used in pediatric care. Overall, 5% (386/8386) of orders placed during the study period generated an alert to warn the ordering physician of a potential duplicate order. Of these cases, 26% orders were cancelled [14]. As well, a CPOE system has been scheduled for implementation between 2013 and 2014 in the Province of Prince Edward Island which would alert ordering physicians of potential duplicate orders [15]. Researching the impact of CPOE upon duplicate order prevention would offer insights into the use of alert functionalities for imaging.

3.2 Picture Archiving and Communication Systems as Solutions to Duplicate Ordering

Again, several participants indicated using PACS to determine if an examination had been performed or scheduled. Interestingly, a study conducted in Ontario noted that the baseline frequency of duplicate imaging examinations was “relatively low and [the researchers] did not find large absolute reductions in the frequency of duplicate imaging examinations after the introduction of PACS” [16, p. 238]. It is unclear whether PACS, in the absence of a CPOE and DDS, would impact duplicate ordering rates. Therefore, more research is required.
3.3 Future Directions

This study adds a qualitative perspective to the duplicate DI ordering literature. Particularly, this exploratory research offers a starting point for further research regarding duplicate DI ordering. Future research could include surveying physicians to determine whether these qualitative findings can be generalized to a larger sample. As well, further testing of DSSs and CPOE as a means to reduce duplicate ordering is needed. Additionally, there is a need to learn more about the effects of domain of expertise in terms of ordering practices among physicians who are family practitioners and those that are specialists in differing areas.

4. Conclusion

Unnecessary duplicate DI ordering can expose patients to radiation, and place strains on human and financial resources in healthcare. Through a qualitative study, non-radiologist physician participants noted how they would either ask a patient to recall their DI history, or consult a PACS or other electronic systems to determine if a DI examination was already performed or was scheduled to take place. However, other research suggested that relying on the patient to remember their DI history may not be accurate. As a solution, some researchers have found reductions in duplicate ordering when using DSS or CPOE systems. More research is necessary to explore whether using PACS could reduce duplicate ordering. Overall, this study adds a qualitative perspective to the DI literature, with a focus on duplicate ordering.

References


Building an Electronic Handover Tool for Physicians Using a Collaborative Approach between Clinicians and the Development Team

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Abstract. In an effort by The Ottawa Hospital (TOH) to become one of the top 10% performers in patient safety and quality of care, the hospital embarked on improving the communication process during handover between physicians by building an electronic handover tool. It is expected that this tool will decrease information loss during handover. The Information Systems (IS) department engaged a workgroup of physicians to become involved in defining requirements to build an electronic handover tool that suited their clinical handover needs. This group became ultimately responsible for defining the graphical user interface (GUI) and all functionality related to the tool. Prior to the pilot, the Information Systems team will run a usability testing session to ensure the application is user friendly and has met the goals and objectives of the workgroup. As a result, The Ottawa Hospital has developed a fully integrated electronic handover tool built on the Clinical Mobile Application (CMA) which allows clinicians to enter patient problems, notes and tasks available to all physicians to facilitate the handover process.

Keywords. electronic handover, electronic handoff

Introduction

The World Health Organization considers communication during handover of patient care among its top 5 safety initiatives. [1] Communication errors are often cited as a significant contributor to adverse outcomes. [2] Although many approaches to handover of care are described in the literature [3,4], there is no single widely-accepted approach, even within individual specialties. During a current state analysis review of eight clinical departments at The Ottawa Hospital, it was determined that although handover occurred regularly at physician transition points, there was no standardized approach to handover of care. A recent study of 14,000 patients, conducted at the University of Ottawa Heart Institute, found a correlation between intraoperative handover of anesthetic care and increased 30-day mortality rates when compared to patients where no transition of care occurred, even after adjusting for confounding
1. Environmental Scan of Existing Handover Tools

As part of the current state analysis, a scan of existing (paper-based) handover tools, processes and workflow associated with the physician patient handover was conducted. This scan revealed that although handover was being performed, there was no consistent method of doing it. In addition, there has not in the past been any formal medical resident training regarding the handover process.

Early on in the project, we conducted a review of existing information technology solutions for handover of care. At a local level, we reviewed a handover project being developed by the department of anesthesiology. We also invited another academic health science centre hospital to provide us with a demonstration of their current electronic handover tool, as we are both using the same base electronic health record platform. Other solutions reviewed included: a South Australian handover tool.

2. Organizational Considerations

2.1 Project Approval

At The Ottawa Hospital (TOH), all new project requests must be submitted by the Executive Vice-President, Vice-President, and/or Medical Department Head to the Information Systems (IS) Steering Committee for consideration. The IS Steering Committee is responsible for prioritizing each project, which is then evaluated and approved. Building an electronic handover tool was identified as a physician priority and was approved in 2013.

2.2 Project Workgroup

Given the variability in current practice and the need for handover standardization, we set out to form a handover workgroup comprised of physicians and the Information Systems project team. The main objective was to build a tool that standardized the process and improved patient quality and safety during handover transition points. It also allowed the primary users, physicians, the opportunity to be fully involved in the design and functionality of the eHandover tool. The workgroup consisted of 21 physicians representing 10 different medical departments, and a project team that consisted of our Chief Clinical Information Officer, the Information Systems Chief Systems Architect, a Project Manager, a Business Analyst, a Clinical informatics Analyst, a Quality Assurance (QA) team member and a member of our Training and Complex Support team. The initial commitment of the workgroup was to meet twice per month for a 2-hour time block.
2.3 Problem identification

We began our process by conducting a current state analysis of the hospital’s handover processes, and identifying challenges and barriers to conducting a safe and effective handover in the context of clinical care. Extensive consultation with staff and resident physicians informed this process. This gave the eHandover team perspective on the need for the tool, and started to shape the scope of the project.

2.4 Current State Analysis

Although the workgroup was well represented across specialties, we felt it prudent to perform an environmental scan of various clinical departments to determine how and when they were performing handover. We began the process by designing a template that would allow us to capture consistent information from each of the departments. Included were typical questions regarding the current handover process: where is it performed, by whom, how often, what the format of the paper tool was, and if they use standard communication tools (e.g. ISBAR, SBAR, IPASS), and what information was communicated. In addition, we asked users to describe to us the desired functionality and scope of an electronic handover tool.

The TOH Clinical Mobile application has been developed to provide physicians with a version of our current data repository built for the iPad. Along with the ability to view patient laboratory and diagnostic medical imaging results, clinicians are able to place orders using the computerized order entry module (CPOE). As the iPad is currently being carried by physicians during their clinical duties, and handover events can occur at many hospital locations, the mobile platform was determined to be ideal for the eHandover tool. Once the platform was selected, the IS team began to look at additional software requirements to support an electronic handover tool.

3. Iterative Design Cycle

3.1 Requirements gathering

Based on the information we obtained during our current state analysis and previous discussions with the workgroup, we built a list of 23 items to be included in ‘the ideal tool’ for review. At this point in the project, we introduced the mobile development team to the project requirements. We designed basic mock ups for the team and began to look at each section of the tool and possible related functionality.

3.2 Design Approach

At TOH, The CMA program that hosts the eHandover module is built using native Apple development tools (xCode and iOS SDK). As a result, CMA looks and feels like a standard Apple app, like Mail. It uses a split view controller that presents a master-detail interface. For example, when the device rotates, the menu on the left is automatically collapsed in a small button and the display is adjusted accordingly. Gesture-based actions can also toggle between the hidden and overlay modes.
Early in the development process, we identified that Tasks and Notes were the 2 main items to be included in the tool. The inclusion or exclusion of a problem list was the first challenge. Our current eHR does not allow clinicians to enter progress notes, and we wished to avoid task duplication with the existing paper medical record.

The original design began with an overview of the in-house handover tool project led by Dr. Hudson. The tool framed the design discussion and led the group to discussions on items such as: inclusion of a problem list in the tool, how to manage tasks, ethical discussions of the role of a handover tool in the patient record, and how the electronic handover tool would complement the current paper and electronic medical records.

![Mock up of the original in-house anesthesia conception of an electronic handover tool](image)

Figure 1. Mock up of the original in-house anesthesia conception of an electronic handover tool

3.3 1st Iteration

From this initial design, feedback and the original mock-up were used to create the first iteration to bring to the development team. The focus at this time was on the main page of the handover tool, but keeping existing CMA functionality in mind for how each of the Problem, Notes and Task overlays were going to function. The working group was then presented with 3 options of the main page view. The project team felt the focus at this time should be on confirming the main page design in order to create a platform for designing functionality of each section of the tool. The main elements of the 1st iteration focused on how to display the Problems, Notes and Tasks, how to navigate to the handover tool and what associated patient information needed to display on the main page.

3.4 Design Feedback on the 1st Iteration

The working group agreed that the use of icons or swiping to view additional information was not conducive to their handover practice; they preferred to see all
problems, notes and tasks from the main page rather than having to swipe or click to view the associated patient information. We further streamlined the displayed patient information in order to maximize information visibility on our home screen.

![Handover Tool Image]

**Option1:**

<table>
<thead>
<tr>
<th>Patient Information</th>
<th>Problems</th>
<th>Notes</th>
<th>Tasks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPOOLAB-THOMPSON, JANET</td>
<td>Hypeension</td>
<td>Staphylococcus</td>
<td>Need to address in AM</td>
</tr>
<tr>
<td>KTHO11, TEST</td>
<td>N/V</td>
<td>MNC</td>
<td>CMV/CMV-Positive</td>
</tr>
<tr>
<td>DWIIS R, LOUISE</td>
<td>N/V</td>
<td>MNC</td>
<td>Neutropenic, change pain Substituted dose</td>
</tr>
</tbody>
</table>

**Option2:**

<table>
<thead>
<tr>
<th>Patient Information</th>
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</table>

**Option3:**

<table>
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</tr>
</tbody>
</table>

![Handover Tool Image]

**Figure 2.** The 3 original design options for the main page of the handover tool.

### 3.5 2nd Iteration

The second iteration focused on designing the patient information section to accommodate increasing row width for the Problems, Notes and Tasks. The second focus was navigation to enter and modify the information. The project team and the development team met frequently to begin focus on functionality of each of the sections of the tool. Several mock ups were designed associated to the different overlays and brought back to the workgroup for feedback.

Each workgroup meeting was followed up by a meeting with the development team to bring back ideas and requests from the workgroup. The development team
would review feedback and requests and provide the project team with ideas on how to improve upon building the tool in keeping with their development standards. During this time the project team began creating functional specifications outlining each of the requirements after they were agreed upon by both the project team and the workgroup. Approximately 7 months prior to the projected pilot date the project team completed functional specifications and the technical team had completed technical specifications. All staff and resident physicians on two services (anesthesiology and geriatrics) on one campus of The Ottawa Hospital will participate in the pilot test of the eHandover tool.

The handover tool begins with a patient list in CMA that allows easy navigation to the main page of the handover view. The user can enter a problem, note or task by tapping into the associated cell. Each problem, note and task page contains 3 tabs; create, edit and history. In addition to the basic functionality of entering problems, notes and tasks, the workgroup identified the need for the following: (1) Ability to enter different types of problems - primary, acute and chronic. Each problem type is displayed differently in the problem section on the main page. (2) Identifying acute patients - the acute patient icon is set on the note page and identified in the patient information cell on the main page. (3) Urgent tasks - tasks can be set as urgent when entering a task and identified in the task cell on the main page. (4) The ability to filter tasks and notes by service.

![Figure 3. 2nd iteration mockup of the main page of the eHandover Tool.](image)

![Figure 4. Screen shot of final handover main page](image)
4. Discussion

Although The Ottawa Hospital does not currently have a standardized process for handover of care, our current state analysis has identified that handover is occurring consistently during transitions of care, and that there is significant physician interest in improving the handover process. By using the clinicians to design the tool and provide feedback on functionality we have provided them with the opportunity to build the electronic handover tool that supports the various needs of our multiple services. It should be noted that the workgroup identified very early on that although we were building an electronic handover tool, it was not meant to replace the face to face handover communication that occurred in each of the services. We do not anticipate that all clinicians will embrace the change from paper to electronic, but we are certain that through our collaborative effort between the two teams we have built a tool the will support their process and standardize patient handover.

References

Modelling Clinical Diagnostic Errors: A System Dynamics Approach

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Abstract. The diagnostic process involves a series of stages in the patient pathway. Any errors or misleading information from any stage could lead to errors in the final decision-making. System dynamics modeling maps the diagnostic process as a whole and seeks to provide a quantitative way of analyzing different errors at each stage as well as relevant key factors. This paper provides a framework based on system dynamics for modeling the tracing of errors inside of the system from where errors initially occur, the routes of errors inside of the system, and how errors are delivered out of the system. Also, a detailed illustration of the phase history and physical examinations is provided as an example to explain how relevant factors can be interpreted and how this affects errors according to the framework.

Keywords. System dynamics, diagnosis, diagnostic errors, modeling, stock and flow diagrams

Introduction

Clinical diagnosis involves a series of phases from history and physical examinations, assessment tests to referral, where errors may occur in any phase and lead to diagnostic errors [1]. This study using system dynamics modeling maps an entire diagnosis process as a system, which not only illustrates the above phases where errors occur, but also covers the possible error detection stages. System dynamics modeling describes the number of errors occurring during different stages, tracks the routes of the errors, and provides simulations to show model behaviors while varying factors inside of the system.

System dynamics is an approach that helps one to better understand problem situations and solve problems through finding different management policies and alternative organizational structures [2]. It was initially used to analyze corporate and managerial problems, and then generalized to non-corporate areas since the late 1960s[3]. Nowadays it has been used widely, including in healthcare. Its current applications in health and social care systems mainly cover illustrating the structure of system resources [4], as well as interpreting experimental results and understanding the dynamics of results in disease research, for example, the research of HIV and human immune system [5]. It is suggested that system dynamics could be implemented into dynamic systems, with time and spatial parameters to help one observe how system behaviors change. [6]

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This study applied system dynamics to the modeling of errors during diagnosis, mainly because of two concerns. Firstly, errors during the diagnostic process change along with the change of other variables in the system. System dynamics could simulate the change and observe system behaviors over a period of time under different scenarios. Secondly, from a systemic view, new errors occur when doctors collect diagnostic information or diagnostic clues that could be detected and corrected in the subsequent stages, through the use of modeling. In other words, errors not only have multiple causes that increase error numbers, but also are delivered out of system via various routes.

System dynamics has been implemented into two steps in this study: causal loop diagrams, and stock and flow diagrams. A Causal Loop Diagram has been designed as the first step by a previous study [7], which shows model variables and their interrelationships. This paper focuses on quantitative analysis using stock and flow diagrams to allow one to observe the information inputs and system behavior outputs.

1. Methods

The basic theory of interpreting diagnostic errors into stock-flow diagrams is illustrated in Figure 1.

![Figure 1. Interpreting diagnostic errors in a system dynamics model.](image)

The above stock and flow diagram contains a rectangle with an input arrow and an output arrow. The rectangle, referred to as “Stock” in system dynamics, indicates a quantitative stock. The input arrow indicates the inflow of the stock, and it increases the stock level. The output arrow indicates the outflow of the stock, and it decreases the stock level. [8]

The stock in Figure 1 denotes the quantitative level of diagnostic errors or “the number of existing diagnostic errors” in the system. The input arrow “new errors” indicates the new diagnostic errors per time unit, while the output arrow “detected errors” denotes the detected errors after diagnosis per time unit.

The stock could use the mathematical representation in Eq. (1) to explain its level changes over a period of time from initial time $t_0$ to current time $t$.

$$\text{The number of existing diagnostic errors}(t) = f^t_{t_0} [\text{new errors}(s) - \text{detected errors}(s)] ds + \text{The number of existing diagnostic errors}(t_0)$$

(1)

where $s$ represents any time between the initial time $t_0$ and the current time $t$. 
2. Results

According to the patient pathway, the model in this study divides the diagnostic process into the following stages: pre-decision making, decision making and after-decision making, which is shown in Figure 2. Specifically, pre-decision making is the period when new errors of diagnostic clues happen. Thus, this stage is further divided into 3 phases to explain where new errors come from, and it includes: “Phase1 history and physical examinations”, “Phase2 assessment tests” and “Phase3 referring to other healthcare providers”. [9]

Figure 2. Diagnostic process represented in the model.

Following this process, the final framework of modeling diagnostic errors was implemented using the software Vensim [10] and is shown in Figure 3.

Figure 3. Framework of system dynamics modeling for errors during diagnosis.
Stocks are the number of patient visit cases. Arrows are the flows that deliver patient cases. The framework describes where errors initially happen, the routes of errors inside of the system, as well as how errors are delivered out of system in the way of “discharged with no harm”, “unplanned hospitalization” or “unscheduled re-visit of primary care, urgent care or ER service”.

By adding relevant factors or variables into the framework, the model can demonstrate the behaviors of these variables inside of the system. It is easy to observe the change of the stocks given changes in the relevant variables. Phase1 *history and physical examinations* is used as an example in this section to explain how one can interpret variables into the framework.

Figure 4. System dynamics modeling of “Phase1 history and physical examinations”.

According to the previous causal loop diagram [7], relevant factors with their interrelationships were identified. These are added into the framework using blue arrows that represent relationships with other variables. Figure 4 shows the system dynamics modeling of Phase1 after adding relevant variables into the framework.

Phase1 is the period of collecting patient history (symptoms) and physical examination (signs). Errors in this phase can arise by missed symptoms, missed signs or examination sensitivity. Three main factors leading to missed diagnostic clues on the next level are: clarity of disease symptoms, communication quality between doctors and patients, and patient medical history retrieval and review [7]. The diagnostic accuracy of the Phase1 is also measured by the sensitivity of results [11]. Presenting symptoms and signs sometimes does not account for the true positive or true negative for diseased or non-diseased subjects. False positives and false negatives arise in Phase1 as well. Thus, sensitivity is another key variable to represent the percentage of individuals with disease who have a positive symptom and sign.
3. Discussion

System dynamics modeling offers a systematic mechanism for the explanation of errors during diagnosis, even though diagnostic errors involve multiple causes with complex relationships. It provides an opportunity to trace the error routes and quantitatively analyze different errors affected by other variables. The model outputs can be tested and compared under “what if” scenarios. After Phase1 is simulated with the assumption of 100 index visits (first visits) per day, Figure 5 shows the number of diagnostic errors over 100 days under different sensitivity values of history and physical examination results. It is the output of a partial simulation of the entire system, which does not present strategy guidance, but explains how different scenarios are reflected into the variations of stocks. Currently, the framework is being extended to add the rest of the relevant variables incrementally which is expected to lead to a more complete view of system dynamics modeling. A full version of the model is expected to determine the dominant factors and suggest possible strategies of diagnostic error reduction by observing system response to the changes of variables, although it faces the challenge of a comprehensive input data to reflect system behaviors precisely.

Figure 5. Diagnostic errors of index visits under partial model simulation.

References

Valuing National Effects of Digital Health Investments: An Applied Method

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Canada Health Infoway

Abstract. This paper describes an approach which has been applied to value national outcomes of investments by federal, provincial and territorial governments, clinicians and healthcare organizations in digital health. Hypotheses are used to develop a model, which is revised and populated based upon the available evidence. Quantitative national estimates and qualitative findings are produced and validated through structured peer review processes. This methodology has applied in four studies since 2008.

Keywords. Digital Health, Evaluation, Modeling, Methodology, Economic Evaluation, Valuing Outcomes

1. Introduction

Quantification of the business case for digital health investments and comprehensive assessments of economic, clinical or patient value are increasingly in demand as healthcare budgets tighten and leadership strives to make evidence informed decisions. A scoping review by Bassi and Lau on economic evaluation of health information systems found a paucity of literature on the topic, and cites a number of additional papers noting this gap and the difficulty in conducting these analyses as a barrier [1]. In the interest of accountability for the public funds under its management, and optimizing the value accruing from investment of those funds, Canada Health Infoway (Infoway) has developed approaches to evaluate and systematically model the estimated value of outcomes related to select digital health solutions nationally.

Infoway, with the guidance of an expert panel, developed a Benefits Evaluation framework in 2006 [2]. An associated Benefits Evaluation Technical Report, first published in 2006 and later updated in 2012, provides tools and resources for digital health projects operationalizing this framework [3]. The framework and associated materials have since been applied in over fifty evaluations across Canada. Projects are encouraged to publish their findings, including indicators and approaches for measurement, as a knowledge base for digital health advancement in Canada as well as a foundation for estimates of national effects.

Infoway’s approach to evaluation takes a benefits realization perspective. Investments in digital health are driven by an explicit or implicit value proposition, which may range from qualitative descriptions of expected outcomes to specific
quantifiable benefits. The benefits realization approach uses evaluation to target and optimize benefits over time by measuring against the original value proposition, investigating unexpected benefits, and identifying how the overall value proposition can be enhanced or leveraged by applying critical success factors. Given this focus, the evaluations generally cover outcomes rather than capital or start-up costs, although relevant information on these subjects and unanticipated outcomes is documented where available.

The concept of pan-Canadian studies to estimate national value was developed in 2006 to summarize results across diverse data domains, settings, evaluation methods and time periods. A systematic approach was required to assess and synthesize evaluation data and communicate the findings to key stakeholders. The studies aim to generate estimates, which are as comprehensive as possible, validated by experts, and reflecting available evidence. They also provide an assessment of gaps and recommendations for increasing and optimizing the use and spread of technologies in order to increase value over time. Four such studies, available on the Infoway website, have been completed to date in the following areas of investment: diagnostic imaging systems [4], drug information systems [5], telehealth [6] and electronic medical records (EMRs) in community settings [7].

2. Methods

The pan-Canadian study methodology draws heavily upon a series of analyses conducted by the Centre for Information Technology Leadership to model future potential costs and benefits of digital health investments. Specifically Walker et al. (2005) [8] and Johnston et al. (2004) [9] were influential. The latter described the methodology as follows:

To study ACPOE’s (Ambulatory Computerized Provider Order Entry) value, we relied on published sources for data, and on expert panelists and market research to fill critical gaps. Using these data, we created an influence diagram to model ACPOE’s value both for the nation and for individual providers.

Building upon the approach taken in these studies, a peer-review model and systematic study process were designed. An independent Advisory Panel with eight to ten members, selected to provide a range of skills, experience and perspectives, is central to this model. Researchers support interpretation of the evidence and validation of the modelling. Clinicians validate the study based on their experiences with the technology, and the challenges and value encountered in their work. Healthcare leadership from delivery organizations and ministries contribute evidence and help ensure that the results are clearly framed to inform relevant policy and implementation discussions.

The study process is made up of six steps designed to build, populate and validate national estimates:
**Initiation:**

Pan-Canadian studies focus on areas of substantial progress across Canada in terms of deployment and adoption across a target setting, data domain and/or technology. The studies also require a sufficient evidence base to build a credible model. In the domains selected, all available evidence regardless of the nature of the results is considered in modelling. The Advisory Panel is formed at the time of study initiation.

**Benefits Hypotheses:**

A comprehensive list of potential outcomes of the defined use of a digital health solution and/or use in a specific clinical practice setting is compiled based upon available literature, evaluations conducted by projects, investment strategies and business cases prepared by Infoway and other healthcare organizations, as well as key informant interviews. The benefits hypotheses are developed with and validated by the Advisory Panel. One example hypothesis was: Community-based practices adopting EMRs experience efficiencies in workflow as staff time is redeployed.

**Target Model:**

Building on these potential benefits, a target benefits model is developed, identifying requirements for as comprehensive a quantitative estimate as possible. These include benefits magnitudes as well as contextual information such as deployment and adoption progress, healthcare costs, workforce data, etc. Simplicity is a core principle of the specification of the quantitative benefits model, with most discrete value estimates derived by multiplying the magnitude of outcome observed per unit x value of outcome x extent of adoption across Canada. Adoption maturity variation (e.g., functionalities used, frequency of use, etc.) is an important driver of value in digital health deployment, so the extent of the adoption used in the model must be matched to the maturity required to achieve the magnitude outcome applied.

**Evidence Search:**

A structured search is conducted for national and international evidence, including review of both peer-reviewed and grey literature, and key informant interviews. If required, additional primary data collection activities are initiated to fill critical gaps in the evidence base. The 2010 survey of community pharmacists as later described by Leung et al., is one such example [10].

**Modelling:**

Empirical analysis of the evidence against the target benefits model is used to assess feasibility of generating quantitative estimates in national currency (CAD) for each potential outcome domain, based upon quality of data. In many cases, multiple evidence sources are available for a given variable in the model, requiring triangulation of the evidence to establish a best estimate or range for each element. A conservative bias is explicitly applied in all cases, and sensitivity analysis is conducted. The Advisory Panel engagement intensifies during this phase, as subject matter expertise is
required to evaluate available evidence and establish consensus on ‘best estimate’ data points. Through this process, a subset of benefit domains that are robust and feasible to be included in the populated quantitative benefits model are isolated. An example of these, related to the hypothesis above would be estimates of net efficiencies gained through faster access to electronic laboratory test results and the value of associated practice efficiency. These final modelled outcomes are compiled into a draft report for advisory and extended stakeholder review.

**Peer Review:**

The review process is initiated with the Advisory Panel, but extends beyond the Panel to researchers whose work is central to the model, provincial/territorial health system leadership, clinician leaders and other stakeholders. The review is an iterative process which takes 1 to 3 months and engages as many as fifty experts, making evidence informed adjustments to the model as required. Comments are addressed systematically. If feedback from a reviewer cannot be integrated into the report, the discrepancy is recorded in the publication. The final document is reviewed by the Advisory Panel prior to publication.

**Final Report and Communication:**

The final report combines the outputs of the model with a description of adoption and maturity of the specific digital health solution and, if applicable, clinical practice setting. A review of available evidence for benefits which cannot be quantified, and an assessment of the critical success factors for optimizing outcomes and their associated value in the future are also included. Communication of the findings to funders, clinicians and implementers is central to these studies, as they are intended to inform policy, encourage effective adoption, and support clinical practice transformation.

### 3. Assumptions and Limitations

The threshold for inclusion of modeled benefits is a central challenge in the process, requiring significant input from reviewers. While this methodology builds in all available evidence to develop a robust understanding of the current state of realized benefits, there are limitations in the data that contribute to this model. In the published Infoway pan-Canadian studies to date, the quality of the evidence varied depending on the type and maturity of the technology in Canada. For instance, some benefit areas have been well documented in project evaluations and the literature, while others have relied on less robust or mixed evidence and are subsequently grounded by input and validation from key informants and peer-reviewers. While study teams generating the benefits model are asked to apply a conservative and defensible approach, the objective remains to generate as comprehensive an estimate of the quantifiable outcomes experienced in the healthcare system as possible.

The economic analysis generally takes a healthcare system perspective. Estimates are expressed in Canadian dollars realized on an annual basis and base assumptions to current contexts are applied and documented. Not all outcomes represent direct financial savings, but where possible a value is expressed financially to allow comparison of magnitudes. Where the literature does not provide sufficient evidence to
quantify the current dollar value of a specific outcome, their value is omitted from
quantitative modeling.

Finally, much of the Canadian evidence contributing to these studies is not yet in
peer-reviewed literature, or publicly available. This is a limitation which Infoway is
actively working to address, encouraging timely publication of results and posting
evaluation reports and other Canadian-based evidence on the Infoway website and
elsewhere. In these cases the rigorous peer-review process, which includes access to all
evidence, is relied upon.

4. Discussion and Conclusion

Pan-Canadian benefits studies have been an important tool for monitoring national
progress and maintaining focus on digital health solutions in which Infoway has
invested. They provide both funders and policy makers with evidence to inform future
decisions; they provide implementers and clinicians with the consolidated evidence to
seek out maximum value; and they stimulate discussion and debate about
transformation of the healthcare system.

These studies have also stimulated debate about the level of rigor and data
evidence required to generate estimates of value at the national level. As healthcare
systems across Canada strive to incorporate evidence into management decisions, the
study authors take the perspective that more evaluations such as these, using mixed
methods and validated by external experts, are essential for making the best available
evidence and thought leadership accessible to decision makers. By highlighting
identified gaps in current evidence, the studies also aim to inform future research.

References

information systems. Journal of the American Medical Informatics Association, amiajnl-2012 (2013)
realization
18(1), 5-8.
Using Business Intelligence for Efficient Inter-Facility Patient Transfer

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Abstract. In the context of inter-facility patient transfer, a transfer operator must be able to objectively identify a destination which meets the needs of a patient, while keeping in mind each facility's limitations. We propose a solution which uses Business Intelligence (BI) techniques to analyze data related to healthcare infrastructure and services, and provides a web based system to identify optimal destination(s). The proposed inter-facility transfer system uses a single data warehouse with an Online Analytical Processing (OLAP) cube built on top that supplies analytical data to multiple reports embedded in web pages. The data visualization tool includes map based navigation of the health authority as well as an interactive filtering mechanism which finds facilities meeting the selected criteria. The data visualization is backed by an intuitive data entry web form which safely constrains the data, ensuring consistency and a single version of truth. The overall time required to identify the destination for inter-facility transfers is reduced from hours to a few minutes with this interactive solution.

Keywords. Healthcare Information Systems, Inter-Facility Patient Transfer, Business Intelligence, Data Visualization

Introduction

In Canada, the adoption of health information technology has been significantly slower than other industrialized nations [1]. Further, when compared with Australia, England, Germany, Singapore, Spain and the United States, Canada has been found to have the lowest rate of health information exchange technologies used in practice [2]. Although health information technologies have been shown to improve the quality and efficiency of care [3], Canada progresses slowly towards optimally integrating them into its healthcare system.

One area of healthcare that has been identified as being suboptimal is the process of inter-facility patient transfer. This is generally due to communications delays and ineffective documentation [4] as well as the fact that transfer destinations are often chosen based on proximity and habit, rather than hospital performance and capability [5]. A service such as patient transfer involves large quantities of centralized data about facility services and specialists, as well as the various transportation options available to each community. Generally, this information is stored in multiple legacy formats making retrieval and upkeep of data not only slow, but dangerous as the quality of the data degrades over time. Patient Transfer can be divided into the following steps that a

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The sending facility must perform: “1) identifying transfer-eligible patients; 2) identifying a destination; 3) negotiating the transfer; and 4) accomplishing the transfer” [5]. The focus of our proposed solution is optimization of the second step: identifying a destination. Further, the system provides simple data entry and data viewing interfaces to be used for consistently maintaining and sharing information pertaining to the specific services available at participating healthcare facilities.

The proposed solution was built using data collected by British Columbia’s Northern Health (NH) Authority and includes a coverage area servicing a population of over 300,000 people and an area of 600,000 square kilometers. The geographic distances encompassed in NH and the extreme variation in capacity of services, in small isolated villages to a large regional center, impact the care of a patient needing transfers. This tool will enhance the decisions regarding the care of the patient with the correct facility and staff mix.

1. Related Work

Business Intelligence (BI) techniques have been successfully applied to healthcare in Canada [9], Poland [10], and the Netherlands [11]. Unfortunately, many difficulties present themselves when integrating BI into an existing healthcare system. One challenge is the non-standardized and often fragmented data which is generated in legacy IT systems with incompatible formats [12]. Further, as the amount of information grows, big data analytics in healthcare needs to be transparently presented in an interactive and user-friendly manner [12]. Once these challenges are overcome, BI offers a mechanism to improve the quality of Healthcare Information Technology, which in turn, leads to lower costs and a better level of care [3].

Finding the most suitable healthcare facility is often the most difficult part of inter-facility patient transfer, whereas the actual transportation of the patient is relatively simple [5]. Having explicable documentation that can be shared between hospitals is fundamental to an effective patient transfer [2]. The Australian government identified that lack of communication and documentation associated with inter-hospital patient transfer are significant areas of concern requiring attention [13]. A decision support tool which provides relevant time estimates for inter-facility transfers based on historical dispatch and call data was proposed in [15]. The tool provides the optimal transportation options taking into account factors such as weather and road conditions.

In British Columbia, the BC Bedline service was used as the primary method of patient transfer in British Columbia until it was replaced by the Patient Transfer Network in April 2013. The replacement works as a 24/7 call center staffed with patient transfer critical care nurse coordinators who act as a communication bridge between sending and receiving facilities [14].

2. Methodology

A highly interactive tool that delivers available services and infrastructure data to transfer operators via a web-based interface is provided. The reports offer a wide variety of instruments that aid users, specifically in the process of optimal facility identification. Accessing a detailed summary of a specific facility, or viewing a side-by-side comparison of multiple facilities can be accomplished through the web interface. A map
is the primary tool used to navigate between facilities. Often, a transfer operator must determine which facilities have a particular set of services or infrastructure, the proposed Facility Mapping tool accomplishes this by filtering facilities based on the selected service options. The user is presented with a list of ideal transfer destinations ordered by proximity from the sending facility; the relevant transportation options can then be explored via a drill-down report. The entire process is accomplished via a highly interactive user interface which makes it much more intuitive and efficient compared with the naive method of analyzing information sheets which often contained inconsistent data.

The proposed solution uses Microsoft’s SQL Server BI tool stack [6] to warehouse the underlying data, provide an ETL (extract-transform-load) process to collect and sanitize data, and to generate the reports which present the information [7]. Microsoft’s ASP.NET [8] is used to create multiple web interfaces, one for data entry with transparent consistency checks, and another for displaying the embedded reports with added web elements for easier navigation. The data integration is thus accomplished via web forms and bulk loading sheets both of which are standardized with metadata and enforce formatting rules. The information in the system is not real-time, but can be updated and processed remotely at any time. The front-end components of our system are designed to be user-friendly and visually appealing. The system can be used without an understanding of the underlying data structures and design. Since the data is transformed into meaningful reports, the complexity of the underlying data becomes transparent to the end-user. Figure 1 shows an overview and interaction of various components of the proposed system.

![Figure 1. Various components of the proposed system.](image)

### 3. Data Visualization

The inter-facility transfer dashboard allows the user to navigate using tabs for: Services by Facility, Facility Mapping, Facility Comparison, and Transportation Options. These pages contain embedded SSRS reports, as well as web elements such as tabs, checkboxes and interactive menus. These elements were added through the use of ASP.Net via HTML and further customized using Cascading Style Sheets (CSS). The underlying data in the reports can be changed through the dedicated data entry web form.
The OLAP cube can also be reprocessed through this web form so that any changes to the data can be seen on the reports in a matter of seconds.

3.1. Services by Facility

A facility can be selected via a map which was created using shape files embedded in the SSRS report, or via the list displayed alongside the map. Information about the selected facility includes general infrastructure and capacity information, patient care services, staff, equipment and rooms, lab and imaging access (Figure 2). The patient care services component contains information about various types of patient care that the specified facility may offer, including Mental Health and Addiction, Dialysis Unit, Social Worker and many more. When a selected facility does not have a service, the nearest facilities offering the desired service, along with the distance and travel time to that destination can be displayed. A breakdown of the available staff employed at a facility can also be seen on this page. Staff are listed by category such as Specialist or Surgeon and can be expanded to show a further level of granularity. The Equipment and Rooms table shows total capacity of services with Beds, such as Hospice Care or Residential Care. These categories can be expanded to show further details and selected to view other facilities ordered by proximity which have the selected services.
3.2. Facility Mapping

The Facility Mapping page (Figure 3) highlights the additional functionality offered by web-embedded reports. This page allows a user to specify multiple requirements for a patient, such as specific types of specialists and imaging needs. Multiple items can be selected from this page to generate a report which displays the facilities that meet the chosen criteria. The results are sorted by distance from the currently selected facility, making it easy to select from the nearest destinations. Interactive checkboxes and tab based displays are not available in SSRS report building but are necessary for easily organizing the data, hence the decision to use ASP.NET web pages and embedded reports. The check box table is also dynamically generated allowing for new specialists or services to be added into the data warehouse without having to rebuild the interface.

![Figure 3. Facility Mapping.](image)

3.3. Facility Comparison & Transportation Options

The Facility Comparison tab provides an interface for comparing up to three facilities selected via the map. With the ability to compare facilities side-by-side, users have a convenient tool for determining the facility which best suits the patient’s needs when multiple options are available. A comparison of the facilities resources, equipment, patient care services, staff, and lab-imaging access is shown on this page.

Transportation options available in a community where a specified facility is located can be viewed. Airport names and types, as well as information on their runways and the carriers that operate on those runways is displayed. Ambulance service information, including station name is shown with details such as crew count and crew description.
4. Conclusion

The importance of replacing legacy healthcare systems with modern BI technology has been demonstrated through improvements in existing patient transfer systems. By removing the need to analyze legacy data sources, the decision of identifying the most suitable facility for transferring a patient can be made with more accuracy and in less time. Web forms provide remote uploading of data to a centralized data warehouse that improves the integrity of the data. The reports generated provide an easy means for users to view the services a facility has, or proximity to services it does not. Specific services can also be set as criteria to determine the candidate destination facilities ordered by proximity to the sending facility. This allows for data driven decisions on where to transfer a patient to rather than decisions based solely on proximity or familiarity. Once a facility has been chosen, transportation options can be retrieved to help arrange the physical transfer of the patient. The developed system is being deployed for use in northern BC; expansion to cover all provincial health authorities is also being explored.

References


Cultural Issues in Adverse Event Reporting  
– An ethnographic study

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Abstract. Adverse event reporting is a frequently used mechanism to establish a learning cycle to avoid future errors. However a precondition is that the potential - as well as the occurred adverse events is reported. This study explores two comparable internal medicine departments to find possible explanations on a differing frequency of adverse event reporting. Ethnographic methods – observation and interviews - are applied to collect data. The analysis reveals specific, but common ways of doing task prioritization and rating of adverse event severity. The interpersonal relationships, however, show significant differences in the two departments and can be the most plausible explanation of the difference in adverse event reporting.

Keywords. Patient safety, medical error, adverse events, staff culture.

Introduction

Since 2004 Denmark has had a self-reporting system for adverse events. The Danish Act on Patient Safety in the Danish Health Care System passed by the Danish Parliament made it mandatory for all health care professionals to report adverse events, to improve patient safety. This lead to the establishment of the national database of adverse events – Danish Patient Safety Database (DPSD) [1] which is managed and maintained by The National Agency for Patient’s Rights and Complaints (NAPRC). All health care staffs at hospitals, nursing homes, GP’s offices, and clinics are obligated to report adverse events. Reported events are sent to and analyzed by the relevant region or hospital. The results of this analysis are returned to the local unit who made the initial report, as learning material in order to prevent future similar events. After the local analysis, events are anonymized and sent to the NAPRC who then analyzes and codes the information on an aggregate level and thereafter distributes knowledge gained on a national level [1].

Knowledge production is a central point to patient safety. Understanding how reported events are capable of producing knowledge is therefore key to maximize the benefits of adverse events reporting. This understanding holds value to all health care professionals involved in adverse events – from hospital management to frontline personnel. Information sharing is vital to facilitate a safety culture everyone adheres to. Any lack of understanding of why reporting and analysis of adverse events is crucial, only hinders the intended learning cycle. A precondition for a complete learning cycle is that all adverse events – near miss or occurred - are reported. However it is known

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that comparable hospital departments have differing reporting frequencies without any obvious explanation [2]. The aim of this study is to find plausible explanations to a different reporting pattern between two otherwise comparable internal medicine departments in two Danish hospitals.

1. Methods and material

The authors met with the management of health care planning and quality in the Region governing the two hospitals, to explain the purpose of the study. The managers pointed at two hospital departments, which were comparable in size, function and patient flow, but different in terms annual reported adverse events. The details of the two departments are shown in Figure 1.

![Figure 1. The two departments included in the study.](image)

<table>
<thead>
<tr>
<th>Department X</th>
<th>Department Y</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Specialty:</strong> Cardiology and internal medicine</td>
<td><strong>Specialty:</strong> Internal medicine</td>
</tr>
<tr>
<td><strong>Beds:</strong> 20 (+2)</td>
<td><strong>Beds:</strong> 26</td>
</tr>
<tr>
<td><strong>Organization of care:</strong> Two nursing groups</td>
<td><strong>Organization of care:</strong> Two nursing groups</td>
</tr>
<tr>
<td><strong>Staff:</strong> 25 nurses and 6 nursing assistants</td>
<td><strong>Staff:</strong> 18 nurses and 12 nursing assistants</td>
</tr>
<tr>
<td><strong>Patients:</strong> 1338</td>
<td><strong>Patients:</strong> 1007</td>
</tr>
<tr>
<td><strong>Patient age:</strong> 83% between ages 47 and 90</td>
<td><strong>Patient age:</strong> 83% between ages 47 and 90</td>
</tr>
<tr>
<td><strong>Average length of stay:</strong> 117 hours</td>
<td><strong>Average length of stay:</strong> 156 hours</td>
</tr>
<tr>
<td><strong>Annual reported adverse events:</strong> 15</td>
<td><strong>Annual reported adverse events:</strong> 35</td>
</tr>
</tbody>
</table>

A qualitative study design was chosen as the optimal method to explore a context rich environment. An ethnographic approach was selected as it aims to understand how individuals perceive their vision of their world. Instead of studying people from afar, ethnographers seek to learn from people through their own accounts of their perception of reality [3,4]. Data was collected over a period of four weeks (January and February 2014) – two weeks at each department. The time for the observations was distributed so that all three shifts were covered at both departments. During the period the observations fell into Spradley’s three forms of observation: descriptive observation, focused observation, and selective observation, where each consecutive observational form led to the next, based on previous identified areas of interest [4]. Accurate field notes were taken during the observation period and the following features were considered explicitly: space, actor, activity, object, act, event, time, goal, and feeling [3]. Both formal semi-structured and informal non-structured interviews were conducted when needed. Informal interviews were used to get an accurate account or detailed description of situations, observations, and thought processes etc. whereas formal interviews were held with key people from the hospital management: the local risk manager, the clinical director, and the chief nurse at each department.

The collected data was analyzed thematically based on a grounded theory approach to derive categories related to work processes and adverse event reporting. Results of the analysis were presented to representatives from the clinical staff for feedback and acknowledgement.
2. Results

The observations of everyday work routines revealed three significant characteristics in relation to adverse event reporting: task prioritization, evaluation of adverse events’ severity level, and interpersonal relationships.

2.1. Task prioritization

Prioritization between specific work tasks was found to be an integral part of how the staff conducts their work in both departments. Having a rigid work schedule, resulted in considerable time pressure when staff members were alternating between patient centered and non-patient centered tasks. Must-do tasks were part of the two work routines in Figure 2 and were not subject to prioritization as these were rigidly scheduled at each ward. Combined with having to balance must-do and should-do tasks simultaneously resulted in mentally demanding work routines, especially for group leaders, as staff were required to remember patient information as well as taking time to treat and care for patients. The use of team-based nursing meant that staff was able to divide certain tasks between group leaders and the remaining staff. Each team handled approximately 50% of the ward’s patients allowing them to focus on fewer patients, resulting in more time for patient care and should-do tasks. However, even though team-based nursing lowered the number of patients in each group, must-do tasks, took up most of staff’s time. Should-do tasks however, were done in conjunction with most of the patient centered must-do tasks like general patient care. Administrative tasks took up most of staff’s time and prioritization was directly observable as specific other tasks, like adverse event reporting, was prioritized much lower than tasks, directly related to the treatment of patients.

![Figure 2: Categories of Must-do tasks](image)

2.1.1. Evaluation of adverse event’s severity level.

Further analysis of the observational data and the interviews showed that another reason why adverse events were not being reported as is mandatory, could be that staff quickly evaluated the severity level of the occurring adverse event.

The resulting key points, in regards to how the severity level of adverse events are evaluated, were that due to large workloads and time pressure, the staff members were required to prioritize between meaningful tasks and pointless tasks. In the case of near misses, they often viewed these as trifles and as such did not report them. There were so many near misses (trifles) occurring that some of the staff members directly stated
that they did not have time to report them all and if they were to do so, they would have to sacrifice other more important tasks. Deciding which near miss adverse events should be reported they evaluated the severity level of each event implicitly, based on their expertise and professional knowledge. Subsequently, if a near miss was evaluated as a trifle the event would not be reported. However, if the event could have led to a potentially catastrophic outcome, these would be subject to a report.

![Severity scale as explained by the staff](image)

Two cases were analyzed more in depth to reveal a possible pattern in the severity level evaluation, see Figure 4.

<table>
<thead>
<tr>
<th>Event one:</th>
<th>Event two:</th>
</tr>
</thead>
<tbody>
<tr>
<td>According to the medication administration system Patient M. was to receive two types of medicine, Vepicombin and Cefuroxim, which is the same type of medication. This would have resulted in a double dosage. A nurse on the night shift noticed this error and proceeded not to administer both drugs. Nurses however, cannot discontinue medication in the system, which resulted in the misinformation was still present the day after.</td>
<td>Newly admitted patient (female) was allergic to penicillin. The admitting doctor was informed during admittance. Because of interruptions the doctor forgot to update this allergy in the patient’s record. After admittance the patient showed signs of infections and the doctor prescribed penicillin as was the standard procedure in such a case, forgetting patients allergy. The penicillin was never administered, but the potential outcome could have been lethal.</td>
</tr>
</tbody>
</table>

![Figure 4 Examples of two adverse events. Event one was not reported, event two was reported](image)

The potential outcome of Event one was evaluated as low on the above severity scale and was therefore not reported, whereas the potential outcome of Event two, was evaluated as potentially catastrophic, resulting in the event being reported. However, each individual staff member had different views upon the severity of potential adverse events. When asking the nursing students about the severity of Event one most of them acknowledge that it should have been reported, whereas most of the experienced nurses all regarded the event as a trifle.

The implicitness of this evaluation led to the belief that ward culture and collegiality could be affecting how prioritization and the evaluation of severity levels were done. Consequently the next stage of the observation focused on the interpersonal relationships at each ward and how these were affecting the research problem.

2.2. Interpersonal relationships

Throughout the observations it was found that the staff members were alternating between two different social spheres, the personal sphere and the professional sphere. Each sphere had two distinct social arenas, where the social sphere mainly took place in the coffee rooms, whereas the professional spheres consisted of all other work
related arenas. Both wards tried to confine all personal conversations and interactions within the coffee room. However, observations of each ward showed that staff, especially at ward Y, tended to be more permissive of personal conversations outside of the coffee room, whereas staff at ward X found it to be more natural to keep all personal matters confined to the coffee room.

The reason for ward Y being more permissive about personal matters outside of their coffee room, could be contributed to the fact that department Y shared its break room with many different departments and professions. Combined with the impending restructuring, department Y and the surrounding wards showed a large degree of solidarity and collegiality as well as seeming closer on a personal level. As such, personal matters were hard to separate from professional matters as staff members were continuously discussing their future, both in regards to their professional lives and their personal lives. The same level of solidarity was not apparent at ward X.

3. Discussion

The results presented, revealed three parameters possibly explaining why reporting frequencies at department X and Y differed. Task prioritization i.e. must-do versus should-do, evaluation of potential adverse events’ level of severity and differences in interpersonal relationships. The effect of each parameter can be expressed in sub-parameters either supporting or impeding the reporting of adverse events – Figure 5.

<table>
<thead>
<tr>
<th>Supporting sub-parameters</th>
<th>Impending sub-parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>- No apparent fear of blame - Understanding that the objective of AER is to learn from mistakes</td>
<td></td>
</tr>
<tr>
<td>- Clear understanding of the severity of adverse events</td>
<td></td>
</tr>
<tr>
<td>- Just culture - healthy interpersonal relationships, meaning high levels of trust</td>
<td></td>
</tr>
<tr>
<td>- Low priority - Less important than tasks, directly affecting patient care</td>
<td></td>
</tr>
<tr>
<td>- (Potential) adverse events often viewed as trifles - not necessary to report</td>
<td></td>
</tr>
<tr>
<td>- In-house control of adverse events - much faster and easier, than official channels</td>
<td></td>
</tr>
</tbody>
</table>

Figure 5 Sub-parameters supporting or impending reporting of adverse events.

Fear of blame was only slightly apparent at both wards, but was not seen as one of the primary reasons of HCPs not reporting adverse events. On the contrary, staff members seemed to have a clear understanding that adverse event reporting is used as a tool for learning. As fear of blame was never mentioned directly, the lack of mention could be contributed to the staff’s perceptions of having an outsider enter their territory. As such, fear of blame, might have been a major impeding sub-parameter, which simply was not made visible throughout the fieldwork. However, the same understanding was apparent when inquiring about the perceived importance of adverse event reporting, where most staff members had a clear understanding of how analyzed reports of adverse events could result in improved patient safety. Nevertheless, some of the more prevalent sub-parameters impeding staff from reporting adverse events, were their perception of
lacking time and how they were prioritizing adverse event reporting, much lower than more meaningful tasks i.e. tasks directly affecting patient treatment and care. This seemingly paradoxical result reveals a situation where; awareness of the importance of adverse event reporting, contradicts its placement within the task hierarchy, constructed by the staff themselves. When asked directly, staff would always answer, “yes, adverse event reporting is important”. However, when task prioritization was observed, adverse event reporting would always be the lowest priority, except under rare circumstances, as was seen with “Event two” (Figure 4). A possible explanation to why this paradoxical situation was occurring could be that the majority of all (near miss) adverse events were considered trifles. The evaluation of severity-level, which determined, if (near miss) adverse events were to be reported, was done in accordance with the severity-scale in Figure 3. The severity-scale has a clear parallel to the SAC scale defined by WHO [5] which is used for categorizing adverse events for further analysis.

In conclusion, the Danish adverse event report system is only one of many, in an international context. One of the shortcomings of the Danish system could be that responsibility is shifted to frontline personnel, not taking into consideration, among others, the parameters presented here. A supplementary initiative could be to introduce the concept of “trigger tools” as a method of measuring and standardizing adverse events [6].

Acknowledgements

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References

Framework For Effective Population Health Management Solutions

Cheryl HERTEL a1 and Kevin MCARDLE a
a Cerner Corporation

Abstract. As the cost of health care continues to rise, it has become imperative for care organizations to move from a volume-based system of care to one of value-based care. In order to make this shift, health care organizations must have the ability to manage entire populations as well as manage care at the individual level. To proactively manage populations and individuals within these populations, organizations must be able to know, identify and predict what will happen within a population, engage patients and providers to take action and manage outcomes to improve health and care. During this session, attendees will explore the technology needed to enable organizations to more easily facilitate consumer engagement, care management and coordination, provider network management and data acquisition.

Keywords. population health, population health management, care coordination, consumer engagement, health care, cross continuum, technology

Making the case

Health care systems are becoming unsustainable all around the world. They struggle to keep up with rising demand caused by chronic disease burden, patient expectations and the costs that come with the advancement of medical care. As a response to these market pressures, health care systems must do more for less [1].

The fundamental strategy to keep health care systems sustainable is to optimize care delivery around the patient [2]. Shifting care to the most appropriate and cost-effective venues keeps patients out of hospitals unless hospitalization is truly necessary. As this shift occurs and acute-based activity decreases, health care systems are using new models of care. These new models must support specialist services being delivered through their own vertically integrated care network – through newly formed partnerships or virtual provider networks.

To further adapt, organizations are moving away from activity-based payment models to health maintenance and wellbeing models based on outcomes [3]. This change is facilitated and made possible by underlying technology, as patient data is coded and digitized and the processes of care are automated across the health and care continuum.

1 Corresponding Author.
1. Managing a population’s health status and cost…one person at a time

There is no one definition of population health management. Successful attempts at creating new care models around the globe have determined that to manage the health and cost of care for a defined population, the process must begin and end with the individual person. Whether pricing a care services contract, determining a population’s health status and risks to target services, tracking utilization or delivering care management tools, population health management requires a focus on each individual person. If a member of the population is not managed effectively, the entire care and cost management system will be unsustainable.

“Population health management tightly integrates the best available diagnostic, clinical and IT tools with the available care delivery and reimbursement processes to deliver the best possible clinical result for individual patients with the most efficient economic outcome for a defined group of consumers.” [4]

The primary goal for population health management is to enable health and social care stakeholders to share data in order to coordinate patient care and support the health economy in achieving the collective population health goals. More specifically, this will enable providers and payers to focus on developing a systematic approach to identification, prediction and proactive management of an objective or medical condition at population, provider and patient levels. The approach enables effective care coordination models and chronic condition management.

To make this transformational shift toward proactively managing a population, health systems need solutions and services to allow providers to:

- **Know**, identify and predict what will happen with their population
- **Engage** patients and providers to take action
- **Manage** outcomes to improve health and care

2. Capabilities and requirements for population health management

2.1. Five key strategic objectives to fulfil

To impact the care of an individual, as well manage population cohorts, population health management requires solutions and services that can fulfil the following high level objectives:

- **Aggregate**, link and share clinical/administrative information at the patient level across the health economy to better understand the individual and how to care for them
- **Attribute** the responsibility of care for a patient to the correct care provider
- **Enable** the management of patients and cohorts to defined quality measures across the health economy
- **Predict** patients at risk and allow providers to take action in real time for individual patients, using the power of big data
Support performance management across provider networks to deliver integrated care provision while balancing supply and demand

2.2. Four major functionalities and workflows of an effective population health management solution

Consumer engagement, care management and coordination, provider network management and data acquisition are the major functionalities required to underpin population health management.

2.2.1. Consumer engagement

Consumer engagement solutions and services require the person to take an active role in managing his/her own health and wellbeing. These solutions and services include access to and the ability to contribute to health records, the ability to support health and wellbeing education programs, and active participation in care management and coordination programs.

To enable population health management, consumer engagement solutions and services must:

- Allow for the design and implementation of incentive programs to encourage service members and their families to take charge of their health
- Include health evaluations, preventive care, educational opportunities, and tools that are individualized to each recipient, and allow individuals to monitor and track progress from one period to the next.
- Provide a care record which spans the entire patient pathway, regardless of venue, enabling a complete longitudinal view with a clear indication of patient status.
- Provide interactive web portal functionality for patients and consumers of health and social care services.
- Provide the ability to interact with care providers from within a portal by providing secure messaging capability, the ability to support patient questionnaires and the ability to integrate with provider scheduling systems to book appointments.
- Be accessible on a variety of devices, e.g. tablet, smart phone, desktop computer.
- Support the download of summary information from the portal for use when an internet connection is unavailable.
- Provide the ability for a patient to request prescription refills electronically.
- Provide interactive capabilities within the portal, promoting self-management of care so that the patient can also enter their own clinical data which will be accessible by provider or care giver.
- Support the ability for devices which record health information (e.g. blue tooth or wireless scales, blood pressure cuffs, glucose monitors) to be directly integrated, minimizing the need for transcription of data.
2.2.2. Care management and coordination

Care management and coordination solutions and services enable the design and execution of coordinated care programs for cohorts of patients across a population. These solutions and services are required to enable delivery of care driven by, and measured against, best practice quality metrics, allowing prioritization and best use of provider resources to have the greatest impact on improving patients’ health outcomes. The ability to coordinate and manage care across the continuum for a population with certain risks, diseases, complications and high utilization is the key to improving health outcomes and reducing cost. Care managers, a new workforce across health systems, are being deployed to better manage care as health systems are taking on additional risk contracts. To enable this new workforce, health care organizations need comprehensive knowledge-driven workflow solutions that support care management across all roles and venues. The aim is to enable the integrated delivery of coordinated, evidence and plan based care.

To enable population health management, care management and coordination solutions and services must:

- Provide a web-based desktop view for care management and coordination services for wellness and disease management.
- Provide tools to build and display specific disease registries as well as locally defined registries by patient cohort.
- Provide registry content including, but not limited to, chronic conditions (e.g. asthma, COPD, diabetes, heart failure, hypertension, cardiovascular disease, mental health) reporting, prevention and wellness.
- Support the ability for care professionals to view and access relevant stratified population information.
- Allow customization for nationally agreed best practice as well as locally defined quality improvements (such as PQRS measures) to be tracked and monitored.
- Integrate with the acute care electronic patient record as well as with primary, community and other care settings and act as a two-way data exchange.
- Integrate with the patient portal, allowing patient-entered information to be accessible to the care professional and vice versa.
- Provide reporting services which allow the ability to report on multiple locations, businesses, and/or service providers at one time.
- Provide the ability to export reports for appropriate national returns.

“Exploratory analysis estimated that by better management of post-acute episodes and sending more beneficiaries to home health, Medicare could save $34 billion to $100 billion over 10 years” [5]

2.2.3. Provider network management

Provider network management enables the design of provider incentive programs and management of their contribution to patient outcomes across a network of providers. These solutions and services enable the ability to monitor and act on provider performance across a population against clinical and financial outcomes, to analyze and
predict population-wide issues requiring attention, and to guide the continual development of how services are delivered. To enable population health management, provider network management solutions and services must:

- Deliver business intelligence based on current and historical data, including utilization, quality and financial metrics across the network and facilitate the identification and exploration of deviant trends that require the attention of a population health coordinator.
- Provide detailed dashboards and risk reports based on locations, regions, counties, etc.
- Identify abnormalities that may constitute fraud, waste or abuse.
- Provide yearly executive reports to measure programs or provider performance.
- Support the management and analysis of data from a large variety of sources, across the health and social care economy.
- Provide a comprehensive and integrated system with one common database to support quality improvement, clinical integration and all needed reporting.
- Enable predictive modelling across the population, supporting early intervention, promoting wellness, preventing illness and keeping patients out of hospitals.
- Provide a systematic way to identify, predict and manage patient conditions.
- Support performance management across the population against nationally and locally agreed criteria.
- Support benchmarking of provider services as well as incentive programs designed to improve outcomes by individual and by groups of providers.
- Provide the ability to edit and build customized measures or programs including provider incentive programs.
- Provide user or role-based level information providing visibility to the individual user’s experience or aggregated information by role or physician/non-physician groupings to enable continuous improvement of the user’s experience with the system.

2.2.4. Data acquisition

Data acquisition is the underlying capability to deliver a real-time, standards-based architecture to share and aggregate clinical and administrative data conformant to patient information governance controls. This aggregated data will allow real-time population health management programs tailored to patient cohorts and orchestrated across health and social care providers. To manage the health of a population, a large amount of data is needed. Currently, health data exist in various venues, from primary care and hospital EHRs, laboratories, pharmacies, home health, mental health, consumer devices and financial claims. To only look at part of the data creates a risk of not reaching the optimal conclusion and generating large inefficiencies. To enable population health management, data acquisition solutions and services must:

- Support multiple data feeds from a variety of sources in different file formats.
- Support multiple (external and internal) data interfaces in different standards based formats: txt, xml, HL7, ABSIx12, XLS & flat file.
- Normalize data feeds to create a system standard format, using natural language processing or other techniques.
- Provide tools to allow manual mapping of local codes by associating them to an appropriate code recognized nationally.

3. A Multi-Purpose Population Health Management platform

Successful Population Health Management requires a solution architecture that operates to standards and provides the following capabilities:

- **Near real-time solutions**: Provides actionable and meaningful data to organizations and the populations they serve, as quickly as data is received
- **Actionable information in the workflow**: Delivers actionable information to patients, caregivers and administrators in the context of what they do every day, whether that is to a person on their smartphone or to a clinician working within their EHR
- **Longitudinal record**: Empowers organizations to make informed care decisions with complete information
- **Programmable**: Allows organizations to customize the platform and the solutions to accommodate their unique circumstances in their community, delivery network and the populations they serve
- **Scalable**: Allows for adaptability to market changes, evolving regulations and continuous solution and algorithm refinement

The solution needs to incorporate a multi-purpose, programmable platform designed to scale at a population level while facilitating health and care at a person and provider level.

The solution should enable health care systems to aggregate, transform and reconcile data across the continuum of care. Through that process, a longitudinal record should be established for individual members of the population that the organization is held accountable for – helping to improve outcomes and lower costs for health and care.

The solution should be scalable, secure and be able to be accessed anywhere, anytime. The solution should combine multiple reference records together by leveraging a complex probabilistic patient matching algorithm that uses demographic and clinical data to create a single source of truth for each patient of the population. This living personal health record should become the foundation for all Population Health Management solutions. The solution should enable organizations to identify, score and predict the risks of individual patients in order to match the right care programs to the right individuals.

In the future, as technology advances, the solution should become a learning system. Where evidence doesn’t exist it should look for patterns of care and prompt the clinician with information on how they usually practice or their colleagues usually practice. This will be used to identify positive or negative trends, which can then be incorporated or eliminated from the workflows.
The solution should also enable the coordination of care across the continuum by the digitization of care pathways and the use of predictive analytics and real-time decision support. It should support surveillance, insightful analytics, new discoveries and research. It should empower proactive member and health care provider engagement.

References

Using the NASA Task Load Index to Assess Workload in Electronic Medical Records

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Abstract. Electronic medical records (EMRs) has been expected to decrease health professional workload. The NASA Task Load Index has become an important tool for assessing workload in many domains. However, its application in assessing the impact of an EMR on nurse’s workload has remained to be explored. In this paper we report the results of a study of workload and we explore the utility of applying the NASA Task Load Index to assess impact of an EMR at the end of its lifecycle on nurses’ workload. It was found that mental and temporal demands were the most responsible for the workload. Further work along these lines is recommended.

Keywords. electronic medical records, task load, workload, nursing

Introduction

Electronic medical records (EMRs) were expected to reduce documentation workload. However, there is a dearth of literature that has evaluated the effects of EMRs on workload. Workload is defined as the relationship between the challenge of a task and a worker’s response to it. In the ergonomics and human factors field there are many instruments that have been designed to measure workload including: Cooper-Harper method [1], Bedford Scale [2], Subjective Workload Assessment Technique (SWAT) [3], Workload Profile [4] and the NASA Task Load Index [3]. Researchers in the human factors literature have compared some of these instruments. Rubio et al. [5] compared the SWAT, Workload Profile and NASA Task Load Index and found all three to be valid and useful but found the NASA Task Load Index easiest to administer. The purpose of this study is to evaluate a critical care information system at the end of life cycle with a focus on workload issues by applying the NASA Task Load index. This represents a novel application of the NASA Task Load index towards understanding the impact of an EMR on nurses’ workload.

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1. Review of the Literature

The original description of the NASA Task Load Index was given by Hart and Staveland [3]. The researchers surveyed a diverse number of occupations and identified 19 factors that were subjectively related to workload (according to the subjects). Using an iterative process, six components of task load were identified: mental demand, temporal demand, physical demand, frustration, performance and effort. The test is straightforward. The subject completes the evaluated task and then is asked to rate each of the components on a 20 point Likert scale from 0-100. A weighting is assigned based on a series of component pairs presented to the subject. The subject is asked to select the one component of the pair that is most responsible for the workload. The rating and the weighting for all six component pairs are then combined to give the overall score.

The NASA Task Load Index has found applications across a variety of occupations such as combat aviation [6], commercial aviation [7], marine workers [8], office workers [9], and electrical power grids [10]. Workload measures have also been used across a wide variety of medical specialties such as critical care [11], surgery [12], anesthesia [13], emergency medicine [14], pharmacy [15], nursing [16] and personal health records [17]. It has been used as part of a pre/post-test evaluation of a new technology [17] and compare the different levels of stress in surgeons between day and night duties [12]. However this tool has rarely been used to evaluate electronic medical records. The NASA Task Load Index was used in evaluating a critical care information system by Ahmed et al. [11]. Ahmed and colleagues asked users to complete standard tasks on either the usual critical care information system interface or their own novel design. In addition to measuring the NASA Task Load Index, they compared the time to complete the task and error rate. They found that their novel design significantly reduced both the time to completion and the workload. From this they concluded that their design resulted in improved data processing and information extraction but drew no conclusions on the validity of using the NASA Task Load Index as a tool.

2. Method

2.1 Subjects

After obtaining institutional ethical approval, twelve critical care nurses were recruited to participate in this study. Workload studies do not usually require minimum and maximum numbers of participants. The subjects should be representative of the working population in terms of knowledge and experience to permit generalization.

2.2 Procedure

Each subject was given a script of a simulated patient that mimicked a typical critically ill patient. Subjects were then asked to use the script to complete a routine daily assessment and to enter it into a critical care information system. At the end of the test, each subject was asked to complete the NASA Task Load Index using an on-line tool available at http://www.keithv.com/software/nasatlx/nasatlx.html.
3. Results

3.1 Demographic Data

A total of twelve subjects were recruited for the study. However, the data for one of the subjects was lost leaving eleven subjects who had their NASA Task Load Index data available for analysis. The mean age for the subjects was 40.5 years. 75% of the subjects were female with an average of 16 years nursing experience and 18 years of computer experience. 16.7% of the subjects had used a critical care information system in the past. 75% of the subjects described having some computer experience, 16.7% had moderate computer experience and 8.3% had a high level of experience.

3.2 NASA Task Load Index Data

The total average overall workload was 51.6. There was a wide variation in the perception of the workload among participants with a range of 25.7 to 85.3. Figure 1 outlines the average weighted score for each component. The mental and temporal demands are most responsible for the overall workload while the physical demand of the system was not an important factor. Frustration was expected to be significant but surprisingly was not rated highly.

![Figure 1: Average Score for Each Workload Component](image)

Each subject’s total weighted score total is 1.00. Breaking this score into the individual workload factors for each subject reveals the relative contribution of each factor to the overall workload score as demonstrated in Figure 2. Mental demand was the consistent factor, contributing 20 – 33.3% to the overall workload. Temporal demand was perceived more variably and accounted for 6 – 33.3% of the workload. Performance was also more variable; from 0 – 33.3%. Overall, no one single factor dominated and accounted for more than one third of the overall workload for any subject.
4. Discussion

This study demonstrates the utility of the NASA task workload index in evaluating EMRs. It is easy to administer and produces consistent results. There was a wider than expected range of scores due to a specific subject group. The first four subjects had a consistently higher overall score because they were nurse educators in the ICU. These subjects did not use the system on a daily basis as bedside nurses and therefore were far less familiar with the nuances of the system. As well, they felt a particular stress when using the system as they are regarded as the experts for all aspects of the ICU. The overall workload for the other subjects was not as high (i.e. average of 37 and ranging from 25.7 to 50). The mental demand for each subject varied much less (from 20 to 33% of the total individual workload score) and represented a larger component of each individual’s workload score. This tighter range suggests a consistent signal for a subset of the NASA Task Load Index.

The results of the overall workload score are comparable to the work of Ahmed et al. [12]. They found the baseline score was 58 and the test system was 38.8. This study found a total workload score of 51.6; comparable to Ahmed’s baseline. Since our system was unmodified, the similar score suggests reproducibility. Excluding the nurse educators, the score falls to a level similar to the test system. The system used in this study had been customized by a team of clinicians prior to implementation. This customization may have contributed to a similar workload experienced in Ahmed’s test system. The only limitation of Ahmed’s study is that he did not break down the workload index into the components so further comparison was impossible.

This study demonstrates the content validity of the NASA task load index in evaluating critical care information systems. Informal conversations support the results of increased workload due to time and mental factors. Staff frequently complained that the system was difficult to use and time consuming. The low physical demand score validates our expectations. All the staff used the system in a simulated environment (i.e. the clinical simulation matched the clinical bedside and the system used in the ICU). As staff sit when they use the system, the physical demand of the technology would be expected to be minimal (as we found).

There are several limitations associated with this study. First, the subjects were limited to only one specialty which may have influenced the generalizability of the results. However, this specific group of users (i.e. ICU nurses) use the EMR the most.
often. Other specialties may have their own specific workload issues. Therefore, further research is needed with other health professionals. The study is also has a small sample size. A final limitation is the fact that this is the first time the full NASA task load index has been used exclusively as a measure of workload. Other studies have included only a portion of the NASA task workload index as part of a larger evaluation of a system and these researchers did not analyze the individual components of the instrument. This study is the first to do so. Therefore, further studies are warranted.

References


In Case of Emergency – Are ICD-10 Codes Enough?

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Abstract. In an acute emergency, the knowledge of the patient’s medical history, allergies, implants, and medication can be crucial. ICD-10 code to document medical diagnoses alone often does not contain enough information. Our comparison of 388 documented diagnoses (ICD-10 codes as well as free text) showed that almost 20% of all coded ICD-10 codes contained less information than the documented free text. Thus, if using ICD-10 codes, free text diagnoses must be a necessary item in the upcoming German Medical Emergency Dataset.

Keywords. Health Card, Emergency Data Set, Electronic Health Record, ICD-10

Introduction

In 2011, Germany introduced the electronic health card (“elektronische Gesundheitskarte – eGK”) (Fig. 1). In 2013, the eGK was handed out to 95% of all mandatory insured patients – around 70 million people. As a smart card, the eGK contains a chip, which can store up to 96 Kbyte of data, so storage space is limited.

Besides storing patient’s address and other demographic information, the eGK is intended to enable several other functions such as e-prescription and support of a yet to be developed German electronic health record (EHR). One such functionality is especially important among those: The Medical Emergency Data Set (MED). [1,2,3]
Using the MED, physicians will be able to store data relevant for medical emergencies on the eGK, such as important diagnoses, allergies, medications, etc. The treating emergency physician or paramedic can access this information (using special identity cards for health professionals - HPCs), so that this vital information can be made available to the treating personnel even if the patient is unable to provide it at the time of need (e.g., unconscious patients). It is important to notice that the MED was not intended to be an EHR, but it should contain all and only the information that the emergency physicians need to know in an acute emergency when time can be crucial.

In case of emergency, information is needed fast and this information must be understandable and easily accessible. On the other hand, the workload of the family physicians entering the MED in the eGK must be minimized. Since diagnosis is mostly stored as ICD-10 code in the family physician IT-system, diagnosis could be stored as ICD-10 codes with official text on the eGK.

The medical emergency dataset is created by the treating physician of the patient, which, most of the time, will be the family physician. Most family physicians use software to document their patients’ histories. Diagnoses, also needed for reimbursement, are coded using ICD-10 GM Version 2014 in the physician offices. Should one of these diagnoses by relevant in case of emergency (e.g., Chronic pulmonary disease or diabetes), it can be stored on the eGK.

ICD-10, however, is a coding system that was originally created for reimbursement and statistical purposes, not for clinical documentation, which means that not all diagnoses can be coded as an ICD-10 code without loss of information. Stages of diseases, especially, cannot always be coded with ICD-10. Thus, ICD-10 code may lack crucial information needed in case of emergency. In order to assess whether ICD-10 codes and the official text are enough or if free text (in addition to ICD-10 codes) may be needed, we looked at the documented diagnoses of the MED created during an evaluation study.

Currently, the technical infrastructure needed to enter and access data on the eGK is being implemented in Germany. The goal is to use the MED in the eGK starting in 2016.

The MED was designed by the German Medical Association based on expert opinions. Beside the MED, several other emergency datasets exist worldwide [4], however, none of these datasets has been evaluated for sensitivity (does it contain all relevant data), selectivity (does it contain only relevant data), and usefulness [5]. The MED in its current state contains the following items:

- Contact details of patient (due to anonymization not used in this study)
- Diagnoses (ICD-10 code, free text, status of diagnosis (approved, suspected, excluded), side (left / right), date of diagnosis, information if the diagnosis was made by the family physician or by a specialist)
- Medication (Name, active pharmaceutical ingredient, dose, type of delivery, information if the medication was prescribed by the family physician or by a specialist)
- Allergies (Name of allergen, type of reaction, information if the allergy was diagnosed by the family physician or by a specialist)
- Implants (Name and type of implant, date of implantation, information if the implant was inserted by the family physician or by a specialist)
- Special needs / additional information (pregnancy, difficulties with communication, danger of running away etc.)
1. Method

The Department of Telemedicine at the University Hospital Münster, Germany, and the German Medical Association started the first worldwide evaluation of a medical emergency dataset in 2013. Family physicians were asked to create MED for selected patients based on their existing health records and provide the patient health records. After anonymization, these MEDs were given to emergency physicians and paramedics, who had to assess their usefulness using virtual emergency scenarios. After that, the medical records were handed to the emergency physicians, who then assessed if the MED contained all relevant data from the health record. The results of this study were presented in Germany to the Ministry of Health in the fall of 2014.

Patients gave their informed consent and were included on the basis of pre-existing conditions with a high likelihood of emergency situations. GPs (FDs) were requested to select patients with the following diagnoses:

- 1 patient with Chronic heart failure
- 1 patient with Chronic airway disease (e.g. COPD, Asthma)
- 1 patient with special medication (e.g. anti-coagulant or immunosuppressive drugs)
- 1 patient with medical implant (e.g. Pacemaker)
- 1 patient with freely selected by the GP

Thirteen family physicians delivered MED and patient health records of 64 patients (12 of which delivered records of five patients and one delivered records of four patients)

The MED was documented using a structured paper form, which was then entered into an MS-Access® database. Family physicians were asked to document relevant diagnoses. Physicians could enter ICD-10 codes, but had to provide free text. Each documented ICD-10 code was supplemented with official text based on the ICD-10 GM code version 2014. Official text and free text entered by family physicians were compared by an emergency physician and the compatibility of both information sets was assessed.

2. Results

A total of 476 diagnoses were recorded for 64 patients, with an average number of 7 diagnoses per patient, ranging from 1 to 15. In one family physicians office, an assistant created the MED (which was then finalized by the family physician). In all other offices, MED were created by family physicians. Most physicians used software for documentation (8 out of 13), while the remaining physicians used electronic as well as paper-based documentation.

88 of the documented diagnoses did not contain an ICD-10 code; 388 diagnoses contained ICD-10 code as well as free text. Out of these 388 diagnoses:

- 311 (80.2%) ICD-10 codes official text matched the free text.
- 62 (15.9%) free texts did contain more information than the ICD-10 code official text. These contained:
  - Localization (e.g., ICD-10 code: Fracture of lumbar vertebrae / Text: Fracture of first lumbar vertebrae)
Stage of disease (e.g., ICD-10: Stenosis of aortic valve / Text: Stenosis of aortic valve, Grade II)
- ICD-10 code: Allergy, NOS / Text: Allergic for theophylline / contrast
- 12 (3.1%) free texts did contain different information compared to the ICD-10 code – the text sometimes described different diagnosis than that of the ICD-10 code. These contained, for example:
  - Different stages of disease (e.g., ICD-10 code AV-Block Grade 2 / Text: AV-Block Grade 3)
  - Acute disease vs. old disease (e.g., Acute myocardial infarction vs. myocardial infarction 10 years ago)
  - Different diagnosis:
    - ICD-10 code: Migraine / Text: Sleep Apnea Syndrome
    - ICD-10 code: Coronary Heart Disease / Text: No coronary heart disease
    - ICD-10 code: Non compliance / Text: Phenprocoumon Medication
    - ICD-10 code: Neurologic disease / Text: Cancer of the kidney
- 3 (0.8%) of all ICD-10 codes were invalid codes.

Thus, the ICD-10 code did contain less or different information compared to the free text in 19.8% of all documented diagnoses.

3. Discussion

The German electronic Health Card (eGK) will give medical emergency personnel – emergency physicians as well as paramedics – the opportunity to quickly access vital information of the patient. Besides information on medication, allergies, and special needs, the medical history (diagnoses) is especially important in acute emergencies.

Our comparison has shown that in one out of five diagnoses, ICD-10 code did not carry all the information the family physician documented in free text. In addition, miscoding is possible (in one case, kidney cancer was coded as a neurological disease). Thus, free text is essential in addition to the official ICD-10 code text.

Currently, the infrastructure for the electronic health card and the medical emergency dataset is set up in Germany. Software support for the family physician to create the medical dataset is crucial in order to save valuable time for the physicians. ICD-10 codes, however, are not enough for the MED. The physician’s software must enable the physician to enter additional text to the ICD-10 code to provide the exact diagnoses to the emergency physician and paramedics.

The challenge will be to find a compromise between providing an easy way of entering the data (or retrieving it from already existing data) relevant for the MED and avoiding the loss of information by using coded information.

Alternative coding systems, such as SNOWMED CT (Systematized Nomenclature of Medicine – Clinical Terms) could be helpful since they provide a comprehensive nomenclature of clinical medicine. However, SNOWMED CT is currently not part of the daily routine documentation of family (and clinical) physicians in Germany. Further research could be helpful to identify possible solutions to integrate a
comprehensive nomenclature system into the daily documentation routine, so that information can be exchanged more easily between different health care sectors, especially in the case of an emergency.

References

Reducing Nosocomial Infections: A User-centered Approach to Developing an eHealth system for Sri Lankan ICUs

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Abstract. Nosocomial infections are a health concern in hospitals both in developed and developing countries. Immuno-compromised patients in intensive care units (ICU) have been identified as being particularly vulnerable. However, despite numerous interventions, infection rates remain high and antibiotic resistance is now of global concern. In Sri Lanka, higher than anticipated infection rates appear linked to a range of factors including hierarchical work flow, poor surveillance feedback and health staff attitudes and awareness. By deploying a user-centered approach to understanding these factors this research-in-progress will develop and evaluate the capacity of an eHealth system to contribute to reduction of nosocomial infections in Sri Lankan ICUs.

Keywords. Nosocomial infections, attitudes, eHealth, User-centered approach

Introduction

Nosocomial (hospital acquired) infections are a major public health concern throughout the world that contribute to increased patient mortality, permanent disability and/or increased length of hospital stay. Rates of infections range from one in twenty admissions in developed countries to one in five admissions in some developing countries [1]. Patients in intensive care units (ICUs) have been identified as particularly vulnerable due to the acuity of their conditions, the range of invasive procedures they undergo and that generally they are more immunocompromised than other patients in the hospital.

Hand hygiene and antibiotic use have long been identified as the primary methods for reducing and/or treating nosocomial infections [2]. However, the widespread use of antibiotics for infection treatment has contributed to less emphasis being placed on prevention of infections per se. This has gradually contributed to a rise of infection rates and the global concern about the growth of antibiotic resistant bacteria [3].

More recently efforts have re-focused on prevention of nosocomial infections and this has led to an expansion of research into measures to prevent/reduce infection rates. These measures include the creation of infection control teams, education programs, replacement of infusion pumps at regular intervals, care in catheterization and urinary

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bag maintenance, universal decolonization, appropriate and targeted use of antibiotics and change in design of ICUs to create single patient rooms [4-8]. However, despite awareness of these measures nosocomial infection rates continue to remain high [1]. This is particularly the case in developing countries, although as Sri Lanka indicates, the association between infection rates and socio-economic status is not simple. Indeed, some of the highest infection rates are not found in the lowest income countries [9-11]. This research-in-progress deploys a user-centered approach to understand the factors impacting on the incidence of nosocomial infections and to develop and evaluate the capacity of an eHealth system to contribute to their reduction in Sri Lankan ICUs

1. Deploying a User-centered approach in Sri Lankan ICUs

Research in Sri Lanka on reducing/preventing nosocomial infections has highlighted improper hand hygiene, inadequate surveillance and antibiotic misuse as significant problems [12]. Interestingly, research done outside Sri Lanka has noted that hand hygiene compliance among “more educated” physicians is significantly lower than nurses[13]. Alongside these human factors, it appears probable that organizational and environmental factors also contribute to persistent high nosocomial infection rates despite clear policy initiatives and guidelines on measures to reduce/prevent infection being in place[14]. In this context, engaging ICU health professionals at all levels through a user-centered approach will allow the development of understanding into the factors that contribute to high nosocomial infections rates and support the development and evaluation of an eHealth system to contribute to their reduction and prevention. User-centered approaches have previously been used to successfully change behaviors and to sustain those behaviors by ensuring a sense of ownership of the new system amongst end-users [15]. User-centered approaches have also been used to support the development of health improvement tools including eHealth systems that are practical and implementable [15] and also improve safety culture and implant positive attitudes towards health care quality [16].

2. Methodological Approach

This research-in-progress will rely on a detailed understanding of end-user attitudes, perspectives and priorities in relation to nosocomial infections. Given the range of ICU stakeholders, the approach adopted has been to involve all stakeholders through use of a participatory design model complemented by agile software development and rapid proto-typing of the evolving eHealth system [17]. Importantly, simple pre- and post-implementation evaluation of the system through quantitative methods is not considered sufficient to capture the potential sustainability of the system. While this quantitative evaluation will be conducted, the research is also engaging in qualitative evaluation with the end-users. The four-phases of the methodology being used in conducting this research adopt a pre- and post- interventional assessment. It should also be noted that although research data collection, analysis, interpretation and system development are discussed as discrete steps, they are iterative processes with the data collection of each phase dependent on outcome of the proceeding phase.

The study sample for this research will include nine tertiary care public hospitals in Sri Lanka. Surgical ICUs have been identified as the primary sites for investigation at
each of the hospitals. Phase one of the project consists of retrospective analysis of nosocomial infection rates data for preceding three years in each of the nine selected ICUs. Based on this data, the ICUs will be categorized into one of three bands – low, medium or high infection rates. Subsequently, one ICU from each of these bands will participate in phase two, where behavioral observations, semi structured interviews and focus group discussions will be carried out to determine the perceptions, attitudes and work practices of hospital staff towards infection reduction. Further, system development will be conducted during this phase utilizing a user-centered approach based on the principles of agile software development methods.

In phase three the developed system will be implemented in three ICUs directly involved in its development and three other ICUs, one from each identified band (to provide comparison and contingency as discussed below). Post interventional qualitative data will be collected in these ICUs during the first, fourth and seventh month of the implementation. Phase four will occur at the end of the seventh month, when retrospective collection of nosocomial infection data will be completed for all nine ICUs.

Analysis of the first and fourth phases will include infection rates in each ICU, rates of infections according to sites, causative organisms, antibiotic usage and relationship between invasive procedures and infection rates. Data from the second and third phases will be coded and analyzed to identify key ideas and behaviors affecting nosocomial infection rates and actions to reduce/prevent their occurrence.

As mentioned above the development of the eHealth system will be based on participatory design combined with agile software development methodology. Requirements gathering for the system will be done in parallel to the phase two data collection with focus groups convened representing all staff and service categories. Rapid prototyping and usability testing will support the evolving system and support awareness, education and training amongst stakeholders.

It is anticipated that data interpretation will explore several dimensions of the research. Pre-intervention data interpretation will include nosocomial infection status, attitudes, perceptions and behaviors of health staff towards reduction of nosocomial infections and requirements of health staff of an eHealth system. Post interventional interpretation will consist of description of the post intervention nosocomial infection status and comparison of post intervention data with pre intervention data. This comparison will include the effects of the eHealth system on nosocomial infection rates in high, medium and low nosocomial infection environments, hawthorn effect on infection rates, effect of invasive procedures on infection rates and the antibiotic usage patterns. These interpretations will facilitate identifying the impact of the eHealth system in contributing to nosocomial infection reduction.

Preliminary work to date in the early scoping phase involved site visits to three hospitals. Observations of work flow in the ICUs and other organizational and environmental elements were carried out. Preliminary insights have highlighted and confirmed the importance of human factors, including awareness, attitudes and perceptions as well as the key relationship between existing workflows and contemporary nosocomial infection rates.

One challenge that has already been identified is differentiating nosocomial infections from other infections. This challenge will be addressed by using strict nosocomial infection guidelines embedded into a computer algorithm to differentiate nosocomial infections from other infections. It is important to address this challenge as it will have a large impact on the final evaluation of the system to be developed.
3. Discussion

Nosocomial infections can be transmitted in several ways. These include: patient to patient, family member/caregiver to patient, staff to patient, equipment to patient, environment to patient and opportunistic parasites on patient’s body acting during reduced immunity. The possibility of acquiring an infection depends on severity of the disease being treated, health status prior to illness, invasive procedures and virulence of organisms in the environment.

In this context, the development of an eHealth system to contribute to reducing nosocomial infections is a complex task. However, existence of nosocomial infections despite all recent advancements in reduction measures requires a novel approach in dealing with these infections, especially in developing countries. Previous reported success in combining user-centered approaches and eHealth to directly address improvement of workflows, work practices and safety culture strongly supports the aims of this research to test a similar approach to contribute to reducing nosocomial infections. Advantages of computer technology in health data collection and dissemination augment the requirement of using an electronic system in addressing this task [18]. Based on experience of successful similar systems, it is anticipated that this system will help the staff to acknowledge the presence of the problem and contribute to development of “their own” system for confronting and controlling the problem. Further, this approach will contribute to reduce the negative attitudes towards computer systems by developing a sense of ownership to the ‘newly’ developed socio-technical system.

The methodological approach described above aims to support validation of the system in several ways. Placing of ICUs in to three bands according to nosocomial infection rates; high, medium and low and selecting one ICU from each band for two test groups and the control group will allow for assessment of the effectiveness of planned interventions according to differences in infection prevalence. Involving one group directly in the development process of the system and an additional test group from that band only in system implementation will help to assess the influence of user involvement in commitment to reducing nosocomial infection status.

User-centered design will have a pivotal role in system development. It will not only identify the user requirements accurately, but also facilitate development of a system which will integrate seamlessly to current workflows and work practices. Though the final design of the system depends of the users’ requirements, it is anticipated that this system will have a suite of solutions including a health education module, a monitoring module, a surveillance module and a decision support module.

Despite this paper providing a logical argument of the way to develop and implement an eHealth system to contribute to reducing nosocomial infections, the ultimate success depends on how this system can be integrated meaningfully into the social setting and work-flow of Sri Lankan ICUs. It is anticipated that this research will directly contribute to improving awareness of and mechanisms for reducing nosocomial infections.

4. Conclusions

This research-in-progress paper has discussed the global challenge of nosocomial infections and the actions currently being taken to reduce these infections. The paper
also discussed why many of these measures have proved ineffective in developing countries like Sri Lanka and proposed an eHealth approach developed using a user-centered approach as a way forward. It is anticipated that this approach will lead to better awareness among all health workers with regard to the threat of nosocomial infections, and their improved awareness of both the threat and preventative measures that can contribute to a reduction of nosocomial infections in Sri Lankan ICUs.

References

Abstract. Telehealth technologies show tremendous promise in helping reduce health care costs by bridging distance and time. However, neither of the two competing visions for how telehealth should be used is scalable. On the one hand, remote telehealth care providers who triage or monitor patients, are not integrated into the health care system. They are outsiders, lacking access to the records of patients. On the other hand, face-to-face providers who provide the bulk of care in the health care system, are increasingly being asked to keep track of remote monitoring data and to manage patients remotely. They are insiders, but lack the time or training to manage patients remotely. In this paper, we propose a third way: integrate telehealth care providers into the primary care team as a virtual team. Being virtual, they can provide complementary services that patients need, but are not getting, such as peak and off hours care, off hours disease management advice, between-visit support and follow-up and remote device monitoring. We also describe the design requirements, issues and solutions for integrating telehealth technology into electronic medical record systems.

Keywords. Telehealth, telemedicine, teleprovider, virtualization, remote monitoring, integration, EMR, EHR,

Introduction

The vision for telehealth and telemedicine is very ambitious: provide care in remote and rural areas [1], improve access to care, provide remote monitoring, reduce costs, improve quality and convenience of health care services, provide medical education and even enable provider-to-provider communications. There are at least two competing models of how telehealth technologies can achieve their goals.

The dedicated telehealth provider model (i.e., nurse or other provider provides remote care exclusively) assumes that the best way to provide remote care is to have dedicated health care providers who can triage patients to the right health care setting, thereby shortening queues and saving costs. These tele-providers may make a few outgoing calls, but for the most part, they are outsiders whose role it is to make the bricks and mortar system more efficient or provide care that the bricks and mortar system is not getting around to doing [2].

The health care provider as part-time telehealth provider is another model. This model assumes that the health care providers who work in the bricks-and-mortar world will also provide virtual care. Several technology firms have bet on this approach [3]. The strength of this approach is that bricks-and-mortar health care providers are
‘insiders’ and therefore have access to the bulk of the patients being seen on a day to day basis in the health care system. However, this approach ignores the fact that a health care provider shortage exists and that clinicians are too busy to care for their existing face-to-face patients, let alone an additional load of virtual patients [4].

We propose a third, hybrid model that overcomes most of the limitations of the two existing models, which constrain their scalability, while retaining much that is good about each of the models.

1. Methods

Semi-structured key informant interviews with 20 stakeholders from the primary care sector, including physicians, nurses, pharmacists, dieticians, quality improvement managers, executive directors of team-based clinics and association leaders. The study perspective was of an organization that provides remote telehealth services. Literature search in Medline on integration of telehealth into electronic medical records yielded few articles [4-6]. The concept of integrating remote telehealth providers into a primary care EMR was not mentioned in any of the articles identified.

We focused our questions on the acceptability of having telehealth providers integrated into primary care, the acceptability of integrating providers into the electronic medical record (EMR) infrastructure in the clinic and the design requirements for integration into the EMR [4]. The study design included an iterative component which took problems identified in earlier interviews, designed acceptable solutions with later interviewees and validated the solutions with the last interviewees.

2. Results

2.1. Areas of opportunity for telehealth providers to integrate into primary care

There was strong support for telehealth providers working with the bricks-and-mortar clinical and non-clinical staff in primary care. The key drivers of interest included: 1) provide administrative support (appointment booking, patient recalls, manage referrals) especially during peak and off hours (24 hours per day/7 days per week), 2) provide clinical triage during off hours, 3) return patient calls for lab results and referral status, and 4) provide clinical support between visits to help patients implement physician guidance and treatment recommendations (Patient Coaching services by a variety of health professionals, including pharmacists, dieticians, diabetes educators, social workers, etc).

Interviewees acknowledged that current approaches to providing high quality, patient-responsive care (i.e.; answering patient questions at the patient’s convenience and pace, providing support in implementing treatments between visits, following-up on goals, etc.) are limited and that bricks-and-mortar approaches are limited in scalability. Some interviewees did believe that team-based care approaches such as the Family Health Team (FHT) in Ontario could provide all the care that patients need and that the care providers in the FHT would be the ones to provide the virtual care that patients need.

However, even the most ardent supporters of team-based care acknowledged that only a few FHTs were close to providing the quality care expected from primary care
for a variety of reasons (e.g., scheduling issues, transportation, over taxed reception, patient follow up, unpredictable patterns of demand) and that many would not be able to ever reach that level. Given that only 25% of patients in Ontario are seen in the FHT model, the dream of high quality, patient-centred care is a distant one. All interviewees agreed that patients need more between-visit support and that telehealth providers were an ideal supplier of that need.

When ardent supporters of team-based care were asked about use of predictive algorithms to start identifying patients at high risk who were not currently being seen, they admitted that team-based care as currently constituted while adept at supporting patients when seen or managed in the clinic setting, was challenged in the implementation of programs designed to identify high risk patients, and to then provide care to them when and where they need support most (i.e. during the 99.9% of the time they spend dealing with their issues outside of the clinic setting). This was another area of potential value to primary care as several respondents mentioned the low effectiveness of the existing telehealth service in Ontario that could potentially be enhanced by greater integration into primary care.

2.2. Issues that arise in integrating telehealth providers with primary care EMRs

Interviewees identified the following issues that need to be considered when integrating telehealth providers into primary care.

- To facilitate peak and off hours appointment booking –the telehealth provider needs full integration with the practice scheduler with strict rules of engagement to ensure control by on-site staff and clinicians
- For maximum productivity and patient safety –full integration of telehealth providers into the practice EMR for documentation of care
- How will privacy, security and confidentiality be maintained? Concerns centered mainly on unauthorized chart access by remote providers.
- How will continuity of care be maintained? Interviewees were concerned that remote teleproviders would be anonymous voices who did not get to know their patients and patients would not get to know and trust them.
- Referring patients to telehealth providers should be seamless for on-site providers
- Patient case-finding and risk stratification. Pro-active identification of high risk patients and ensuring that they are provided good care was seen as a value add that would make the telehealth provider service much easier to accept and adopt in primary care and much easier to justify from a budget perspective.
- Services provided need to be evidence-based and effective
- How will I know what is happening to my patients?
- The system needs to be a turn-key operation –with minimal to no implementation issues

2.3. Design solutions for integrating telehealth providers into primary care EMRs

Privacy and confidentiality concerns were addressed by making the teleprovider part of the ‘Circle of Care’ through appropriate contractual agreements and management of patient consent. Ensuring that an audit log was maintained and reviewed periodically was seen as necessary to identify unauthorized access to patient records. Having the
telehealth provider organization maintain the audit log and provide quarterly reports was considered ideal, since primary care providers do not have the resources to maintain or police such a log. Adding a feature where the patient’s chart was automatically pulled up when the patient called (by the patient entering their health identifier number before speaking to the teleprovider) was seen as a positive step in protecting patient confidentiality.

Integration into the scheduler and EMR was not considered problematic, once privacy and security barriers were addressed. A key decision is where login credentials should be managed –by primary care or by the telehealth provider organization? Since primary care does not have the capability of managing login credentials for remote teleproviders, the best solution is to have a single sign-on from the telehealth provider organization system (telehealth system) and have the organization manage the audit logs of who signed on to the primary care EMR and when.

Managing continuity of care was seen as balancing the trade-off between having a single virtual and shared work queue for remote providers (most efficient arrangement) and having staff dedicated to a very small number of patients (least efficient). The best solution is to assign staff to a few clinics so that continuity is maximized, but have a shared queue for emergency calls that can be handled by the first available resource, deferring non-urgent cases to the appropriate staff members, if circumstances permit.

Streamlining referrals to teleproviders was identified as an issue. If it takes too much time or effort to refer, it would be under-utilized. The solution most acceptable to all stakeholders was to develop specific, standardized, evidence-based referral ‘packages’; e.g., referral for smoking cessation counseling, new medication start, nurse weight loss support, etc. These packages would make it easy for providers to know what they were sending the patient for, allowing faster explanations and quicker referrals. Having a referral button within an encounter template would enable quick and easy referral to these intervention packages. For example, a referral button for smoking cessation counseling would be incorporated into the smoking history template, allowing a 1-click referral to the standardized teleprovider service. A description of how to place a referral button in multiple EMRs and in the right place is beyond the scope of this paper, but is described in a companion paper.

Patient case-finding and risk stratification can be layered on as part of the system. This would require using advanced data extraction and cleaning tools that can provide EMR data for analytic uses. A data extraction, cleaning, case-identification and risk stratification service will be essential to the success of any remote provider project that integrates with primary care. The Canadian Primary Care Sentinel Surveillance Network (CPCSSN) is capable of providing this type of service in Canada and is developing new technologies to become more scalable [7].

Providing progress information on referrals was seen to be essential for full acceptance of the concept. Admittedly, in current practice, physicians are expected to read the notes of their team members to get up to speed on what happened with a patient. But this was not seen to be acceptable for a teleprovider system where the providers were remote and saw patients outside of office hours. A dashboard that gave providers information about who had been referred, who had been seen and what their current status was seemed to satisfy the need to know what was going on with their patient. Providers wanted to be informed more urgently if any important patient health issues arose, but were satisfied with a dashboard for more routine patients.
3. Discussion and conclusion

Current approaches to using telehealth are not scalable. They either use ‘outsiders’ who do not have access to the bulk of patients and their medical records or they use ‘insiders’ who are already over worked. The approach proposed in this paper makes outsiders into insiders by integrating them into the primary care team as a virtual workforce, picking up the slack and providing services that cannot realistically be provided in a bricks-and-mortar facility, such as between visit support. The approach also adds two innovative technologies to enable proactive care—a case-finding and risk stratification system, based on existing technologies and a patient care dashboard for reporting on progress. Most of the barriers identified by key informants were able to be resolved through policy, process or technological design fixes.

Although there are likely to be limitations of this approach, many of them can be accommodated in the design. The key finding is that primary care stakeholders found the integration of remote providers acceptable and would be interested in piloting such a system if it were made available.

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References

The Next Generation EMR

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Abstract. Electronic medical/health record (EMR) usage in North America has increased significantly in the last half decade. But there is widespread dissatisfaction with the technologies that are currently available in the market place. Our hypothesis is that EMR vendors and the market place alone cannot solve the issue of poor technology. We propose an architecture for the next generation of electronic records that solves current concerns of end users and addresses the needs of additional stakeholders, including health system funders, patients, researchers and guideline implementers. By including additional stakeholders, we believe that additional resources, competencies and functionality can be unleashed to solve the larger problems of the current generation of EMRs. The architecture also addresses future requirements that are likely to arise from technological developments such as mobile apps and PHRs and from innovations in medicine, including genomics, artificial intelligence and personalized medicine. The paper makes a call to action for informatics researchers to play a greater role in R&D on EMRs.

Keywords. EMR, EHR, integration, architecture, usability, user interface, CDSS, requirements, business analysis, interoperability,

Introduction

Although electronic medical/health record (EMR) uptake in recent years has been rapid and widespread, it has not been driven by exceptional value for end users or their patients [1]. There is widespread dissatisfaction with and switching of EMR [2].

In spite of the current poor design and function, expectations of EMR continue to grow [1]. A large number of health care stakeholders are interested in EMR functionality. Health system managers need data to forecast and manage costs, allocate resources and evaluate the effectiveness of their investments. Researchers need structured data for research and surveillance. Guideline implementers need to deliver clinical decision support to point of care and app developers want to integrate with them to access data for use by patients. Although HL7 has approved functional standards for EMRs [3], implementation has fallen far short of what users consider easy to use and productivity enhancing. Leading advocates of EMR change continue to focus narrowly on functionality for physicians and patients, ignoring the needs of other stakeholders [4]. This approach has largely failed. This paper takes a broader approach and proposes functionality that will bring in additional stakeholders to help lower risk and increase the likelihood of success of EMRs for the health care system.

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1. Methods

Interviews with over 90 stakeholders in the health care system in Ontario (from 8 different stakeholder segments) who articulated their needs for the next generation EMR and insights drawn from analysis of primary care data from the Canadian Primary Care Sentinel Surveillance Network (CPCSSN) extracted from 12 different EMRs from the practices of over 500 physicians across Canada on 600,000 patients [5]. We identified key stakeholders through a brainstorming approach. Stakeholders represented 9 key categories, including: Healthcare Providers, Patients, Researchers and Academics, the Ontario Ministry of Health, eHealth Ontario, OntarioMD, EMR Vendors, the Privacy Commissioner’s Office, Guideline Implementers, and Non-Governmental Organizations and Associations. We used purposive and snowball sampling.

We used a Collaborative Interviewing approach to design the system. Each stakeholder was asked to validate findings identified by previous stakeholders and told about what other stakeholders desired. The system design was iteratively modified to take into consideration each stakeholders’ concerns and suggestions. There were no mutually exclusive needs identified. The following section describes the final system design based on interviews with all stakeholders.

2. Design requirements for the next generation EMR

Design of the next generation EMR (EMR-NG) is driven by 3 major ‘strategic’ goals described by stakeholders: 1) Meet the needs of a greater range of stakeholders to create a learning health system [6, 7]; 2) Manage individual and population health risk proactively, rather than document care only for medico-legal and memory aid purposes [8, 9]; and 3) Assist health care providers to improve their clinical productivity (increase quality/quantity of care and decrease or maintain costs) by continuously adopting and iterating advances in technology and ensuring that work is done by the appropriate team member, including the patient or care giver.

2.1. The needs of multiple stakeholders and creating a learning health system

Healthcare stakeholders provide oversight, guidance, funding and direction to health care practitioners who provide frontline care. Funders invested hundreds of millions of dollars in EMR over the last decade, expecting a return on information.

Stakeholders clearly articulate their role and how it fits into a continuum of setting policy, design, information capture, processing and analysis, knowledge production, knowledge dissemination and evaluation. Novel governance structures to integrate more stakeholders are needed to enable technology integration and interoperability. Design considerations for a learning health system are described in a companion paper.

2.2. The needs of personalized medicine and population health management

Advancing knowledge in medicine now allows us to predict rather than react to disease and disease outcomes [8, 9]. This new knowledge is creating opportunities to manage patient populations in addition to individual patients [10]. Data required to manage populations is well known, yet poorly captured in most EMRs [11]. EMR-NG needs to
not only capture past medical history and history of present illness, it also needs to capture the future medical history (predictive analytics and genomics) and provide options for managing the future history (prescriptive analytics).

Data on diet, exercise and risk factors, all of which are extremely important for health, are poorly captured in most EMRs [11]. Socio-economic status, a large contributor to poor health, is barely acknowledged in most EMRs. Current EMRs are too poorly designed to capture information needed for addressing health system needs.

2.3. Advancing health care provider productivity

The architecture of EMR-NG needs to provide more functionality to support virtual health. Advanced patient segmentation and predictive analytics capabilities need to be added. EMR-NG needs to support two-way communication with patients; forcing patients to engage face-to-face creates incredible inefficiencies. EMR-NG needs to support team-based care – both virtual and bricks and mortar.

Healthcare is one of the last industries to virtualize its practice: face-to-face and bricks-and-mortar dominate patient-provider interactions. Yet, models that work elsewhere are unlikely to work here; medicine is high touch and will need novel approaches to achieve virtualization. To achieve these goals, EMR-NG needs to modernize at every level of the software architecture [12].

3. Software Architecture Design Recommendations

3.1. The user interface

The user interface of most current EMRs is premised on an outmoded paradigm of documentation (i.e., paper) and on an old-fashioned graphics user interface. The tabbed metaphor that separates various parts of many EMRs serves to fragment information across screens and leads to errors [13], some that could cause patient harm. The user interface needs to be modernized to allow for better visualization of patient health – without switching screens or asking for a report [14, 15]. It also needs to support better visualization of health risks and how those risks are monitored or mitigated. Use of ‘archetypes’, such as OpenEHR, is gaining maturity and may be appropriate for data collection for research and for quality improvement [16].

3.2. The business rules (clinical decision support)

Business rules within current EMRs are woefully inadequate for the many functions EMRs need to serve. Drug utilization review systems are unpopular and alerts frequently ‘overridden’ [17] or shut off. In the US, billing decision support has caused controversy because it can potentially lead to over-billing [18]. EMRs typically do not have good clinical decision support, other than what physicians can program themselves. Business rules to ensure good data practices don’t exist. For example, it is easy to prescribe insulin to a patient without a diagnosis of diabetes in the problem list.
3.3. The database

Many EMR databases are poorly designed and can’t support advanced use, such as real-time data analytics and clinical decision support. There is rampant use of multiple tables that hold similar information, poor normalization and inadequate indexing of data. As a result, current EMRs can’t support real-time queries without impairing performance for other logged-in users.

EMR-NG requires innovation in database technologies to allow for transformation of data for 1) disease registries for population management [19], 2) data warehousing for research and surveillance [20], 3) clinical decision support and 4) for integration with ehealth and mhealth applications [21]. Many new database technologies exist to support these functions [22].

3.4. Interfaces with other systems

Current EMRs are stand-alone systems with few interfaces to other systems. In most cases, the EMR is integrated only with laboratories. HMOs and integrated delivery systems in the US have had interfaces with hospitals and specialists for over two decades, but the vast majority of physicians outside these organizations can’t access them. Health information exchanges are promising but hampered by poor economics.

A good part of the problem is the attempt by standards developers to drive ‘semantic’ interoperability, a notion that has not yielded much benefit in over a decade. The standard for interoperability should be lowered to ‘eyeball-to-eyeball’ semantics; i.e., transmit the documents clinicians already transmit to each other and let them read the documents and act on the contents. Once documents are interoperable, the focus needs to be placed on ‘high value’ interoperability; i.e., that which is required to solve important clinical problems, such as diseases which cause high morbidity and mortality.

Another important interface is to telehealth providers who can provide coverage outside office hours and who can be part of the health care team, virtually.

4. Business rules for the next generation EMR

EMR-NG needs to be the air traffic control system for physicians who are responsible for the health of hundreds of patients from birth to death. Without good business rules, physicians will not be able to manage the health of their patients safely.

Recent advancements in predictive analytics, prescriptive analytics and population health optimization algorithms can predict patient risk of various disease outcomes, including genetic diseases, and need to be incorporated into EMR-NG. Clinical guidelines are also increasingly available for incorporation into the EMR from open source and commercial sources [21, 22]. These guidelines could make it easier for physicians to keep up with rapid innovations in medicine and apply them to their eligible patients faster, speeding up the transfer of new research to the bedside.

But guidelines and clinical decision support are not linear systems and they don’t work seamlessly. They will require partnership with academics and researchers who can monitor the effectiveness of the decision support and iterate the recommendations toward greater effectiveness. These systems will also require extensive research to prove that they work, requiring long-term involvement of researchers and evaluators.
5. Conclusion

EMRs have achieved significant penetration throughout North America. With rapid advances in medicine, physicians need more advanced technology to successfully take on the new tasks that are increasingly being asked of them. The EMR industry is unable to conduct the research and development (R&D) necessary to innovate and transform the EMR. Governments, EMR vendors and researchers and academics need to consider new models of partnership that can accelerate R&D in the EMR space.

References

Workarounds to Computer Access in Healthcare Organizations: You Want My Password or a Dead Patient?

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Abstract. Workarounds to computer access in healthcare are sufficiently common that they often go unnoticed. Clinicians focus on patient care, not cybersecurity. We argue and demonstrate that understanding workarounds to healthcare workers’ computer access requires not only analyses of computer rules, but also interviews and observations with clinicians. In addition, we illustrate the value of shadowing clinicians and conducting focus groups to understand their motivations and tradeoffs for circumvention. Ethnographic investigation of the medical workplace emerges as a critical method of research because in the inevitable conflict between even well-intended people versus the machines, it’s the people who are the more creative, flexible, and motivated. We conducted interviews and observations with hundreds of medical workers and with 19 cybersecurity experts, CIOs, CMIOs, CTO, and IT workers to obtain their perceptions of computer security. We also shadowed clinicians as they worked. We present dozens of ways workers ingeniously circumvent security rules. The clinicians we studied were not “black hat” hackers, but just professionals seeking to accomplish their work despite the security technologies and regulations.

Keywords. Workarounds, cyber security, computer access, workflow

Introduction

A significant gap exists between cybersecurity as taught by textbooks and experts, and cybersecurity as practiced by actual end users [1-9]. In previous work, we looked at the general problem of how users work around security controls in general [10] and in healthcare [11]. Here, we focus on cyber security evasions healthcare and how ethnographic methods help reveal them.

Cyber security efforts in healthcare settings increasingly confront workarounds and evasions by clinicians and employees who are just trying to do their work in the face of often onerous and irrational computer security rules. These are not terrorists or black hat hackers, but rather clinicians trying to use the computer system for conventional healthcare activities. These “evaders” acknowledge that effective security controls are, at some level, important—especially the case of an essential service, such as healthcare. As we observed, earlier, without such tools, the enterprise cannot protect

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against adversarial cyber action. Unfortunately, all too often, with these tools, clinicians cannot do their job—and the medical mission trumps the security mission.

The problem is the workers humans who build, use, and maintain the systems—often Chief Information or Technology Officers (CIOs/CTOs), Chief Medical Informatics Officers (CMIOs), sometimes cybersecurity experts, and often just IT personnel—did not sufficiently consider the actual clinical workflow. For example, the bolus of passwords, each with specific requirements and time limits, are seen as an annoyance, not as a patient safety effort. Equally important, circumvention of cybersecurity is seldom examined by those concerned with workflow, HIT usability, barriers to teamwork, thought-flow, or user frustration. Cybersecurity and permission management problems are hidden from management, and fall in the purview of computer scientists, engineers, and IT personnel.

We find, in fact, that workarounds to cyber security are the norm, rather than the exception. They not only go unpunished, they go unnoticed in most settings—and often are taught as correct practice. In rare exceptions, when the workarounds become obvious to leaders—such as a security breach involving a patient’s record—there may be repercussions. These common forms of ignorance, or willful blindness, or incomprehension allow organizations to continue to deploy security that doesn’t work.

1. Methodology

We interviewed medical personnel in their workplace settings—nurses, doctors, chief medical officers, chief medical information officers, cybersecurity experts, CIOs, IT workers, everyday users, and managers—to obtain their perceptions of computer security rules. We collected reports from medical discussion lists and other literature. In addition, we shadowed many clinicians as they conducted their work.

As with our prior research, the interviews were usually face-to-face, but a few were via the phone. Several involved follow-up calls and emails. A semi-structured interview schedule is available from the authors. (We are currently engaged in deeper analysis and experimental work based on our findings.)

Security controls must obviously be addressed in concert with sociological and workflow issues. Tensions will remain among IT’s security needs, IT’s security policies (reasonable or otherwise), circumvention “justified” by perceived clinical necessities and actual clinical necessities. In addition, there is a continual dance between cyber security engineers and the clinicians who seek to treat patients; where clinicians view cyber security as an annoyance rather than as an essential part of patient safety and organizational mission. As two of us observed in a recent analysis, workarounds are often the only way essential tasks can be accomplished, the organization’s mission can be served, and the conflicting perspectives of the players accommodated [12].

2. Authentication

The standard way to ensure that only the right users access the appropriate files in the hospital, clinic or practice is to have the system authenticate the user. In healthcare (as in most other domains), this is typically done with a username and password.
However, in healthcare, we see endemic circumvention of password-based authentication. In hospital after hospital and clinic after clinic, we find users write down passwords everywhere. Sticky notes form sticky stalagmites on medical devices and in medication preparation rooms. We’ve observed entire hospital units share a password to a medical device, where the password is taped onto the device. We found emergency room supply rooms with locked doors where the lock code was written on the door—no one wanted to prevent a clinician from obtaining emergency supplies because they didn’t remember the code. One vendor even distributed stickers touting “to write your username and password and post on your computer monitor”. A newspaper found a discarded computer from a practice contained a Word document of the employees’ passwords—conveniently linked from a desktop icon.

Clinicians share passwords with others so that they can read the same patients’ charts even though they might have access in common. A misbehaving hospital technician used a physician’s PIN code to create fake reports for patients.

Standard accepted practices for strong password hygiene can be non-existent in healthcare—the US Inspection General notes that NIST will certify EHR systems as secure even if passwords are only one-character long [13]. However, it’s not clear that stronger password requirements yield better security. A medical informatics officer lamented that “routine password expiry…forces everyone to write down their password.” Dhamija and Perrig [14] observed that users forced to change one password may change all their other ones to match. Observing authentication in medical IT, Heckle [15] noted that clinicians tried to do that but were annoyed when passwords expired at different times.

Expiry can also directly impact patient care: one physician colleague lamented that a practice may require a physician to do rounds at a hospital monthly—but that unfortunate expiration intervals can force the physician to spend as long at the help desk resetting an expired password as he or she then spends treating patients.

3. De-Authentication

After authentication comes what some medical security officers call the de-authentication problem. How do we ensure a user’s computer session ends when the user leaves? If a user’s computer session extends beyond the active need of the user, it leaves the computer vulnerable to misuse by an unauthorized person (say, a passing visitor) or to an authorized user who assumes he or she is entering information for a patient different that the one still logged in on the screen. Koppel et al [16] document physicians ordering medications for the wrong patient because a computer was left on and the doctors didn’t realize it was open for a different patient.

Previously, we reported how clever clinicians at one hospital defeated proximity-sensor-based timeouts by putting Styrofoam cups over the detectors, and how (at another hospital) the most junior person on a medical team is expected to keep pressing the space bar on everyone’s keyboard to prevent timeouts.

Since then, we’ve heard a physician complain that a clinic’s dictation system had a five-minute timeout, requiring the physician re-authenticate with a password (which takes one minute). During a 14-hour day, the clinician estimated he spent almost 1.5 hours merely logging in.

Heckle offered several relevant observations here [15]. She saw clinicians offering their logged-in session to the next clinician as a “professional courtesy,” even during
security training sessions. IT personnel added an easy key-sequence to force easy logout—but failed to do this on all machines, so that clinicians attempting to do the right thing would still leave themselves logged in. Nurses would circumvent the need to log out of COWs by placing “sweaters or large signs with their names on them” or hiding them or simply lowering laptop screens.

Failure to have automatic de-authentication is also a usability problem. A nurse reports that one hospital’s EMR prevented users from logging in if they were already logged in somewhere else, although it would not meaningfully identify where the offending session was. Unfortunately, the nursing workflow included frequent interruptions—unexpectedly calling a nurse away from her COW. The workflow also included burdensome transitions, such as cleaning and suiting up for surgery. These security design decisions and workflow issues interacted badly: when a nurse going into surgery discovered she was still logged-in, she’d either have to un-gown—or yell for a colleague in the non-sterile area to interrupt her work and go log her out.

4. Breaking the Representation

In our earlier analysis [12], we looked at a set of health IT usability problems as mismatches between the medical reality and its representation in the electronic system. A large number of medical workarounds involved creative clinicians introducing distortions into what should be a direct correspondence. For example: a) In one EHR, patients meeting protocols for blood thinners prophylaxis force clinicians to order blood thinners before they can end their computer session—even if the patient is already on blood thinners. Clinicians must carry out a dangerous workaround of ordering a second dose (lethal if the patient actually receives it), quit the system, then re-log-in to cancel the second dose; b) At a large city hospital, death certificates require the doctor’s digital thumbprint. However, only one of the doctors has thumbs that can be read by the digital reader. Consequently, only that one doctor signs all of the death certificates, no matter whose patient the deceased was.

As in other domains, clinicians would also create shadow systems operating in parallel to the health IT. Doctors have “shadow notes.” Nurses have the “nurse’s brain:” a single page with all one’s tasks for all of one’s patients. “You’d be lost without it, e.g., “at 2:00 I need to do this, later I need to do this, mother is nasty so don’t answer phones from her, etc.” “Occasionally, information in the brain is not information you want in the formal record.” Nurses are told to discard paper notes not in the electronic system. A dental hygienist enthusiastically reported keeping a shadow dental record when computer systems did not allow for the desired level of precision.

At one hospital, nurses in pre-op need to physically move patients to the OR, which is 2 minutes away. It's important to the OR people that the time of the transfer into the OR is accurately recorded (to the minute). But the patient record (and the EMR portal) is at pre-op, not in the doorway to the OR. When the hospital had a paper-based EMR, the nurses would enter “current time + 2 min” into the paper record before rolling the patient down the hall. However, the new EMR does not allow future times; consequently, the nurses leave themselves logged in but turn the monitor off--and then come back to the pre-op afterward and record the OR transfer time.
5. Permission Management

We also see many workaround scenarios stemming from the difficulty of permission management in healthcare. Permission management, or provisioning, refers to the business process of specifying which individuals or groups are allowed access to which files and data. On paper, it’s easy; in reality, it’s not [17]. Clinicians often have multiple responsibilities—sometimes moving between hospitals with multiple roles at each one, but accessing the same back-end EHR. Residents change services every 30 days during their training. If access is limited to one service, it needs to be reconfigured that often. However, a resident may be consulted about a former patient, to which he/she no longer has access. More frequent are clinicians who serve in multiple roles: the CMIO may need access to every patient record, not only those in her/his specific medical sub-discipline. A physician who focuses on infectious disease may also be on the committee that oversees medication errors, and thus requires access to the pharmacy IT system and the nurses medication administration system. In some hospitals, nurses sometimes authenticate as nurses and sometimes as doctors.

6. Undermining the Medical Mission

Many workarounds occur because the health IT itself can undermine the central mission of the clinician: serving patients. At a hospital with a “tele-ICU,” patients must be monitored from a distant nurse’s station, but when bathing the patient, the nurses will cover the camera for patient privacy.

Harrison et al observed “HIT implementation can alter or disrupt oral communication among clinicians, even when talk is faster, more clinically accurate, and safer than transmitting information through the HIT” [18]. Another study found that patients regarded physicians who used EMR as “less capable than a physician using unaided judgment” [19].

In one EHR, a doctor could not find the needed medication in the hospital’s formulary (list of available medications)—so entered the drug in a free-text box he thought would be seen. However, the box was not visible; the order was not seen, and the patient suffered loss of half his stomach [16]. (In this case, the failure of the EHR to be sufficiently expressive led to a workaround which did not work.)

7. Conclusion

Understanding circumventions of cybersecurity in a healthcare setting clearly requires more than an analysis of the computer rules and the computer-generated logs of access from those with and without designated permission levels. We found it necessary to conduct interviews, focus groups, and observations; to shadow clinicians, attend meetings, and to conduct surveys of staff. Ethnographic investigation of what happens in the medical workplace emerges as a key method because in the inevitable conflict between even well-intended people vs. the machines and the machine rule makers, it’s the people who are more creative and motivated. This is especially true in healthcare settings, with professionals who carry the responsibility of patient care.
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References

Integrating Heuristic Evaluation with Cognitive Walkthrough: Development of a Hybrid Usability Inspection Method

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Abstract. Developing more usable healthcare information systems has become an important goal in health informatics. Although methods from usability engineering have appeared and been effectively applied in the design and evaluation of healthcare systems, there continues to be reports of deployment of unusable systems and issues with adoption of healthcare IT worldwide. In this paper we propose a new cost-effective usability engineering approach for healthcare IT that integrates two of the major usability inspection approaches (heuristic evaluation and cognitive walkthrough) into one combined approach that leverages the advantages of both heuristic evaluation and cognitive walkthrough. The approach will be described as will a pilot application of the method in evaluating the usability of a well-known electronic health record system. Implications and future work will also be described.

Keywords: Usability engineering; usability inspection, heuristic evaluation, cognitive walkthrough, system evaluation, healthcare information systems, electronic health systems

Introduction

The usability of healthcare information systems is currently a major issue. Globally, there are many reports of major usability problems encountered when healthcare systems have been deployed for use. Currently well-known usability engineering methods such as usability testing (which involves observing and recording end users interacting with a system or user interface to carry out tasks) and usability inspection methods (where an analyst steps through a system or user interface to identify potential usability problems) constitute the main usability engineering methods used today [1]. However, despite the usefulness of these approaches, there continues to be a need for new and improved usability engineering methods. In this paper we describe how we have combined two well-known forms of usability inspection, namely heuristic evaluation and cognitive walkthrough. The intent is to combine the advantages of both methods into a new integrative method that involves consideration both of end user cognition and application of usability heuristics.

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1. Background: Usability Inspection

Unlike usability testing, which involves observing users interacting with a system, usability inspection methods do not involve end users, but rather they involve analysts who inspect user interfaces or systems [2]. The two most well-known usability inspection methods are heuristic evaluation and the cognitive walkthrough. Heuristic evaluation was pioneered by Jacob Nielsen and has been widely used to help in the evaluation of user interfaces and information systems [3]. Heuristic evaluation involves one or more usability analysts systematically stepping through a user interface and noting violations of well-known usability heuristics. The approach is based on applying ten criteria (heuristics) which include the following: showing the user system status, using appropriate language in the interface, having consistency of operations, having appropriate error handling and minimizing cognitive load through chunking of information. When a violation of a heuristic is identified by the analyst(s) doing the heuristic evaluation, it is noted and its severity is assessed (typically using a 4 point scale, from cosmetic problem to minor, major and finally the most serious level of problem – usability catastrophe). Based on such analysis, recommendations may be provided to designers of the system being evaluated. An advantage of this approach is that it does not involve testing with real end users, it can be conducted rapidly and at low expense (hence it has been referred to by Nielsen as a “discount” usability engineering approach [3]).

The other main usability inspection method is known as the cognitive walkthrough and involves the usability analyst systematically stepping recording aspects of potential user interactions with a system or user interface, including the following: user actions that are taken in completing a task (e.g. selection from a menu, scrolling etc.), the system responses to user actions (e.g. information displayed to the user), user goals and sub-goals (e.g. to enter information into a healthcare system), and potential user problems in carrying out a task [4]. The results of the analyst(s) conducting the cognitive walkthrough can be provided to designers and developers to correct issues that might affect usability of the system [5]. The advantage of this approach is that it provides a fine-grained analysis of the number and nature of steps needed by the end user to complete a task successfully using a system. This information can be used to optimize user interactions and also for comparison of systems regarding carrying out the same task (e.g. comparing two medication administration systems regarding number of steps needed to enter a medication).

From our prior work we have found the two methods to have different strengths and weaknesses. For example, application of heuristic evaluation can allow the analyst to rapidly identify usability problems and rate them as minor, major or usability catastrophes in providing feedback back to developers and designers. However, in our prior work [6] we have found that when applied in healthcare this method is less useful when considering the interaction among the user, the system and user interface in testing that goes beyond surface and static user interface features, especially when evaluating systems for their impact on user cognition, decision making and workflow [7]. For assessing cognitive aspects of the user interaction, the advantages of the cognitive walkthrough become apparent, since the focus is on tracking and logging potential user problems and issues which can be applied to studying more complex user interactions and goals (e.g. using health information systems for complex interactions). However, the cognitive walkthrough focuses on low-level details of an interaction and does not provide a high-level or holistic view of user interactions. Furthermore, this
method used alone does not apply the potentially useful heuristic criteria proposed by Nielsen in heuristic evaluation. The following question therefore arose in our work: can the benefits of both approaches be gained through integrating the methods? The second question is how can the methods be integrated in a useful and effective manner that can be readily applied? In this paper we address these issues.

2. Methodological Approach

Our approach to integrating cognitive walkthrough with heuristic evaluation is described in this section of the paper. The overall approach involves the following steps:

Step 1. Preparatory Background Work – Users:
This step involves identification of who the intended users are of the system being evaluated. Consideration should be given to their goals, their background understanding of technology and the application being evaluated (as preparation for the next steps).

Step 2. Selection of Tasks to Guide the Evaluation:
A set of representative tasks (that can be carried out using the system being evaluated) needs to be identified to drive the process. These tasks will be used to carry out the evaluation and should be of importance to end users and of interest to the evaluators. Tasks might include for example entry of patient data into an electronic health record system (EHR), or application of information from clinical guidelines.

Step 3. Carrying out the Evaluation:
In carrying out the evaluation we borrow from the cognitive walkthrough approach to guide the overall evaluation process. For example, as in the cognitive walkthrough initial user goals and sub-goals are considered and entered into a log file. Then, as in the inspection process proceeds, the analyst systematically steps through the task noting: (1) user goals, (2) user sub-goals, (3) user actions, (4) system responses and (5) potential user problems. What is different in our extended approach is that at each major sequence of steps in the walkthrough process, we also note any violations of Nielsen’s heuristics (as they are applied during heuristic evaluation). We thus can note heuristic violations (applying the heuristic evaluation approach) within the structured and systematic sequence of steps documented in the log file corresponding to the results of the cognitive walkthrough. In addition, we recommend capturing any issues with screenshots so that the heuristic violations as well as potential problems identified from the cognitive walkthrough approach can be reviewed by developers of the system being evaluated. Table 1 provides an excerpt of a log file that illustrates the approach taken in evaluating an EHR (a demonstration version of the United States Veteran’s Affairs CPRS system) for the first few steps of the task of adding a patient medication to a patient’s record. As can be seen from Table 1, a log file is created that documents the steps of the integrated inspection process. Heuristic violations and their assessed severity are considered at each stage of the inspection - see Table 1. Numbers corresponding to Nielsen’s heuristics which are violated are given in the first column of the table (1= visibility of system status, 2= match the system to the real world, 3= user control and freedom, 4= consistency and standards, 5= error prevention, 6= recognition
rather than recall, flexibility and efficiency of use, aesthetic and minimalist design, help users recognize, diagnose and recover from errors, help and documentation, while the second column of Table 1 gives the analyst’s assessment of the severity of each of those violations. As can be seen, user goals, sub-goals, user actions, system responses and comments are also entered into the log, along with links to screenshots that illustrate heuristic violations as well as potential user problems, as the inspection process proceeds through the task.

<table>
<thead>
<tr>
<th>Heuristic</th>
<th>Severity</th>
<th>Clinical Risk</th>
<th>Goal</th>
<th>Action 1</th>
<th>Action 2</th>
<th>Action 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sub-Goal 1</td>
<td>Select a Patient</td>
<td>1, 8</td>
<td>2, 2</td>
<td>Click on ADEMOPATIENT, FIVE (OUTPATIENT).</td>
<td>Click on “Action” in the menu bar and select “New Medication”.</td>
<td>Enter data in open fields (type of visit, date picker, then click “OK”).</td>
</tr>
<tr>
<td>System Response</td>
<td>System opens patient record (Screenshot A). This appears to be the cover page.</td>
<td>System opens a new page to medication related information.</td>
<td>Pop-up modal appears in centre of screen with data entry fields (Screenshot B).</td>
<td>Enter data in open fields (type of visit, date picker, then click “OK”).</td>
<td>Error message appears (Screenshot D).</td>
<td></td>
</tr>
<tr>
<td>1, 3</td>
<td>2, 2</td>
<td>Potential Problem</td>
<td>Overall, page layout may not be aesthetically pleasing as there are a lot of sections with no data; and in order to accommodate this, the font is very small. The inspector was able to locate under “view”, a “preference” section where font could be altered, although adjusting the font size changes the screen so that not everything can be viewed.</td>
<td>Labeling of this page is not very clear – only the button at the bottom of the page is highlighted slightly by a different button sizing (Screenshot B). Suggest this should be a different colour to make it easier to identify. In addition, suggest that these buttons should be at the top of the page to make more clear. It was noted after that user could use “view” on the menu bar to access the various chart tabs.</td>
<td>Error message is completely uninformative. Inspector tried to re-create the message but it would not appear again. Could be a demo problem. Regardless, message wording needs to be adjusted to help user.</td>
<td></td>
</tr>
</tbody>
</table>

Step 4. Recommendations for Modifications:

Based on the results of the integrated cognitive walkthrough/heuristic evaluation, specific recommendations for re-design and optimization of a user interface or healthcare information system can be made (using the summary of the number of steps required, potential problems identified as well as the results regarding heuristic violations). Outputs of the process include tangible artifacts in the form of the corresponding screen shots illustrating issues and problems.

3. Experiences to Date

Our initial work in conducting clinical simulations in-situ involved a project where the user interface to a public health system was evaluated to determine where efficiencies and optimizations could be made in order increase usability. We have also applied the approach to assess the usability of a “gold standard” EHR – the Veteran’s Affairs
CPRS. Results of this analysis indicated that although the user interface of this EHR was generally effective, there were several areas where it could be improved from a usability perspective. For example, potential improvements in display of system status, consistency problems and aspects of workflow were identified. We are also in the process of applying our approach in collaboration with EHR designers to provide input into how system features can be optimized regarding both usability and workflow.

4. Discussion and Future Work

There is currently a need for improving the usability of healthcare information systems. Two usability inspection methods have been applied on a range of healthcare projects: heuristic evaluation [8] and the cognitive walkthrough [1]. In this paper we have described our approach to combining both methods and its early application in the evaluation of health information systems. This work has been motivated by the need to employ a single comprehensive and integrated approach both for logistical reasons (saving time and effort by not having to conduct separate heuristic evaluations and walkthroughs) as well as for the advantage of being able to link results of both methods together in an integrated way. Along these lines, creating a record in the form of a log file as described in this paper (that indicates where heuristic violations occur within a user’s steps in carrying out a task) links heuristic evaluation (which has been criticized for focusing on static user interface elements [6,7]) with the advantages of the cognitive walkthrough in delineating the steps/workflow needed by a user to successfully carry out work tasks. We have found the method to be effective and are currently using it on several projects. We are also planning an empirical evaluation of employing such a combined approach, as compared to conducting heuristic evaluation and cognitive walkthrough in isolation. We are also working on evaluating the effectiveness of the combined integrative approach described in this paper as compared to results obtained from usability testing (involving end users) for applications we have piloted the method with (in order to validate the approach).

References

Determinants of Health Behavior Choices in Patients Using Computer-Mediated Decision Aid

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Abstract. Using discriminant analysis an optimal set of predictors was identified which determined healthy behavior choices of users of a computer-mediated decision aid. The resulting set included smoking status, smoking cessation success estimate, self-efficacy, BMI and diet status. Prediction of smoking cessation choice was the most accurate (73%) followed by weight management choice (67%). Physical activity and diet choices were much better identified in a combined cluster (76%-87%) indicating that the decision about these two behaviors was affected by the same variables and the variables that could separate them may have been missing from the dataset. Presence of variables related to individual risks and levels of success in accepting certain health behaviors in the final set of predictors confirmed significance of the computer-mediated decision aid which presented these very variables for the user consideration.

Keywords. Consumer informatics, decision aid, health behaviors

Introduction

Successful patient-centered health systems support patient engagement and empowerment by accounting for patient needs, preferences and values [1]. Decision-aids designed to incorporate patient preferences into health decisions have been shown to facilitate patient-centered care [1]. We designed the Therapeutic Lifestyle Change Decision Aid (TLC DA) system to provide support for a person to make an informed choice about which behavior change to work on when multiple unhealthy behaviors are present [2]. TLC DA report contains four components: 1) behavioral risk and clinical risk; 2) readiness and confidence scores for changing each of the four behaviors; 3) qualitative equations to elicit patient priorities for change and 4) an action plan to affirm their behavior change priorities and goals. TLC integrates clinical data elements (height, weight, waist circumference, total cholesterol, HDL cholesterol, systolic and diastolic blood pressure, diabetes diagnosis) with patient assessment data to run its decision logic for the tailored outputs [3]. Patient assessment consists of five standardized questionnaires pertaining to 1) diet, 2) weight 3) physical activity 4) tobacco use and 5) psychosocial issues. For each of the four behaviors, we also assess

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the level of engagement in the unhealthy behavior (i.e., number of cigarettes smoked and level of nicotine dependence) as well as the patient’s transtheoretical stage of change for improving the behavior and self-efficacy in their ability to sustain the behavior change.

Factors that determine behavior choices by TLC DA users are unknown. The main goal of this study was to identify primary determinants of health behavior choices made by patients after using the TLC DA system.

1. Methods

Data collected from 82 consecutive adults (44 females and 38 males) using TLC DA were analyzed in this study. Baseline patient characteristics were represented by 45 variables reflecting their age, blood pressure, body mass index (BMI), smoking status and behavioral characteristics associated with behaviors of choice. Detailed characteristics of these variables were described previously [4]. Stratified analysis based on patient choice has been performed.

All statistical analyses were performed using IBM SPSS Statistics 22 (IBM, USA). Group statistics were conducted to examine the overall means and standard deviations of 45 independent variables for 4 patient’s behavior categories. Discriminant analysis was conducted (1) to find the best variable set that determines choice of health behavior; (2) to compose discriminant functions based on linear parameter combinations; and (3) to build a predictive model determining most likely choice of health behavior patients decide to adapt after using a computer-mediated decision aid. To achieve that a stepwise analysis was carried out, specifically Wilks’ lambda method was used.

2. Results

2.1. Group Statistics

The means and standard deviations of 45 baseline variables were calculated for each of 4 patient behaviors. All nominal variables were converted into ordinal variables for the purpose of this analysis. The study subjects were grouped based on their choice of health behavior after using the decision aid to corresponding categories including “Physical Activity,” “Diet,” “Weight Management,” and “Smoking”. For each group average characteristics were calculated as presented in Table 1.

2.2. Canonical Discriminant Functions

To discriminate a priori defined categorical groups (“Physical Activity,” “Diet,” “Weight Management,” and “Smoking”), a stepwise discriminant analysis was performed. At each step, the parameters that minimized the overall Wilks’ Lambda were entered. The maximum number of steps was 90, entered independent variables were S Status, BMI, S Success, S Soc and D Status, and the other 40 independents were eventually removed.
Table 1. Patient characteristics depending on behavior choice

<table>
<thead>
<tr>
<th></th>
<th>PA</th>
<th>Diet</th>
<th>WM</th>
<th>Smoking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
<td>Mean SD</td>
</tr>
<tr>
<td>Age</td>
<td>40.72 (11.00)</td>
<td>52.09 (10.22)</td>
<td>51.81 (12.39)</td>
<td>50.09 (9.07)</td>
</tr>
<tr>
<td>SHP</td>
<td>142.72 (12.22)</td>
<td>146.74 (14.39)</td>
<td>147.10 (17.39)</td>
<td>138.09 (11.25)</td>
</tr>
<tr>
<td>DBP</td>
<td>92.74 (19.70)</td>
<td>88.76 (15.88)</td>
<td>85.48 (10.22)</td>
<td>90.64 (18.53)</td>
</tr>
<tr>
<td>BMI</td>
<td>36.65 (6.99)</td>
<td>31.35 (5.57)</td>
<td>28.38 (5.58)</td>
<td>26.78 (8.67)</td>
</tr>
<tr>
<td>Weight</td>
<td>220.46 (58.99)</td>
<td>193.48 (42.28)</td>
<td>185.33 (43.09)</td>
<td>168.73 (50.76)</td>
</tr>
<tr>
<td>Weight Normal</td>
<td>155.11 (18.38)</td>
<td>151.84 (14.90)</td>
<td>159.88 (18.99)</td>
<td>157.35 (29.14)</td>
</tr>
<tr>
<td>WM Readiness</td>
<td>3.84 (1.03)</td>
<td>4.04 (1.07)</td>
<td>4.10 (1.14)</td>
<td>3.82 (1.83)</td>
</tr>
<tr>
<td>WM Confidence</td>
<td>2.08 (0.57)</td>
<td>2.22 (0.74)</td>
<td>2.24 (0.62)</td>
<td>2.09 (0.83)</td>
</tr>
<tr>
<td>WM Risk</td>
<td>9.64 (5.52)</td>
<td>10.26 (6.60)</td>
<td>8.67 (5.42)</td>
<td>6.18 (2.23)</td>
</tr>
<tr>
<td>WM SoC</td>
<td>3.84 (1.03)</td>
<td>4.04 (1.07)</td>
<td>4.10 (1.14)</td>
<td>3.82 (1.83)</td>
</tr>
<tr>
<td>WM Success</td>
<td>2.72 (0.54)</td>
<td>2.65 (0.49)</td>
<td>2.70 (0.44)</td>
<td>2.45 (0.69)</td>
</tr>
<tr>
<td>WM Benefit</td>
<td>2.66 (0.56)</td>
<td>2.52 (0.65)</td>
<td>2.38 (0.73)</td>
<td>2.36 (0.65)</td>
</tr>
<tr>
<td>PA A score</td>
<td>3.36 (1.87)</td>
<td>2.09 (1.16)</td>
<td>2.67 (1.28)</td>
<td>3.00 (1.90)</td>
</tr>
<tr>
<td>PA S score</td>
<td>0.96 (1.31)</td>
<td>0.87 (1.18)</td>
<td>0.95 (1.24)</td>
<td>1.18 (1.47)</td>
</tr>
<tr>
<td>PA SE</td>
<td>15.84 (4.76)</td>
<td>14.65 (4.75)</td>
<td>16.60 (6.46)</td>
<td>17.00 (6.87)</td>
</tr>
<tr>
<td>PA Readiness</td>
<td>3.72 (1.43)</td>
<td>3.17 (1.37)</td>
<td>3.76 (1.28)</td>
<td>3.91 (1.64)</td>
</tr>
<tr>
<td>PA Confidence</td>
<td>1.12 (0.54)</td>
<td>1.52 (0.59)</td>
<td>1.00 (0.77)</td>
<td>1.91 (0.83)</td>
</tr>
<tr>
<td>PA Risk</td>
<td>6.32 (3.34)</td>
<td>7.83 (3.36)</td>
<td>7.25 (3.36)</td>
<td>6.73 (4.28)</td>
</tr>
<tr>
<td>PA SoC</td>
<td>3.72 (1.43)</td>
<td>3.17 (1.37)</td>
<td>3.76 (1.28)</td>
<td>3.91 (1.64)</td>
</tr>
<tr>
<td>PA Success</td>
<td>2.40 (0.71)</td>
<td>2.04 (0.82)</td>
<td>2.52 (0.66)</td>
<td>2.45 (0.69)</td>
</tr>
<tr>
<td>PA Benefit</td>
<td>2.24 (0.60)</td>
<td>2.43 (0.66)</td>
<td>2.48 (0.64)</td>
<td>2.27 (0.65)</td>
</tr>
<tr>
<td>D status</td>
<td>5.36 (3.19)</td>
<td>4.43 (2.81)</td>
<td>7.10 (2.57)</td>
<td>7.00 (3.08)</td>
</tr>
<tr>
<td>D SE: Positive</td>
<td>30.32 (14.97)</td>
<td>36.74 (16.90)</td>
<td>32.43 (13.85)</td>
<td>30.36 (13.83)</td>
</tr>
<tr>
<td>D SE: Negative</td>
<td>25.60 (12.68)</td>
<td>32.04 (10.73)</td>
<td>28.00 (11.18)</td>
<td>27.45 (11.69)</td>
</tr>
<tr>
<td>D SE: Habitual</td>
<td>19.00 (7.08)</td>
<td>23.13 (8.19)</td>
<td>20.00 (6.73)</td>
<td>18.18 (9.41)</td>
</tr>
<tr>
<td>D SE: Temptation</td>
<td>39.48 (16.88)</td>
<td>46.91 (16.89)</td>
<td>38.00 (17.64)</td>
<td>36.82 (18.29)</td>
</tr>
<tr>
<td>D Readiness</td>
<td>3.52 (1.33)</td>
<td>3.91 (1.31)</td>
<td>2.62 (0.88)</td>
<td>2.91 (1.70)</td>
</tr>
<tr>
<td>D SE</td>
<td>1.96 (0.80)</td>
<td>2.43 (0.79)</td>
<td>2.14 (0.85)</td>
<td>2.00 (0.89)</td>
</tr>
<tr>
<td>D Risk</td>
<td>6.56 (3.36)</td>
<td>6.61 (2.02)</td>
<td>7.00 (4.01)</td>
<td>5.91 (2.43)</td>
</tr>
<tr>
<td>D SoC</td>
<td>3.52 (1.33)</td>
<td>3.91 (1.31)</td>
<td>2.62 (0.89)</td>
<td>2.91 (1.76)</td>
</tr>
<tr>
<td>D Success</td>
<td>2.40 (0.76)</td>
<td>2.61 (0.39)</td>
<td>2.25 (0.77)</td>
<td>2.00 (0.77)</td>
</tr>
<tr>
<td>D Benefit</td>
<td>2.20 (0.65)</td>
<td>2.30 (0.62)</td>
<td>2.43 (0.73)</td>
<td>2.18 (0.60)</td>
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<td>S Status</td>
<td>0.52 (0.90)</td>
<td>0.04 (0.21)</td>
<td>0.29 (0.09)</td>
<td>4.08 (2.14)</td>
</tr>
<tr>
<td>S SE: Positive</td>
<td>6.08 (6.81)</td>
<td>6.78 (6.91)</td>
<td>3.33 (5.62)</td>
<td>8.55 (3.14)</td>
</tr>
<tr>
<td>S SE: Negative</td>
<td>5.76 (6.85)</td>
<td>6.65 (6.99)</td>
<td>3.43 (5.09)</td>
<td>5.82 (2.27)</td>
</tr>
<tr>
<td>S SE: Habitual</td>
<td>6.56 (7.17)</td>
<td>7.39 (7.39)</td>
<td>3.57 (6.05)</td>
<td>8.27 (2.26)</td>
</tr>
<tr>
<td>S Readiness</td>
<td>4.40 (1.41)</td>
<td>4.91 (0.42)</td>
<td>4.76 (0.89)</td>
<td>2.45 (1.21)</td>
</tr>
<tr>
<td>S Confidence</td>
<td>1.92 (1.08)</td>
<td>1.91 (1.00)</td>
<td>1.48 (0.85)</td>
<td>2.45 (0.69)</td>
</tr>
<tr>
<td>S Risk</td>
<td>7.80 (5.13)</td>
<td>8.48 (5.09)</td>
<td>6.76 (3.09)</td>
<td>9.36 (4.32)</td>
</tr>
<tr>
<td>S SoC</td>
<td>3.60 (2.28)</td>
<td>3.06 (2.49)</td>
<td>0.95 (1.99)</td>
<td>2.00 (1.10)</td>
</tr>
<tr>
<td>S Success</td>
<td>3.23 (0.48)</td>
<td>2.48 (0.51)</td>
<td>2.19 (0.49)</td>
<td>2.45 (0.52)</td>
</tr>
<tr>
<td>S Benefit</td>
<td>2.32 (0.56)</td>
<td>2.39 (0.58)</td>
<td>2.33 (0.73)</td>
<td>2.55 (0.52)</td>
</tr>
<tr>
<td>PS SE: Support</td>
<td>3.98 (0.91)</td>
<td>3.80 (0.95)</td>
<td>4.09 (0.87)</td>
<td>3.36 (1.09)</td>
</tr>
<tr>
<td>PS SE: Stress</td>
<td>9.00 (3.15)</td>
<td>9.04 (2.85)</td>
<td>10.05 (2.69)</td>
<td>7.82 (2.93)</td>
</tr>
<tr>
<td>PS SE: Literacy</td>
<td>2.60 (1.73)</td>
<td>3.08 (1.56)</td>
<td>3.25 (1.38)</td>
<td>2.45 (1.69)</td>
</tr>
</tbody>
</table>


In the resulting model, S Status had 0.744 of tolerance, 55.536 of F to Remove and 0.583 of Wilks’ Lambda, BMI had 0.808 of tolerance, 9.481 of F to Remove and 0.246 of Wilks’ Lambda, S Success had 0.069 of tolerance, 9.578 of F to Remove and 0.246 of Wilks’ Lambda, S SoC had 0.075 of tolerance, 7.188 of F to Remove and 0.229 of
Wilks’ Lambda, D Status had 0.932 of tolerance, 4.322 of F to Remove and 0.208 of Wilks’ Lambda, and the model made by these 5 parameters had 11.632 of F to Remove and 0.176 of Wilks’ Lambda as shown in Table 2.

Table 2. Parameters in the Discriminant Analysis

<table>
<thead>
<tr>
<th>Step</th>
<th>Tolerance</th>
<th>F to Remove</th>
<th>Wilks’ Lambda</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>S Status</td>
<td>0.744</td>
<td>55.536 0.583</td>
</tr>
<tr>
<td></td>
<td>BMI</td>
<td>0.808</td>
<td>9.481 0.246</td>
</tr>
<tr>
<td></td>
<td>S Success</td>
<td>0.069</td>
<td>9.578 0.246</td>
</tr>
<tr>
<td></td>
<td>S SoC</td>
<td>0.075</td>
<td>7.188 0.229</td>
</tr>
<tr>
<td></td>
<td>D Status</td>
<td>0.932</td>
<td>4.322 0.208</td>
</tr>
</tbody>
</table>

As the result of this analysis, three canonical linear discriminant functions were generated to calculate Function 1, Function 2 and Function 3:

Function 1 = 1.060 S Status – 0.085 BMI + 4.779 S Success - 0.893 S SoC + 0.057 D Status – 8.131

Function 2 = 0.288 S Status + 0.094 BMI – 1.335 S Success + 0.488 S SoC - 0.256 D Status + 0.641

Function 3 = 0.145 S Status + 0.095 BMI - 3.184 S Success + 0.437 S SoC + 0.147 D Status + 2.815

The eigenvalues of Function 1, 2 and 3 were 2.989, 0.300 and 0.095 respectively. The proportion of discriminating abilities of the Function 1, Function 2 and Function 3 were 88.3 %, 8.9 % and 2.8 % respectively. The canonical correlations of Function 1, Function 2 and Function 3 were 0.866, 0.480 and 0.295 respectively as shown in Table 3.

Table 3. Eigenvalues in the Discriminant Analysis

<table>
<thead>
<tr>
<th>Function</th>
<th>Eigenvalue</th>
<th>% of Variance</th>
<th>Cumulative %</th>
<th>CC</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.989</td>
<td>88.3</td>
<td>88.3</td>
<td>0.866</td>
</tr>
<tr>
<td>2</td>
<td>0.300</td>
<td>8.9</td>
<td>97.2</td>
<td>0.480</td>
</tr>
<tr>
<td>3</td>
<td>0.095</td>
<td>2.8</td>
<td>100.0</td>
<td>0.295</td>
</tr>
</tbody>
</table>

CC: canonical correlation

Table 4. Classification Results

<table>
<thead>
<tr>
<th>Modes</th>
<th>Predicted Group Membership</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PA</td>
<td>Diet</td>
</tr>
<tr>
<td>Original %</td>
<td>64.0</td>
<td>24.0</td>
</tr>
<tr>
<td>Diet</td>
<td>26.1</td>
<td>56.5</td>
</tr>
<tr>
<td>WM</td>
<td>4.8</td>
<td>4.8</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Cross-validated %</td>
<td>52.0</td>
<td>32.0</td>
</tr>
<tr>
<td>Diet</td>
<td>34.8</td>
<td>43.5</td>
</tr>
<tr>
<td>WM</td>
<td>14.3</td>
<td>14.3</td>
</tr>
<tr>
<td>Smoking</td>
<td>0.0</td>
<td>9.1</td>
</tr>
</tbody>
</table>

As the result of this analysis, three canonical linear discriminant functions were generated to calculate Function 1, Function 2 and Function 3:

Function 1 = 1.060 S Status – 0.085 BMI + 4.779 S Success - 0.893 S SoC + 0.057 D Status – 8.131

Function 2 = 0.288 S Status + 0.094 BMI – 1.335 S Success + 0.488 S SoC - 0.256 D Status + 0.641

Function 3 = 0.145 S Status + 0.095 BMI - 3.184 S Success + 0.437 S SoC + 0.147 D Status + 2.815

The eigenvalues of Function 1, 2 and 3 were 2.989, 0.300 and 0.095 respectively. The proportion of discriminating abilities of the Function 1, Function 2 and Function 3 were 88.3 %, 8.9 % and 2.8 % respectively. The canonical correlations of Function 1, Function 2 and Function 3 were 0.866, 0.480 and 0.295 respectively as shown in Table 3.
2.3. Classification Statistics

The classification was processed for overall 82 patient variable sets that included 25 sets of “Physical Activity,” 23 sets of “Diet,” 21 sets of “Weight Management,” and 11 sets of “Smoking,” and the prior probabilities was set for all groups equal.

As shown in Figure 1, the group centroids (Function 1, Function 2) of “Physical Activity,” “Diet,” “Weight Management,” and “Smoking” were (-0.968, 0.395, 0.346), (-0.726, 0.278, -0.428), (-0.232, -0.889, 0.040) and (4.162, 0.216, 0.031) respectively.

The classification results are shown in Table 4. The classification success was assessed using original and cross-validated modes which in case of our data sets did not differ. Percentage of correct and incorrect classifications was based on the generated Function 1, Function 2 and Function 3. In case of “Physical Activity,” 64.0% of observations were classified correctly as “Physical Activity” group, but the remaining cases were incorrectly classified as “Diet” (24%) and “Weight Management” (12%). In case of “Diet,” 56.5% of observations were correctly identified as “Diet” but 26.1 % were misclassified as “Physical Activity” and 17.4% as “Weight Management.” In case of “Weight Management,” 85.7 % of observations were correctly classified as “Weight Management” but 4.8% were misidentified as the other behaviors. In cross-validation each case was classified by the functions derived from all cases using the leave-one-out method. As shown in Table 4, there was difference in prediction of patient’s behavior between the original validation and the cross-validation. Original classification estimates yielded overall 71.3% of correctly classified cases using Function 1, Function 2 and Function 3 generated by discriminant analysis. Cross-validation resulted in 72.7% correct classification results for the “Smoking” category, 66.7% - for the “Weight Management” category, and 75.5-86.6% - for a combined group of “Physical Activity” and “Diet.”
3. Discussion

Using discriminant analysis an optimal set of independent predictors was identified which determined behavioral choice of users of computer-mediated decision aid. The resulting set included smoking status (S Status), success estimate in smoking cessation (S Success), smoking self-efficacy (S SoC), body mass index (BMI) and diet status (D Status). Prediction of smoking cessation choice was the most accurate (73%) followed by weight management choice (67%). Physical activity and diet choices were much better identified in a combined cluster (76%-87%) indicating that decisions about these two behaviors were identified by the same variables and the variables that could separate them may have been missing from the dataset. Presence of variables related to individual risks and levels of success in accepting certain health behaviors in the final set of predictors confirmed significance of the computer-mediated decision aid which presented these very variables for user consideration via the TLC DA system. The TLC DA system was instrumental in assisting patients in making informed heath decisions.

References

A Framework of ‘p’-Benefits In Health Information Technology Implementation

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bInfoClin Inc, Toronto, Ontario
cUniversity of Victoria, Victoria, BC

Abstract. Implementing health information technology (HIT) into clinical settings is still problematic despite extensive efforts and research. HIT issues are caused by a gap in fit between users and technology. The transition from paper (p) to electronic (e) systems is a key factor in the chasm between users and technology. While a significant body of research exists on behavioral or usability evaluation of HIT, there is far less research that looks how to support the transition from p to e systems. This paper presents a framework of ‘p’ benefits to help us understand why issues occur in the transition from ‘p’ to ‘e’ systems. The framework can help us design and evaluate HIT in a manner that bridges the transition from p to e and helps close the user-technology chasm.

Keywords. Change management, HIT implementation, benefits, transition, EMR, EHR, systems design

Introduction

Introducing health information technology (HIT) into clinical settings has met with mixed results [1,2]. While a significant body of research exists on evaluation using behavioral approaches like the Technology Acceptance Model (TAM) or the Task-Technology Fit Model, or usability testing [3], a shortcoming with these approaches is their focus on the technology as object. Novak et al. suggest there is often a substantial difference between the ostensive (i.e. model representation) and performance (i.e. actual clinical reality) dimensions of how tasks are done [4]. Similarly Smith and Koppel identified 50 ways and 5 overarching categories in which HIT, including electronic medical and health records (EMR,EHR), did not fit with the workflow of end users [2]. We suggest that the cause of these performance issues is a chasm between how work is done in a non-digitized (i.e. paper based) system and how work changes when the system is digitized [5].

A better understanding of how users transition from paper to electronic processes could enable us to describe differences in performance dimensions caused by HIT and subsequently how to better design, implement, and evaluate HIT to bridge the paper (‘p’) to electronic (‘e’) chasm.
1. Methods

The authors have studied HIT implementation in a variety of settings including community care, acute care, and perioperative systems [6-11]. We reviewed our respective findings from these papers as well as other papers on paper persistence and HIT [11]. Our objective was to search for insight into why HIT implementations so often fail to deliver on their promise.

A commonality that we observed in all the studies was the relationship between work practices in the pre-HIT (i.e. paper based) and post-HIT settings. We focused on how processes are transformed in moving across work practices (i.e. data entry, retrieval, decision making) from ‘p’ to ‘e’ systems. In the sections below we use our integrated analysis to develop a framework for describing benefits from p-systems. We then use the framework to describe use cases on HIT implementation from our studies. We conclude with implications of our work for the design and evaluation of HIT.

2. Framework for Describing ‘P’ Benefits

In reflecting on our experiences in HIT implementation we noticed that while e-systems are often heralded for benefits such as rapid retrieval of records, ability to trend data and clinical decision support, there is often little said about the benefits of p-systems and how they may be morphed or lost in the transition to e-systems. From our studies we identified several benefits from p-systems, such as ability to view multiple documents at one time and ability to gauge patient complexity through physical affordances (e.g., the thickness of a patient chart.) Our hypothesis is that in the zeal to digitize care delivery, vendors of e-systems have designed novel benefits into their products, but have neglected to retain the benefits of p-systems, thereby forcing a trade-off on physicians and other adopters of HIT. The observations of Saleem et al [12] that care providers reintroduce paper processes after HIT implementation to overcome post-HIT issues strongly supports this view. We developed a framework of p-benefits (Table 1) to help us better understand the unique benefits of p-systems.

<table>
<thead>
<tr>
<th>Benefit</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive Context retention</td>
<td>Ability to start a new task in another context so that task switching is efficient and less prone to error; e.g., prescribe a medication for a patient in response to a pharmacist phone call while seeing another patient</td>
</tr>
<tr>
<td>Visible Affordances for communication</td>
<td>Ability to provide visual cues to staff that an action is required; e.g., place referral on chart so staff see it and act</td>
</tr>
<tr>
<td>Data Transfer</td>
<td>Ability to transfer data from one document (e.g., consult note or discharge summary) into multiple fields easily without having to switch back and forth.</td>
</tr>
<tr>
<td>Environmental Recall Cues</td>
<td>Ability to use physical objects to aid memory and recall; e.g., Retrieve lab order pad to order lab test later in visit</td>
</tr>
<tr>
<td>Low Cognitive Overhead</td>
<td>Ability to complete complex tasks with minimal need to compute the answer in a separate context prior to entering</td>
</tr>
</tbody>
</table>
3. Application of Framework to Use Cases

We use case studies to provide specific examples of how the above framework enables insight on the transition from p to e systems.

Case 1: An anesthetist has an EMR in the operating room (OR), but the patient is first seen in the hallway prior to being wheeled into the OR. Because of a loss of portability the anesthetist has to view the EMR record in the OR, remember or record the patient’s name and other key information on paper, and then step out to consult with the patient in the hallway. The Anesthetist then goes back into the OR to document patient findings in the EMR.

In moving from p→e, the Anesthetist lost the benefits of Portability and Low Cognitive Load as they are required to memorize key information, which could lead to medical error. It also leads to use of small bits of transitional paper that are discarded after use.

Case 2: A family physician is documenting a visit with patient B when a local pharmacist calls with an urgent request to make a change to patient A’s medication immediately since patient A is waiting in the pharmacy. In the p scenario, the FP pulls out their prescription pad from their pocket, fills out the prescription and faxes it over to the pharmacy. The paper chart is still open at exactly the location of last use. The FP easily resumes the encounter. In the e scenario, when the pharmacist calls, the FP switches out of patient B’s chart and pulls up patient A’s chart in the EMR. The FP then updates patient A’s medication record and re-transmits the prescription to the pharmacist. The FP must now re-retrieve patient B’s chart, reconstruct where they were in the encounter, find the place where they left off and resume the encounter documentation.

In moving from p→e, the FP has lost Cognitive Context Retention and Communication Flexibility, which are required for efficiency, productivity and patient safety.

Case 3: As patients move through the perioperative spectrum they accumulate a lot of data. Significant data points include symptoms or vital signs as managing these are part of continuity of care. However, each patient is unique and a patient’s post-operative symptoms or vitals only get their meaning from how they compare to the pre-op point of reference for symptoms or vitals. Nurses in the post anesthesia care unit (PACU) described it as challenging to find the pre-op reference data as they have to scroll back through several screens of data to get to the pre-op data.
In moving from p\rightarrow e, the PACU nurse lost Visualization and Fanning with respect to viewing data for decision making regarding the patients’ post-operative symptoms and vital signs.

4. HIT Design Implications

The p-benefit framework provides novel insight to assist system designers on how to design HIT to ensure that benefits realized from a p-system are not all lost in the transition to e-systems. For example, the Portability benefit asks us to consider mobility needs so an electronic record can be toed around just like paper can. Perhaps by adding a tablet version that is synchronized with the main record, users can regain the benefits of paper, while still being able to gain the benefits of the electronic technology. Tablets and mobile technologies can also facilitate Cognitive Context Retention by making it easier to complete interrupting tasks on the mobile device instead of switching contexts on the electronic record.

The Data Transfer benefit requires us to consider the need to maintain data transfer abilities afforded by paper charts. The development of a ‘window within window’ feature for HIT (i.e. EHR) would allow users to see two or more documents at the same time to enable efficient data transfer of relevant data between auxiliary HIT (i.e. lab, DI) and the EHR and to enable Fanning. The Visualization benefit is important for patient care where data points of reference are important such as monitoring symptoms or vitals over time. HIT design features such as being able to view previous and current symptom data simultaneously, or the ability to bookmark historical data points, would provide better visual support for processes that depend on longitudinal data.

5. Discussion

Moving from ‘p’ to ‘e’ systems is a challenge that forces several types of trade-offs and deprives health care providers of benefits to which they have become accustomed. Designers and vendors of HIT need to be aware of the types of impacts that introduction of HIT can cause and should strive to develop HIT that can replicate p-benefits of p-systems. While we are often quick to implement HIT with the newest feature we often do not consider the benefits that are provided by paper based systems. Portability, Visualization, Cognitive Context Retention, Low Cognitive Overhead, Visible Affordances for Communication, Environmental Cues for Recall and Fanning are p-benefits that have evolved over decades of use of paper in the health care enterprise. It has been easy to overlook these benefits since they have been largely implicit and we had no formal names for them. At a minimum HIT designers should map e-features to our list of p-benefits to enable users to see what functions they may lose or have altered after HIT implementation. That would enable better change management in the move to e-systems. While workflow analysis is often done as part of HIT design, such analysis often focuses on explicit workflows while not capturing implicit (i.e. performance level) workflows. Our framework can help capture these implicit workflows as part of HIT workflow analysis.

Limitations of this study include a lack of empirical testing. However, future plans are to use the framework to formally design and evaluate HIT in different clinical settings. We have also not mapped p-benefits to e-benefits to study the tradeoff...
between the two of them. Studying how tools such as digital paper and ink and touch tablets can better support ‘p’ to ‘e’ transitions are also a future research direction of ours.

Acknowledgements

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References

A Knowledge Translation Project on Best Practices in End-of-life Care

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¹ University of Victoria, Canada, ² Fraser Health, Canada, ³ Private Practice, Canada, ⁴ Victoria Hospice, Canada, ⁵ Island Health, Canada

Abstract. This is a knowledge translation project to promote the uptake of best practices in end-of-life (EOL) care within the primary care setting in British Columbia (BC) through the use of tools embedded into electronic medical records (EMRs). The knowledge-to-action model is used to engage primary care providers in co-designing, adopting and evaluating the EOL care toolkit built for 3 EMRs. The toolkit has a set of EMR-specific data entry templates, query/report functions and access to additional downloadable resources. It is based on the EOL learning module designed and offered by the BC General Practice Services Committee’s Practice Support Program to improve EOL care by primary care providers in the province. Our web-based distribution method allows providers to download and install the toolkit then take part to evaluate its use and impact. Initial feedback from phases 1-3 (of 4) has been favorable and has led to iterative improvements.

Keywords. Knowledge translation, best practices, primary care, end-of-life care, electronic medical record

Introduction

In the past decade there have been major advances in the approach to and delivery of end-of-life (EOL) care for patients with advanced illness at risk of dying in the next year. Examples are the Gold Standards Framework (GSF) for EOL care in United Kingdom [1], the population based approach to palliative service planning in Australia [2], the hospice palliative EOL care norms of practice in Canada [3] and methods of identifying palliative patients at risk of dying within the year [4]. In British Columbia (BC) there have been several initiatives to support the implementation of the palliative approach² among primary care providers. These include the introduction of: (a) three palliative care guidelines from the BC Cancer Agency Family Practice Oncology Network and the General Practice Services Committee (GPSC) [5]; (b) the Practice Support Program (PSP) learning module for EOL care from GPSC with an extensive EOL care algorithm based on the GSF supplemented with tools and resources such as

¹ Corresponding Author: Francis Lau, School of Health Information Science, University of Victoria. P.O. Box 1700 STN CSC, Victoria, BC, Canada V8W2Y2; email: flau@uvic.ca
² Palliative approach refers to care that improves the quality of life for individuals with an advancing illness, by reducing their suffering through early identification, assessment and treatment of their physical, psychological, social, cultural and spiritual needs [2].
symptom assessment forms and printable guidelines [6]; and (c) the Medical Orders for Scope of Treatment and Advance Care Planning policy from one health region for all care settings [7]. For electronic support, Scotland has introduced a Palliative Care Summary tool based on the GSF for sharing with out-of-hour services, hospitals and emergency departments [8]. In the United States computer based reminders for completing advance directives and managing elderly patients with advancing illness have been reported [9]. In BC, some primary care providers have locally designed tools in their electronic medical record (EMR) to support EOL care. These are promising initiatives as they promote practice change in primary care with integration of the palliative approach for patients not traditionally served by palliative care programs [10].

By identifying EOL patients sooner, providing best practice tools for assessment and care planning and prompts for appropriate care when needed, we can enhance the quality of care, while keeping patients out of hospitals and emergency rooms and avoiding unnecessary sufferings. More work is needed to improve the adoption of these innovations and to measure and understand their impacts. Also needed are effective strategies to make these innovations scalable and sustainable. Supporting the uptake of EMR practice support tools also offers the opportunity to measure the quality of care and provide the data needed for further improvement. Our hypothesis is that thru rigorous knowledge translation and rapid evaluation methods we can design an EMR-supported best practice model for EOL care with help from peer/practice leaders that can be adopted by primary care providers.

1. Objectives

This is a 2-year knowledge translation project funded by Technology Value Network (TVN) which is part of the Networks of Centres of Excellence program in Canada. Our objectives are to: (a) assess the current state of EMR-supported EOL care in BC; (b) develop generic requirements for an electronic toolkit based on the GPSC PSP EOL module; (c) build the requirements into tools for specific EMRs; (d) promote the adoption of the EMR-specific toolkit by primary care providers; and (e) evaluate the impact of EMR-supported best practices on EOL care. Our key question is: can the palliative approach that is integrated into the EMR of primary care providers through the toolkit enhance EOL care in ways that are measurable, scalable and sustainable?

2. Approach

In this project we applied the knowledge-to-action (KTA) model by Graham et al. [11] to frame the design, adoption and evaluation of EMR-supported best practices in EOL care as cycles of knowledge creation and action activities. In knowledge creation, we worked with palliative/primary care providers to design the care guidelines, tools and resources from the PSP EOL module as generic electronic tool requirements then built as EMR-specific tools. In knowledge action we worked with healthcare organizations and groups involved in primary care to promote adoption of the EMR-specific toolkit. We also applied the rapid evaluation methods from our eHealth Observatory [12] to examine the adoption of the EMR-specific toolkit and its impact on primary care providers and patients/families. The project organization, knowledge-to-action cycles and rapid evaluation methods are described below.
2.1. Project Organization

This project is conducted with a team of 6 health informatics researchers, 3 palliative care providers and 3 primary care providers. A steering committee with 5 primary care providers and 1 health region representative provides oversight. Most of the work is being done virtually via real-time web conferences with some face-to-face sessions in different BC locations. Project coordination/communication is done mainly through teleconferences, emails and a project website managed by the researchers on the team.

2.2. Knowledge-to-Action Cycles

(a) Review of current EOL care practices – The current state of EOL care practices including EMR-supported tools in primary care were reviewed through the project team, steering committee, recruited peer/practice leaders and published literature.
(b) Generic toolkit requirements development – A set of generic requirements for best practices in EMR-supported EOL care based on the PSP EOL learning module was developed by the palliative/primary care providers on the project team.
(c) EMR-specific toolkit construction – The generic requirements were used to guide the construction of EMR-specific tools and resources by software developers and peer/practice leaders on the team with expertise in specific EMRs.
(d) EMR-specific toolkit adoption – BC healthcare organizations and groups involved in primary care are being asked to promote the adoption of the toolkit.
(e) EMR-specific toolkit evaluation – Primary care providers who adopted the EMR-specific toolkit are being invited to help evaluate its use and impact.

2.3. Rapid Evaluation Methods

(a) Evaluation design – A quasi-experimental design is used with months 0, 3 and 9 as the time periods. The intervention is the EMR-specific toolkit being adopted by primary care providers in their EMR at month-0 as the baseline period.
(b) Participants – The intervention group has primary care providers who use an EMR and have taken the GPSC PSP EOL module in the last 2 years. The comparisons are with the intervention group over 3 time periods for changes and with providers who have adopted the toolkit but not taken the GPSC EOL module for differences.
(c) Measures – They include the quality indicators in the PSP EOL module such as the number of identified EOL patients and those with documented advance care plans, symptom assessments, collaborative care plans, referrals, EOL related billing and diagnostic codes, and bereavement follow-up. There are also subjective measures such as provider confidence and patient/family satisfaction in EOL care delivery.
(d) Data collection and analysis – At baseline, 3 and 9 months the team is to conduct interviews and workflow inspections with providers on their EOL care practices, collect summary indicator data from their EMRs, and conduct satisfaction surveys with their patients/families. At 3-month a survey is also done to ensure providers are using the toolkit as intended. All data are to be collected virtually if feasible.
3. Findings

We are 17 months into this knowledge translation project as of August 2014. We have completed the review of current EOL care practices, developed a generic set of tool requirements and built the toolkit for 3 commercial EMRs. We have started to promote this toolkit through BC healthcare organizations and groups involved in primary care and to collect baseline data for evaluation. Some key activity outputs are listed below.

3.1. Knowledge-to-Action Outputs

(a) We recruited 4 peer/practice leaders and 2 medical office assistants (MOAs) to examine their EOL care practices and tool requirements. These leaders all have ≥5 years EMR experience and some already have templates in their EMR for aspects of EOL care such as the palliative performance scale and referral forms, and resources such as the advance care plan and the BC guideline website link. None have an EOL patient registry but some flag EOL status for query and record action plan in encounter notes. Overall we found the existing EOL care tools, resources and patient data are scattered in different parts of the EMR with no consistency across and even within the same EMR type. The suggested requirements include patient support, reminder of available resources, integration and interoperability.

(b) We designed a set of generic requirements as the blueprint based on the PSP EOL learning module and additional information resources collated in our review [13]. Examples of key functions are: an EOL registry; recording encounter information including clinical notes, assessment scores and interventions; completion of EOL transition stage-appropriate tasks; inter-professional care plans; decision support including reminders; quality indicator reports; family bereavement follow-up; symptom assessment/management tools, and patient self-management resources.

(c) We built the EOL care toolkit into 3 EMRs (OSCAR, Profile and Med Access). The toolkit was built with EMR-specific templates/forms that can be downloaded and installed by users into their EMR without the need for system upgrade. The toolkit is distributed via a public website with downloadable zipfiles, installation instructions and tutorials on how to use the toolkit for each EMR. Since its debut in June we have made content/process changes based on user feedback after having adopted our toolkit (website http://ehealth.uvic.ca/eolmodule/).

(d) We started working with executive/clinical leaders and coordinators from the EMR Communities of Practices, Divisions of Family Practice and GPSC to help promote the adoption of the EMR-specific toolkit to all primary care providers in BC. Our target audiences are the 30+ Divisions and 100+ EMR Communities with 4000+ primary care providers where ~60% have taken the PSP EOL learning module. We plan to conduct dissemination sessions at divisional and user community meetings, promote the toolkit via newsletters and emails, and align with the EOL learning module as one of the provincial GPSC priorities for primary care providers.

3.2. Initial Rapid Evaluation Outputs

(a) We invited primary care providers who downloaded the toolkit to help evaluate its impact on their EOL care practices. We conducted phone interviews with these providers and MOAs and collected baseline performance data from their EMRs, and had them invite patients and families to complete satisfaction surveys by mail.
The baseline data collected thus far showed car providers do try to apply what they have learned from the GPSC PSP EOL module but have difficulties tracking their patients. While these providers feel confident in the EOL care being provided they are less confident in addressing their patients’ ongoing issues/needs and are unsure if other providers (e.g. Emergency Department staff) are aware of the status of their patients when providing care. Most providers are not able to generate EOL care quality indicator reports from their current EMRs and are eager to adopt the EOL care toolkit in their EMR.

4. Discussion

With the aging population and the increasing prevalence of chronic illnesses in Canada, timely access to quality EOL care has emerged as both a regional and national priority. One of the pillars of the BC EOL care strategy is to integrate the palliative approach across settings. This is important in primary care where being proactive can improve the quality of life for seriously ill patients as they transition through the EOL stages. Most primary care providers look after a small number of identified EOL patients and those at risk of dying within the year. Thus having a set of EMR-supported tools can enhance providers’ EOL care delivery and confidence, while increasing patient/family satisfaction at the same time. Thus far the EMR-specific toolkit and the web-based distribution method seem promising as tangible ways to improve EOL care. The next steps are to increase adoption of this toolkit, measure its impact, then scale up the toolkit to other EMRs and find ways to sustain the effort past the end of this project.

References

Sociotechnical Design of an Electronic Tool for Managing Transient Ischemic Attack in the Emergency Department

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b Island Health, BC, Canada
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Abstract. This paper describes the adoption of a prototype electronic decision support tool for managing transient ischemic attack (TIA) in the Emergency Department (ED) of a health region in Canada. A clinician-driven sociotechnical design approach is used to develop, test and implement the prototype with the aim to improve TIA management in the ED. In this study, we worked closely with ED staff to: identify issues and needs in TIA management; build/test/refine prototype versions of the electronic TIA decision support tool; and explore strategies to implement the tool for routine use in the ED. A blood protein biomarker test under development will also be incorporated as part of this tool in a subsequent phase. Thus far the prototype has demonstrated the potential to improve triage, risk stratification, and disposition decisions based on historical TIA and mimic cases. A prospective multi-site clinical utility study is planned for spring of 2016.

Keywords. Transient ischemic attack, acute cerebrovascular syndromes, emergency department, socio-technical design, decision support

Introduction

Transient ischemic attack (TIA), also known as minor stroke, is a medical emergency that requires prompt diagnosis and treatment to reduce the risk of recurrence and progression to a disabling stroke [1]. Collectively, TIA and stroke represent a spectrum of focal ischemic neurologic diseases referred to as acute cerebrovascular syndrome (ACVS). The risk of stroke or death following TIA ranges from 4 to 10% within 7 days, and increases to 8 to 12% by 90 days [2]. In Canada, the annual incidence of TIA is estimated at 68 per 100,000 population. Of the 50,000 new stroke cases in Canada each year 20,000 are preceded by TIA. The annual cost of stroke in Canada is $2.7 billion and accounts for 3 million hospital days [3].

A review of the current literature on TIA management in the ED has identified four key findings. First, TIA can be difficult to diagnose and distinguish from TIA-mimics such as migraine and seizure. This is complicated by the fact that for many patients the symptoms have subsided when they arrive in the ED so the diagnosis is
based mostly on clinical history. Misdiagnosis is common since there are many non-ischemic causes of neurologic events [4]. One study estimated 1 in 5 suspected TIAs were clinically a TIA-mimic [5]. Second, there is disagreement among physicians in diagnosing TIA. In one study ED physicians had discordant diagnoses from neurologists in 36% of suspected TIA cases [6]. Even with neurologists the agreement in TIA diagnosis is poor [7]. Third, there is a direct negative impact on TIA clinic throughput if more TIA-mimics have to be assessed thus causing delays in genuine TIA follow-up. A Canadian regional TIA unit reported high TIA-mimic rate to have an inversely proportional effect on TIA-to-unit time [8]. Fourth, there is a need for decision rules to help diagnose and manage TIA. An international survey of 1,150 emergency physicians has identified diagnostic imaging rules for suspected TIA as one of the top 10 priorities [9]. In a Canadian survey 95% of 324 neurologists responded that they would consider using a sensitive validated clinical decision rule to risk-stratify TIA patients [10]. Current tools such as the ABCD2 and TIA recognition tool are inadequate [11,12], suggesting the need for a more sensitive and specific decision support tool for TIA triage, risk stratification and disposition in the ED.

1. Objective

This GE3LS study is to develop, test and implement an electronic decision support tool for managing suspected TIA in the ED of a health region in Canada. It is part of a larger proteomics project that includes developing a simple and inexpensive blood test and incorporating the blood test results and clinical decision algorithms into this electronic tool to triage, risk-stratify and manage TIA patients. The goal of the proteomics project is to improve the overall management of ACVS in the ED by helping ED staff to: (a) rapidly triage and risk-stratify TIA patients for proper follow-up care; (b) reduce exposure of non-TIA patients to expensive and potential harmful imaging; and (c) reduce the number of mimics referred to the TIA clinic for follow-up assessment. This paper reports on early observations from two hospital settings (urban) and work is ongoing over the course of the larger proteomic project.

2. Approach

This study uses a clinician-driven sociotechnical design approach to develop, test and implement a TIA decision support tool in the ED. The clinician-driven aspect means that all of the TIA management issues/needs identified and the electronic tool design ideas came from clinicians who manage ACVS in the region. The sociotechnical aspect emphasizes the user, tool, task and environmental components of the clinical work for TIA management. Our approach draws on Yen’s sociotechnical view of health information technology (IT) usability [13], Kushniruk’s usability engineering methods [14] and Venktatesh’s unified theory in acceptance and use of technology (UTAUT).
The models/methods and data collection/analysis techniques are described below. The clinical decision algorithms in the tool were developed by a separate design team using multiple statistical and machine learning techniques on historical patient-cases supplemented with clinical experience (for detail see [16,17]). Institutional approval to conduct this study was granted by a joint university and health region ethics board.

2.1. Sociotechnical Models/Methods

Yen’s [13] sociotechnical view of health IT usability has three stratified levels: Level-1 aims to understand user-task interaction requirements for system development. Level-2 examines task performance to assess system validation and human-computer interaction. Level-3 includes environmental factors such as clinical utility to identify work processes and impacts in real settings. Kushniruk’s [14] usability engineering methods are used to study human-computer interactions and include cognitive task analysis, prototyping, usability testing, and usability inspection to ensure the computer-user task is relevant, useful, easy-to-use/learn and satisfying. Venkatesh’s [15] UTAUT, to be applied later, is used to assess the likelihood of technology acceptance and use that is influenced by performance and effort expectancy, social influences and facilitating conditions, and by gender, age, experience and voluntariness of use.

2.2. Data Collection and Analysis

(a) Semi-structured interviews on requirements – Interviews were conducted with ED staff from different hospital sites in the health region. These included physicians, nurses, managers, educators and clerical staff. The intent was to find out the current ED information and work flows for TIA management, issues and needs. Interviews were recorded, transcribed and analyzed for common themes then summarized in a tool adoption requirements report. Walkthroughs were conducted using an embedded design, in which a GE3LS clinician researcher shadowed a stroke nurse during their scheduled shift in the ED and observed their workflow and patient interactions in real time.

(b) Prototyping and usability assessment – The design team built different electronic versions of the tool using the clinical decision algorithms, accessible via the region’s intranet website on desktop computers, iPads and/or smartphones. The multiple tool versions were evaluated by the GE3LS team and ED staff using historical patient cases and compared against the final clinician diagnosis from the TIA clinic. This served as a metric for diagnostic sensitivity and specificity, acceptable risks and recommended actions. New versions of the tool were generated based on feedback on tool usability and performance.

(c) Utility study and impact analysis – A multi-site clinical utility study is planned with concurrent cohorts after the tool has reached acceptable thresholds in triaging, risk stratification and safe disposition of TIA patients from historical cases. The proposed outcome measures are the extent of usage, tool sensitivity/specificity, and TIA clinic throughput rates (TIA vs. mimics).

(d) A province-wide online survey was done with clinical heads of all EDs and Urgent Care Centres (UCCs) on their current TIA management practices and needs.
3. Findings

During a 9-month period in 2013-2014 the GE3LS team conducted 14 requirement interviews and seven usability assessments with 16 ED staff and two stroke nurses from three hospital ED sites in the health region. The ED staff are physicians, nurses, managers and clerks involved with the care of patients seen in the ED including those suspected of TIA. The ED nurses serve different roles that include triage, assessment and care, and education in the ED. The two stroke nurses are involved with enrolling patients from multiple ED sites into the larger proteomic study to determine the performance of the electronic tool and blood protein test. The TIA issues/needs identified and initial tool prototyping/usability assessment results are summarized below. Details of the clinical utility study—including the UTAUT results—will be reported later when they are available.

3.1. Issues/Needs in TIA Management

The ED interviews identified current workflow activities, roles, issues and needs in managing TIA. The activities include triage assignment, nurse assessment and hand-off, and physician assessment, diagnosis, treatment and disposition. We have generalized the roles to initial ED assessor, ED nursing assessor and ED clinician assessor with the possible future addition of the ACVS patient and pre-ED assessor. The key issues identified by the ED staff include: (a) inadequate education on ACVS management in the acute care setting; (b) workload pressures limiting patient assessment time; (c) limited access to resources such as assessment tools, medical imaging and clinical support; and (d) inadequate follow-up and discharge planning. Note that while our initial focus was on TIA management, early feedback from ED staff led to broadening our scope to cover the entire spectrum of ACVS management issues/needs in the region.

The identified needs are for a decision support tool that: (a) is fast and easy to access and use; (b) has multiple components for specific roles in ED triaging, nursing and physicians; (c) goes beyond diagnosis to provide decision support in risk stratification and advice on patient management; (d) leverages existing data in the ED information system (EDIS) such as patient demographics, medications and medical history; (e) is platform independent and can be accessible from different media e.g., smartphone; and (f) shows tangible benefit such as improved clinical outcomes and resource utilization.

3.2. Prototyping/Usability Assessments

CarpeDiem, orClassifier Algorithm for TIA Referral using Proteomic-clinical-data in an Electronic Decision support Evidence-based Module, is the electronic tool being developed to address the issues/needs identified. The current prototype of the tool has a built-in clinical decision algorithm, with the proteomic component to be added when the blood protein panel is developed. The clinical decision algorithm has three parts – a triage calculator, a risk-stratifier and an order set advisor. The triage calculator would be used by the ED nurse to determine the likelihood of TIA and initiate the blood protein test based on a minimal set of medical history collected at time of triage. The risk-stratifier would be used by the ED physician to stratify the risk of TIA/stroke based on additional history and findings collected from the patient. The order set advisor would provide a set of recommended actions such as MRI/CT imaging tests,
referral to TIA unit within 48 hours, follow-up specialist consult or discharge to home. Currently the prototype triage calculator is available as an agnostic web-based tool via the ED’s intranet. The risk-stratifier and order set advisor are still under development. The plan is to incorporate the tools into the EDIS via external links in fall 2015.

Thus far seven usability sessions have been conducted with one ED physician, four ED nurses and two stroke nurses at one ED site. The sessions first addressed general concepts and design elements of a clinical decision support tool for ACVS, then went on to evaluate the initial prototype of the triage calculator and screenshots of the risk stratifier. The key comments derived from the usability sessions reaffirmed that: (a) the triage calculator needs to be exceptionally fast, easy to use and help guide actions to be considered useful; (b) ED staff want a standardized assessment approach, and a decision support tool with useful information that can risk stratify TIAIs and provide management advice; and (c) can be accessed via different modalities from paper to an electronic tool that is integrated with the EDIS.

3.3 Province-wide ED/UCC Survey

Results from the web survey of 103 clinical heads of EDs/UCCs [18] indicate that of the 29 responses received (~29% response rate), 69% agree that TIA management in ED/UCC can be improved. Regarding interest in decision support tools for TIA, 76% are interested in a TIA decision support tool for risk stratification and TIA management, and 97% are interested in a TIA biomarker test to assist in TIA identification and risk stratification. The interests in TIA decision support as an embedded ED order entry system, a paper-based tool, a web-based tool and a smartphone-based tool are 62%, 66%, 79% and 90%, respectively. These findings reaffirmed that we are on the right path to offering CarpeDiem as an agnostic decision support tool that may improve TIA management in the ED and potentially beyond.

4. Discussion

CarpeDiem is being designed as an electronic decision support tool to help ED staff identify TIA separately from stroke and mimics from ACVS. Results from the GE3LS study thus far indicate that staff would like a tool that would help distinguish benign mimics from those with a high risk of morbidity and mortality. They would also appreciate a tool that would act as a risk stratifier to help decide the intensity treatment, such as the need for imaging and/or specialist referral within the next 48 hours. This risk stratification should include an indication of the risk of a bad outcome in the near future, such as an impending stroke.

Currently, the intended use of this tool is at triage. Its integration into the existing hospital EDIS is being explored. There are some early signs that deployment of this tool may be a challenge and might be better deployed with ED nurses and physicians. However, these observations may be specific to urban acute-care settings and further data collection in community and rural settings is planned to gain further insights on its adoption in different settings. In the future, the tool could be evaluated for use by paramedics, patients waiting in the ED, and by general practitioners and in that case it would be of great value to have a design that is user-agnostic.
References

Evaluation of a Portable Stress Management Device

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Abstract. Portable consumer health management devices are increasingly gaining attention from health consumers. StressEraser is a portable biofeedback device widely advertised as a stress reliever and cognition enhancer. However, number of evaluation studies assessing effect of StressEraser on cognitive performance improvement and stress relief is very limited. The purpose of this study was to evaluate the effect of StressEraser on cognitive performance and stress relief using a crossover design. A computerized psychomotor vigilance task (PVT) was selected as a mental stressor. The cognitive performance and stress level were measured in fourteen subjects having two 10-minute PVTs and 10-minute StressEraser intervention in between the PVTs. All main PVT metrics of cognitive performance (MeanRT, MedianRT, and Fastest10%) became significantly worse after StressEraser application (P<0.05). On the other hand, six heart rate variability (HRV) parameters (MeanRR, SDNN, RMSSD, aLF, aHF, and LF/HF) used to assess stress level showed no significant differences between the first and the second PVTs. Furthermore, the subjective stress levels reported by the study subjects after the first and the second PVTs were not significantly different. We concluded that the StressEraser had a negative effect on cognitive performance and no effect on stress level.

Keywords. Consumer informatics, self-management, StressEraser, cognitive performance, stress

Introduction

Patient-centered health systems promoting consumer engagement and self-management are gaining wide recognition [1]. According to the trend, a number of consumer health devices has been launched and advertised as effective tools to manage an individual’s stress. StressEraser (Helicor, Inc., New York, NY) is a portable consumer device for biofeedback that is widely advertised as a stress reliever and cognition enhancer. It provides respiratory sinus arrhythmia (RSA) biofeedback to help a user complete a deep-paced breathing session, which usually lasts for 10 minutes. Specifically, it asks a user to exhale slowly at the appearance of a triangle around a peak of its biofeedback graph and, after counting up to 4 or 5, inhale slowly until a new triangle appears. As a result, the time-domain heart rate variability (HRV) parameters, including standard deviation of normal R-R intervals (SDNN), are supposed to increase during the session. The manufacturer claims that the increased HRV should be associated with stress relief because the increase in time-domain HRV parameters is observed when a subject becomes relaxed or is not under stress [2]. A few peer-reviewed articles described

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assessment of the effect of StressEraser on relaxation in different contexts. Reiner reported that 24 patients with anxiety disorders who participated in breathing training with a StressEraser reduced state and trait anxieties [3]. Ebben et al. reported that, when 10 subjects without a history of sleep disorders were randomly assigned to either a StressEraser intervention group and a control group, the intervention group (n=5) showed a significantly lower sleep disturbance score than the control group (n=5) [4]. Prinsloo et al. showed that StressEraser could improve cognitive performance by comparing reaction times (RTs) and response consistency to a modified Stroop task before and after the intervention in 18 healthy male participants [5]. They also reported significantly increased HRV parameters—high frequency (HF) power, SDNN, and root mean square successive difference (RMSSD)—during the second task after the intervention, suggesting that the intervention may help in stress level reduction after completion of a stressful task [6]. However, repeated use of Stroop task may result in a training effect compromising the study results on improving cognitive performance [7]. The purpose of this study was to evaluate the effect of StressEraser on cognitive performance and stress level using a crossover design based on application of a computerized psychomotor vigilance task (PVT) as a mental stressor [8].

1. Methods

A crossover study design was used in which each subject was subjected to treatment (StressEraser) and control (rest) intervention in a random order on different days. A PVT, which was shown to be free from learning effects, was used as a stressor and cognitive performance measure. Subjects were asked to participate in two study visits. They were instructed to complete a 10-minute computerized PVT twice at every visit. During the PVT, they were asked to click the left mouse button as soon as they recognized the number appearing on the screen at random intervals between 2 to 10 seconds. Between the two PVTs, subjects had either a 10-minute StressEraser or control (rest) intervention on different visits. The day of StressEraser intervention was called “Day A” and that of control intervention - “Day B.” The study participants had Day A at the first visit and Day B at the second visit, and vice versa depending on a random allocation. On arrival to the laboratory a subject was asked to wear a heartbeat monitor (BioHarness 3, Zephyr Technology, Maryland) and was shown how to use StressEraser for about 3-5 minutes and how to carry out a computerized PVT training for about 1-2 minutes on both Day A and Day B. Before staring the first PVT, a subject was given 5 minutes to adapt to the study room environment while relaxing. The inclusion criteria were as follows: age 21 and older; stable health condition; slept well during the previous night; no smoking within 6 hours of intervention; no caffeine consumption within 6 hours of intervention; no medication within 1 day of intervention; no meal within 2 hours of intervention. To evaluate the effect of StressEraser on cognitive performance and stress level, the computerized PVT and HRV metrics were utilized. In addition, we investigated subjective stress levels rated at the moments of baseline, after the first PVT (PVT1), after intervention, and after the second PVT (PVT2). The self-rating question was “How much do you feel stressed?” and the scale ranged from 0 (not at all) to 10 (extremely stressed). The study protocol was approved by the Johns Hopkins School of Medicine Institutional Review Board (Application No.: NA_00093496). Written informed consent was obtained from all subjects.
The metrics used for evaluating a subject’s cognitive performance were MeanRT, MedianRT, and Fastest10%, which represent average RT, median RT, and average of 10% fastest RTs. All these values were retrieved from the computerized PVT software (BHSAI, http://bhsai.org/software/). The stress evaluation metrics included six HRV parameters during PVT1 and PVT2 and subjective stress levels rated after PVT1 and PVT2. The HRV parameters included MeanRR, average RR interval, SDNN, RMSSD, aLF, spectral power of low frequency component (0.04-0.15Hz), aHF, spectral power of high frequency component (0.15-0.40Hz), LF/HF, ratio between aLF and aHF. An electrocardiogram (ECG) recorded and digitized at 250 Hz by the wearable heartbeat monitor was downloaded to a computer using a log downloader. Because the signal range of the downloaded ECG recordings varied widely, every ECG recording was multiplied by a certain gain so that the amplitude of R peaks ranged between 50 and 150 ADC (analog-digital conversion) units. The R peaks were detected by a well-described algorithm [9] implemented in Matlab R2013a (MathWorks, Inc., Massachusetts). The six HRV parameters were calculated from the detected R peaks using HRV analysis software (Kubios HRV, http://kubios.uef.fi/) [10]. The above mentioned parameters were used to evaluate the effect of the StressEraser intervention as compared to control (rest). All values are described as mean ± standard deviation. As Kolmogorov–Smirnov test revealed that three PVT metrics and six HRV parameters were not normally distributed, the Wilcoxon signed rank test was used to determine differences. A p value of <0.05 was considered to be statistically significant.

2. Results

Fourteen subjects (10 males and 4 females, 36.64±6.85 yrs) participated in the study. The baseline scores of day time sleepiness were: none - 8; slight - 2; moderate - 2; considerable - 1. The subjective stress levels in the last month were: none - 1; mild - 7; moderate - 1; severe - 5. All subjects reported that they were familiar with a computer and had no experience in using the StressEraser. According to a random table generated before the recruitment, six subjects were assigned to have Day A at the first visit and the remaining eight subjects - at the second visit. The subjects’ relaxation score displayed on the StressEraser LCD after the 10-minute intervention was 40.50±7.71.

To confirm the role of computerized PVT as a stressor, we compared the subjective stress levels obtained before and after PVT1. Of fourteen subjects, twelve subjects reported increased stress levels by 1.83±0.94 and two subjects reported no changes. Using a Wilcoxon signed rank test, a significant difference between stress levels was confirmed ($P<0.0005$). Thus, we concluded that the computerized PVT involved in this study induced statistically significant mental stress in the subjects.

Cognitive performance measured by MeanRT, MedianRT, and Fastest10% during PVT1 and PVT2, that is, before and after the StressEraser intervention are summarized in Fig. 1. Before the intervention, MeanRT, MedianRT, and Fastest10% were 263.33±29.82, 250.46±27.25, and 198.61±12.15 (msec), respectively. After the intervention, MeanRT, MedianRT, and Fastest10% were 277.80±46.18, 261.50±34.89, and 206.16±14.61 (msec), respectively. The difference in MeanRTs measured before and after the intervention was 14.47±27.46 (msec). While twelve subjects responded slower after the intervention (difference=20.07±25.06), two subjects were able to respond slightly faster (difference=-19.10±16.16). The Wilcoxon signed rank test revealed that there was a significant deterioration in response to PVT caused by the
intervention \((P=0.0245)\). For MedianRT, the difference obtained before and after the intervention was found to be \(11.04\pm16.94\) (msec). Ten subjects showed increased MedianRT \((\text{difference}=18.50\pm13.15)\), three subjects - reduced MedianRT \((\text{difference}=-10.17\pm8.58)\), and one subject - no change. The statistical test showed that there is a significant difference in MedianRT before and after the intervention \((P=0.0374)\). Similarly, after the intervention, Fastest10\% increased by \(7.55\pm9.56\) (msec) rather than became shorter. Five subjects were found to have slightly improved ability to respond faster \((\text{difference}=2.07\pm0.93)\). However, two-thirds of the subjects demonstrated deteriorated ability to respond quicker \((\text{difference}=-12.90\pm7.62)\). Overall, a significant difference in Fastest10\% measured before and after the intervention was found \((P=0.0203)\). Considering all the above mentioned results, the StressEraser intervention caused users to react slower to a cognitive challenge as compared to their response before the intervention. On the other hand, our data confirmed that the computerized PVT used in this study had no learning effect because all RTs \((\text{MeanRT, MedianRT, and Fastest10\%})\) became longer during the second task \((\text{PVT}2)\). In addition, a Mann-Whitney test confirmed no significant differences in the RTs during PVT1 between the first and the second visits \((\text{MeanRT}, P=0.3012; \text{MedianRT}, P=0.2320; \text{Fastest10\%}, P=0.3953)\).

To evaluate the effect on stress level, six HRV parameters during PVT1 and PVT2 and subjective stress levels after PVT1 and PVT2 were investigated. MeanRR, SDNN, and RMSSD during PVT1 \((\text{before the intervention})\) were \(840.50\pm109.71, 50.92\pm18.15, \text{and } 33.64\pm13.71\) (msec), respectively. During PVT2 \((\text{after the intervention})\), they were \(834.55\pm108.95, 55.77\pm17.57, \text{and } 33.26\pm14.21\) (msec). No significant difference in the time-domain parameters measured before and after the intervention was found \((\text{MeanRR}, P=0.8077; \text{SDNN}, P=0.0906; \text{RMSSD}, P=0.8552)\). HRV in the frequency domain \((\text{aLF, aHF, and LF/HF})\) before the intervention were: \(1,111.02\pm845.89\) (msec\(^2\)), \(429.29\pm296.93\) (msec\(^2\)), and \(2.79\pm1.20\) (a.u.), respectively. After the intervention, those parameters were \(1,113.58\pm603.53\) (msec\(^2\)), \(404.82\pm304.64\) (msec\(^2\)), and \(3.54\pm1.68\) (a.u.). In the frequency-domain parameters, no significant differences was found \((\text{aLF, } P=0.6257; \text{aHF, } P=0.3575; \text{LF/HF, } P=0.2166)\). These findings differ from the previous report \([6]\) that found the StressEraser intervention caused significant increases in aHF.
SDNN, and RMSSD during the second task followed by the intervention. Our data implies lack of the benefit of stress relief or stress protection from StressEraser. This was corroborated by the fact that the subjective stress levels assessed after PVT1 and PVT2 were also not significantly different (5.43±1.50 vs. 5.57±1.83, $P=0.7266$).

3. Discussion

In this crossover study, the effect of StressEraser on cognitive performance and stress level was evaluated. We selected the computerized PVT as a tool to induce mental stress because it has no learning effect, unlike previously used Stroop task. Contrary to the previous reports [5], the cognitive performance measured by three reaction times significantly deteriorated after the StressEraser intervention. The deterioration may be related to the previously reported fact that 15% and 55% of subjects experienced dizziness and drowsiness, respectively, as side effects [3]. To evaluate the effect on stress level, we investigated HRV parameters shown to reflect stress response [12] and subjective stress levels. Although significant changes in three HRV parameters were reported previously [6], in our study the HRV parameters were not found to be significantly affected by StressEraser. The fact that the subjective stress levels measured after PVT1 and after PVT2 were not significantly different corroborates this finding. Our results call for further evaluation of existing claims that StressEraser can effectively reduce stress and improve cognitive function.

References

An Evaluation of Health Information Technology Outsourcing Success

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Abstract. Outsourcing involves contracting out functions performed by an organization to another organization. Many healthcare organizations are exploring outsourcing as a way to address demands for health information technology (HIT). This study researches the success of outsourcing in the health informatics industry in Canada. The study is designed to help understand whether outsourcing four functions of HIT (i.e. development, implementation, operations, and maintenance) can prove successful for an organization. Findings demonstrate that outsourcing these four functions occurs in Canada; however, the research from the semi-structured interviews finds that operations and maintenance may be more commonly outsourced in Canada, over development and implementation functions. Despite this, findings from this research suggest that outsourcing development and implementation may offer more benefits and fewer challenges than outsourcing operations and maintenance. The research also finds that there can be benefits of outsourcing, such as gaining access to expertise and improving service levels. A weakness of outsourcing may be that internal knowledge is lost and having to manage the change required from outsourcing. The study proposes that there are many factors that need to be considered when outsourcing to ensure it is successful.

Keywords. outsourcing, health information technology, health information systems, organizational behavior, strategy

Introduction

Outsourcing refers to the contracting out of services by transferring them to an external service provider in order to deliver services or functions that are more efficient and cost effective than the host organization can provide. Initially, research showed that outsourcing was seen as a mechanism to reduce costs and executives thought they could save 10-50% of their information technology (IT) expenditures [1, 2]. In recent years, outsourcing is seen as a way to adapt to ever changing environments, improve quality and performance, and conserve the most effective resources [3, 4]. Today many healthcare organizations are turning to outsourcing as a mechanism to deliver health information technology (HIT) services in a more efficient and effective manner. It has been found that organizations may outsource different HIT functions, such as HIT development, implementation, operations and maintenance [5, 6]. HIT development, implementation, operations and maintenance are considered major functions, as defined in the system development phases of the system development life cycle [7, 8]. It has
been found that healthcare organizations across Canada are outsourcing one or more of these four HIT functions [9, 10].

There is a need to determine if organizations that have outsourced HIT functions have realized qualitative and quantitative benefits. The literature tends to demonstrate results in countries outside of Canada and in the industries other than healthcare. There is a strong need to understand the benefits outsourcing different HIT functions can have on healthcare organizations in Canada. This study asks research questions around 1) what the perceived benefits and impacts of outsourcing are; 2) what functions (development, implementation, operations, maintenance) are outsourced in Canadian HIT organizations and why; 3) what functions are perceived as providing the most benefit from outsourcing; and 4) what the perceived strengths and weaknesses of outsourcing are, compared to internally delivering HIT services. By answering these questions the health informatics industry will gain an understanding of the types of functions that are most often outsourced in Canada, and which functions may provide the largest benefit to an organization.

1. Study Design and Methodology

An interview based study was conducted which employed qualitative research methods. After obtaining consent from participants, demographic data, HIT experience, and level of experience with outsourcing was collected from each participant. Following the data analysis of the questionnaire, semi-structured interviews were conducted and qualitative content analysis was used to analyze the data from the interviews. The interview asked questions on the participant’s outsourcing experience, their perceptions of outsourcing, any positive and negative consequences of outsourcing, their beliefs on the strengths and limitations on outsourcing, and their thoughts of outsourcing compared to in-house delivery of services. After each interview, open coding was performed to review similarities and differences and group concepts together. Saturation was reached with 14 participants. Recruitment methods included the University of Victoria Health Information Science listserve and snowball sampling. All participants were in the Canadian health informatics industry. The majority were seasoned leaders: Managers, Directors, Chief Information Officers, VP or Executive equivalent. All participants were familiar with HIT outsourcing.

2. Summary of Study Findings

The semi-structured interviews led to findings on what outsourcing is, the characteristics of outsourcing, and the results that organizations may gain from outsourcing. It was found that general outsourcing is very similar to HIT outsourcing, and that organizations may outsource for many different reasons, such as gaining vendor expertise, cost savings, and improving service delivery. Participants indicated that HIT outsourcing was common with operations and maintenance; however, outsourcing development and implementation functions has also been seen. They also stated that outsourcing could achieve its intended outcomes and that it could improve service levels, expediency to deliver work, and create efficiency. However, participants indicated that financial benefits of outsourcing were rarely seen and that it may be more of a cost neutral strategy. The interview findings also suggest that organizations have a
variety of ways of managing performance and that outsourcing can have an effect on organization performance levels. It was found that some organizations saw an increase in performance, and achieved on time and on budget service delivery from the external service provider; whereas other participants expressed that performance declined with outsourcing. Participants also stated that, when outsourcing, an organization should be transparent on what the performance measures are and ensure the results of the performance measures are communicated across the organization and its customers.

3. Discussion on Health Information Technology Outsourcing Success

Through the literature review and the data collection, the researcher gained an understanding of the perceptions that exist about the benefits and impacts of outsourcing, the HIT functions that are outsourced, and the perceived strengths and weaknesses of HIT outsourcing. This section answers the four research questions posed.

3.1. Perceptions of Benefits and Negative Impacts of Outsourcing

It was found in the interviews that the benefits of outsourcing centered on the qualitative benefits, opposed to the quantitative or financial benefits. Despite not stating many financial benefits, interestingly participants stated the top reason that organizations outsource is because of cost savings. Consistently, Lorence and Spink [11] found that saving money is one of the major factors that influences a healthcare organization’s decision to outsource. However, the financial benefit of cost savings was not found to be a major benefit stated by the participants. Instead, participants commonly stated benefits around improved outcomes and service delivery, explaining that external service providers can deliver services faster and more efficiently. Participants also stated benefits of outsourcing such as ensuring service levels and gaining external expertise.

Despite the benefits associated with outsourcing, negative impacts of outsourcing were also found in the research. Outsourcing can change many things for an organization including the way services are delivered. When asked about service delivery, participants (speaking from a customer perspective) stated that outsourcing can decrease service levels for customers (for example decreasing how quickly customers receive service and support). Other negative impacts stated by the participants included the loss of internal expertise as some skillsets have move to the external service provider and the change impact on the organization’s staff. The research from both the semi-structured interviews and the literature finds that clear communication from leadership is required to support employees through the change of outsourcing.

3.2. Type of Functions Outsourced and Functions that may Provide the Most Benefit from Outsourcing

It was found that all functions of HIT development, implementation, operations, and maintenance are outsourced in Canadian healthcare organizations. According to the participants, outsourcing operations and maintenance functions may be more common than outsourcing development and implementation functions in Canada, and more common than outsourcing all four functions together. This differs from the literature.
that has found that outsourcing operations and maintenance occurs less often than
development and implementation [5].

When looking at what functions may benefit most from outsourcing, there was also
a difference found between the literature and the interview findings. When looking at
what provides the most benefit when outsourcing, it was found by the interview
transcripts that outsourcing development and implementation functions may offer
slightly more benefits and less impact than outsourcing operations and maintenance
functions. This differs from the literature that finds the opposite for general outsourcing
[5]. This may highlight a difference in the findings between general outsourcing and
HIT outsourcing.

3.3. Perceptions on the Strengths and Weaknesses of Outsourcing

While strengths and weaknesses of outsourcing may stand-alone, many of the strengths
of outsourcing may also lead to a weakness in the outsourcing model. A common
strength stated by the participants was that outsourcing can provide external expertise;
however, participants also stated that this can result in a potential loss of internal
expertise. Another strength found was that outsourcing has the ability to improve
service delivery, yet a corresponding weakness stated is that it may end up costing the
organization more. It was also found that outsourcing has the ability to drive process
change in an organization. Participants described that by outsourcing organizations are
forced to define process through the contract negotiation, and the external service
provider will come in and often change process to improve it. This may be satisfactory
for many organizations; however, it was found that this can also be perceived as a
weakness by many of the organization’s customers as they may not understand the new
process or see it as being complex. Another strength of outsourcing is that is can enable
control for organizations, as organizations can drive the desired service levels through
controlling the external service provider to meet the service levels through the
outsourcing contract. However, participants also stated that outsourcing can cause
organizations to lose control of service levels if the contract is poorly written and
negotiated. Additionally, organizations may feel they lose control when they become
more reliant on the contracted organization to deliver its services. Lastly, it was found
that outsourcing has the ability to transfer risk, such as staff benefits, pension and
expenses, to the external service provider. However, outsourcing can also create a
number of risks for an organization. One common risk stated by the participants is that
outsourcing can have negative change and impact on an organization, its employees
and its customers. Participants stated that outsourcing requires huge change, as
employees transfer to another organization. Organizations should be aware of these
strengths and weaknesses prior to entering into the outsourcing agreement. Mitigation
strategies should be developed for any of the perceived weaknesses and potential risks
with outsourcing.

4. Study Limitations

There are many benefits associated with the use of qualitative approaches; however,
this particular method of study can have potential limitations. A limitation in this study
may be the relatively small sample size as the study recruited senior roles, which made
the pool of eligible participants small. In the data collection, semi-structured interviews
took place, which may be another limitation. Open ended questions allowed participants to provide very detailed information and discuss their perceptions of outsourcing; however, a different approach to the questionnaire and interviews, such as a web-based questionnaire for all CIOs across Canada, may have elicited a larger sample size. Work from the research could be used to develop an online questionnaire as part of future research. Despite this, in this research, the smaller sample size and semi-structured interviews allowed for rich data to be obtained during the data collection.

5. Conclusion

This research has helped gain an understanding of the types of functions that are most often outsourced in Canada, and which functions may provide largest benefit to an organization. The study also identified the perceived strengths of outsourcing (such as having external expertise, improved service delivery, and positive process change) and weaknesses (such as loss of internal expertise, increased costs, and complexity with change) of outsourcing. By reviewing the findings to the research questions the health informatics industry, including healthcare administrators and health informatics practitioners, can gain a deeper understanding on the impacts to outsourcing HIT functions. Understanding these impacts is important as healthcare organizations are increasingly looking at outsourcing as a mechanism to deliver HIT services differently.

References

Information Technologies to Improve Public Health: A Systematic Review

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Abstract. This systematic review examines a total of eighteen studies on the use of health information technologies to improve public health. Health information technologies are tools that allow for the management of health information in computerized systems. Health information technology, including electronic health records, computers/emails, social media, and cellphones/text messaging are becoming widespread and readily accessible to populations around the globe. In this review, the use of these technologies and interventions are discussed and evaluated for their potential to improve public health. This review found some good-quality evidence on the use of electronic health records and little good-quality evidence on the use of email, social media, cell phones and text messaging to improve healthcare, illustrating the need for further study in these areas.

Keywords. Health Information Technology, Electronic Health Record, Email, Social Media, Cell Phone

Introduction

Health information technologies (HIT) are tools that allow for the management of health information in computerized systems [1]. HIT is often viewed as a great asset in improving patient safety, quality of care, clinical effectiveness, and public health surveillance and response [2]. The electronic health record is seen as an essential tool that must be developed and implemented as a way of allowing an individual’s health information to be stored electronically and accessed across jurisdictions [3]. Today, social networking and media platforms are commonly used by people of all ages and socioeconomic backgrounds in order to share knowledge and experience [4]. Furthermore, a significant number of people utilize computers and cellphones to seek and share health-related information. As these HIT tools become more widespread and pervasive, it is important to evaluate their potential to improve public health.

1. Methods

1.1 Search Terms

The review process was limited to literature that was produced from 2003 to 2014. Searches were conducted from the following databases: Academic Search Complete,
Health Technology Assessment, CINAHL with Full Text (EBSCO), PubMed, Web of Science (ISI), ScienceDirect (Elsevier), Medline with Full Text (EBSCO), Cochrane Database of Systematic Reviews (EBSCO). The search strategy included a combination of the following terms: health information technology, health informatics, public health, electronic records, cellphone, text message, SMS, social media, and Twitter. The searches were limited to studies in English-language publications. Titles and abstracts of citations were reviewed and potentially relevant articles were retrieved. Only full-text papers published in peer-reviewed journals were included.

Websites of Canadian government agencies were also searched. The search strategy included a combination of the following terms: Canada, health information technology, health informatics, public health, electronic records, cellphone, text message, SMS, social media, and Twitter. Searches were limited to studies in English-language publications.

1.2 Strength of Evidence

Studies were selected for inclusion using the evidence of the efficacy of an intervention guidelines described by the NHS Health Development Agency [5].

2. Results

2.1 Electronic Health Records

A 2013 survey reported that 56% of Canadian primary care physicians report using electronic medical records, which is much higher than in 2004 when physician use rates were reportedly 16% [6,7]. Another survey of primary care physicians in Canada found that only 14% use at least nine out of fourteen clinical information technology functions of advanced electronic capability [1].

A 2005 systematic review examined the impact of electronic health records on time efficiency of nurses and physicians [8]. Only two out of eleven studies reported statistically insignificant differences between paper-based and computer-based documentation systems, while three studies did not have sufficient data to determine whether the results were significant [8]. Overall, bedside terminals saved nurses an average of 24.5% of their time spent documenting information, and central station desktops saved them an average of 23.5% [8]. Six of ten studies related to the impact of electronic health records and time efficiency of physicians found statistically significant differences between paper-based and computer-based documentation systems [8]. Overall, bedside or point-of-care systems increased physician documentation time by 17.5% [8]. Two possible reasons cited for this increase included a lack of incentive to utilize electronic health records and poor adoption rates, the latter of which could be explained by less support and training sessions for physicians, compared with nurses [8].

A 2010 pilot study used patient previsit review of electronic health record medication lists to help improve patients' understanding of their medications [9]. It was found that 41.9% of patients had at least one problem, concern, or question [09]. These issues could then be addressed during the subsequent physician visit [9]. The previsit review
also caught at least one discrepancy for 78.0% of patients, including 8.9% of patients indicating that at least one medication was not listed on their electronic health record list [9].

A 2011 Cochrane review looked at electronic health record interventions to support patient smoking cessation [10]. The reviewers were only able to identify a total of eleven studies of fair to good quality [10]. The reviewers found that electronic health record use resulted in minor improvements in some of the recommended clinical actions steps on tobacco use [10].

2.2 Computers/Email

An American survey of local health departments found that more than five hundred different software programs were used [11]. Commonly used software included Microsoft Office, Microsoft Outlook, ArcView, Health Alert Network, and Epi Info [11]. The study emphasized that public health agencies and organizations must be able to communicate with each other effectively, and it is important to note that this ability could be hindered by system incompatibility [11].

A 2012 Cochrane review examined the use of email as a means of clinical communication between patients, caregivers, and healthcare professionals [12]. There was not enough data to evaluate the effect of email as a means of communication [12]. The reviewers noted that one study found some evidence that telephone counseling yielded greater changes in some lifestyle modification factors than email counseling; however, the evidence was low-quality [12]. The major limitations of this review were that only nine trials were included and all were at risk of bias [12]. Further high-quality research is needed in this area.

Another 2012 Cochrane review looked at the use of email for clinical communication solely between healthcare professionals [13]. A randomized controlled trial showed that email reminders to physicians significantly increased the likelihood of healthcare professionals providing guideline-recommended osteoporosis treatment compared to the control group [13]. It is crucial to note that only one study was included in this review, and there is a high risk of bias; therefore, it is recommended that more high-quality, low-bias research is conducted before the effects of email for clinical communication between healthcare professionals can be adequately assessed.

2.3 Social Media

A 2010 study randomly chose 1,000 tweets that referenced antibiotics; 29 were removed as irrelevant [4]. The remaining tweets were categorized as the following: general use, advice/information, side effects/negative reactions, positive reactions, diagnosis, resistance, misunderstanding and/or misuse, animal, wanting/need, cost, and other [4]. This study illustrated the potential of harnessing Twitter to gather real-time health data, with the ability to track information by location; for example, a disease outbreak could be tracked in a specific region [4]. Twitter-based posts could be used to educate and remind individuals about a wide range of health issues, including vaccinations and lifestyle changes [4]. Physicians or other health care professionals could also use Twitter to answer individual's questions or make referrals to appropriate health care services [4].

A 2014 review looked at how social media is being used as a tool for health promotion and behaviour change [14]. Several studies found that social media use
varied by age and gender [14]. Those born between 1961 and 1981 were more likely to participate in online wellness programs than those born between 1982 and 2001 [14]. Women were found to be more likely to investigate health problems and medications, while men were more likely to research vitamins, supplements, and health insurance [14]. These findings indicate that health promotion could utilize social media to tailor messages and services to these groups depending on their needs and wants.

Studies and meta-analyses investigating the effects of internet-based interventions, including tobacco cessation and physical activity, have found evidence of a positive impact [14]. Furthermore, numerous studies have found that patients are more empowered by web-based interventions compared to traditional face-to-face interventions [14]. This may be due to the ability of patients to educate themselves about their health through online learning [14].

A survey of physicians and their use of social media as a professional development tool and as a means to share information with other health care professionals found that twenty-four percent of utilized social media at least once a day in order to search medical information, and 14.2% stated that they contributed information at least once a day [15]. The primary reasons cited for using social media included ease of use and usefulness [15]. A substantial number of physicians (60.0%) reported that social media improved their quality of patient care [15].

Few studies exist on use of social media websites, such as Twitter, Facebook, and LinkedIn, to promote health; however, there is great potential to use these platforms as vehicles to deliver health-related messages inexpensively.

2.4 Cellphones/Text Messaging

A 2009 systematic review investigated the role of cellphone voice and text messaging use in healthcare and associated health outcomes [16]. Sixteen studies found a change in health outcomes due to text message or voice intervention, and twelve found significant changes in clinical health outcomes [16]. In one randomized controlled trial, personalized smoking cessation support and distraction message messages were sent to participants daily, both before and after a predetermined quit date [16]. At the end of the study, it was found that the intervention group had significantly greater rates of abstinence with three or less lapses [16].

A 2012 Cochrane review examined the utilization of mobile phone messaging as a means to deliver preventative health care [17]. Only four randomized controlled trials were included in the review, illustrating that more high-quality research needs to be done in this area [17]. One study found that pregnant women who received prenatal support via text messages were significantly more satisfied with antenatal care than women who did not [17]. Women who received text messages were also more confident and less anxious than women who did not receive text messages; however, during the perinatal period, there was no statistically significant difference in confidence and anxiety between the intervention and control groups [17]. Another study sent personalized text messages containing cessation support and advice to daily smokers [17]. The intervention group reported higher rates of smoking cessation after six weeks and twelve weeks compared to the control group; however, after 26 weeks there was no difference in complete abstinence rates between the intervention and control groups [17]. Another study examined the impact of text messaging on vitamin C supplementation for preventative purposes [17]. People who received text message
reminders reported higher rates of adherence to the supplementation routine compared to the control group [17].

A 2013 Cochrane review looked at the impact of cellphone text message reminders on patient attendance at health care appointments [18]. Seven studies showed moderate quality evidence that text message reminders increases rates of attendance at health care appointments, and three studies showed that text message reminders had the same effect on attendance rates as phone call reminders [18]. This finding is noteworthy as two of the studies reviewed found that the costs per text message were less than half the cost of phone call reminders; therefore, there is potential for cost-savings to the healthcare system [18]. The small number of studies reviewed shows the need for more studies on text message use and patients' attendance rates.

Another Cochrane review examined the impact of text messaging on self-management of long-term illness [19]. Two studies looking at the effect of text messaging interventions on glycemic control and one study examining the effect on mean blood pressure found no statistical difference between the text message intervention groups and the control groups [19]. Another study found that diabetic patients in the text message intervention group had higher Self-Efficacy for Diabetes scores and Diabetes Social Support Interview scores; however, there was no statistically significant difference in knowledge of diabetes between the groups [19]. The small number of studies and total sample size indicates that any evidence is low to moderate in quality and that these interventions need more research.

### 3. Discussion

As HIT, such as electronic health records, computers/emails, social media, and cellphones/text messaging become widespread and more accessible to populations across Canada and around the globe, it is important to investigate the potential use and benefits of the application of these technologies to the field of public health. In this systematic review, the use of these technologies and interventions were discussed and evaluated for their potential to improve public health. A total of eighteen studies were selected and reviewed. There was some good-quality evidence on the use of electronic health records and little good-quality evidence on the use of email, social media, and cellphones and text messaging to improve healthcare. This review exemplifies the need for good-quality, low-bias research in these HIT areas.

This systematic review may have some limitations. A relatively small number of papers were examined. Many studies included were not good-quality and had moderate- to high-risk of bias. A more in-depth review may have yielded more good-quality studies with low-risk of bias. In particular, a review of the gray literature may have provided relevant data. Furthermore, many of the studies reviewed here indicated that while there may be some association between information technologies and improved health outcomes, there are many information gaps and much more research is needed before robust conclusions can be drawn.

### 4. Conclusion

This review found some indications that the use of electronic health records email, social media, cellphones and text messaging may improve public health. This review
highlights the evidence gaps regarding the use of these emerging HITs and illustrates the need for more well designed studies to better assess the effects of these interventions.

References


Undergraduate Nurses’ Preferred Use of Mobile Devices in Healthcare Settings

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Abstract. The growth of digital technology has created challenges for appropriate and safe use of mobile or portable devices in healthcare environments. There is perceived risk that the use of mobile technology for learning may distract from provision of patient care if used by undergraduate students during work-integrated learning. This paper reports on a study that aimed to identify differences in preferred behavior of student nurses in their use of mobile technology during and away from the clinical practice environment. A previously validated online survey was administered to students during a period of work integrated learning in a range of healthcare settings in two Australian states. Respondents agreed that mobile devices could be beneficial to patient care. Overall, students proposed they would use mobile devices for accessing information, during work integrated learning, less than when away from the workplace. The development of policy to guide the use of mobile devices, in situ, is important to the provision of safe and competent care and improved health outcomes for patients.

Key words: undergraduate nurse; mobile technology; work integrated learning; mobile learning.

Introduction

The rapid growth in the use of mobile technology has created new challenges for learning and teaching (L&T) in the workplace. The easy accessibility of L&T resources via mobile devices challenges traditional strategies of knowledge and skill acquisition [1]. Currently, access and use of mobile or portable devices and web-based materials in the healthcare settings is mixed [2, 3]. While professional bodies and some organisations in Australia have developed social media guidelines, guidance regarding the access and use of portable devices for mobile learning at point of care is mixed [4]. Policies limiting access to mobile devices in healthcare environments are commonplace, indicating the need for guidance to support the development of trust by all stakeholders [2, 5, 6]. Additionally, there are reports of the benefits, barriers and challenges of the use of mobile devices [2, 7]. These risks include distraction from patient care, in situ, if used by students during work integrated learning (WIL) [8, 9]. To facilitate efficient and competent care to patients, the development of a culture of appropriate use of mobile devices is desirable. Undergraduate students are the next generation of nurses. Their perspective on the value of access and use of mobile devices in the workplace needs to be heeded if healthcare environments are to remain relevant and contemporary.
in their approach to communication and accessing information. This study examined undergraduate nurse perceptions about proposed access and use of mobile devices to enable safe, effective and competent care delivery by health professionals.

1. Methods

This cross-sectional study captured self-report of undergraduate nurses’ access to Internet or device-based resources, using a mobile or portable device, at and away from the workplace. The study involved administration of a validated (7) online survey to undergraduate nurses, while they were undertaking WIL during January 2014, at a range of healthcare settings in Australia. This research was approved by the University of Tasmania Human Research Ethics Committee, approval number H0013729.

Eligible participants were undertaking WIL during the study period. They were recruited via email. Two reminder request emails were sent at two-week intervals following the initial request. Consent was implied by completion of the survey. Survey data was analysed using SPSS (version 21). Descriptive analysis, Chi-square and Wilcoxon signed rank tests were used to explore differences in responses to scales for away from, and during WIL while Mann-Whitney U tests were used to investigate differences in median scores between hospital settings. All tests were two-sided and differences were accepted at $p < 0.05$ significance level.

2. Results

Students (n=476) undertaking WIL were invited to participate in this online survey and 84 responded (18% response rate). A filter question requiring access to a mobile or portable device rendered 37 respondents ineligible to complete the second section of the questionnaire, resulting in 47 complete survey responses. Fifty-two percent undertook WIL at major hospitals, the remainder were dispersed at district hospitals or community-based facilities. No differences were found in access to mobile devices for gender [$\chi^2(1) = 0.0, p = 1.0$], or geographic location [$\chi^2(1) = 0.8, p = 0.4$]. There were insufficient expected cell frequencies to establish associations for age group and focus of healthcare organisation. Additionally, there was no difference between the two groups when the categories were collapsed to investigate associations between access to a mobile device and type of WIL organisations.

Table 1. Proposed use of portable or mobile technology devices

<table>
<thead>
<tr>
<th></th>
<th>Away PEP Median (IQR)</th>
<th>During PEP Median (IQR)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobile telephone (not smartphone)</td>
<td>1 (1-3)</td>
<td>1 (1-2)</td>
<td>0.003</td>
</tr>
<tr>
<td>Smartphone</td>
<td>5 (3-5)</td>
<td>4 (1-5)</td>
<td>0.011</td>
</tr>
<tr>
<td>Audio player</td>
<td>1 (1-3)</td>
<td>1 (1-1)</td>
<td>0.002</td>
</tr>
<tr>
<td>Laptop computer</td>
<td>5 (3-5)</td>
<td>3 (1-5)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Mini laptop</td>
<td>2 (1-5)</td>
<td>2 (1-4)</td>
<td>0.07</td>
</tr>
<tr>
<td>Mini tablet</td>
<td>3 (1-5)</td>
<td>2 (1-4)</td>
<td>0.27</td>
</tr>
<tr>
<td>Tablet computer</td>
<td>3 (1-5)</td>
<td>3 (1-5)</td>
<td>0.8</td>
</tr>
</tbody>
</table>

Scale: 1 low use; 3 medium use; 5 high use; *p-values from Wilcoxon signed rank tests (7)
There were differences in reports of behaviour of respondents in their preferred use of mobile devices away from and during WIL (Table 1). Students indicated they would use a mobile telephone (not smartphone) less during WIL than away from WIL. Respondents proposed they would use smartphones and laptop computers in a moderate amount during WIL and have high use when away from the workplace. Students also indicated they expected to have low use of audio players during WIL, and medium use away from WIL. Students proposed there would be no difference in the use of mini laptops, mini tablets and tablet computers during or away from WIL.

### Table 2. Preferred use of mobile devices by students based at major hospitals and other healthcare facilities

<table>
<thead>
<tr>
<th>Item</th>
<th>Major Hospital Median (IQR)</th>
<th>Other health facility Median (IQR)</th>
<th>p-value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>I believe portable and mobile devices could be beneficial to patient and client care</td>
<td>4 (3-5)</td>
<td>4 (3-5)</td>
<td>0.55</td>
</tr>
<tr>
<td>I believe portable and mobile devices could be distracting to patient and client care</td>
<td>4 (2-5)</td>
<td>2.5 (1.00-3.75)</td>
<td>0.007</td>
</tr>
<tr>
<td>I believe portable or mobile devices can be a useful for learning during PEP</td>
<td>4 (3-5)</td>
<td>4 (3.25-5.00)</td>
<td>0.66</td>
</tr>
<tr>
<td>I believe portable or mobile devices can be a useful for learning away from PEP</td>
<td>5 (4-5)</td>
<td>4.5 (3.25-5.00)</td>
<td>0.39</td>
</tr>
<tr>
<td>I believe patients or clients think portable or mobile devices could be beneficial their care</td>
<td>3.5 (2.00-4.25)</td>
<td>3 (3.00-4.75)</td>
<td>0.75</td>
</tr>
<tr>
<td>I believe patients or clients think portable or mobile devices could be distracting to their care</td>
<td>4 (3-5)</td>
<td>3 (2.00-3.75)</td>
<td>0.12</td>
</tr>
<tr>
<td>I believe other health profession staff think portable or mobile devices could be beneficial patient or client care</td>
<td>4 (3.00-4.25)</td>
<td>4 (3-4)</td>
<td>0.67</td>
</tr>
<tr>
<td>I believe other health profession think portable or mobile devices could be distracting to patient or client care</td>
<td>4 (3-4)</td>
<td>3 (3-4)</td>
<td>0.35</td>
</tr>
<tr>
<td>I believe other health profession staff think portable or mobile devices could be beneficial to accessing learning or professional education and development information during PEP</td>
<td>4 (2.75-5.00)</td>
<td>4 (3-4)</td>
<td>0.35</td>
</tr>
<tr>
<td>I believe other health profession staff think portable or mobile devices would not be useful for accessing learning or professional education information during PEP</td>
<td>2.5 (1.75-4.00)</td>
<td>3 (2-4)</td>
<td>0.68</td>
</tr>
<tr>
<td>I am confident in using portable or mobile technology devices for communication during PEP</td>
<td>5 (3-5)</td>
<td>4 (1-5)</td>
<td>0.12</td>
</tr>
<tr>
<td>I am confident in using portable or mobile technology devices for communication away from PEP</td>
<td>5 (5-5)</td>
<td>4 (3.25-5.00)</td>
<td>0.003</td>
</tr>
<tr>
<td>I am confident in using portable or mobile technology devices for study purposes during PEP</td>
<td>5 (4-5)</td>
<td>4 (2.50-4.00)</td>
<td>0.17</td>
</tr>
<tr>
<td>I am confident in using portable or mobile technology devices for study purposes away from PEP</td>
<td>5 (4.75-5.00)</td>
<td>4 (4-5)</td>
<td>0.15</td>
</tr>
</tbody>
</table>

1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree; *p-values from Mann-Whitney U tests (?)

Analysis of preferred use mobile devices questions with gender, age, facility type and cohort demonstrated no difference between males and females or age. There was a difference between respondents based on WIL setting (Table 2). Students in community settings indicated they disagreed that portable and mobile devices could be distracting to patient and client care, whereas students based in major hospitals indicated they agreed with the statement. These respondents also strongly agreed they were confident in using mobile devices for communication away from WIL, whereas
those students located in community settings only agreed they were confident. The students at major hospitals were more confident in using mobile devices for communication for study and work purposes than those based in community settings. Students based at major hospitals also believed mobile devices can be useful for learning away from the workplace.

Pooled responses indicated respondents agreed the use of mobile devices could be beneficial for patient care and useful for learning during WIL. They also indicated health profession staff believed mobile devices could be beneficial for patient care and accessing learning or professional education and development information during WIL. Students based at major hospitals disagreed more strongly than the community based students that health profession staff would not find mobile devices useful for learning or professional education information during WIL. Respondents were less sure whether patients believe portable or mobile devices could be beneficial their care.

3. Discussion

The findings support the fact there has been growth in access and use of mobile technology over the last 10 years. Generational difference may have contributed to the preferred ubiquity of mobile devices in the workplace [10]. With two thirds of the respondents being aged under 41 years they would have used digital technology for much of their lives, so the proposal to have easy access to mini-laptops and tablet devices at the workplace is no surprise. Currently access to mobile devices within healthcare settings in Australia is low [9,10]. Students based in major hospitals were strident in their views indicating they strongly agreed they were confident in the use of mobile technology, consistently rating their agreement with the statements about mobile device use higher than students based in community settings.

Respondents from major hospitals perceived that patients and staff were more likely to believe that the use of mobile devices could be distracting to their care. This notion may be related to the perceived nature of the activities undertaken within this acute setting. Students may perceive this environment as more technological or complex than the out-of-hospital setting. Students may also perceive the acuity of patients is higher within the ward context than community settings. Due to the patient-load, routine or timeliness of care delivery in this setting, students may perceive there is less time or opportunity to use mobile devices. As the use of mobile devices in healthcare environments in Australia remains a novelty, students may be unaware of their potential capacity to assist with effective delivery of patient care. Students in community settings believed that the use of mobile devices was less likely to distract than students from major hospitals. The range of activities undertaken in community settings is broader than in major hospitals. Caseload, timeliness and focus of care delivery may contribute to student perceptions about the use of mobile devices being less distracting to patient care within the community context. Furthermore, communication styles and types of information shared may differ between the settings.

Study limitations include the low response rate which may reduce generalizability of the findings. Additionally, whilst anonymous, survey administration by university staff, may have resulted in social desirability bias occurring. Student enculturation about the use of mobile devices in healthcare settings may have occurred prior to survey completion. Peer disapproval and current hospital policies may reinforce student perceptions about use of mobile devices at work [9].
One method to progress the integration of mobile learning as a legitimate nursing function in the work place or in situ would be establishing a suite of appropriate resources that can be accessible by health professionals. An agreed standard of resources could begin to ameliorate perceived inappropriate or ad hoc access issues that form the basis of concerns about professionalism and consumer safety [6,11]. Consensus of credible resources would enable work places to guide students and staff in appropriate access while development of evidenced-based policy using further research into mobile learning in situ in healthcare settings is undertaken.

4. Conclusions

Undergraduate students are the next generation of health professionals. To enable them to deliver safe and competent care there is a need to integrate the use of mobile technology into the workplace. For the development of a culture of learning using mobile devices, there needs to be development of policies and guidelines to support student and health professionals, in the use of mobile devices in healthcare settings.

References

Modelling System Level Health Information Exchange: An Ontological Approach

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Abstract. Investment of resources to purposively improve the movement of information between health system providers is currently made with imperfect information. No inventories of system-level digital information flows currently exist, nor do measures of inter-organizational electronic information exchange (HIE). Using Protégé 4, an open-source OWL Web ontology language editor and knowledge-based framework we formalized a model that decomposes inter-organizational electronic health information flow into derivative concepts such as diversity, breadth, volume, structure, standardization and connectivity. Self-reported data from a regional health system is used to measure HIE; the ontology identifies providers with low and high HIE, useful for planners, and using a related database is used to monitor data quality.

Keywords. Ontological model; data quality; electronic health information exchange; health system performance

Introduction

Ensuring patients receive integrated care despite needing to navigate a complex and often disjointed collection of health care providers is a recognized precursor to providing quality care. It is also well recognized that a key enabler of integrated care is access to information about patients across the continuum of care [1]. It is interesting that while there is almost universal acceptance of the value of integrated, electronic health information; investments to improve the movement of electronic health information between providers are currently made with imperfect information. No inventories of system-level digital information flows currently exist, nor do measures of inter-organizational HIE [2]. Moreover, our limited understanding of information exchange between the sophisticated systems in hospitals and medical clinics is missing for entities in the extended circle of care such as home care and pharmacies.

The use of information and communication technologies to enable inter-provider exchange of information remains low in the healthcare domain [3]–[6]. Providers must make clinical decisions based on partial information, service can be delayed [7], [8], information is sometimes missing or received too late to be useful [9], [10]. Clearly there is a need to systematically describe and then assess progress towards healthcare system interoperability. An established body of literature describes and tests interoperability frameworks and models, much of it from military and business
domains (for example [11]–[14]). Unfortunately, to date there is no framework or model to describe system-level electronic information flows in the healthcare sector. A promising solution may lie in the use of an ontological approach to conceptualize the flow of information between providers, with the added benefit that if these flows can be modeled, they can also be measured – thus helping to solve the associated performance measurement conundrum [2], [15], [16]. While ontologies are common in biomedicine and are increasingly used in designing controlled vocabularies [17] and reference terminologies [18], there is little research into the use of ontologies applied to health information systems themselves [19], or in support of healthcare performance measurement [20]. Without shared or standardized semantic and lexical models, reliable and accurate comparison of health performance data across sectors and geographic borders is unachievable.

Here we explore the utility of an ontological model designed to conceptualize and measure electronic health information exchange (HEIO) between health entities in a regional healthcare system in Ontario, Canada. HEIO was created in Protégé 4, an open-source OWL Web ontology language editor and knowledge-base framework (Stanford Center for Biomedical Informatics Research, Version 4.1.0 Beta, 2011, from http://protege.stanford.edu). All data collection received ethics clearance from the University of Waterloo’s Research Ethics Board in accordance with protocols for research with human participants, including informed consent.

Methods

Model Design

An informal conceptual model of electronic health information exchange between a system of regional healthcare providers was developed based on an iterative process of brainstorming, reference to literature, and consensus development. Referring to Figure 1, our conceptual model focuses on technical interoperability, represented by Electronic Health Information Exchange, which is enabled via a digital connection with other health entities (the infrastructure - hardware, software and information system architecture, is outside the scope of this study). The model decomposes HIE into its derivative concepts and was used to design the formalized ontological model.

Ontology Development

The design of the ontology was informed by a questionnaire and interviews that were used to collect information from data originators and data consumers in a regional health setting in Ontario, Canada. A flexible, iterative process was used; natural language annotations were created for all classes, objects and data properties.
Results

Access to the OWL version of the HEIO ontology is available at BioPortal: HEIO http://purl.bioontology.org/ontology/HEIO. An example from the ontology’s upper level Class hierarchy is provided below (see Figure 2). The class of Health Entities has a subclass called Small Hospital Entities which has two properties – “hasOrganizationGroup” (that has a value (1) that identifies it as a Hospital Entity versus a Laboratory) and “hasOrganizationType” (that has a value (3) that identifies it as a Small Hospital versus a Community Hospital). Restrictions placed on classes (in this case derived from values on the questionnaire), allow the reasoner to automatically assign new data points to the correct class i.e. hospitals here were classified by a numeric value. However they might also have been classified by constraints such as a minimum number of beds or oversight by an academic institution).

**Ontology Use for Measuring Individual Provider’s Exchange Activity**

With the ontology created, we gathered self-reported electronic health information exchange data from 182 of 519 providers in a healthcare region. The data collected described the exchange activities of each individual provider under the conceptual concepts outlined in Figure 1. This data was used to populate derived classes such as the electronic health information exchange indicator (eHIE – a summative measure of electronic health information exchange), and high or low interoperability health entities (due to space restrictions these results will be reported elsewhere). The data were
manually entered into a database using SPSS (17.0.2., SPSS Inc., Chicago, IL) and a script written to import the data into the ontology. No imported individual data violated the class or property rules suggesting that all possible use-cases were successfully addressed by the model, and that there were no logically conflicting classes.

In order to quantify the electronic health information exchange activities of each of the health entities which submitted data, a number of new classes were created. Individual instance’s properties are inferred from their class associations as determined by their data and object property rules. For instance, we captured instances whose interoperability scores (eHIE) were deemed to be “high” (rule: eHIE > 0.5 out of a possible 1) or “low” (eHIE ≤ 0.5) in new classes called “HighInteroperabilityEntities” and “LowInteroperabilityEntities”.

**Other Uses**

Beyond extensibility, the automatic classification of new classes, properties and instances, the ontology may help to better understand and visualize relationships between the concepts in our model, and assist with regional analysis and planning to improve digital information exchange.

Few health systems are sufficiently resourced to fund the investments needed to support the most basic exchange activities [21], let alone assure semantic interoperability. A summative measure was calculated for Health Entities that estimated their Impact based on their patient volume, and the number of partners with whom they might exchange information. The use of the inference engine or reasoner allows for quick and accurate identification of Health Entities with a high Impact score but low Interoperability. This information could assist planners and policy-makers to prioritize investments into systems that will optimize improvements and adoption.

The ontology also allowed us to use a related but different database to triangulate the quality and reliability of self-reported data imported into the ontology. The class

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Figure 2. Hospital Entity sub-Class Small Hospital Entities and its Axioms
“ConflictedHealthEntities” was created for logical inconsistencies such as a respondent reporting they send or receive referral information without using an electronic provider registry.

Discussion

In 2007, Overhage referred to the inevitably of a “network of networks” that would transfer data between health information systems, and called for the need to formulate common requirements and “general concepts” for these interfaces [22]. These general concepts and common understanding of the network actors, their capacity for sharing information, and exactly how much information is being shared, are particularly important when measuring progress towards goals set by policy makers and funding agencies.

A number of approaches were considered to model the electronic health information exchange domain. For instance, entity-relationship (ER) diagrams are able to describe abstract conceptual models, and provide rich descriptions of entities, their relationships and attributes. However, ER diagramming is not hierarchical, nor does it provide the reasoning support that is so powerful when using an ontological approach. The ontological reasoner allows induction of novel information from the application of rules that are defined to constrain the classes. Future research might warrant the extension of the ontology using network analysis to map relationships between Health Entities and better understand how networks or coalitions with the regional health system are facilitating the adoption of information and communication technology to enable electronic health information exchange. We created a conceptual model of regional health information exchange with a hierarchy of classes, and properties for each class, describing various features and rules that enable the inference of new knowledge. The flexibility to extend a conceptual model and classify new concepts (for example, new health entities that will provide care in the future) is a hallmark of ontologies. This extensibility will allow the ontology to change in response to a relentlessly changing healthcare environment and also ensures that new definitions and concepts are immediately updated across any ontology linked to it currently, or in the future.

One of the reasons to gather data on the capability of individuals and systems to share health information electronically is to help decision making on where scarce financial resources can be put to the most productive use. The summative measure of regional electronic health information exchange might be used to set benchmarks that will allow policy makers and funders to compare the progress of regions towards the goals of semantic interoperability and seamless sharing of information. Clear communication of concepts, measurement models, validation of data and visualization of the domain of interest all improve the likelihood that the measurement of complex concepts such as interoperability can be communicated, understood, accepted by stakeholders and adopted for use.

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References


Nursing Handover using an Electronic Application for Community Nurses

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Abstract. Handover from one healthcare professional is an essential component of patient care. This can be a challenge in the community setting where care occurs in the patient’s home and clinicians do not have the benefit of face-to-face interactions with colleagues. The purpose of this study was to explore the nurses’ perceptions of handover and their views on using an electronic application as opposed to their current email system. Nurses completed two surveys, one prior to viewing the application and the second after reviewing the application. Both surveys were analyzed by educational preparation and age to explore whether either factor influenced opinions of handover or the electronic application. Nurses reported that handover was important and standardization of reporting improved their knowledge of their patients’ care plan.

Keywords. Nursing handover, electronic health record, reporting, safety

1. Introduction

Handover defined as “a transfer of acceptance of patient care responsibility achieved through effective communications. It is a real-time process of passing patient specific information from one caregiver to another... for the purpose of ensuring the continuity and safety of the patient’s care” [1]. This practice informs clinicians about the plan of care and efficacy of interventions provided by the healthcare team. Despite the World Health Organization’s identification of clinical handover as a top priority and a focus of research, many healthcare settings do not follow any type of formalized structure to pass on patient information [2]. Community nursing is a challenging environment to conduct handover when contrasted with acute care settings because patient data are stored in a number of locations, including charts in the home, the corporate office, and in electronic systems. This may lead to fragmented knowledge and potentially affect the quality of care and patient safety.

Transition points, as during handover are a time of risk for patients because of the transfer of authority from one provider to another. An Australian study found that 19.6% of patients had adverse events during a stay as short as 24 hours with communication issues were to blame in 11% of the time, and in some instances resulted in morbidity or even mortality [3]. The literature also describes a number of problems associated with inadequately structured handovers using the example of an increase in the number of fatal falls resulting from communication gaps between healthcare professionals to time...
workers. Inadequately monitored patients were at risk because of a failure to communicate \cite{4}. Findings from other studies found that information technology contributed to improved outcomes for patients by minimizing risks and “improve communication and collaboration among clients, families and health providers”\cite{5}. Stakeholders, including nurses who use report to understand the plan of care and the patient’s progress towards mutually defined goals can provide valuable information about the design and quality of an electronic handover application. While a standardized process for handover is found in some hospitals and long-term care facilities, they require adaptation to the community practice milieu to reflect the variances between environments. Evidence suggests that nurses whom trialed an electronic reporting application found it beneficial because it organized relevant information in “one spot”\cite{6}. However, applications must tell the patient’s story as opposed to just presenting data.

2. Objective

The objective of this study was to explore the perceptions of community nurses on the subject of patient handover and to understand their views on adopting an electronic handover application as part of their professional practice. Other questions considered included whether level of education or age affected nursing perceptions of handover or the use of an electronic handover application.

3. Methods

3.1. Design

The research took place in 2013 with nurses working at one community healthcare agency located in Southern Ontario. A convenience sampling method was used targeting visiting nurses, managers, and wound care consultants involved in the care of a medical/surgical patient population. There was a total potential sample size of 65 with 22 actual participants yielding a 34% response rate overall.

3.2. Procedure

Participants gave consent, received a brief definition of nursing handover, and completed Survey I. Survey I consisted of a 12-question likert-scale structured to explore participants’ overall satisfaction with the current practice of using email for patient handover.

Before viewing the electronic handover application, participants received a brief description of what they were about to see and trialed the application on a lap top computer. They viewed a wound care pathway and the “systems” tab, which summarized patient information according to body systems e.g. cardiovascular, hematological, and gastrointestinal in the application. After reviewing the forms, participants completed Survey II, a 12-question likert-scale tool, which asked their perceptions of the application. A search of the literature failed to find validated survey tools that would satisfy the research questions for this project and an implementation
satisfaction survey from Canada Health Infoway was adapted for this project \[7\]. To ensure readability and face validity, a small pilot group, representative of the sample, tested the surveys prior to conducting the research.

3.3. Data Analysis

Data analysis focused on determining whether academic preparation or age influenced the acceptance of an electronic handover application. Responses were analyzed according to their positive (“strongly agree, agree”) or negative (“strongly disagree, disagree”) response to express the degree to which participants aligned with a statement on a 5-point rating scale by statistical analysis including calculation of the means and a t-test for equal variance at a 0.05 confidence level. Participants were classified into three age groups. Statistical analyses of the data were not conducted for the 52-67 year old age group because of the small sample size and instead, the data were reviewed for recurrent themes in the responses.

4. Results

4.1. Demographic Data

Nurses working were grouped in the following three age categories.
- 50% (n=11) in the 20-35 year old age group
- 36% (n=8) in the 36-51 year old age group
- 14% (n=3) in the 52-67 year old age group.

4.2. Survey I Results

Survey I evaluated how nurses felt about the current reporting structure and their overall views on nursing handover (See Table 1.). Questions focused on exploring participants’ views of the email reporting system, whether they read report from peers, and if a lack of information had affected their patient care. Findings suggested a similarity between the responses of the 20-35 year old and the 52-67 year old groups suggesting that both viewed report on a mobile device as essential to nursing practice. Furthermore, both groups reported that a lack of information affected their patient care to the detriment of the patient.

Survey I results were also analyzed according to professional designation comparing registered nurses (RNs) to registered practical nurses (RPNs) to determine if there was a difference between the level of academic preparation and preference for electronic tools. The null hypothesis was there was no difference between the responses of RNs and RPNs. Mean responses were calculated and a t-test based of equal variance performed. At a 0.05 significance level, the p value for the two-tailed t-test with equal variance was 2.07 and the t stat was 0.403. The t-stat was smaller than the critical value and therefore it is not possible to reject the null hypothesis that there was no difference in the responses from nurses based on their professional designation.
Survey II questions explored acceptance of the electronic handover application in terms of useful information, ease of use, and effect on care. Comparison of the age groups found a strong similarity between the responses of the 20-35 and the 52-67 year old groups. Both were in favor of the application and suggested that it would contribute to their nursing knowledge.

Responses to survey II were also analyzed according to professional designation comparing RNs to RPNs to determine if there was a statistical significance between the level of academic preparation and acceptance to using the application (See table 2.). The mean scores of the two groups were calculated and a t-test based on equal variance performed. The t stat at the 0.05 confidence level and 22 degrees of freedom is 2.074 and the value for the t-test comparing responses by professional designation is 7.01, which is larger than the calculated value. Therefore, the null hypothesis in this comparison that there was no difference between the responses based on professional designation and the acceptance of adopting an electronic handover application was rejected. The RPNs had a higher level of acceptance for the electronic handover tool than the RNs in the study.

When asked what other elements should be included in the handover tool, participants provided the following feedback.

- Space to describe changes in wound status with diagrams and products used in care
- Embed formulas to perform wound calculations to monitor percentage healing
- Access information at point of care
- Access to medication administration records within the reports
- Provide free text fields to permit narratives
- Link handover with supply ordering
5. Limitations

While the sample may be representative of nurses in Southern Ontario and takes into account both rural and urban practice differences, the findings may not be generalizable to other areas of Ontario or Canada. Furthermore, the sample size for this project was small and could skew the results. Recognizing these limitations, this work was useful to highlight future research questions concerning safety during transitions in care.

6. Future Considerations

Healthcare organizations expect information technology will keep patients safe and improve care. Unfortunately, the electronic health record (EHR) does not address the issue of the heightened time of risk as one clinician passes responsibility to the oncoming team member. While EHRs hold information to inform practice, it lacks a way to present information in a meaningful way. The patient’s story becomes jumbled into unrelated sections and lacks flow. The handover application could pull information from the tables embedded within the EHR into a structured report according to a standardized methodology. This concept ties the two applications together linking patient data to a framework supports patient care and safety.

7. Conclusions

Nurses viewed handover as an essential part of professional practice and an electronic handover tool would improve nursing knowledge and promote safety. Research on the content and style of report, including the use of Minimum Data sets demonstrated that specific and structured report was important to staff and improved communication among team members. [8] Similarly, participants indicated that structured reports enhanced their nursing knowledge and improved their ability to provide care. Finally, other research findings emphasized the point that even when clinicians were using an EHR, they still required some type of oral or written handover [9]. During this study, nurses reported that the EHR did not adequately describe the patient’s clinical presentation and the use of a handover application supplemented the information in the EHR.

References


Abstract. Augmented Reality (AR) is a method whereby virtual objects are superimposed on the real world. AR technology is becoming increasingly accessible and affordable and it has many potential health applications. This paper discusses current research on AR health applications such as medical education and medical practice. Some of the potential future uses for this technology (e.g., health information systems, consumer health applications) will also be presented. Additionally, there will be a discussion outlining some of usability and human factors challenges associated with AR in healthcare. It is expected that AR will become increasingly prevalent in healthcare; however, further investigation is required to demonstrate that they provide benefits over traditional methods. Moreover, AR applications must be thoroughly tested to ensure they do not introduce new errors into practice and have patient safety implications.

Keywords. Augmented Reality, Heads-Up Display (HUD), Consumer Health Applications, Health Information Systems, Human Factors, Usability.

Introduction

Augmented Reality (AR) is a method whereby virtual objects are superimposed on the real world. AR is considered “a live view of physical real world environment whose elements are merged with augmented computer-generated images creating a mixed reality” [p.vii, 1]. AR should respond in real-time with the user’s movements in the real world and the computer-generated data is ideally semantically integrated with what occurs in the real world [1].

Several different ways of integrating computer-generated data with the real world exist. Hand-held see-through displays and projections are two methods for overlaying the real world with virtual objects [2]. Some AR systems use a camera to videotape the user in the real world and display back the recording to the user on a monitor, as though it were a mirror with additional information superimposed (e.g., [3]). It seems that Heads-Up Displays (HUDs) are destined to become the dominant delivery method of AR in the near future. A HUD is “any transparent display that presents data without requiring users to look away from their usual viewpoints” [4].

The reason HUDs are expected to dominate the future of AR is that they are emerging on the commercial market. For example, Epson has released Moverio™ to developers. This is Epson’s second generation of smart glasses equipped with accelerometers to detect movement, a front facing camera, and a display of both 3D and AR. However, interaction with Moverio™ requires the use of a cord-tethered...
control unit, which has obvious limitations [5]. Google is also in the initial stages of
releasing Google Glass™, a compact and inconspicuous HUD [6]. Given their
commercial deployment, HUDs will soon be easily accessible and relatively
inexpensive. The availability of this AR hardware will likely inspire application
developers to create and capitalize on AR in health informatics. This paper will discuss
the emerging trends and potential uses of AR as well as human factors considerations
of AR in healthcare.

1. Emerging Trends of AR in Healthcare

Given the technology’s increasing affordability, AR will likely proliferate in healthcare
because of its ability to synthesize information, literally, around the patient or consumer.

1.1. AR Medical Education

Several applications of AR for medical education have been proposed, are being
developed, or are in the early stages of release. Given the relative ease of integrating
information and images into the real world, AR could prove to be a useful learning tool
for medical students and health consumers alike. For example, AR applications exist
for teaching anatomy (see Figure 1). Researchers have developed a system that
superimposes a scaled set of standard CT images onto the front of the user and cross-
sectional anatomical views are displayed in the corner of the monitor [3]. The user
navigates through frontal and cross-sectional views by moving his hand up and down
and changes the direction of the slicing (i.e., sagittal, coronal, transverse) by changing
the plane of the hand [7]. Additionally, this system can also display 3D models of
organs, informative text, and images [3]. AR has also been adopted to show
visualizations of skeletons on medical manikins [8].

![Figure 1. Examples of Anatomy AR Learning Tools. A) Arm Bone, an application that teaches the bones of the arm and hand. Image courtesy of the developer Damon Hernandez. B) Mirracle, an application that teaches anatomy internal organs. Image courtesy of Ma Meng, University of Munich.](image)

1.2. AR Medical Practice and Procedures

In medical practice, AR can often replace traditional, independent monitors because
physiological and graphical data can be mapped directly onto the patient or within the
clinician’s field of view. For example, AR can be used to visualize ultrasounds [9] and
CT scans [10]. AR is also being explored for use during surgery. An optical camera was combined with a mobile X-Ray device to allow surgeons to simultaneously view internal elements (e.g., bones) and the standard real-world view (e.g., scalpel, surgeon’s hands) [11]. Recently, a Google Glass™ application was developed by Avvent to guide dental surgeons during implantation surgeries [12]. The application includes: a preoperative checklist; QR code implant verification; guided surgery protocol; and the ability to take photos for surgery documentation [12].

1.3. AR Health Records

AR may also become useful for recording and displaying patient data. Unlike current computer based records, AR would allow providers to view the relevant data simultaneously as they conduct examinations [2]. There are two important ways that AR could facilitate providers’ cognitive processing. First, providers will no longer have to divide their attention between computers and patients. Second, the natural mapping of AR onto the patient’s body could make previously documented issues immediately apparent to providers. By improving the contiguity of the information, the need to scan text-based records for pertinent information is mitigated. Another potential benefit of using AR to record patient data is that health issues that manifest themselves visually (e.g., cysts, moles, wounds) can be monitored for progression over time using built-in cameras. Further, the previously documented size of the issue could be projected onto the current size to provide an easy comparison of improvement or deterioration. It seems likely that AR technology will adopt more functionality to become increasingly useful in general practice. For example, having a flashlight embedded directly in the AR device would likely be useful when performing exams. Or perhaps, a camera could be added that is able to zoom in and show more than what can standardly be seen. Moreover, as AR technology becomes more powerful, it becomes plausible that these systems will be able to detect health issues (e.g., microorganisms, tumors) that are not visible to the naked eye and facilitate care provision through early detection.

1.4. AR Consumer Health Applications

In addition to providing educational resources, AR may benefit consumers. Given the popularity of health monitoring devices, it is likely that there will be a rapid uptake of AR for this purpose. As with existing health monitoring devices, AR will likely be used to monitor and provide feedback on performance indices such as users’ heart rate, speed, distance, route, and progression towards daily goals. However, most health monitoring devices currently available provide feedback at intervals (e.g., audio of average pace at every km) and in between these intervals the devices must be viewed to extract this information. Unlike traditional health monitoring devices, Oakley developed Airwave™ [13] a pair of HUD goggles for snow sports that displays metrics such as the user’s current speed, maximum speed, jump height, jump distance, and airtime directly into the field of view as the user descends down the slopes. Thus, it is expected that AR will be adopted for other sports such as running, cycling, and walking. Facilitating the feedback loop by allowing users to view their speed in real-time, without having to shift their attention to a device, will likely allow users to improve their adherence to activities such as a) interval training which requires speed transitions b) maintaining a specific heart rate during exercise (see Figure 2). This type of immediate monitoring may also be useful for people suffering from stress and anxiety.
by providing guided breathing exercises and showing the corresponding physical responses.

Figure 2. Example of a potential AR consumer health application.

Future uses of AR for consumers may include preoperative education and postoperative rehabilitation. In one study, surgeons responded positively to the concept of an AR supported patient education system for preoperative consultations [14]. After undergoing surgery, consumers are provided discharge plans and AR may be a valuable tool in adhering to these plans. AR could facilitate medication management by reminding consumers of administration times, helping users select the correct medication and determining the correct dose, as well as guiding the actual administration of the medication (e.g., an injection). AR may also assist users in correct performance of rehabilitation exercises and prevent detrimental movements by using accelerometers to detect potentially problematic postures.

2. Usability and Human Factors in AR

The appeal and potential of AR in healthcare may lead to its premature deployment in healthcare. It is unclear whether this technology clearly provides benefits over traditional methods of healthcare provision as of yet. To improve their likelihood of success and efficacy AR systems in healthcare must be designed with careful consideration for a) who their users will be, b) what tasks they will be used for, c) where these systems will be used, and d) what unintended implications their use might have.

Perhaps one of the greatest challenges for AR is the method of interaction. That is, because AR is displayed in the user’s field of view and not a device, new methods of interaction must be explored beyond the traditional graphic user interface. Examples of interaction methods currently used for AR include: control pads, hand gestures and
body movements, as well as voice commands. It is predicted that eye tracking and blinking gestures will also be tested for their potential utility for AR interaction.

Another important challenge for AR in healthcare is to limit the display to only pertinent information, presented at the most meaningful times, without overloading or distracting users. Designers must be aware the risks of phenomena such as attentional capture and inattentional blindness [15], as these effects have been associated with HUD use in other domains. For example, pilots failed to detect important events in their environment (i.e., a plane on the runway) until too late, because they were so intently focused on the HUD information [16]. Thus, it is imperative to extensively test AR health applications in controlled environments (e.g., simulations), as they may have repercussions on patient safety if they are poorly designed or in certain situations.

In summary, AR has a vast potential of applications in clinical and consumer health informatics. AR may even revolutionize the delivery of healthcare and health promotion. However, it has yet to be demonstrated whether these new types of information displays offer any benefits over their predecessors. Further, issues remain around AR technology and software design with respect to human factors and usability that must be identified and remedied for these systems to be successful.

References

Optimizing the Efficacy of Multimedia Consumer Health Information

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Abstract. Using two or more communication methods (e.g., text, narration, pictures, animation, video) is known as multimedia. Multimedia has been used in a broad range of domains. Not surprisingly, multimedia is gaining popularity in the field of consumer health information as its benefits are being recognized. However, there is a large body of evidence in the cognitive literature that could be used to inform and optimize multimedia presentation of consumer health information. This paper outlines the Cognitive Theory of Multimedia Learning (CTML) and presents the application of this model for consumer health informatics. The CTML is a valuable resource for the development and revision of consumer health information to optimize its efficacy. Current research on multimedia and consumer health information is described. Finally, the outstanding opportunities to leverage the CTML for consumer health information are discussed.

Keywords. Multimedia, Consumer Health Information, Cognitive Theory of Multimedia Learning

Introduction

One approach to information design that is gaining popularity in consumer health is multimedia. Multimedia combines multiple communication methods to convey information in an attempt to communicate more successfully than if only a single method was used. Therefore, multimedia learning is the formation of mental representations from words and pictures and multimedia is defined as “presenting words (such as printed text or spoken text) and pictures (such as illustrations, photos, animation, or video)” [1, p. 2]. Currently, consumer health information materials are often at risk of being suboptimal, because they are developed without leveraging the existing body of research on multimedia that contains evidence-based principles to facilitate learning through the design of multimedia presentations.

Multimedia has been deployed successfully in a variety of domains (e.g., education, entertainment, advertising) [2]. More recently, healthcare providers have also begun to embrace multimedia for an array of purposes including provider education and training (e.g., virtual reality based anatomy software), patient-provider interactions (e.g., telemedicine), collaboration amongst providers (e.g., annotated digital imaging, teleconferencing), patient rehabilitation programs, as well as early exploration into educational interventions for health consumers [2]. Consumers are adopting more participatory roles in their healthcare and multimedia is a promising area for enhancing their understanding of health information. Yet, there is a paucity of

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research exploring the utility of applying cognitive theory to multimedia design for conveying health information.

This paper will outline a) the Cognitive Theory of Multimedia Learning (CTML) b) a selection of current research on multimedia and consumer health information c) the outstanding opportunities to leverage the CTML and extend this model to consumer health information.

1. Cognitive Theory of Multimedia Learning

One of the foremost theories in multimedia is the Cognitive Theory of Multimedia Learning (CTML) [3]. CTML represents multimedia learning from a human information-processing perspective [4]. As shown in Figure 1, CTML is comprised of three memory systems or stores: sensory memory, working memory, and long-term memory [3]. Sensory memory holds exact visual and auditory information, but this information is subject to rapid decay [4]. Working memory plays a critical role in multimedia learning, as working memory is where sound and image information brought in from sensory memory are constructed into pictorial and verbal models, which are then integrated with existing knowledge from long-term memory [4]. Thus, working memory is aptly named because it system that organizes new information and merges it with previous experience and understanding to generate mental models. Working memory is limited in capacity and information in this system decays rapidly (though less rapidly than sensory memory) [4]. In contrast, long-term memory stores a vast amount of knowledge over a long duration.

Mayer [3] provided three pivotal assumptions to CTML: (1) audio and visual information are processed in two independent channels (2) these channels have a limited capacity of information they can hold and process; (3) people must actively engage with the information to construct knowledge from multimedia.

The CTML has been applied specifically for consumer health information in this paper (see Figure 2). Figure 2 emphasizes the differences in the processing of consumer health information in terms of a) the type of multimedia presentation (consumer health information), b) the type of system inputs (health words, health pictures), and c) how the presentations are integrated with long-term memory (previous health knowledge).

Figure 1. Cognitive Theory of Multimedia Learning (CTML) (from Mayer 2005b, p. 37, with permission)
2. Multimedia Principles

Mayer [3] proposed a set of design principles for multimedia learning to facilitate how people cognitively process multimedia presentations. That is, the multimedia principles were developed to guide the design of multimedia presentations to optimize the selection of relevant information, the organization of the selected material into a mental model, and its integration with existing knowledge. As a result, using the multimedia principles improve understanding, memory, and the ability to extrapolate information. Several of these principles are grounded in previous effects reported in cognitive psychology. Mayer [3] tested these effects more extensively with multimedia presentation stimuli and generated evidence that certain conditions led to improved retention and transfer. Based on his research, Mayer [3] originally proposed the following seven research-based principles for multimedia learning (see p. 184): Multimedia Principle, Spatial Contiguity Principle, Temporal Contiguity Principle, Coherence Principle, Modality Principle, Redundancy Principle, Individual Differences Principle. However, additional multimedia principles (e.g., Signaling principle, Segmenting Principle, Pre-training Principle, Personalization Principle) have subsequently been identified that also benefit multimedia presentation design [5]. In summary, the multimedia principles aim to guide multimedia design to communicate more effectively by ensuring a) extraneous processing is reduced b) essential processing is manageable and c) generative processing is fostered [5].

3. Studies on Multimedia Consumer Health Information

A PubMed search using the terms “multimedia learning principles” and “health information” identified no studies explicitly leveraging the guidance of the multimedia principles for consumer health information. However, a recent paper [6] advocated for borrowing from the cognitive literature on multimedia learning to enhance communication between pediatricians and parents.

Although the multimedia learning principles are underutilized, there is a growing body of evidence that supports the CTML in consumer health information. Specifically, the advantages of using pictures to complement text in health communications has been recognized and investigated (for review see [7]). Houts and colleagues [7] found that health information with pictures tended to attract more attention, as well as improve comprehension, recall, and adherence. Moreover, these researchers also noted that the
gains associated with adding images to text were frequently more substantial for those with limited health literacy [7].

The utility of incorporating pictographs (i.e., simple, descriptive, line drawings or symbols) into health information is becoming increasingly popular. Older, limited-literacy participants reported that hip replacement discharge instructions pictographs enhanced their understanding of the materials [8]. Additionally, techniques are being developed and tested that can automatically generate pictographs from text. For example, written discharge instructions were parsed for content (e.g., call doctor, faint, dizziness) and matched with pictographs in a database to automatically generate illustrated discharge instructions [9]. These illustrated discharge instructions were found to improve recall over their standard text-based counterparts [9].

Although consumers are provided monographs for new prescriptions at the pharmacy, it cannot be assumed that consumers are able to understand and make use of this information. In one study, nearly four out of five participants misinterpreted at least one out of 10 common prescription labels [10]. Given its demonstrated value in other domains, different types of multimedia presentation have been explored for their utility in conveying medication information. For example, participants reported that pill cards using pictographs to depict the purpose of the medication and when the medication should be taken were helpful tools to scaffold memory [11]. Similarly, many community-based pharmacies have adopted the use of pictographs on blister packs to reinforce the time of day medications (e.g., morning, lunch, dinner, bed time) should be taken. In a review of the efficacy of pictorial aids in medication instructions, the evidence suggested that pictorial aids often facilitated recall, comprehension, and adherence [12]. Additionally, Katz and colleagues [12] suggested that pictorial aids were particularly beneficial for depicting dose times, dose instructions, as well as communicating the importance of completing a course of therapy (e.g., antibiotics). However, these authors noted that some studies did not yield benefits from using images to convey medication instructions and posited that some icons (e.g., clock icons) may not have enhanced understanding because they were too complex [11]. Thus, these authors endorsed a combined approach using images in conjunction with written or oral medication instructions to mitigate image misinterpretation [12].

4. Opportunities for Multimedia Consumer Health Information

Despite mounting evidence in support of the benefits of using multimedia to convey health information to consumers and in support of the CTML, the empirical evidence from multimedia learning does not appear to be leveraged in material development. Thus, there is an inherent risk that these materials are not being designed to optimize learning. Moreover, there are likely opportunities to improve existing multimedia consumer health information to improve its efficacy.

A parallel comparison of the landscape of multimedia in consumer health information can be drawn with an emerging body of literature surrounding multimedia for medical education. A wide range of multimedia has been deployed for teaching medicine (e.g., anatomy, physiology, surgical procedures) to clinicians [13], yet many of these instructional materials are not developed to ensure they convey the information as effectively as possible [14]. The majority of Mayer’s research on multimedia occurred in controlled laboratory conditions, with brief stimuli exposures, and primarily undergraduate student participants, which may limit the generalizability of
the principles. However, medical students who viewed a slide presentation grounded in the multimedia learning principles had significantly better retention and overall scores than those who were shown a traditional presentation on shock [15]. Further, a recent review found that the multimedia principles were generally underutilized in an extensive set of medical animations \([n = 430]\) [16]. Thus, despite evidence that the multimedia principles enhance learning in medicine, these principles are not commonly incorporated in medical education materials.

A similar situation is emerging in consumer health information as in medical education whereby evidence supports the CTML, yet the multimedia principles are underutilized. Thus, consumer learning could be suboptimal when materials are developed without being informed by the multimedia principles. As multimedia presentations of consumer health information become increasingly common, it is prudent recognize the value and embrace the multimedia principles for the development and revision of materials to optimize learning.

References

Using Personal Health Records to Scaffold Perceived Self-Efficacy for Health Promotion

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Abstract. According to Bandura (1977), believing in one’s ability to achieve a goal is one of the best predictors that a goal will be accomplished. Given its predictive power, the concept of belief in one’s ability to succeed, or perceived self-efficacy, is well researched for its influence on health promotion. It has been argued that a paradigm shift must occur away from illness treatment towards illness prevention and health promotion, for healthcare to accommodate the needs of the population. Personal Health Records (PHRs) may be a tool to help facilitate this paradigm shift. PHRs are repositories of information that individuals can use to access, manage, and share their personal health information. An extension of Bandura’s model of self-efficacy will be presented here which identifies opportunities for PHRs to enhance perceived self-efficacy through mastery, social modeling, social persuasion, and physiological state. Bolstering self-efficacy through PHR tools will expand the utility of PHRs beyond self-management to also facilitate health promotion and illness prevention and gains in self-efficacy are also likely to transcend into other areas of consumers’ lives.

Keywords. Perceived Self-efficacy, Personal Health Records, Health Promotion, Illness Prevention

Introduction

“I think I can. I think I can.” [1]. Despite being a children’s story the Little Engine That Could [1] instills an important message for attaining success at any age: believing in your ability to succeed. In fact, this concept, referred to as perceived self-efficacy, is one of the best predictors of achievement [2]. Bandura defined perceived self-efficacy as “a person’s belief in their ability to produce desired results by their own actions” [3] and further described it as the foundation of human motivation and accomplishment. Indeed, a review revealed that self-efficacy was often successful in predicting and explaining a variety of health behaviours (e.g., adherence to medication, risky sexual activities, physical exercise, nutrition and weight control, addictive behaviours) [4].

Believing that one can change and overcome obstacles is essential to adopting healthy behaviours and abandoning poor habits [5]. Bandura [5] also asserted that self-efficacy acts similar to a lens that filters goals, outcomes, and obstacles. That is, individuals with high self-efficacy set higher goals, anticipate more favourable outcomes, and are more likely to persevere to overcome obstacles [5]. In contrast, those

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with low self-efficacy set lower goals, anticipate unfavourable outcomes, and are liable to succumb to impediments and admit failure [5]. Therefore, consumers with low perceived self-efficacy require the most instruction and guidance to achieve health related behavior change [5].

Personal Health Records (PHRs) allow individuals to govern (e.g., save, maintain, share) their own health information gathered from a variety of different sources. PHRs exceed the repository nature of paper records, by having added functionality due to their digital format. PHRs offer minimal inherent value, if they simply provide access to an individual’s health record; the potential value of PHRs rests within the opportunity to integrate tools for self-management in a single, seamless software application which can provide informational and emotional support its users [6]. PHRs have been lauded for their capability to promote chronic illness self-management; however, they may also have value in facilitating health promotion. Specifically, healthy behaviours might be more readily adopted if PHRs provide tools that scaffold perceived self-efficacy. Although, perceived self-efficacy is a well-researched construct, there is a dearth of research on opportunities to enhance perceived self-efficacy through the design and use of Personal Health Records (PHRs). This paper will present a modest extension of Bandura’s model of perceived self-efficacy to depict how this construct could be bolstered through the use of PHRs tools to support the adoption of healthy behaviours.

1. Sources of Perceived Self-Efficacy

Perceived self-efficacy is derived from both direct and mediated experiences that contribute to several sources of information regarding capability [2]. There are four sources of self-efficacy: enactive attainment, vicarious experience, verbal persuasion and physiological state [2, 5]. Bandura [3] described that each of these four sources have respective methods for developing self-efficacy: mastery, social modeling, social persuasion, and physical and emotional states. The potential for PHRs to contribute to fostering self-efficacy through these four methods will be discussed and summarized in an extension of Bandura’s model.

Perhaps the most influential source of acquiring information pertaining to perceived self-efficacy is enactive attainment because it is derived from personal accomplishments through which mastery is achieved. Personal successes enhance evaluations of personal efficacy, whereas failures mitigate them [7]. Furthermore, a robust sense of self-efficacy acts as a protective barrier to minimize the negative effects of failure and promote perseverance [7]. Some of the factors that influence enactive attainment are: task difficulty, expended effort, and required assistance [7]. That is, task success has the most enhancing impact on self-efficacy if the task is challenging, requires sustained effort, and the individual does not require assistance for its completion.

Another source of information about personal capabilities to be considered is vicarious experience. An observer can be convinced that he or she also has the capability to achieve success in similar tasks by observing or visualizing other people accomplish tasks [8]. Thus, social modeling is an effective tool to enhance self-efficacy by demonstrating both effective techniques to achieve success and portraying the successes of individuals who are similar to the observers themselves [5]. The extent of similarity (e.g., age, gender, educational and socioeconomic level, race, ethnicity)
between the model and the observer is a primary factor in enhancing self-efficacy through social modeling [5].

The third origin of information about personal efficacy is *verbal persuasion*. Social persuasion is a prevalent method used to convince people they have the capabilities necessary to achieve success [5]. However, Bandura [5] warns that its effects on enhancing self-efficacy may not be sustained over time, especially if the results of an individual’s subsequent actions are not successful. Moreover, it is unfortunate, but self-efficacy is more susceptible to deleterious social persuasion than beneficial social persuasion and the negative effects of social persuasion can be enduring [5].

The final source of self-efficacy information described by Bandura [5] is *physiological state*. That is, how the body responds to stressful or taxing situations affects how individuals evaluate their capabilities [5]. Physical indicators of self-efficacy also extend beyond the autonomic system and include strength and stamina [5]. Thus, bodies cue individuals about performance through feedback and also dictate limitations.

2. Opportunities for PHRs to Scaffold Sources of Perceived Self-Efficacy

As previously noted, PHRs may be able help their users adopt healthy behaviours by developing the four sources of self-efficacy. Methods of bolstering the four sources of self-efficacy through PHRs will be proposed by complementing Bandura’s [3] model (see Figure 1) and these new opportunities will be discussed.

![Figure 1. Model depicting the sources perceived self-efficacy, example methods to develop these sources (in brackets), and how PHRs might employ these methods to bolster perceived self-efficacy.](image)

PHRs can be used to help individuals attain their goals and help them foster a sense of mastery, which contributes to the *enactive attainment* source of self-efficacy. Further, these successes are documented so individuals can observe their progress retrospectively and thus enhance their sense of accomplishment. PHR self-management
tools (e.g., record medications, nutrition, exercise) may also be useful for enactive attainment. Moreover, using the PHR to record and observe changes that are not visible (e.g., lowered blood pressure, a few pounds of weight loss) may sustain motivation. Thus, the tools within PHRs can help individuals stay motivated, reach their goals, and look back on their previous successes. By offering relevant examples (e.g., video clips) of others who have achieved success and the methods they employed to attain this success, PHRs might enhance vicarious experience. Further, because PHRs contain demographic information, the models used to portray task accomplishment can be automatically selected for the user.

Social support is another facet of vicarious experience that PHRs might enhance. There is consistent evidence of a number of positive health outcomes associated with social support [e.g., 9]. The effectiveness of social support has been recognized and integrated into programs (e.g., Weight Watchers, Alcoholics Anonymous) to help facilitate behaviour change for decades. PHRs can be used to connect similar individuals online so that they can rely on each other’s experiences and provide one another encouragement [10]. Individuals can be matched automatically by PHR data based on their personal characteristics, goals and illnesses. Thus, these relationships will be based more on empathy than sympathy. Furthermore, these individuals can relate to each other’s struggles and provide genuine support and motivation through difficult challenges that may arise. In addition to online social support, PHRs can be used to notify individuals of local community programs and events to encourage their participation. Local programs provide support and can enhance their self-efficacy by learning how others have achieved success and feeling as though they are capable of succeeding. Participating in local programs may also help sustain motivation for goal pursuit. The difference between whether or not individuals feel as though they are facing challenges alone may play an imperative role in facilitating behaviour change and maintaining this change over time.

PHRs can be used to for verbal persuasion by relaying, and automatically generating, encouraging statements and reminders. Although some PHRs offer secure physician-patient messaging, it is unlikely that a care provider will monitor a PHR unless a critical intervention is necessary (e.g., smoking cessation, weight loss, diabetic stabilization). However, the PHRs could act as messaging forums to facilitate social support so that individuals can exchange messages of encouragement and progress. Using PHRs to exchange progress reports and express concerns when real-time face-to-face interaction is not possible may extend the aforementioned benefits of social support. Furthermore, the capacity for PHRs to automatically generate encouraging statements based on successes (and failures) may be prove useful. For example, if an individual has been increasing their exercise levels and has been logging their daily activity but has not entered any exercise in two days the PHR could prompt the user “You are doing so well! Don’t stop now. It’s a great day for a bike ride.”

Providing feedback to users about their physiological state may be another opportunity for PHRs to enhance perceived self-efficacy. Although our bodies provide cues to indicate when we have reached our limit, sometimes the changes in our bodies may be so subtle they go unnoticed (e.g., losing a few pounds, a decrease in blood pressure). However, PHRs offer the capacity to complete a feedback loop of information that may go undetected and monitor these values over time. Scales, glucometers, blood pressure machines, and other health monitoring devices are being integrated with PHRs to automatically input physiological data and it is likely that this list will continue to expand.
3. Discussion

There is an opportunity to capitalize on the capacity of PHRs to support health promotion and this initiative will likely be more successful if the construct of perceived self-efficacy is incorporated into PHR design. As shown in the extension of Bandura’s model of perceived self-efficacy presented here (see Figure 1), PHRs can foster positive judgments of self-efficacy through enactive attainment, vicarious experience, verbal persuasion and physiological states. Given the impact of self-efficacy on behaviour both directly and indirectly (i.e., through outcome expectations, goals and perceived facilitators and impediments), it is crucial that PHR design incorporate as many methods as possible to enhance judgments self-efficacy.

Given the potential of PHRs to reach a broader audience and provide anonymity to their users, they are a viable supplement to the success observed through traditional behavioural intervention methods. Providing tools for health promotion will foster the paradigm shift from merely treating illness to preserving and facilitating health. Convincing consumers in their capability to accomplish goals gives them the best chances at achieving favourable outcomes. Moreover, developing self-efficacy in one domain (i.e., health promotion) is also likely to have beneficial effects on consumers’ more generalized sense of self-efficacy. However, there is also a risk that if users become frustrated with PHRs or find them unusable, PHRs could become an impediment and negatively affect consumers’ perceived self-efficacy. Further work is required to validate the extensions to Bandura’s model described in this paper and explore whether PHRs might even detrimentally affect consumers’ perceptions of self-efficacy.

References

Readiness of Nurse Executives and Leaders to Advocate for Health Information Systems Supporting Nursing

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Abstract. Literature suggests that nurses at all levels remain unprepared to make use of full use of technologies required for current practice. Specifically, nurses lack sufficient background to engage with information systems, electronic records, and unit-level and aggregated data that could support understanding of the contributions of nursing services to care and the development of best practice guidelines. Given that nursing leadership is needed in this area, the authors conducted a review of graduate nursing curricula preparing nurses to take on leadership, management and executive roles. Findings revealed that only 12 out of 36 graduate nursing programs on the west coast of the US and Canada required any content in informatics, and five more offered elective opportunities. Implications for education and practice are discussed.

Keywords. Nursing informatics, nursing curriculum, health information systems

Introduction

Health information systems today present opportunities for practice improvements based on increasingly sophisticated technologies that can be used to capture, store, retrieve and use data. These systems provide information to support planning safe, reliable and efficient care at a unit or institution level, and can also provide ability to aggregate, analyze and mine large data sets to identify and evaluate best practices and achievable outcomes. However, many clinicians (e.g. nurses, physicians, dieticians, occupational therapists) in health care leadership or executive positions may not have a sufficient background to fully embrace the technologies that are used in practice, understand their impact on professional work, or to begin to imagine the changes in practice that one could envision when using a modern data-driven system. Nursing faces challenges, perhaps more than other health professions, where on the one hand there is an identified specialty of Nursing Informatics and on the other hand, there seems very little advocacy about health information systems and nursing information systems from nurses outside the specialty (i.e. nurse leaders). Nurses working in informatics know how important it is to have colleagues working together to design...
and implement information systems, and value the notion of professionals listening to others’ needs for planning, documentation, and assessment of workflow changes created by information systems. However, literature documents that many nurses, including those in advanced practice and leadership roles, have little background in informatics to understand the needs other nurses express for an information system that supports nursing documentation, quality improvement initiatives and research. In an effort to explore this state, the authors evaluated the educational programming in health informatics for future nursing leaders to determine the level of exposure nursing graduate students have to the field of nursing and health informatics and will provide recommendations for graduate nursing programs, moving forward.

Relevant Literature

Nursing literature documents a resistance to teach, use and advocate for nursing and health information systems. Current data show that practicing nurses [1], nursing faculty [2], nursing doctoral students [3] and graduating nurses [4] do not hold sufficient knowledge of information systems to make full use of them in clinical practice, let alone to guide the design and development of nursing and health information systems. Yet, there is a history of over 40 years in Nursing of development of standardized language systems (see Table 1). These terminologies were developed for use in digital documentation of the full range of nursing activities and each can be mapped to SNOMED-CT. These terminologies encompass an assessment of the human response to health conditions faced by patients and their families, identification professional activities addressing patient needs, and movement toward (or achievement of) outcomes that are a result of personalized plans of care. Use of these standardized languages, all of which are computer-codeable, provide a means of documenting day-to-day care. In addition, researchers have observed additional benefits. Several have concluded that use of consistent and standardized nursing language results in improved clinical reasoning among the nurses [5-8]. These authors have suggested such use leads to higher quality nursing care and that standardization has influenced retrieval of data quality outcomes with demonstrated the value of professional nursing. Other researchers have documented benefits provided by all electronic health care systems including: tracking data, using data intelligently, and understanding population-based trends [9-10]. Yet, there are few examples of health information systems that incorporate nursing language and even fewer examples of nursing executives working with hospitals and vendors to make the changes to information systems. Without the documented benefits for Nursing and its contributions to the health status of individuals, it is hard to understand the seeming lack of interest and support for nursing information systems among nurses. One reason suggested for this lack of interest is a move toward ‘inter-professionalism’ or ‘inter-disciplinary’ practice that can be taken up in a way to prohibit use of any disciplinary language [11]. Another reason might simply be that nurses do not have the background to articulate or to hear the need of the discipline to have information systems responsive to nursing practice as the literature implies. Thus, we asked the question: “Are we preparing nurse leaders with the competencies needed to advocate for inclusion of nursing information systems?”
Method and Design

We answered the question by exploring whether or not the content of nursing and health information systems are included in current course descriptions of curricula preparing current and future nurse leaders.

We designed a descriptive study to apply qualitative content analysis to determine frequency of informatics content in graduate level nursing leadership curricula. A list of 36 schools of nursing on the west coast of the United States and Canada was generated. Publicly available course descriptions were reviewed for all courses in graduate and post graduate nursing leadership programs. Key phrases that contained the following words were used: Informatics, Electronic Documentation, Standardized Language, Clinical Information System, Interoperability, and Nursing Diagnosis. Tabulation of data was conducted noting the course name and number where the sought-after key words were found.

Table 1 Nursing Standardized Languages

<table>
<thead>
<tr>
<th>Terminology Name</th>
<th>Description</th>
<th>Intended Use</th>
<th>Year First Developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Omaha System</td>
<td>Taxonomy of data elements</td>
<td>Documentation of care in community agencies, home care, public health</td>
<td>1970</td>
</tr>
<tr>
<td>NANDA-I</td>
<td>Taxonomy and Classification of Nursing Diagnoses (patient care concerns for which the nurse is accountable)</td>
<td>Documentation of issues addressed independently as part of professional nursing practice</td>
<td>1987</td>
</tr>
<tr>
<td>Nursing Interventions Classification (NIC)</td>
<td>List of nursing activities carried out in all areas of nursing practice</td>
<td>Documentation of nursing actions</td>
<td>1990</td>
</tr>
<tr>
<td>Nursing Outcomes Classification (NOC)</td>
<td>List of patient care outcomes for which the nurse in accountable</td>
<td>Outcome assessment of nursing care; assessment of change in status such as movement toward intended outcomes</td>
<td>1992</td>
</tr>
<tr>
<td>International Classification of Nursing Practice (ICNP)</td>
<td>Unified system of nursing terms that include nursing diagnoses, interventions and outcomes</td>
<td>Documentation of nursing care</td>
<td>1990</td>
</tr>
<tr>
<td>Perioperative Nursing Data Set (PNDS)</td>
<td>List of nursing terms related to the perioperative experience</td>
<td>Documentation of the nursing diagnoses, interventions and outcomes specific to perioperative practice</td>
<td>1993</td>
</tr>
</tbody>
</table>
Curricula from thirty-six schools of nursing were reviewed in the following states/provinces: Alaska, Hawaii, Oregon, California, Washington, and British Columbia. The number of schools that offered graduate courses in nursing leadership in each state were as follows: Alaska – No programs, Hawaii – 1, Washington – 5, Oregon – 2, California – 24, and British Columbia – 3. Degrees offered from these programs included the Master of Nursing (MN), the Master of Science in Nursing (MSN) and the Doctor of Nursing Practice (DNP). The focus areas of these degrees included advanced practice leadership and nursing administration.

Findings

Data indicated that 12 schools required a nursing informatics course for completion of a nursing leadership degree. All of these 12 schools were state and university schools located in the United States. Six schools offered courses in informatics as an elective only. These schools were located in both the United States and Canada. Fourteen schools offered no content that contained the key words identified. For these schools we did not find any mention of nursing informatics content in program or course descriptions; thirteen of these fourteen schools were located in California. Thus, of 36 programs preparing nurse leaders in five US states and one Canadian province, only 33.4% required a course in health information systems. Additionally, 16.6% of the schools offered an elective course in informatics content. In the remaining programs, or 38.8% of our sample, there was no evidence of attention to nursing diagnoses, interventions or nurse-sensitive outcomes in any of the current course descriptions. Content such as standardization of terms, interoperability, interface and reference terminologies, and negotiations (or procurement of systems) with vendors was evident only in courses specifically designated as informatics or nursing informatics courses.

Conclusion/Discussion

While published course descriptions may not provide a full accounting of actual course content, results of the study certainly suggest that nursing leadership programs lack health information systems and nursing informatics content. Such a lack of informatics preparation leaves Nursing ill-prepared for a future reliant on clinical information systems to support practice decisions. Further, lack of Nursing content in clinical information systems will leave those systems without the ability to consider important elements of care and healing that are a direct result of nursing services. Encouraged as we are by the publication of the American Association of Colleges of Nursing (AACN) Essentials of Master’s Education document that includes requirements for informatics content in all Master of Nursing programs [12], and the initiative through Canada Health Infoway and the Canadian Association of Schools of Nursing (CASN) to develop informatics competencies for nursing education [13], there may still be a lack of receptivity or understanding of informatics importance from a executive leadership perspective. An important initiative that sets a new standard is the 2014 recommendation from the State of Minnesota’s eHealth Advisory Board that has approved the use of standardized nursing terminologies in electronic health records in
all settings [14]. This new initiative will require executive knowledge and understanding of these languages and may become a model for future practice elsewhere.

We most certainly support such inclusion of informatics content within graduate nursing programs. We believe this content should include an overall introduction to the health informatics field, use of interface and reference terminologies for nursing practice, and application of nursing data to quality and safety initiatives. Additional content related to procurement, employee training, and system usability would very likely dictate an entire course, and would be useful. In all settings, we most certainly support better communication between nurse executives and nurse informaticians and recommend that, wherever possible, graduate students preparing for each role share coursework or seminars to begin such interaction early in their careers. Organizational structures in healthcare systems that place nursing informaticians outside of the ‘Nursing’ function of the organization or outside a direct reporting line to ‘patient care services’ could be an inhibiting factor for continued nurse executive – nurse informatician dialog and might also be addressed early through graduate school experiences. There is agreement among health informatics specialists that listening to clinicians about their practice needs and data needs is essential. There is a need for two way communication between clinician executives and health informatics specialists for executive needs to be met. An important stimulus for this communication is an understanding of how information systems can be used to support nursing practice and organizational decision making where nursing is concerned. It could be that Nursing has not fully embraced a need within the profession to listen to various specialties within Nursing to understand how current and future nursing work can be supported by and changed by information systems. We believe this opens up areas for further evaluation – those of intra-professional communication and planning. In the meanwhile, we recommend collaborations between nurse executives and nurse informaticians that could take place formally at regional/national meetings already scheduled (such as meetings of national association of nurse executives) or informally at health care institutions. Further, we welcome involvement of nursing faculty outside of those teaching informatics, to collaborate with other nurses who are involved with nursing informatics. This work should be done in addition to making modifications to nurse executive curricula at the graduate level to develop such competencies in nurse executives.

References


Closed circuit video for organizational learning in emergency unit

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Abstract. The ER is a highly erratic and error-prone environment where continuous organizational learning is an important part of providing good quality medical care. The article aims to evaluate how closed circuit video system is used in the ER department based on qualitative interviews with staff members. The results show that the system is used to improve work processes and treatment decisions as well as aid in professional training. Often video recordings provide the most objective information about a critical situation. The staff considers the system to protect and help professionals in their work and the security measures to be sufficient to protect patients.

Keywords. Organizational learning, Video surveillance, Emergency unit, qualitative evaluation

Introduction

Since Chris Agyris, Donald Schön and Peter Senge introduced the concepts of double loop learning and organizational learning these principles has been widely used in health care organizations [1,2].

Within the concept of team learning there has always been a limitation in health care as the central part of providing health care is in the direct contact between the patient and the provider. This contact is often characterized by a one to one encounter between the patient and the provider. Occasionally an apprentice accompanies the provider and participates in a learning relationship during the service. In particular situations e.g. operations it has been possible to share the actions to a larger audience via video transmission. This has been possible because it is a planned event and because the patient identity is not exposed. In other situations such as treating patients in an emergency unit it is more complicated to achieve a team learning process as very few health professionals can participate in the actual care activities, and the patient reactions and involvement is complicated to hold on to for later learning events.

By having video cameras recording all the actions in a treatment unit it would be possible to achieve learning material from real situations to improve the team learning processes as the health professional staff could discuss and evaluate the recordings in internal seminars and workshops.

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The aim of this study is to evaluate the emergency unit in North Estonia Medical Centre, where ceiling mounted video cameras record all treatment actions, with respect to scenarios of use, learning outcomes and confidentiality.

1. Methods and material

The closed circuit video surveillance (CCVS) system is evaluated and described by a qualitative methodological approach. Data is obtained by a semi-structured interview with the head of the Emergency Care Department at North Estonia Medical Centre (ER), the largest tertiary care hospital in North Estonia serving a population of 400,000. The interview was conducted based on an interview guide about how the department used the video surveillance system in their daily work, the learning process, and security and privacy aspects of the solution. Short commentaries were also received from an ER nurse and a physician regarding their experience with the system. The data was collected and transcribed to reveal the different scenarios of video system use in the hospital.

The emergency unit in North Estonia Medical Centre is divided into a green, a yellow, and a red zone according to traditional triage of incoming patients. The yellow zone has 20 treatment units each equipped with a stretcher bed, various medical devices, utensils, and a ceiling mounted video camera (see figure 1). The cameras are also installed in the corridors, procedure rooms (see figure 2) as well as the operating theatres.

An analog video recording system was first installed in the old department at the beginning of the 2000s. The initial idea was to enhance the security in the ER. The system was extended beyond hospital corridors since security related incidents also oc-
curred in the wards. After the construction of a new ER department in 2010, the analog system was replaced by the digital Milestone XProtect™ system.

The CCVS system is not connected to the hospital EHR but managed and controlled by a separate security and logistics department within the hospital. The head of the department and a security specialist are the only two people to have full access to it.

The ER department retrieves offline recordings on the basis of a written application to the security specialist. This includes a problem description, reasons for requesting the data as well as details about the number and location of the cameras that contain the requested information. The head of the ER department is responsible for all communication with the security and logistic department concerning the recordings although either the senior nurse or physicians often initiate the request. The offline recordings do not include audio to optimize server storage capacity.

Physicians have access to the online video surveillance footage with an audio component at the workstations or via a tablet computer. The North Estonia Medical Centre is using a multimodal security mechanism involving smart card based identification and passwords to access the information system. The combination will grant the staff access to full range of information, however, with just the password, certain functionalities have been disabled. The past and also the current system are in compliance with the Estonian Personal Data Protection Act and other laws concerning privacy in Estonia.

2. Results

The CCVS system is used in the ER for two main purposes regarding organizational learning. The first group of scenarios is related to improving work processes and treatment decisions. The CCVS system is seen as a tool to help the ER respond to patient complaints. The most common complaints involve excessive waiting time and neglect in the ER. The interviewee: “I answered one such complaint. I had the pictures there as well, you could clearly see, what time the nurse came to see him and what he did. He introduced him to the procedures. It wasn’t instantaneous but it
happened within one hour. But it wasn’t the way the patient claimed that he waited for 20 hours and no one came to him”.

The ER staff review all incidents of resuscitation using offline recordings. Every person involved in the incident is expected to participate to determine if the situation was handled optimally and how to improve cooperation in critical situations. According to the head of the ER people are less able to objectively reflect back on a stressful situation and offline video recordings help to determine the temporal sequence of events and activities performed. The interviewee describes a case: “We lost valuable minutes…the intubation should have happened earlier but it didn’t. Now the question remained, did the equipment arrive late or was the decision-making process too slow.”

In the latter case, the analysis revealed that the resuscitation equipment was retrieved from two different locations although all the sets included the full range of necessary devices. Therefore, after this incident analysis, the head nurse introduced routine weekly reviews of resuscitation equipment sets and their location.

The ER uses the Japanese lean manufacturing concept of poka-yoke or mistake-proofing where the aim of the analysis is not to place blame but to change the work processes in a way that will minimize or prevent human error. The Interviewee explains: “There are thousands of details in these processes that in the end can harm the patient.” In the case described, the video recording also revealed relevant medical information about the patient’s condition, enhancing the completeness of the patient medical data in the Electronic Health Record (EHR).

Once a week and three times a month the ER staff use the CCVS system to review all severe trauma cases. The analysis involves three monitors: one for the video recording, second for laboratory tests and third for diagnostic tests regarding each case. All resident physicians, nurses and physicians are involved in the regular discussions. The overall aim is to determine if all necessary activities were performed and whether they were done appropriately and in a timely fashion. A similar process takes place with stroke patients. Thrombolysis following stroke can significantly improve the outcomes but it is highly time-critical. It would be difficult to analyze these incidents without the video data since documentation is completed afterwards and objective reflection is often flawed. ER Physician: “Every time we review the video recordings with the timeline we can see exactly what time what activity occurred and how fast we performed with each patient”. In the future, they plan to introduce the thrombolysis incident analysis into routine work practice.

The third use of the system relates to professional training of medical personnel. The ER department hosts regular seminars with resident doctors. The online video is used when one group of physicians in a seminar room monitors the other group working in the ward with a patient simulation. The process is followed by joint analysis of the procedures.

The interview revealed that the staff is aware of potential privacy concerns but believe that the improvements to quality of care outweigh the privacy issues. Moreover, access to the system is limited and all regulations are followed. There is little concern among the staff themselves around their privacy. On the contrary, it is believed to enhance staff motivation to continually learn and perform better. The interviewee: “If you’re doing your job right, you don’t need to be afraid of being watched.” The overall mentality of openness is also transferred to other situations such as allowing patient relatives to stay at the ER ward or watch the activities via the online video. More transparency is believed to lead to better outcomes in patient communications. A nurse confirms: “it [the video system] protects us. It’s in our interest.”
3. Discussion

The CCVS system using online and offline video is used for both continuous professional training and work process optimization. Video recordings are well recognized in the training of health care professionals. Real recorded trauma [3] and resuscitation episodes [4, 5] provide valuable information for physicians to learn and improve work processes. Video reviews are useful for analyzing whether treatment protocols are followed [5]. In addition to training purposes, video recordings of critical events at the North Estonia Medical Centre revealed problems with staff performance and workplace ergonomics.

The learning outcomes of using CCVS recordings for work process optimization and better care provision have become routine and valuable for the ER professionals. The ER is a highly error-prone environment where decision-making is faced with time constraints as well as high cognitive workload [6, 7]. The interview revealed that information from video recordings often provides the most objective view about a critical situation. This enables to identify errors in medical decision-making or suboptimal processes that would otherwise be impossible to detect through reflection or observation only. Moreover, CCVS recordings can enhance the quality of hospital EHR information, which, in turn can improve future decision-making.

ER physicians are aware of concerns about patients’ privacy in other countries that has prevented them using similar technologies. However, the cultural context in Estonia is somewhat unique. For example, a large proportion of the population trusts smart-cards and e-services for their voting and health data. Moreover, the ER staff feels that the video system is helping them perform better as professionals, enhance transparency and patient communication.

Regardless of the Estonian context, the apparent success of the technology in the ER department of North Estonia Medical Centre can also be influenced by the organizational culture fostered by the ER management. According to the Interviewee, another Estonian hospital failed a similar attempt due to staff opposition. It is possible that the poka-yoke mentality has enabled to create an atmosphere of trust among the staff. Therefore, more research is needed to explain the factors of success and failure when introducing controversial technology into the workplace.

CCVS system has a clear potential to improve patient safety and quality of care in the ER, however, video recordings are largely underused presumably due to security concerns. However the analysis of the CCVS system showed how this technology could be applied productively. A next step could be to develop a structured database with video sequences for teaching and possibly also instructions or guidelines. To encourage progress in this direction more research will be needed to evaluate how video surveillance more specifically can improve work processes in the ER in different organizational cultures.

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References


Mining Association Rules in the BCCA Liver Cancer Data Set

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Abstract. The objective of this study is to apply data mining techniques to determine factors that are commonly associated with liver cancer incidence, using an anonymized data set of 6064 patients from the British Columbia Cancer Agency (BCCA). The association rules indicate that in BC the patient demographic factors associated with increased liver cancer include: age ranges 60-69, male gender, and geographic location in the Greater Vancouver area. The main factors associated with decreased survivability in BC were being male and in the age range 70-79. In the Yukon, being male and in the age range 60-69 was the main factor associated with both increased incidence of liver cancer and decreased survivability.

Keywords. Data Mining, Associations, FP-Growth, Liver Cancer, Health Care

Introduction

Liver cancer has the lowest survivability rate amongst all types of cancer, with approximately 1 million deaths each year \cite{1}, and its incidence is projected to continue rising, with 12.7 million deaths expected in the year 2030 \cite{2}. The overall five-year survival rate observed in the Surveillance, Epidemiology, and End Results (SEER) Program database of the US National Cancer Institute from 2003 to 2007 is at 14\% \cite{3}.

Only a few of the risk factors associated with liver cancer are known, such as hepatitis, excessive alcohol intake and exposure to toxins \cite{1, 4}. In addition to those factors, researchers believe that environmental factors and patient characteristics play a significant role in the development of the disease \cite{5}.

Early detection significantly reduces morbidity and mortality rates from liver cancer, and so is determining therapeutic options that prolong survivability and improve the quality of life for patients in the advanced stages of the disease \cite{6-8}. However, liver cancer patients are usually not aware of their disease in its early stages, due to the absence of symptoms until an advanced stage \cite{9}. Screening and early detection programs, as well as nationwide hepatitis B vaccination efforts, have reduced the liver cancer mortality rate in several countries, such as Japan, Korea, Mongolia, Malaysia and Taiwan \cite{3, 10-12}.

Data mining, which is part of the field of knowledge discovery in databases, can be of great benefit when applied to cancer detection and management \cite{13-19}. It can

\begin{footnotesize}
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provide better understanding of the mechanisms and risk factors associated with cancer development. Many published studies have reported using data mining association algorithms in cancer detection and surveillance and the discovery of cancer prevention factors, such as [20-22] for breast cancer, [9] for prostate cancer, [23] for lung cancer and [24] for colorectal cancer. However, association mining algorithms had not been applied to liver cancer data prior to this study. The main objective of this research is to apply FP-growth association algorithm to discover association rules in the liver cancer patient data obtained from the British Columbia Cancer Agency. The association rules indicate what patient demographics affect incidences of liver cancer.

1. Methods

1.1. Data Source

This study is carried out using anonymized data obtained from the British Columbia Cancer Agency (BCCA). The dataset consists of a total of 6,064 patients (6,047 from British Columbia, 17 from the Yukon) diagnosed with liver cancer between January 1, 1970 and December 31, 2010. The diagnoses include ICD-O-3 (International Classification of Diseases for Oncology Third Edition), cancer sites C220 (liver) and C221 (intrahepatic bile duct), and exclude pending or unconfirmed cases.

1.2. The Data Mining Algorithm

We apply the FP-growth association rule mining algorithm to determine factors that are commonly associated with liver cancer incidence and decreased rates of survivability.

The FP-Growth was selected for the data mining tool due to its better computation efficiency compared with the commonly used Apriori algorithm. It encodes the input data set into a frequent-pattern tree (FP-tree), constructed by reading the data one transaction at a time and mapping each to a path in the tree. A higher compaction factor is achieved when paths in the FP-tree overlap due to different transactions sharing common items. A small FP-tree will fit in main memory, from which frequent item sets can be extracted directly, instead of making repeated passes over the data storage.

1.3. Data Pr-processing

The data mining process starts with the data pre-processing and cleaning steps, followed by data transformation. Preliminary data processing and exploratory data analysis were performed using ACL Desktop version 9.3.0 and began with the creation of additional attributes as calculated fields. Some of these calculated fields were used for the purpose of filling voids in the data set, by adding necessary additional attributes, such as calculating ages from years and encoding data as binary variables, as required by the FP-growth algorithm.

1.4. Data Analysis

In order for attribute values to be distinguished in the files that are output by the FP-growth program, they were coded to include a unique prefix consisting of either one or
two digits. To extract patterns, the categorical and symmetric binary attributes are transformed into items, so that the FP-growth association algorithm can be applied. This transformation can be accomplished by creating a new item for each distinct attribute-value pair. For instance, after the age variable is calculated, patients are grouped into a new binary variable in terms of age ranges, having an item such as 40 to 60 years old, with a corresponding value of 1 for the patients in that age range and a 0 for any patient younger than 40 or older than 60.

Further data exploration and processing were followed by the selection of a final set of data attributes to work with. To achieve dimensional reduction, the data attributes observed to be unnecessary were excluded from further analysis. After dimensional reduction, the final data set includes 10 attributes: gender, age range, current health authority (geographic division for health administration), diagnosis health authority, cancer site, ICD-O histology code, tumor subgroup (liver, Hodgkin’s, non-Hodgkin’s, undefined, other), death age range, patient status code (alive or deceased), and treatment (chemotherapy, radiotherapy, surgery).

Comma-delimited text files to be used with the FP-growth algorithm had the attributes encoded numerically. Those files were then submitted through a pre-existing C++ implementation of the FP-Growth algorithm. Varying levels of support were attempted until the best level of support was determined.

2. Results

2.1. Preliminary Data Analysis

In BC, 4,173 (M D+A) liver cancer patients were male, compared to 1,874 female. This shows an incidence rate of liver cancer in males being 2.226 times that of females. However, the life-death ratio, calculated as the number of living to deceased patients, is the same, 0.10 for both men and women (Figure 1). In the Yukon Territory, males are affected about three times as much as females, although the number of patients may be too small to be of significance. The life-death ratio is 1.00 for women (2 patients deceased, 2 patients alive) and 0.30 for men (10 patients deceased, 3 patients alive).

![Figure 1. Counts of patient alive vs. deceased by gender (A=Alive, D=Death)](image)

Among the six health authorities in BC (5 regional and 1 provincial), the highest liver cancer incidence authority is Vancouver Coastal Health, although the Fraser Health Authority has the largest population, and the largest life-death ratio is the Vancouver Coastal Authority (0.131, Figure 2).
BC liver cancer patients who were alive at the time of data acquisition had been diagnosed at a younger age than the ones who were deceased. In Yukon, the opposite trend holds. In BC, 77.2% of patients die within two years of diagnosis and 86.1% within the first four years. In the Yukon, 58.83% of patients die within two years and 70.6% within the first four years. Figure 3 shows the BC data distributed by gender, with the number of deceased male patients per year of survival after diagnosis being approximately double that of females.

The analysis of the treatment data shows:

a) In BC, 672 patients have been recorded as having had chemotherapy; 11 patients are known as having had hormone therapy; 229 patients are known to have had radiotherapy, although only 3 have knowingly had it through the BCCA; 900 patients are known to have had surgery, but it was either only diagnostic or not known to have been performed by the BCCA.

b) In Yukon, only 1 patient has been recorded as having had chemotherapy; none is known as having had hormone therapy; only 1 patient had radiotherapy and 2 patients had surgery.
2.2. Association Patterns

The main factors associated with increased liver cancer incidence are:

- In BC, age ranges at 60-69 and 70-79 with 91-97% and 87-97% confidence respectively; male gender with 88-100% confidence; geographic location in the Vancouver Coastal and Fraser Health Authorities which cover the Greater Vancouver Area with 96% and 88% confidence respectively.
- In Yukon, age range at 60-69 with 100% confidence.

The main factors associated with decreased survivability are:

- In BC, age range at 70-79 with 100% confidence; male gender with 88-92% confidence. Note that the results of the BC survivability data, which excluded records where treatment was undefined, coincided with the results of the BC survivability data which excluded all treatment attributes.
- In Yukon, age range at 60-69 with 100% confidence.

3. Discussion

The data analysis did confirm higher incidence of liver cancer in male- compared to female patients, although the life-death ratio was the same for both genders in BC. This means males are more likely to develop liver cancer than females but have the same likelihood of dying from the disease. That is again confirmed by the gender distribution per number of survival years.

BC liver cancer patients who were alive at the time of data analysis were diagnosed at a younger age than the ones who were already deceased, which confirms the importance of early detection in reducing mortality. Some diseases such as hepatitis C virus and diabetes may link to the liver cancer. The increased rates of these diseases may shift liver cancer incidence from typically elderly patients to relatively younger patients between the ages of forty and sixty years [25]. However, the BCCA data set does not provide information to support the hypothesis.

4. Conclusion

The objective of exploring the associations between liver cancer and patient characteristics and developing rules to describe them has been successfully met. Testing the applicability of the association analysis paradigm to analyze liver cancer data and produce association rules with high levels of confidence has also been accomplished.

Recommendations for future work would include stratifying the data from British Columbia by Health Authorities and applying the association algorithms individually to each Health Authority, as that may reveal association rules and factors that were lost in the current study due to different numbers of patients in each Health Authority. Island Health (Vancouver Island Health Authority, VIHA), for instance, has a much higher mean age than the other Health Authorities and, as such, it may have specific rules that are not frequent when patient data from all Health Authorities are analyzed together.
References

Using Usability Evaluation to Inform Alberta’s Personal Health Record Design

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Abstract. Alberta Health is deploying the Personal Health Portal (PHP) (MyHealth.Alberta.ca) to all people in the province of Alberta, Canada. The PHP will include several components such as a Personal Health Record (PHR) where users can enter and access their own health data. For the first PHR of its kind in Canada, Alberta Health asked the University of Victoria’s eHealth Observatory to evaluate the PHP, including the PHR. The evaluation includes pre-design, design, and adoption evaluation. This paper focuses on early usability evaluations of the PHR software. Persona-based usability inspection was combined with usability testing sessions using think aloud. These evaluations found that while people were familiar with the web-based technology, several aspects of the PHR information architecture, content, and presentation could be improved to better support and provide value to the users. The findings could be helpful to others designing and implementing similar PHR software.

Keywords. Personal Health Record, usability testing, usability inspection

Introduction

Electronic Personal Health Records (PHRs) are patient controlled records that support self-care and provide access to health records and information [1]. PHRs are expected to improve care [2-4]. There is a research gap in evaluating PHR design and benefit [5, 6]. The impact of PHRs have varied [7], possibly due to usability issues. Improved usability may help the adoption and impact of PHRs. The purpose of this paper is to add to the growing research on PHRs by sharing a usability evaluation of a developing provincial PHR.

1. Background

The Personal Health Portal (PHP) is the first provincial, online consumer health application developed by Alberta Health and Canada Health Infoway. PHP’s deployment began in May of 2011, providing a trusted consumer health information site at MyHealth.Alberta.ca. The upcoming general release will include PHR components such as a medication management module and various health trackers. The PHR software will, in time, connect to other health information systems.

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The eHealth Observatory at the University of Victoria was invited by Alberta Health to complete the benefits evaluation of the PHP through its phases. Multiple methods have been planned to assess the PHP and the PHR software throughout each release cycle. Evaluation was considered in three stages in each release: pre-design, design, and deployment. The evaluation has been designed to provide timely feedback to help improve the PHP program through its initial, targeted release phases.

2. Methods

To assess the early design of the PHR software, a combination of usability inspection and usability testing was used. These methods were chosen to fit with the readiness of the PHR and the time available in the release cycle. Findings were shared to the PHP program team such that adjustments could be made prior to early test deployments.

2.1. Usability Inspection

PHR usability inspection was conducted using a combination of heuristic inspection [8, 9] and persona-based inspection methods. For the persona-based inspection, two patient personas were developed. Personas were representative of target end users of the initial PHR release. For each persona, scenarios were developed to illustrate expected use of the PHR. Personas and scenarios were validated with the PHP Clinical Working Group and the PHP project team.

2.2. Usability Testing

Usability testing occurred with representative end users, which were recruited from two groups: people who had been engaged in the PHP project (e.g. committee members), and interested students and staff volunteers at the University of Victoria who had no prior knowledge of the PHR. Users were asked to follow think aloud protocols while they performed two sets of actions. First, they were asked to explore the PHR freely. Second, they were asked to follow specific scenarios that matched the expected activities of the targeted end users of the initial PHR release. The scenarios assured coverage of all key PHR tasks. The sessions were recorded, including PHR screens and audio, and each session was analysed by one researcher. The research team reviewed findings.

3. Findings

3.1. Usability Inspection

Usability inspection occurred twice: June 2012 and April 2013. The PHR contained a large set of modules that allowed users to enter and view their health information in the PHR. Areas in need of improvement were identified across many modules:
Information Architecture: The PHR had a deep navigation hierarchy. There were several layers of screens before patient health data were typically available. This nesting increased cognitive load and reduced the ease of finding specific modules (where to record height and weight). The deep navigation structure also presented a challenge for several scenarios where related modules were found in different locations of the PHR. For example, recording blood pressure and weight (an expected and frequent activity for patients with heart failure) required traversing the navigation tree. Further, the majority of data were module-centric (they were isolated to their module and not readily available to other modules or parts of the application). This could lead to errors. For example, insulin entered in the “diabetes module” would not be available in the “medication module” and the reverse was true.

Content: There were modules necessary for cardiac care (e.g. blood pressure, medications, weight, cardiac care planning); however, other modules were missing that would be needed for a general release or that could be needed for patients with multiple conditions (such as family history or complementary therapies). Clinical terminology lists had gaps. Terminologies for medications or for health conditions in some cases were not clear and in others were not complete. In many input areas users could add free text instead of a coded entry. This could have downstream impacts when using free text for medications or diagnoses and connecting the PHR to other electronic health information systems or using these data in decision support. Several modules had little data entry validation of content.

Presentation: The PHR looked clean and clear; however, some improvements of the presentation could aid usability. Summary pages that would show specific information back to patients and show trends would help users. Existing overview pages did not show sufficient personal health information (such as only showing the last three medications added, but not all current medications) and others, such as printable reports, were not well organized, making them unnecessarily long and making information difficult to find. There were some inconsistent data entry approaches that increased cognitive burden and the chance of error.

Strengths: The PHR provided many tools that could add value to patients including visual gauges to assess how well the user was meeting specific targets, the ability to select and track Wellness Plans, and graph data over time in some modules (e.g. blood pressure). Further, the PHR contained condition-specific tools such as a Cardiac Tracker and an Asthma Tracker that could help patients with those conditions.

3.2. Usability Testing

Twenty-one participants completed usability testing from January to March 2013. Participants found the PHR appealing and were supportive of the idea of a PHR. They felt they could use the PHR without training. There were areas that could be improved:

Information Architecture: Users often found it difficult to find modules to complete specific tasks such as recording height. Users were sometimes challenged by the module names or the location in specific screens. Users found the module segmentation confusing. For example, cholesterol values entered into the laboratory module were not
used in the cholesterol Health Gauge. However, cholesterol values entered into the cardiology module were.

**Content:** Users found gaps in the available modules. For example, users wanted to record advanced directives. They wanted to document significant medical events from their history but it was not clear which module could be used. The terminologies used in the PHR were sometimes inadequate. Users were confused when common terms were not found. There were missing validity checks (e.g. height), which allowed them to confuse units or enter data improperly.

**Presentation:** Users found the nesting structure hard to navigate. Users were expecting that their health data would be available in the top-level screens. Instead, it was often nested two levels down before the data would be viewable. The sign-in process was unclear to most users. There were some inconsistencies in data presentation between modules. Some users could not discover how to enter data in some modules.

**Strengths:** Users were able to use the system with minimal training. On-screen buttons and editing tools were clear in most cases. Users felt that several modules were useful to have in their PHR including the Health Gauges (which matched data to personal targets in an easy-to-view manner), Wellness Plans, journals, and the graphing of data.

### 4. Discussion

The intent of this ongoing evaluation is to provide constructive feedback to the PHR project team in a timely way such that the PHR software can be improved prior to the launch of each phase. Findings from this usability inspection and testing were largely consistent. From these findings, we made several recommendations focusing on three principles: be clear for new users, support user tasks, and demonstrate PHR value to the user beyond a repository of information. While these findings are specific to this particular project, they have generalizability in two ways. First, the Alberta PHR is using a commercial PHR product that is in use elsewhere and many of these challenges may impact other groups. Second, this evaluation is an example of embedding evaluation into the lifecycle of a government project. This study is one part of an evaluation that has been embedded into the life cycle of the PHP program. Even with appropriate timing of feedback, it can be challenging to get recommendations put into subsequent phases of the program, given constraints of timing, funding, and capacity.

**Information Architecture (IA):** We recommended revising the structure and organization of the modules. A clearer top-level navigation with a combination of content oriented tabs and user specific tabs could improve the ability to find information. A “home” tab would provide a clear clinical summary and surface information that might be new to the user (e.g. reminders). Modules could be present in multiple screens where it would fit clinical need, provided the data were stored once.

**Content:** The early versions of the PHR were tailored to support targeted workflows for cardiac care. However, a broader range of content modules will be needed. Further, careful consideration should be made on clinical terminologies so that they are comprehensible, comprehensive, and compatible with other standards in the province.
**Presentation:** Focus should be made on displaying clinically relevant data back to the users early so there is a greater perceived value in the PHR. Health Gauges that show when targets are being met are a good example of how the PHR can provide value back to the end user, interpreting data into meaningful information. Some modules should be revised to ensure consistency in presentation and data management across modules.

5. Conclusion

This paper describes a usability evaluation from early phases of the Alberta Health’s PHR. This study highlights the challenges of tailoring existing research and evaluation methods into an existing commercial product deployment. Evaluations need to be timely and there needs to be capacity in the product lifecycle so that recommendations can be incorporated into the product’s future phases. Iterations and flexibility have proved to be important both in evaluation and deployment planning. Evaluation needed to be tailored to what was possible at each stage. For example, recruitment of actual representative users was not initially possible for this usability testing, but was included in subsequent evaluation of user experience in deployment. The findings and challenges are likely not unique to this PHR. These findings and recommendations could be helpful to others who are implementing similar PHR software. There is a gap in overall PHR evaluation that should be addressed at multiple levels. We have provided some research into the usability and design of the PHR with this study. Future evaluation could include comparative evaluation between PHR products and the development of recommendations on best practices for PHR user interfaces.

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**References**


Value versus Use for Patients: Findings from an ICT supported Cystic Fibrosis Self-Management Project

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Abstract. This paper presents findings from the implementation of an online symptom monitoring diary that was part of a broader project aimed to support self-management of cystic fibrosis and the development of an online community of practice (CoP). The findings challenge conventional perspectives on how value is acquired by patients and their families from electronic tools designed to provide them with support. Additionally, the findings highlight complex relationships between user needs and subsequent tool use that challenge approaches to the measurement of value from ehealth projects.

Keywords. User evaluation of ICT, Cystic Fibrosis self-management, ICT Symptom monitoring, ICT evaluation challenges

Introduction

Chronic disease in Australia amounts to over 80% of the health care burden due to death, disability and a lower quality of life [1]. The use of information communication technologies (ICT) to support chronic disease condition management and self-management is steadily increasing [2-4] and there is the potential to assist patients and health care providers with improving health outcomes for people living with a chronic condition [5, 6]. The focus of these developments originally captured the needs of the patient users through the advocacy and expertise of their health care providers, but increasingly user-centred approaches have become more common [7].

Cystic Fibrosis (CF) is a multi-system chronic condition and it is the most common life-shortening condition in the world [8]. In Tasmania, Australia CF has the second highest incidence in the world with 1 person in every 1800 people [9]. CF was once considered a paediatric disease however due to research and improved treatment techniques this is no longer the case. The impact of CF extends to the entire family, parents and siblings [10]. CF is typically diagnosed at birth and the management of CF includes balancing daily medication, treatment, and management regimes.

The impact of CF on the Tasmanian population led a team of clinicians, researchers and information technology developers to explore if ICT tools and mobile applications could be used to support people living with CF. Initially this focused on
adults living with CF and the development of self-management self-efficacy [11]. This early project indicated that mentoring assisted the adult participants with the development of self-management self-efficacy and that further research would be beneficial. Subsequently, this initial project was expanded from adults with CF to teenagers and young adults [11]. The outcomes of the expanded project highlighted that health mentoring had a positive impact on an individual’s self-management self-efficacy and that there was interest and support for extending the projects further [11].

This paper presents the results from one aspect of the final project (implementation of an on-line symptom monitoring diary) and focuses on the participant experience and the initial evaluation of the online symptom monitoring diary and how it fitted into their lives. The final project leveraged insights from the two previous projects, expanding the participants to include individuals of all ages (including children and their parents/carers) and the piloting of a single platform containing educational, mentoring and symptom-monitoring elements.

1. Method

As with the two previous projects, the final project continued to rely primarily on clinician advocacy on behalf of CF patients for driving the design of the ICT tool to be provided. Initially, clinicians envisaged a web-portal would include educational, mentoring and monitoring resources. It emerged that passive patient involvement and differences in perspective amongst the multi-disciplinary project team, opened up an opportunity to deploy more user-centred approaches to the pilot implementation [4].

The purpose of the pilot implementation was to allow participants to provide a review on the look, feel, navigation and the functionality of the online symptom monitoring diary that had been developed on behalf of, and without direct input from CF patients. Participants were identified by their attendance at one of the Tasmanian CF clinics and underwent randomised selection after splitting potential participants into age-based cohorts; paediatrics (0 to 10), teenagers (11 to 17) and adults (18 years plus).

The data for the pilot was collected at three different time points; the first time point focused on the experiences of the participants as they were introduced to the pilot implementation, the second time point focused on the exploring the participant experience of the pilot implementation of the online symptom monitoring diary, and the final time point aimed to develop detailed understandings of the participants lives. The pilot ran for a period of six weeks.

An inductive thematic analysis approach was used to analyse the pilot implementation data. This enabled a detailed description of the data [12] and the generation of insight [13]. Coding of the data was applied at a sentence level with memos assisting to recapture thought processes [4]. Summary codes were first developed from the interview transcript and were then further refined into open codes. This process reduced the 6,102 summary codes to 2,852 open codes. The axial codes increased the abstraction of the open code label to that of a concept, resulting in the development of 153 axial codes. The axial codes underwent a number of iterations to focus and refine the concepts represented in each axial code. The final level of data analysis involved looking at the attributes of each axial code and creating the final level themes. The development of the final themes was likened to Attride-Stirling’s global themes as holding the principal metaphors of the entire data set [14]. The theme development resulted in 19 final level themes.
2. Analysis and Interpretation

2.1. Pre-Pilot

Participants were not included in the design of the pilot implementation however they were encouraged to describe their requirements, post-design, from how they understood the pilot implementation. It was evident that the ability to connect to others living with CF in Tasmania was a desired requirement that would assist participants with the management of CF. Parents expressed concern over their child(ren) being isolated from other children, due to the cross-infection fears that prevent people living with CF having close social contact. “…they’ve got each other, who else has he got, you know when you don’t have an interaction with the other children and you feel so segregated it makes it hard”

The concept of ‘social connection’ was included in participants’ formulations of perceived helpfulness. During the pre-pilot stage, participants indicated that they desired a means to connect to others for peer support and information gathering. “…gee it would be lovely to have a mum to, you know what did you do for this and how did you get the kids to do that and I’m having trouble getting them to do this…”

The participants anticipated the online symptom monitoring diary would facilitate future interactions with their peers. The ability to connect to other parents for parenting support as a supporting mechanism and a desire to feel socially connected to other people living with CF was identified. Interestingly, social media were not identified as a method to gain news and support. The participants anticipated using the pilot implementation to assist them with obtaining information and experience from others living with CF in Tasmania. In essence, the participants were describing the desire for the development of an online community. As the pre-pilot interviews progressed it was evident that the characteristics of the online community more accurately represented a community of practice (CoP). “…the start of a help for the future of CF so I’m happy to help that.” “….I’ve lived with it for 50 years, so I think I have some things to share.”

Concepts of information sharing, building a resource for future use and being kept up-to-date on events that are relevant to those living with CF all emerged from the pre-pilot interviews. The initial findings from this data collection pointed to the participant perception of the value of social connections as enabling information gathering and emotional support.

2.2. Pilot-Implementation

Parents were more expressive of the desire to reach out to others to connect, whilst teenagers viewed the communication with the pilot information as one way – they retrieved information, and viewed this as important as the need to engage in communication. “Just don’t think it will be used only – not really for talking just get information and stuff.”

However, there was some recognition of the emotional impact of connecting with others living with CF. This included reaching out to others through the sharing of positive life events and information. The perception of relating to others in similar circumstances is seen to reduce the feelings of isolation. “To prompt for someone to say no, there is always hope.”
Discussion around peer support was passionate and constantly linked back to technology assisting when they could not meet face to face. The requirement to prevent cross contamination between people with CF created an automatic inability to interact physically with others, and this contributed to the feelings of isolation.

The pilot implementation had some additional features that were considered to be future peer support areas. The pilot of the online symptom-monitoring diary included a blog, a user profile page, and useful contacts page. Surprisingly, the interaction with these areas of the pilot implementation was low for the majority of participants despite the initial findings that emerged from the first data collection point [15]. Participants expressed a desire to create greater online connections. “There’s a lot of us out there I suppose so it’s nice – because you don’t meet anyone, they don’t like us to mingle.”

After the pilot, participants still expressed a sense of disconnection from others, and the desire to connect with other families. However despite this there was very limited use of these features of the pilot implementation. The initial findings from this data collection point was that social connections was desired and expressed as a need but when available was not used, even though participants continued to view it as important to have available.

2.3. Pilot Follow-Up

Participants found the emotional attachment of the pilot implementation to be of comfort to them, even when they did not physically interact with the online symptom monitoring diary. The implementation was perceived as something that was reassuring to have and this initial finding re-enforces the requirement of connectivity as a concept, rather than an activity. “We don’t need to use it daily or anything, it’s good to know that it is there.” For each participant group, participants who interacted with the pilot implementation at a twice-daily or greater rate were in the minority. In terms of connectivity and social communication, the interaction with the peer support areas only accounted for 7% of the total pilot implementation site interactions [15]. The participants’ measurement of usefulness was not dependent on actual use. Emotive criteria such as inclusion and accessibility were included in the participant evaluation and this is not easily measured through the actual use of the system.

3. Discussion

The pre-pilot data analysis and interpretation revealed that the participants wanted a development of an online community. As the participants’ responses were further explored, it emerged that the online community was required to be based around the framework of a CoP. The results from the pilot period demonstrated that the participants did not use the elements that could act as a foundation for a CoP, conflicting with the initial requirements provided by the participants. However, participants continued to express the acquisition of value from these elements even though they did not use them in practice. What then, are the participants actually trying to describe when they present elements of a CoP?

The user-based approach during the pre-pilot stage did not anticipate the complexity of determining intangible participant centered requirements that resulted in minimal use of the system. The final evaluation is further complicated as the participants do not perceive the pilot implementation as a project that has failed.
This research has highlighted that participants connected to the pilot implementation on an emotional level, and the perceived helpfulness of the ICT tool is something that is relevant to others living with CF, as well as themselves. It raises questions the respective roles of clinician advocacy and user-centred approaches in designing tools when ultimately neither approach promotes their use. The project also highlights the need for greater sensitivity to what values (emotional, perceptual, actual) use and non-use denote in ehealth projects.

4. Conclusion

This research challenges conventional perspectives on how value is acquired by patients and their families from electronic tools designed to provide them with support. Tool use appears not to be the only measure of ‘success’ and measurement of non-use may also reveal value that requires further investigation.

References

[9] Tasmanian Clinical Genetic Services, Email communication from Tasmanian Clinical Genetic Services, 2011.
Patient-centric Care and Chronic Disease Management: A Stakeholder Perspective

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Abstract. By taking a stakeholder perspective, the paper explores reasons why the political commitment to patient-centric integrated care, facilitated by eHealth applications, is so difficult to meet. In spite of hundreds of pilots, still today there is a dearth of evidence on how to indeed successfully organise such services. Outcomes from a variety of implementation projects supported by the European Union were analysed, focusing on benefits and costs for the diverse stakeholder groups involved or impacted. The re-engineering of the services may result in a considerable shift in these variables between groups. Rendering both positive clinical impacts and a positive (overall) socio-economic return is not sufficient to assure wide acceptance and long-term sustainability. However motivated stakeholders may be, few will operate against their economic interests. Successfully establishing modern eHealth facilitated services is not so much a technical, but a social, organisational, and business innovation. We need to better understand in detail the benefits and costs, or the new ‘business models’ that go with integrated care for each involved stakeholder group, and the likely impacts for each of them, with a focus on how to best assure a win-win situation for all. Health policy has to respond to this, and a promising approach would be to promote organisational integration with shared budgets and outcome targets.

Keywords. Patient centric, integrated care, chronic disease, stakeholder, coordination, benefits, costs

Epigraph

“Comprehensive programs, such as those directed to bring maximum benefit to persons with chronic diseases ..., require the coordination of the efforts of many individuals and agencies... The home care program clearly demonstrates the importance of the close integration of clinical, public health, and other services if the needs of chronic disease patients are to be met.”

Source: Burney, 1954 [1]

1. Introduction

As the epigraph illustrates, already sixty years ago public health policy makers noted that "comprehensive programs, such as those directed to bring maximum benefit to persons with chronic diseases ..., require the co-ordination of the efforts of many

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individuals and agencies” [1]. Today’s “patient-centric” or “patient centred” integrated care vision for chronically ill patients still aims to realise such a model of service delivery. Patient-centric has been defined as “clinical treatment, provided by medical practitioners, that focuses on and respects patients’ personal preferences, desires, and values” [2]. This concept is more or less identical with patient centred: “Being patient centred actually means taking into account the patient’s desire for information and for sharing decision making and responding appropriately” [3]. The relatively old concept of “patient empowerment” goes even a step further by focusing on and educating patients, who are emotionally and physically able to do so, assuming a certain responsibility for treatment decisions: “Empowerment is defined as an educational process designed to help patients develop the knowledge, skills, attitudes, and degree of self-awareness necessary to effectively assume responsibility for their health-related decisions” [4].

Modern health and social care systems provide for many services to help chronically ill and older, frail citizens. “But these services are split into organizational clusters such as Health, Social Care, Housing, and others, each in most settings separately organized, delivered and recorded by organizations and their staff who are separately funded, managed, and regulated. As a result patients are surrounded by uncoordinated Islands of Excellence, when what is needed is Coordinated Care” [5]. This requires high-quality collaborative working relationships, commonality of objectives and care plans, frequent communication among team members, etc. – all facilitated by eHealth solutions to support optimal coordination. For quite some time, it has been asserted that “telemedicine should be viewed as a stepping stone to a more cost-effective, proactive, and preventative health care model, where information technologies, electronic patient records, and novel medical devices converge to provide a truly patient-centric care environment” [6]. However, still today there is a dearth of evidence on how to indeed best organise integrated care, and even the GBP 31m “Whole Systems Demonstrator (WSD) for telecare and telehealth” [7] did not provide sufficient facts: “Latest evidence doesn’t warrant full scale roll-out but more careful exploration for telehealth roll-out” [8].

To better understand and provide guidance when shifting towards more integrated, patient centric health and social care provision, the European Commission has also supported a wide variety of implementation projects, usually involving six to ten and even more health and social care systems in a variety of European Union Member State regions. A focus has been put there on more carefully considering and analysing the not necessarily concordant interests, benefits and costs of each of the stakeholder groups involved or impacted [9].

2. Methodology

Initial evidence from such projects – SmartCare [10], Beyond Silos [11], CareWell [12], Independent [13], CommonWell [14], PALANTE [15] - focusing on the role of key stakeholders was analysed. In each case, the methodological approach relies on developing existing/new services through eHealth applications, adapted care pathways, and/or new types of co-operations. In a formative evaluation approach, the services are implemented, monitored, optimised and validated. This involves measuring – as applicable - at project start and end core variables, like

- Clinical: medical indicators and outcomes
• Patient/family carers: QoL, convenience, reassurance, ...
• Service providers: cash flow, sustainability
• Health system/society: socio-economic benefits

For understanding and analysing such complex organisational changes and new delivery processes, a single method like an RCT focusing on only one or two intervening variables is not sufficient to capture the respective impact of complex interventions imposed by these services. Tools like LimeSurvey, telephone and F2F, Excel and SPSS are used for interviews, data gathering and aggregation, and analysis. Complex benefit-cost analyses as illustrated by Figure 1 focusing on given stakeholder groups are applied.

Figure 1. Benefit-cost analysis framework (© KAS/empirica)

Intangible impacts are measured by, e.g., imputing a time value to patient inconvenience, the use of monetary proxies, or “willingness to pay” approaches[16].

3. Results

Exemplary data are reported for a concrete instance: the community alarm and telecare service provided by the Milton Keynes Council, UK, in support of high risk COPD patients. In case their condition deteriorates, they are supported
• through a 24/7 service availability
• through an immediate response to emergencies
• “red alert” follow-up by clinicians without delay

Benefits observed include:
• patient's quality of life and peace of mind
admissions into hospital and GP visits avoided
Time and travel cost saved for GP visits and hospital stays

The service concept focuses on COPD patients leaving hospital after an exacerbation of their condition. An innovative early support discharge pathway was collaboratively developed across service providers, referrals to clinical community nursing teams assured, and telecare equipment (social alarm) and telehealth monitors (blood pressure, SPO2, temperature) installed. A joint call centre (telecare and community matrons) was established, through which also daily triaging by community matrons is facilitated as needed.

Figure 2 summarises the overall socio-economic return (i.e. the relationship between the changes over time in the monetary values of financial, liberated and intangible resources and the respective costs) estimated for all stakeholders taken together, i.e. for the service as such, over a period of about seven years:

Figure 2. Overall socio-economic return (© INDEPENDENT/empirica)

However, as seen in the following Figure 3, the benefits and costs are very unevenly distributed across the core three stakeholder groups:

Figure 3. Socio-economic returns for three stakeholder groups (© INDEPENDENT/empirica)
Whereas patients, informal and professional carers seem to gain, it is not necessarily beneficial for the care organisation/their owner or, indirectly, the payer.

With respect to many other regions across Europe and different types of integrated, patient centric services, there was a great variability of results measured across countries and regions, reflecting the diversity of (European) care systems. But one outcome is very stable – the considerable disparity in the net difference between the types of benefits and costs measured for each stakeholder group, and a sometimes very considerable shift in these is observed which was due to the new organisational model.

4. Analysis and discussion

When taking a longer-term perspective, at the system level many of the piloted and implemented integrated, patient-centric innovative services, facilitated by eHealth applications, render both positive clinical impacts and a positive (overall) socio-economic return. But this is not sufficient to assure wide acceptance, or their long-term sustainability and success.

Applying a value system analysis framework, it becomes clear that integrated service delivery requires a variety of service providers to collaborate in a complex, holistic health value system, while each of them has to manage its own value chain, including its interfaces with the value chains of its collaborators.

This, in turn, requires that also at the individual organisational level each provider and payer needs a clear ‘business case’. Only in a win-win situation for each stakeholder such complex innovations will become attractive and sustainable. However, delivering on a value-proposition that indeed meets the needs of direct clients such as patients, and of indirect clients such as Third Party Payers, and also assuring a business case for the organisation has so far proven difficult, if not elusive.

Furthermore, it turned out that these new models may entail relatively high initial investment needs for the involved delivery service(s) with respect to both financial and human resources. This opens up the issue of affordability, even if at the financial rate of return level the longer term outlook is positive. Also, it needs to be noted that a positive socio-economic rate of return does not necessarily imply a positive overall cash flow, which for any private undertaking would be a fundamental condition for survival, and also for many public institutional service providers.

At the mere technical side, a sometimes not insignificant lack of usability, usefulness and reliability of eHealth equipment was observed, which also adds to the barriers to be overcome.

5. Conclusions

To assure the sustainability of our health and social care systems and improve their quality, implementing integrated wellness, health and social care service models have been proposed for a long time already. They should be patient-centric and, when and where feasible, empower the patient. Successfully establishing such modern eHealth facilitated services is not so much a technical, but rather a social, organisational, and business innovation, imbedded into its respective idiosyncratic health and social care value system context – which reflects the wide diversity of national and regional health
and social care systems globally. This observation implies that we can learn from each other, but not simply copy supposedly “best” practice.

We need to better understand in detail the benefits and costs, or the new ‘business models’ that go with integrated care for each involved stakeholder group, and the likely impacts for each of them, with a focus on how to best assure a win-win situation for all. Only then will it become possible to reap the benefits expected from integrated service delivery, where diverse actors together ‘produce’ and sustain health and social wellbeing both for individual clients and populations.

In discussions on the quality of care services the importance of professional ethos, motivation, adequate staffing levels and training are often stressed. Although these factors are important, they have a limited ability to change behaviours [17]. However motivated stakeholders may be, few will operate against their economic interests. Payment and reimbursement systems can present significant barriers [18]. Health and social care polices must therefore critically assess how financial flows in health and social care systems may provide incentives or disincentives for cooperation across providers and for integrated care, taking into account that the ‘business case’ for telehealth may be very different for various players in a given healthcare system. A promising approach would be to promote organisational integration with shared budgets and outcome targets.

References


The Evaluation of Electronic Perioperative Nursing Documentation Using a Cognitive Walkthrough Approach

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Abstract. Health Information System (HIS) implementations are on the rise in North America as the result of increased investment by governments. According to the evidence, systems not only have the potential to introduce error, but poorly designed user interfaces can result in systems that are not usable and possibly unsafe. Therefore, the need to evaluate HIS during the early phases of the system development lifecycle is becoming increasingly important. Researchers have begun to propose usability engineering methods that can be applied to help evaluate systems during design and development using an iterative evaluation process. A cognitive walkthrough was used to evaluate an Operating Room Management Information Systems’ (ORMIS) electronic perioperative documentation. The resulting usability problems are discussed along with recommendations for improvement in this paper.

Keywords. Cognitive walkthrough, ORMIS, electronic documentation, usability, technology induced error

Introduction

The application of usability engineering methods in evaluating health information systems (HIS) is gaining wider acceptance. Researchers have employed these methods to not only improve human computer interaction and usability but to help prevent errors that result from the use of HIS. Technology-induced error, an “error that inadvertently occurs as a result of using a technology” [1] can arise from system design, development, implementation, customization and new workflow design [2]. In recent years, researchers have focused on applying usability inspection and usability testing methods early in the design phase of the system development life cycle (SDLC) to ensure the system meets the needs of the end user and the healthcare organization prior to its deployment into a production environment and with the ultimate goal of developing effective and safe systems [3].

With the healthcare system under growing pressure to deliver high quality care and improve efficiencies, the Operating Room (OR) is one department where these pressures are escalating. The OR generates over 42% of the revenue and a commensurable share of costs [4]. As fiscal constraints continue to increase, the demand is high for the OR to find alternate ways to streamline workflow, implement

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lean processes and reduce costs without impacting the delivery of care. The knowledge that workflow in the OR may have to change as a result of real-time electronic documentation reinforces the need for evaluation of HIS before implementation. A usability inspection method known as Cognitive Walkthrough was utilized in the analysis of the user interface of a vendor ORMIS to identify specific usability problems and present recommendations for improving system design prior to implementation.

1. Literature Review

Poorly designed user interfaces impact the learnability of a system, place increased cognitive demands on users and have the potential to lead to error [3-7]. HIS evaluation is required for many reasons including ensuring the system being implemented appropriately meets the needs of the end users as well as that of the healthcare organization and ensuring the system being implemented is safe [3]. Usability inspection methods provide a systems development approach to evaluation, focusing on system design alongside end user requirements. These methods are seen as viable due in part to the cost-effectiveness of using an approach where an analyst systematically reviews a system (rather than observing a number of end users) in detecting usability problems as they inspect the user interface [3,5,8]. Through the use of usability inspection methods, analysts are able to identify major usability problems [9]. Cognitive walkthrough is seen as a formal usability inspection method due to its structured approach to identifying usability problems through the evaluation of the user interface by analyzing the cognitive processes required to complete a task [3,5]. In one study evaluating a computerized physician order entry system for medication ordering using the cognitive walkthrough approach, researchers were able to identify 56 usability problems with 18 of them being deemed major and catastrophic [10].

2. Methods

A cognitive walkthrough was conducted to evaluate the ORMIS operative record for the degree of ease with which a task or action could be performed. The evaluation of each step required to perform a task can detect disparities in the interpretation and understanding of different aspects of the system [5]. Cognitive walkthrough involves an evaluator sequentially stepping through the system to carry out each defined task, while at the same time documenting the user actions required to complete each step and the problems that may be encountered. The usability problems that result from conducting a cognitive walkthrough are related to inconsistencies between the user’s goal and their actions required to achieve the goal [3].

2.1 Evaluator

A usability analyst with clinical and health informatics experience conducted the cognitive walkthrough of the operative record using pre-determined task scenarios (more details will be provided below), as well as conducted the analysis.
2.2 User Population and Background

The intent of the operative record is to enter clinical information related to the patient’s surgical procedure throughout the perioperative journey. The end-user population who could use the operative record includes RN’s in the surgical daycare and post anesthesia care unit, OR nurses and Anesthesiologists. Background experiences that could potentially influence their interaction with the operative record are experiences with using other functions within the ORMIS, experiences using other modules within the HIS, and the use of other vendor solutions.

2.3 Identification of Tasks

A cognitive walkthrough was conducted around the following task scenarios in the ORMIS operative record: (1) identification of the patient and the scheduled surgical appointment, (2) entry of data related to the patient preparation and positioning, (3) entry of data related to the surgical procedure performed, and (4) entry of data related to the surgical counts. The identified tasks are representative of some of the tasks the OR nurse would complete during the intraoperative phase of the surgical procedure. A task analysis of each of the task scenarios above was explicated into a series of action sequences that were required to complete each of the tasks.

2.4 Data Collection and Analysis

The cognitive walkthrough can identify two main types of usability problems: goal problems and action problems. The execution of the cognitive walkthrough resulted in data being collected and documented using a log file, created for each task. Data collected within the log file included the overall task, the goal, subgoals, and actions carried out for the specific tasks, along with the system’s response to the actions and the potential problems that resulted [3]. Once the cognitive walkthrough was completed by the analyst, a list of all problems encountered during the cognitive walkthrough was compiled. Each problem was examined and assigned a severity rating based on the rate of occurrence, ratio of end-users that might encounter them, potential for error to occur and possible impact on the end-user [5, 10].

3. Findings

A cognitive walkthrough was conducted on each of the four tasks. Each action performed in order to complete each task was examined and documented. The goal, subgoals, the actions required by the user, the system response to the action and the identification of potential problems were documented and analyzed.

3.1 Task Data

The breakdown of the number of subgoals and actions required to complete each task along with the number of potential problems that could be experienced by the end user are summarized in the following table:
Table 1: Number of subgoals, actions and potential problems for each task.

<table>
<thead>
<tr>
<th>TASK</th>
<th># SUBGOALS</th>
<th># ACTIONS</th>
<th># POTENTIAL PROBLEMS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>10</td>
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<td>2</td>
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<td>20</td>
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<td>4</td>
<td>7</td>
<td>15</td>
<td>9</td>
</tr>
</tbody>
</table>

3.2 Usability Problems

Twenty five potential problems were identified through the cognitive walkthrough. Of the 25 problems, the majority could potentially lead to confusion and frustration for the end user due to lack of clarity around what the user is required to do, inadequacies in system design or missing functionality with the system. One problem has the potential to result in errors in the documentation of the surgical procedures performed. Each problem was rated for severity, resulting in 19 minor, 5 major and 1 catastrophic usability problems. The 25 potential problems were categorized based on actions that led to the problem and the documented system response. Five categories were identified. Three were pre-defined from the literature (i.e. ambiguous information, absence of system functionality and default entries) [8,10], and two emerged (i.e. inadequate design and lack of system instruction). Four of the five categories contained the major and catastrophic usability problems. These are described in the table below:

Table 2: Usability Problems Identified

| Absence of system functionality | One major problem was identified concerning the absence of system functionality in the worklist routine. The user did not have the ability to select more than one OR room from the lookup. This could potentially lead to confusion and time delays. |
| Inadequate design               | Within the operative record panels, there are separate screens to be completed. These screens are identified with an i next to the name of the screen. The user has to click the i to pull up the additional screen. This major problem could result in confusion and frustration for the end user and also inefficiencies and time delays due to the number of screens the user has to access to enter basic perioperative information. |
| Lacks of system instruction     | Two major problems were identified where the system does not provide instruction on how to make selections in certain screens or how to effectively search for information. Important information could potentially be left out of the operative record due to lack of instruction around how the user is to select multiple entries. Lack of system instruction could lead to end user frustration and time delays and the potential of picking an incorrect entry. |
| Default Entries                 | One catastrophic problem was found with default entries. When entering the actual surgical procedures performed, the proposed procedures default. Because what is proposed is not always what is performed, there is the probability that the wrong procedure could be documented resulting in an error in the electronic record. |
4. Discussion and Conclusion

Conducting a cognitive walkthrough [3] with the operative record, resulted in the analyst successfully identifying a set of usability problems based on the actions taken by the analyst and the system responses that were generated. The cognitive walk through resulted in 25 usability problems being identified. Twenty-four of the usability problems occurred on more than one occasion with 19 recurring throughout the cognitive walkthrough. The usability problems were separated into five categories: ambiguous information, absence of system functionality, inadequate design, lack of system functionality and default entries and given a severity rating. Six of the usability problems were identified as major or catastrophic errors requiring moderate to high priority to fix. The potential problems identified in the cognitive walkthrough and the severity of the problems that resulted has demonstrated that cognitive walkthrough can effectively be applied in the evaluation of an ORMIS.

When examining the results of the cognitive walkthrough, specifically looking at the number of subgoals and actions required to complete a task, two of the four tasks could be considered cognitively challenging to the end-user. One in particular, task 3, the entry of the surgical procedures required ten subgoals and 22 actions for the entry of a single procedure, and also required the user to enter and exit multiple screens. Completing this task could be cognitively taxing for the end user especially if the patient has more than one surgical procedure performed. For each procedure the end user would have to follow all but one subgoal and two actions. From a system design perspective, only five potential problems were identified with this task but the number of actions is very high. Recommendations could be made to the system designers to look at redesigning the task to decrease the cognitive load on the end user.

The findings of the cognitive walkthrough further validate previous usability problems expressed in the literature [10] and extend them using the cognitive walkthrough method. Furthermore the work in this paper describes first work in applying cognitive walkthrough for an ORMIS. As demonstrated in this paper by employing the usability engineering method of cognitive walkthrough, usability problems associated with the user interface and the content of the application can be identified and potentially mitigated before they reach the end user.

References


A Recommendation-based Mobile Web Application for Health Information Service

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Abstract. Information overload and irrelevant information are major obstacles for drawing conclusions on the personal health status and taking adequate medical actions. The objective of this study is to design a recommendation-based mobile web application to assist patient efficiently search online health information at anytime, anywhere and via any devices. In the system, we use a collaborative filtering approach to recommend health information to users.

Keywords. Health information, Mobile web service, Collaborative recommender, Rough Set Theory, Cloud-Computing.

Introduction

In light of the advancement of health information and communication technologies, many for-profit (e.g. PatientsLikeMe, http://www.patientslikeme.com) and none-for-profit organizations (e.g. HealthLinkBC, http://www.healthlinkbc.ca/) have provided much online medical information available for general public. In fact, more and more people use the information for personal health care management or patient-oriented decision making [1]. For example, according to a recent study report by the Pew Research Center’s Internet & American Life Project, 81% of U.S. adults use the internet and, of those, 72% say they have looked online for health information in the past year [2]. Through the online media, people connect with others who have the same disease or condition and track and share their own experiences. Many studies have shown that such effects influence the patient-physician relationship, as patients tend to become empowered as active participants in the health care decision-making process [3-6], especially for those living with one or more chronic illnesses [7, 8]. Manafò and Wong [9] further argue that “Health literacy has the potential to improve an individual’s capacity to access, understand, evaluate, and communicate basic health information and services needed in order to make appropriate health decisions”.

Unfortunately, the information relevant to the patient’s concern is usually scattered across many different (web) sites. It is, therefore, difficult for patients to find reliable medical information with the number of site and information source choices increasing and the overwhelming high volume of data to review. With this in mind, the study proposes to apply Collaborative Filtering (CF) technique to develop a web-based recommendation system to help user as an application to efficiently obtain their preferred health information.

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1. Literature reviews

A Recommendation System (or Recommender System) is an information filtering technology to present information in an application that are likely to be of interest to the user [10]. It usually produces a list of recommendations to the user through collaborative or content-based filtering methods [11-13]. Collaborative filtering approaches build a model from a user's past behavior (e.g. information/products previously selected and ratings/rankings given to those information/products), or similar decisions made by other users. Then, the software system uses that model to predict information/products (or ratings of their items) that the user may be interested in. While content-based models examine properties of the information/products recommended. For example, if an eBay user has purchased many tablet products, then recommendations to that user are IT devices classified in the database as having the "mobile device" genre.

Recommendation systems are mainly used in the field of electronic commerce; however, only a limited number of applications are used in the area of healthcare. Among these, Morrell and Kerschberg [14] propose a semantic recommendation system that allows a patient to consult authoritative ontologies and reputable information sources to provide semantically enhanced recommendations. Mohanmmed and Benlamri [15] propose a Differential Diagnosis recommender model to make health information recommendations by utilizing semantic web app technologies [15]. Lou [16] applies various health knowledge and computer science techniques to automatically provide patients with personalized healthcare information to facilitate overall well-being. Unfortunately, each has its own limitations [1, 17]. To improve these drawbacks, we propose a new approach for recommending health information.

2. The recommendation-based mobile web architecture and functions

In this study, the proposed recommendation system includes five components: 1) a cloud computing based database; 2) a web based user interface; 3) a health information query module; 4) a collaborative recommender; and 5) a physiological indicators-based recommender. The functions of each component are described as below:

(1). Cloud computing-based database – It stores a large volume of health knowledge provided by a Taiwan health and medical information portal, recommendation system user profile, rough-set-based prediction generated matrix table and physiological indicators. The cloud database runs on a cloud-computing platform with many benefits (please see [18] for detail discussion).

(2). Web-based user interface – Patients use the interface to search useful health information. It was developed using HTML5, CSS, JavaScript, jQuery and PhoneGap techniques so that users are able to use the system to query the health information at anytime, anywhere, and via any devices (e.g. desktop computer, laptop computer, iPad, Smartphone, etc.)

(3). Classified Health information query module – Users can query interested health information by clicking on classified items, such as drugs & health products, diseases & conditions, first aid, health diet, children & teens' health, women's/men's health, and seniors' health.

(4). Collaborative recommender – It applies the Rough Set Theory to recommend health information to the users. Through this service function, users not only can
access content of consistent information, but also dramatically reduce information searching time.

(5). Physiological indicators based recommender – The module uses the data provided by physiological measurement devices (e.g. heart rate monitor, blood pressure monitor, thermometer, blood sugar glucose meter) to recommend health information. The data could be sent to the system via Bluetooth, WiFi or RFID.

3. The collaborative filtering recommendation method

The working of this study uses the collaborative filtering approach to recommend health information to users. We apply the FRSA (Fusion of Rough-set and Average-category-rating) algorithm proposed by Su et al. [19] to implement this function. The process of the algorithm includes three stages, as follows:

Stage 1. Data preprocessing – A transaction corresponds to an interest content of a user, and items in a transaction are terms extracted from its content [20]. The main task of this stage is to analyze the transactions gathered from different system users. Each transaction consisting of multiple contents and a rating that is split into three tables: a user profile table; an item profile table; and a user-item matrix. The user profile table stores registered user's demographic information, information searching history, and the information item corresponding with the rating score, etc. The item profile table consists of characteristics (e.g. drug name, disease type) of the information item that are easily discovered. And the user-item matrix encodes the individual preferences of users for items in a collection. The next step in this stage is to discover the user content, item content and rating score (U-I-R) relationship rules from the transaction data.

Stage 2. Users clustering – In this stage, the algorithm cluster the users into several groups by computing Pearson Correlation Coefficient. The main purpose of the clustering is to reduce the computation cost [21]. The discovered rules in stage 1 and the clustered user-item matrices are stored into the databases.

Stage 3. Target information prediction – The prediction function starts to work from a user (called active user) who first time searches for a specific health information (called target item). The target item values for the active user can be inferred by cluster determination, imputation of unknown values and target-item-value prediction [19]. The algorithm assumes that users with similar characteristics/opinions always make similar item options. Based on this assumption, the irrelevant users will be removed from the user cluster that the active user was in. Then, the algorithm determines the related user-item cluster matrix. Using U-I-R relationship rules imputes all of the unknown values in the particular matrix. Finally, through fusing rough-set-based prediction and average-category-rating calculation, the target health information (items) in the found matrix are reasoned.

4. The recommendation process

Firstly, a new user needs to register to the system to use the services. The system stores the user's democratic information and service preference (e.g. health diet) in the user profile table. When the user revisits the system to search for the pertinent health
information, the collaborative recommender applies rough set-based prediction and average categorized-rating calculation to predict the user's target information (see section 3). Then, the system records the user's browser log and uses the information for other user's target information prediction. The health information recommendation process is as shown in Figure 1.

![Diagram of health information recommendation workflow]

**Figure 1.** The health information recommendation workflow

5. Conclusion

Health knowledge can enhance a patient’s capacity to access, understand, evaluate, and communicate basic health information and services in order to make better health care decisions [9]. Online health information search systems play a very important role in improving health literacy acquisition and helps online health information seekers (OHIS) make more informed decisions on health knowledge pertinent to them and their previous knowledge [22]. However, information overload and irrelevant information are major obstacles for drawing conclusions on the personal health status and taking adequate actions [23].

In this study, we propose a recommendation-based mobile web application to assist users efficient searching of health information that is likely to be of interest and to not know or fully understood beforehand. The system adopts the FRSA (Fusion of Rough-set and Average-category-rating) algorithm to perform the health information collaborative recommendation. Because of the space limitation in this paper, the system implementation details will be published elsewhere. Our future work is to complete the system implementation, examine the proposed method's feasibility, test the system usability and human-computer interactions, and analyze the empowering impact of the recommendation system on user's personal health care management and patient-oriented decision making.
References


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Abstract. Many health information and communication technologies (ICT) are safety-critical; moreover, reports of technology-induced adverse events related to them are plentiful in the literature. Despite repeated criticism and calls to action, recent data collected by the Institute of Medicine (IOM) and other organization do not indicate significant improvements with respect to the safety of health ICT systems. A large part of the industry still operates on a reactive “break & patch” model; the application of pro-active, systematic hazard analysis methods for engineering ICT that produce “safe by design” products is sparse. This paper applies one such method: Information System Hazard Analysis (ISHA). ISHA adapts and combines hazard analysis techniques from other safety-critical domains and customizes them for ICT. We provide an overview of the steps involved in ISHA and describe

Keywords. healthcare information systems, safety, hazard analysis, ISHA

Introduction

Information and communication technologies (ICT) have become part of the safety critical infrastructure of modern healthcare systems. A report issued by the Institute of Medicine (IOM) fifteen years ago found that the ICT has the potential to prevent medical errors. The report also found that ICT had contributed to new types of safety problems, so-called technology induced medical errors [1]. A key recommendation of the IOM report was to shift focus of safety practices from reacting to active errors to analyzing and mitigating latent errors, which are seen as more significant contributors to accidents. Active errors are mistakes committed (or contributed to) by the “front line personnel” dealing with patients, while latent errors are mistakes that indirectly contribute to decreasing safety margins, e.g., technology design flaws, insufficient maintenance, etc. A second report issued by the IOM twelve years later investigates the growing impact of health ICT on patient safety and finds that “[t]he current state of safety and health IT is not acceptable.” [2] It again stresses the importance of investigating latent errors and also highlights the need for early lifecycle safety analysis by quoting from an NRC report: “As is well known to software engineers ... by far the largest class of problems arises from errors made in ... eliciting, recording, and

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A key recommendation of this second report is to require software developers to make explicit, evidence-based claims about safety properties. Safety requirements elicitation in other industries (e.g., avionics, energy, defense) usually involves hazard analysis processes, where a hazard can generally be defined as a condition, event, or circumstance that could lead to or contribute to an unplanned or undesirable loss event. However, in contrast to more traditional safety-critical industries, the notion of hazard analysis in ICT systems is less established. This paper presents Information System Hazard Analysis (ISHA), a method developed at the University of Victoria, which draws on a combination of hazard analysis methods from other industries and contextualizes them for application to healthcare information system software. ISHA considers the safety of a health ICT system from three different, complementary perspectives and uses an underlying system-theoretic accident model for synthesizing the analysis results. This paper provides an overview of ISHA and illustrates its application in a case study of a computerized medication prescription system.

1. Related Work

1.1. Studies on the nature of health ICT-induced errors

In addition to commissioned reports like [2] and [1] researchers have also studied the nature of health ICT related adverse events. Koppel discusses mechanisms by which ICT facilitates medical errors directly [3], and how workarounds which arise to account for misalignment between ICT and workflow present risks of medical error [4]. Ash discusses how consequences of ICT implementation are pervasive and challenging to qualify [5] and highlights the prevalence of unintended consequences of computerized provider order entry (CPOE) [6]. Coiera warns that we are at risk of perpetuating these dangers over the next ten years when more ICT will be deployed than in the entirety of the history of medicine [7] and that though the relative rate of patient harm resulting from these technologies may remain constant, an absolute increase in patient harm will occur unless the issues which lead to dangers with these tools are addressed. Weber and Mason-Blakely provide synthesis and categorization of EMR related errors [8] and also discuss the suitability of regulating Electronic Medical Record (EMR) software in ways which are similar to how other medical devices [9] are regulated.

1.2. Safety engineering methods

Safety engineering methods applied in health informatics have primarily focused on late lifecycle stages (evaluating software designs) rather than early lifecycle stages (e.g., requirements analysis, design). Kushniruk, Boricky et al. have studied the relationship between ICT safety and usability and employed usability studies identifying hazards [10]. Chan et al. found that the application of user-centric design methods positively impacts safety [11]. Win [12] and Bonnabry [13] apply failure modes and effects analysis (FMEA) on various health ICT systems. De Rosier presents Healthcare FMEA (HFMEA) as method adaptation [14]. Weber and Mason-Blakely adapt Levenson’s system theoretic accident model and processes (STAMP) [15] for EMR-related hazards [9].
2. Related Work

We have developed and continue to adapt Information System Hazard Analysis (ISHA) [16], a safety engineering method for information systems. ISHA integrates adaptations of several existing hazard analysis and usability engineering methods using a system-theoretic accident model (STAM). ISHA triangulates hazards from three complementary perspectives: Event-Cause Analysis (ECA), Process-Fault Analysis (PFA), and Component-Fault Analysis (CFA). The method may be used retrospectively or prospectively for the identification of technology induced/related hazards.

ECA is a top-down technique that first identifies potential mishaps (i.e., accidents) and then drills down to hazards and contributing events that may lead to the mishaps identified. ECA is based on FMEA and may be guided by data on past failures [14] - a retrospective accident detection technique. PFA considers a model of the workflow process in the system under investigation (SUI) and uses a HAZOP-based guide-word technique to identify potential hazards [17], and thus prospectively identify where the risk of an accident exists. CFA utilizes one or several architectural models of components of the SUI to elicit failure modes in these components that may cause accidents - again a prospective hazard identification technique. CFA at the User Interface (UI) level utilizes usability engineering methods e.g., [18].

ISHA uses a STAM for synthesizing the hazards identified in the ECA, PFA and CFA. The STAM is based on Leveson’s STAMP [15], which models a socio-technical system as a set of controllers, displays, controls, sensors, actuators and controlled processes. The controllers connect to the processes via input and output links representing control and perception activities. Using this model, computer-based information systems can be modelled as indirect control loops where the physician controller uses an EMR to observe information about the status of the patients health process and issues orders (e.g., prescriptions, tests, etc.).

3. Related Work

This section describes ISHA in more detail and reports on its application to a computerized prescribing system. This research has been carried out in a collaborative project between the University of Victoria (Engineering / Health Information Science) and UBC Family Medicine in the context of a larger initiative to design the next generation prescribing system for the OSCAR EMR system. The project involved structured expert interviews of lead user clinicians, design and evaluation workshops, as well as team-based data collection and literature analysis activities.

3.1. Event-Cause Analysis

ECA identifies mishaps. At first glance this appears to be straight forward for our application in prescribing, where the two major mishaps would be patient harm from (1) taking a medication based on an inappropriate prescription or (2) not taking a medication that should have been prescribed. A deeper investigation of known accidents reveals the limitations of such a simple definition of mishaps. The notion of “appropriateness” is problematic. Patients may be harmed even if all prescriptions can be considered “appropriate”. Consider, for example, a provider writing a prescription without complete and accurate knowledge of the patient’s currently active medications.
Such prescription would commonly be considered appropriate but could nevertheless lead to a harmful drug interaction. We thus introduce the concept of an incongruent prescription: a prescribing act of commission or omission that is considered inappropriate assuming perfect knowledge about the patient’s health process. Categorizing actions using this term significantly limits subjectivity during identification of concrete mishaps and thus strengthens analysis. Once mishaps have been identified, ECA progresses in a hierarchical fashion by first identifying potential hazards (e.g., “no alert on harmful drug interaction”), then identifying failure modes for each hazard (e.g., “CDSS relies solely on coded data”), and finally contributing factors for each failure mode (e.g., “uncoded drug in discharge medication from hospital”).

3.2. Process-Fault Analysis

PFA takes a different and complementary perspective and seeks to identify hazards by considering potential deviations from the normal process workflow. We adopted the Bassi-Partridge prescribing process model developed at the eHealth Observatory for our case study [19]. PFA systematically iterates through each step in the process model and applies a list of predefined guide words to consider the impact of possible process deviations. We use guide words from HAZOP, including no (complete negation of intent), more/less (quantitative increase/decrease), as well as / part of (qualitative increase/decrease), other than (complete substitution), early / late (temporal), before/after (sequence), etc. For example, applying the guide word “other than” to process step Identify Patient in the Bassi-Partridge model will elicit a possible patient miss-identification hazard. Our experience shows that PFA tends to identify different hazards from ECA.

3.3. Component-Fault Analysis

CFA focuses on the system components used in the design of a system under investigation. These components may be on the User-Interface (UI) (e.g., displays, controls) or “under the hood” (e.g., program functions). In this paper we consider UI components only. CFA of UI components starts by defining a number of concrete usage scenarios and then generating detailed process models for each using the UI components in the context of these scenarios. We have used Keystroke Level Modeling (KLM), a simplified form of Goals, Operators, Methods, and Selection rules (GOMS) [18] for this process. Each step in the KLM process models is then analyzed using a guideword technique to consider the potential impact of deviations at the fine grained activity level. The guidewords used are similar to the ones used in PFA. However, the change in perspective results in identification of hazards which are specific to the design of the SUI. In other words, our experience shows that the CFA perspective yields different, previously undetected hazards and is thus complimentary to ECA and PFA. For example, in our application, CFA of a design for a new prescribing UI indicated a hazard associated with a component that was purposed to show medication changes, received through an interoperability interface link (e.g., new medications prescribed by other prescribers). Applying the guideword “no” uncovered a potential hazard associated with misinterpreting a blank feed to mean that no news about the patient existed, when the output could instead have arisen from an interoperability issue where no data was received.
3.4. Hazard synthesis, prioritization and mitigation

The hazards elicited by applying the three analysis perspectives described above are synthesized in a unified STAM which provides a high level categorical structure. They are then prioritized based on likelihood, severity and observability. Mitigation will then focus on addressing the hazards in priority order. Discussing this synthesis and prioritization in detail is out of scope of this paper.

4. Conclusion

Methods for identifying technology-induced latent errors in healthcare ICT are not well established but have great potential to increase safety. We have synthesized other methods to develop ISHA which fills this gap. This paper presented the method and illustrated its application to the design of a prescribing interface. Our current work focuses on refining the method and developing tool support to assist in its application.

References

Conceptual Analysis of a Diverse Set of Healthcare Quality Indicators

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Abstract: Computerisation of quality indicators for the English National Health Service currently relies primarily on queries and clinical coding, with little use of ontologies. We investigated attributes and relationships in a diverse set of over 200 healthcare quality indicators, categorising by clinical pathway, inclusion and exclusion criteria and Institute of Medicine purpose. Our results, some of which are described in this paper, were used to create an ontology that could reduce duplication of effort in healthcare quality monitoring.

Key Words: Quality Indicators, Health Care; Medical Informatics Applications; Ontologies

Introduction

Ontologies, described as a specification of a representational vocabulary for a shared domain of discourse [1], can facilitate automated quality monitoring by categorising and establishing relationships between concepts. In terms of ontology development, conceptualisation is the informal representation of domain terms in the form of concepts, instances, relations, and properties [2]. Chan et al [3] suggest a need for research into attributes of quality indicators to support electronic health record (EHR) compatibility. Identification of levels of indicator relationships can serve as a step towards repackaging formulas into reusable components.

A 2009 set of over 200 indicators, collated by the English National Health Service Health and Social Care Information Centre (NHS HSCIC) was chosen to attempt to address some of the gaps in research exploring ontologies and healthcare quality indicators [4]. The gaps included: research on healthcare quality indicator purposes, an ontology for healthcare quality indicators that is not dependent on data available in EHRs, an ontology that covers many clinical subject areas, and a healthcare quality indicator ontology that does not require a framework for indicator development.

We set out to identify relationships and layers of inclusion and exclusion criteria for a large, diverse set of quality indicators from the English NHS. The indicators, originating from different sources ranging from the UK Renal Registry to the NHS Quality and Outcomes Framework, are measures related to processes and outcomes. Our analysis served as the conceptualisation stage for an ontology for the indicators.

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1. Method

We created a Glossary of Terms (Table 1), inspired by the NHS HSCIC’s Metadata Library Guide [5]. We used conceptualisation techniques of categorical sorting and repertory grid analysis [6] to analyse relationships between classes of information.

1.1 Quality Indicator Dimensions and Next Stage Review Pathways

The categories of Clinical Pathway and Quality Dimension were based on Lord Darzi’s strategic report for the NHS [7]. The pathways include: Acute Care, Children’s Health, End of Life Care, Learning Disabilities, Long Term Conditions, Maternity and Newborn, Mental Health, Other, Planned Care and Staying Healthy. Darzi identified three broad dimensions, Effectiveness, Safety and Experience, for the clinical areas.

1.2 Quality Indicator Purpose, with Related Indicators

We created a table categorising the quality indicators by IoM guideline purpose [8] to assess the number of indicators in the Screening and Prevention category and thus suited to expression using Arden Syntax. In the same table, we also indicated any related indicators sharing broader, narrower or same level inclusion criteria to each indicator. Jenders [9] tested Arden Syntax, which uses Medical Logic Modules (MLMs), to assess computer interpretability for a set of quality indicators ACOVE (Assessing Care of Vulnerable Elders). However, most MLMs, originally intended as automated single reminders, have been designed for screening and prevention [9].

The IoM [8] purposes for clinical guidelines are: 1) Screening and prevention, 2) Diagnosis and prediagnosis management of patients, 3) Indications for use of surgical procedures, 4) Appropriate use of specific technologies and tests as part of clinical care, and 5) Guidelines [we used the term ‘Indicators’] for care of clinical conditions.

1.3 Inclusion/Exclusion Criteria

We used Statement and Definition metadata from the NHS HSCIC to specify inclusion and exclusion criteria.

2. Results

2.1 Glossary of Terms

Table 1 shows the Glossary of Terms used to initiate the conceptualisation process.

2.2 Quality Indicator Dimensions and Next Stage Review Pathways

The total numbers of indicators for each Dimension and Next Stage Review Pathway are available from the NHS HSCIC [11]. Listing each indicator alongside the relevant Dimension and Pathway enabled us to enter the Dimensions and Pathways as properties of the indicators in our ontology. This supported our goal of making searching for indicators in a particular pathway possible in the ontology.
Table 1. Glossary of Terms. The majority of the terms have been sourced or modified from the NHS Information Centre’s Metadata Guide [5].

<table>
<thead>
<tr>
<th>Term</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unique Identifier</td>
<td>Unambiguous reference number or string of letters and/or numbers</td>
</tr>
<tr>
<td>Reference</td>
<td>The source from which the indicator has been derived. The dataset applied</td>
</tr>
<tr>
<td>Statement</td>
<td>A sentence or paragraph clearly describing what is being measured</td>
</tr>
<tr>
<td>Formula</td>
<td>Formula for determining indicator data result</td>
</tr>
<tr>
<td>Creator</td>
<td>Developer of the indicator</td>
</tr>
<tr>
<td>Publisher</td>
<td>Party or parties responsible for making indicator available</td>
</tr>
<tr>
<td>Version History</td>
<td>Record of revisions to the indicator</td>
</tr>
<tr>
<td>Access Point</td>
<td>Location(s) of results</td>
</tr>
<tr>
<td>Relations</td>
<td>Other indicators which may need to be considered in conjunction with this</td>
</tr>
</tbody>
</table>
<pre><code>                                                                  | indicator and vice versa                                                   |
</code></pre>
<p>| Clinical Terminology  | The clinical term or terms used to source data to calculate the indicator,   |
| along with the corresponding codes                                          |
| Code                  | URL with the most detail about methodology                                   |
| Dimension             | Three dimensions, identified from a collated vision from ten NHS Strategic  |
| Health Authorities [5]:                                                     |
| 1) Effectiveness                                                            |
| 2) Safety                                                                   |
| 3) Patient Experience                                                       |
| Next Stage Review Pathway | Eight priority clinical areas, also known as pathways, identified in a     |
| collated vision from ten NHS Strategic Health Authorities [5]:               |
| 1) staying healthy                                                          |
| 2) maternity and newborn care                                                |
| 3) children and young people                                                 |
| 4) mental health                                                            |
| 5) long-term conditions                                                      |
| 6) planned care                                                             |
| 7) acute care                                                               |
| 8) end of life care                                                         |
| Purpose               | The Institute of Medicine [6]:                                              |
| Screening and prevention                                                    |
| Diagnosis and prediagnosis management of patients                           |
| Indications for use of surgical procedures                                  |
| Appropriate use of specific technologies and tests as part of clinical care |
| Indicators for care of clinical conditions                                  |
| Notes                 | Miscellaneous information to support the organisation and referencing of    |
| quality indicators.                                                         |</p>

2.3 Categorisation of Indicators by IoM Purpose, with Related Indicators

Categorisation of the indicators by IoM purpose for guidelines [8] supported the hypothesis that Arden Syntax is inadequate to express different types of indicators. This categorisation showed that the most common purpose was Indicators for the Care of Clinical Conditions, rather than Screening and Prevention. There were 149 indicators with a purpose of Care of Clinical Conditions and just 28 indicators with a purpose of Screening and Prevention. Categorisation of the indicators by IoM purpose, with related indicators, also allowed us to enter Purpose and broader, narrower and same level relationships as properties of the indicators in our ontology.
2.4 Inclusion and Exclusion Criteria

Variations in complexity of the indicator formulae and inconsistent and incomplete metadata regarding the formulae interfered with the fulfillment of the inclusion/exclusion criteria objective during the conceptualisation process. Dependencies were recorded at the same level. For example, “number of doctors washing their hands between seeing patients” shows a dependency between doctors and patients. “Access to scanning within 3 hours of admission” has two concepts that are recorded at the same level because “within 3 hours of admission” must apply to scanning.

3. Discussion

Our conceptual analysis of a 2009 set of NHS quality indicators sought to determine attributes of healthcare quality indicators and relationships between indicator components. We developed a Glossary of Terms, followed by categorical sorting and repertory grid analysis of concepts within the indicators. Two popular healthcare quality-related publications [7,8] were used to inform some of the categories.

3.1 Glossary of Terms

The following headings were added to supplement those chosen from the NHS HSCIC list: Creator, Access Point, Clinical Terminology Code, Dimension, Next Stage Review Pathway and Purpose. Although the NHS HSCIC had a ‘Creator/Producer’ heading, this referred to the party responsible for providing the outcome data for the indicator, rather than the creator of the indicator formula, methodology or intent. We added Access Point, due to the intended audience including clinical auditing communities and providers of access to indicator data sets. We added Clinical Terminology Code as clinical codes can assist with sourcing data for indicator outcomes. Dimension, Next Stage Review Pathway and Purpose were added to support categorical sorting.

3.2 Next Stage Review Quality Domain and Clinical Pathway

While the NHS HSCIC listed Darzi’s [8] Dimension and Clinical Pathway for each indicator and created a table with the number of indicators for each Dimension and Clinical Pathway [11], they did not create a table showing which indicators were assigned to each Dimension and Pathway, grouping related indicators together. Such a table is useful to the ontology conceptualisation process because it shows how indicators from different sources are related.

3.3 Categorisation of Indicators by IoM Purpose, with Related Indicators

Some IoM categories were broader than others (e.g., ‘Guidelines for care of clinical conditions’ is broader than ‘Appropriate use of specific technologies and tests as part of clinical care’. Where more specific categories would be possible had the information given been more specific (e.g., treatment vs. surgery), we noted this in our analysis.
3.4 Inclusion/Exclusion Criteria

Semantics influenced the number of layers of Inclusion/Exclusion criteria. There were sometimes more concepts than layers. Dependent concepts were recorded at same level. For example, “the number of doctors washing their hands between seeing patients” shows a dependency between doctors and patients, as the doctors must have seen patients. “Access to scanning within 3 hours of admission” has two concepts that are recorded at same level, as “within 3 hours of admission” must apply to scanning.

3.5 Limitations

This study was limited by unpredictable changes in the indicators, lack of previous ontology development experience, level of medical expertise and quality of metadata.

4. Conclusions

The conceptual analysis of this set of indicators serves as a snapshot into indicator status, categories and relationships. Categories of dimension, clinical pathway and purpose were identified as attributes of the indicators, along with broader, narrower and same level relationships between indicators from different sources and sets. This conceptualisation process focused on the indicators themselves, rather than interoperability with EHRs. The benefit is the ability to search components of quality indicators from different sources, with a view to reducing duplication of effort in gathering data for indicators with common criteria.

References

Hospital Discharge and the Role of ICTs: Considering Patient Perspectives

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Abstract. Hospital discharge is associated with high risks and potential adverse events for patients. While significant efforts have been made to improve discharge, patients and their families/carers have tended to be marginalized in discharge processes. Evidence from user-centred approaches to the development of eHealth emphasize the importance of engaging end-users to optimize the safety and quality of health services. This paper promotes a patient-centred approach focusing on discharge back to the community and the development of electronic tools as a method for contributing to improving the safety and quality of discharge processes. Understanding and engaging with patients as end-users avoids simplistic technocentric and info-centric approaches to discharge improvement.

Keywords. Hospital discharge, user-centred, patient-centred, information communication technologies (ICTs)

Introduction

Discharge can be broadly defined as “the processes, tools and techniques by which an episode of treatment and/or care to a patient is formally concluded by a health professional, health provider organization or individual” [1]. Patients can be discharged back to the community or to a care facility. Hospital discharge is a high risk scenario [2,3,4]. Some patients have to be readmitted and this is often attributed to inappropriate discharge related to inadequate arrangements for follow-up action and/or inadequate communication during discharge [4,5]. Significant efforts have been undertaken to improve the discharge process including reducing unplanned re-admissions [6], enhancing hospital to community discharge [7] and implementing e-discharges [8]. To date, most of these efforts have been heavily focused on the needs of healthcare providers with limited involvement of patients and their families/carers. A recent study has found that the discharge process continues to be problematic with patients feeling disengaged throughout the entire process [9].

In designing and developing e-health systems, it is essential that we are explicit about who are the users and their contextual settings of use and how we translate these rich insights into safe e-health systems [10]. Involving patients as users has been recognized as being important in improving quality and safety in healthcare [11]. However, there has been limited evaluation of the efficacy of these approaches in

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improving the safety and quality of discharge and limited evaluation of patients and their families/carers being engaged with e-discharge.

This paper highlights different strategies aimed at improving hospital discharge and broadly classifies them into two themes – those that are info-centric and those that are techno-centric. It is argued that these discharge improvement strategies often have limited success because they focus primarily on healthcare provider processes and/or information exchanges per se, without adequately accommodating the importance of the patient and their psycho-social and contextual situation as inputs in safe and high quality discharge.

Current trends in quality and safety have shifted the focus from healthcare providers to patients in efforts to improve the delivery of healthcare services. These approaches have highlighted that safety is, often not only, about information exchange but also concerns a wide range of individual, social and contextual factors. This paper promotes the importance of moving towards a patient-centred discharge (especially for discharge back to the community) that focus on understanding and designing systems and processes with patients and their empowerment as a goal. This approach repositions the nature of actions and communication both within and between health professionals, such that, (where possible) emphasis is placed on ensuring patients and/or their families/carers are ready, willing and able to act upon the advice provided. This advice needs to be provided in preparation for, during and after hospital discharge. Information regarding discharge and care coordination should be delivered to patients at a time and in a form that they can understand, want and need to contribute to successful discharge. In exploring these issues, this paper examines different roles information communication technologies (ICTs) can play in supporting patient-centred discharge. The paper highlights that appropriately designed and implemented ICTs have real potential to transform the discharge process but that this will require a complementary shift in discharge thinking that places the patients at the centre.

1. Interventions to improve patient discharge

The discharge process is associated with significant risks to the patient and hospital readmissions. It has been shown that approximately 19% of patients experienced adverse events after discharge [2]. About half of these adverse events are preventable and the reasons were thought to be a failure to follow-up either by the patient and/or the healthcare provider [5] and inadequate information transfer between healthcare providers in the hospital and the community [3,4].

A review of the literature identified several strategies to improve the discharge process. These strategies can be broadly classified into two themes. The first theme relates to info-centrism where improving information flow and coordination of care between health professionals is deemed sufficient to ensure the safety and quality of discharge. This includes care coordination between hospital and community such as the implementation of discharge planning [12], shared involvement of care between hospital and community healthcare providers [13,14], discharge coordination [15], discharge bundles [16] and medication reconciliation [17]. The second theme relates to techno-centrism, where ICTs are deemed to be the answer to the problem of how best to improve the accuracy, timeliness and effectiveness of the discharge process through the use of electronic tools to improve the generation of discharge summaries [18] and more specifically e-discharge [8]. Again, the focus is health professionals and their use
of new technologies, with almost no exploration of the value of sharing some parts of this electronic information directly with patients and/or their families/carers.

The underlying assumption behind these strategies is that the discharge process can be improved if the right information is delivered to the right healthcare provider at the right time so that appropriate follow-up actions can be taken. However, despite all these efforts, the discharge process continues to be problematic [9].

Patient involvement has not been traditionally thought of as being an important element in improving hospital discharge. Studies in considering the patients’ role in discharge improvement efforts have been scant. This paper promotes the importance of moving towards more patient-centred discharge (especially for discharge back to the community) that focus on understanding and designing systems and processes with patients and their empowerment as a goal.

2. Healthcare provider-centred versus patient-centred view

The literature on hospital discharge has focused on information transfers between hospital and community healthcare providers and care coordination for patients between hospital and community healthcare settings. In more recent years, there is a growing trend in the use of ICTs and more specifically e-discharge in attempts to improve hospital discharge [8]. However, the focus of these improvement efforts are primarily healthcare providers and do not adequately accommodate the importance of the patient and their psycho-social and contextual situations as inputs in safe and high quality discharge. Recent literature has confirmed patient involvement during discharge can be very important to ensure safety [9]. However worryingly despite many improvement efforts, many discharge processes continue to leave patients feeling disengaged and disempowered about their own care [9].

Engaging patients and finding mechanisms to empower them, has been shown to be very important for improving the safety of patient care and patient outcomes, particularly in chronic disease management [19,20]. The safety and quality literature also emphasizes the value of patient-centred care approaches [11]. Yet with discharge, where most patients return home and become the primary person responsible for their care and any follow-up required, only limited effort has been expended to engage or empower them. This cannot be viewed as a sensible or safe strategy for hospitals and as re-admission rates suggest it non-engagement with patients’ needs to be addressed.

This paper promotes the perspective that to improve and transform existing discharge processes (in conjunction with existing efforts around information transfer and care coordination between hospital and community healthcare providers), it is imperative that patient-centred discharge processes are instantiated. The literature suggests that patient-centred approaches and patient empowerment concepts have not achieved their full potential in chronic disease management models as outcome measures are still focused on healthcare providers [21]. It is argued finding ways to understand, engage with, and respond to patients’ needs, concerns and insights during discharge will contribute to improving the quality and safety of discharge processes. It is anticipated that this research, which is part of a broader Tasmanian project on continuity of care, will also contribute to better defining holistic outcome measures for discharge.
3. The patient-centred discharge project and the potential role of ICTs

This project aims to explore patient understanding of (i) The discharge process (ii) Their own care requirements and care coordination post discharge (iii) Strategies to improve engagement and empowerment during discharge (iv) The role of ICTs in patient-centred discharge (v) Appropriate outcome measures for the discharge process. Patients admitted to a General Medical Ward at a local tertiary teaching hospital will be invited to participate in the study. Initially semi-structured interviews will be conducted one week after the patient’s discharge from hospital to allow them time to reflect on their experience of hospital discharge and to suggest potential areas for improvement. All interviews will be audio-recorded with consent. It is anticipated that approximately fifty interviews will be conducted. Data will be analyzed drawing on the principles of grounded theory to provide insights to address the aims described above. A major aim of the study is to understand the potential role of ICTs in improving patient-centred discharge. The analysis process will not only provide a socio-cultural understanding of the patient-centred discharge process but will also provide ICT design principles that will underpin future work in the use of ICTs to support patient-centred discharge. ICTs can play various roles in ranging from straightforward information delivery to more complex intelligence systems and ubiquitous computing designed to assist patients during the process. At the most basic level, ICTs can be used to deliver patient information that is standardized and readable. At a more advanced level, ICTs can also be interactive and provide reminders as a way to engage patients in their care after discharge. Finally, it is also possible that ICT can be used to build 3D simulation models of care requirements, home monitoring and sensor-network utilization to assist patients with care coordination for health and wellbeing maintenance. However, a key requirement will be to engage patients as end-users by adopting a user-centred approach when designing, developing and implementing ICTs for discharge.

This research project aims to commence the process of adopting a user-centred approach to understand the potential role of ICTs in patient-centred discharge. The outcome measures from the patients’ perspectives will also guide the development of ICTs to achieve the outcomes as perceived as important by the patients. It is anticipated that the results of this study will be used to guide the development of ICTs to improve the discharge process in order to engage with and empower patients to be involved in their discharge planning and coordination for better patient-centred outcomes.

4. Conclusion

Patient discharge from hospital is associated with risks and adverse events. Significant efforts have been undertaken to improve the discharge process. To date, most of these efforts have been heavily focused on the needs of healthcare providers with limited involvement of patients and their families/carers. The discharge process continues to be problematic with patients feeling disengaged and disempowered throughout the process. This paper has promoted the importance of moving towards more patient-centred discharge that focuses on understanding and designing systems and processes with patients at the centre. This paper has also discussed different roles ICTs can play in supporting patient-centred discharge and highlighted that appropriately designed and implemented ICTs have real potential to transform the discharge process but will require a complementary shift in discharge thinking.
References


Structured Data Capture from Multiple EMRs: Towards an Architecture for Clinical Research

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Abstract. EMR adoption by primary care physicians in Canada has increased dramatically in recent years. This provides an excellent opportunity for researchers to collaborate with primary care providers to capture structured data at the point of care. This paper describes the feasibility of converting a popular well-baby checklist form into an electronic version for research data collection. Usability and scalability of the instrument to large numbers of physicians was assessed. We developed and tested a standardized, electronic version of the Rourke Baby Record (eRourke) that was embedded into two different EMRs at four primary care clinics in Southern Ontario over a 6-month period. We utilized qualitative and quantitative research techniques, including on-site observation, key informant interviews and administration of pre- and post-questionnaires. Implementation of the eRourke improved the quality of data for research and reporting significantly. Providers also reported a subjective sense of having collected better quality data. Enhancing the usability of the form in 3 specific areas would likely increase the receptivity to the form to larger numbers of providers. Overall, providers were satisfied with the eRourke and felt that it captured higher quality information than previous versions (55\% Agree before vs 88\% Agree after).

Keywords: Structured data, standardized data, EMR, EHR, research, child development, early childhood, well-baby record, surveillance, information system, case report forms, CRF, eCRF, translational research, data collection.

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Introduction

EMR adoption by primary care physicians in Canada has accelerated in the past several years [1]. This has provided an excellent opportunity to repurpose existing clinical data to pre-populate structured forms [2, 3] and to collect structured data at the point of care to facilitate clinical research. One of the advantages of standardized data is to collect patient-centred data for research leading to improved patient care. Collecting structured electronic data from EMRs has been demonstrated to be feasible [4] and is gaining policy importance [5]. A previously conducted pilot study showed that primary health care providers are willing to enter data into structured forms, even when the average number of data fields in the form doubled from 23 to 46 per encounter [6].

When creating clinical forms to be used at the point of care, the importance of domain knowledge cannot be over-emphasized [7]. Thus we used a form that is well known and routinely used in primary care. The Rourke Baby Record (RBR) is a “well baby” surveillance form-based instrument used by primary care providers and health practitioners in Canada to monitor children’s development [8, 9]. Although the RBR has been implemented into multiple electronic medical records (EMR), the data collected is not standardized and is neither extractable nor transmissible—all the features needed for surveillance, research and system management. We sought to study the Rourke Baby Record in an electronic format (eRourke) to be used to detect children “at-risk” and those with developmental issues. Currently approximately 25% of Ontario’s children start school with developmental vulnerabilities, with fewer than 30% having a diagnosis. The eRourke could help provide early detection, intervention and resource planning.

1. Methods

An observational study was conducted at 4 primary care clinics in Southern Ontario, all of which were part of the Family Health Teams. The eRourke form was incorporated into 2 EMR vendor systems, with the assistance of the EMR vendors; the form included a user interface for collection of visit data, an XML data extraction schema and some simple clinical decision support. Participants were 20 primary care providers (physicians and nurse practitioners) who use an EMR/EHR in their practice (10 using OSCAR and 10 using Practice Solutions Suite) and who were willing to try a new, structured data entry tool for well-baby visits. We administered pre- and post-questionnaires and performed on-site observation as well as post-study key informant interviews. We conducted quantitative analysis of anonymized data collected from the eRourke during the study period. Ethics approval was obtained from the McMaster University Research Ethics Board. The study was conducted over a 6-month period.
The eRourke structures data to capture standardized data on children from 1 week to 5 years of age. We maintained a log of physician and nurse practitioner use of the eRourke and recorded the types of issues they encountered in using the tool. We also conducted one-on-one interviews with 8 of the participating providers to get their summative impressions of the eRourke. The primary outcomes were the number of issues with the eRourke (to estimate support effort required to support large numbers of users), satisfaction with the form, quality of data collected and the ability to transmit the data in a standard manner, regardless of EMR|EHR. The secondary outcomes were the types of issues seen at the 18-month visit in primary care practices in Southern Ontario. We conducted the sample size calculation to determine whether the template could be scaled up to 5000 primary care providers across Ontario.

2. Results

Of the 20 providers invited to participate, three users at one site decided not to use the form after it was installed in their EMR. This left 17 users using the eRourke for 6 months. We obtained pre-study questionnaires from all 20 providers and we obtained post-study questionnaires from 17 providers, including the participants who withdrew; the 3 missing questionnaires were from participating providers who were lost to follow-up for a variety of reasons (left the practice, maternity leave), not the ones who refused to participate. Data on over 5000 visits for ~2500 patients was captured during the 6-month study.

The collected data was analyzed and findings are categorized into 3 categories: 1) User satisfaction, 2) implementation issues that limit scalability and 3) data quality. We then determined whether the template is scalable to 5000 primary care providers across Ontario.

2.1. User Satisfaction

Comparing the pre- and post-study periods, we observed increases in user satisfaction with the eRourke. 88% of the providers felt that they were able to capture higher quality data using the new tool, compared to 55% in the pre-study period. Overall, more providers were satisfied with the eRourke than with the previous version, with satisfaction increasing from 70% to 82%. Table 1 presents the findings as they relate to key usability and satisfaction dimensions (note different Ns for pre- and post-study.) Statistical analysis was not conducted because of the small sample size.
Table 1. Pre- and Post-Study Questionnaire Responses

<table>
<thead>
<tr>
<th>Pre-Question n=20</th>
<th>Agree</th>
<th>%</th>
<th>Post-Question n=17</th>
<th>Agree</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1- Satisfied with current well baby template in my EMR</td>
<td>14</td>
<td>70%</td>
<td>1- Satisfied with the eRourke</td>
<td>14</td>
<td>82%</td>
</tr>
<tr>
<td>2- Format of current template is appealing</td>
<td>13</td>
<td>65%</td>
<td>2- Format of the eRourke is appealing</td>
<td>14</td>
<td>82%</td>
</tr>
<tr>
<td>3- Current template allows views of previous visits easily</td>
<td>11</td>
<td>55%</td>
<td>3- eRourke allows views of previous visits easily</td>
<td>11</td>
<td>65%</td>
</tr>
<tr>
<td>4- Current template is easy to use</td>
<td>16</td>
<td>80%</td>
<td>4- eRourke is easy to use</td>
<td>14</td>
<td>82%</td>
</tr>
<tr>
<td>5- Current well baby template allows me to record important findings quickly and easily</td>
<td>13</td>
<td>65%</td>
<td>5- eRourke allows me to record findings quickly and easily</td>
<td>13</td>
<td>76%</td>
</tr>
<tr>
<td>6- Current well baby template allows me to capture high quality information</td>
<td>11</td>
<td>55%</td>
<td>6- eRourke allows me to capture high quality information.</td>
<td>15</td>
<td>88%</td>
</tr>
</tbody>
</table>

2.2. Implementation Issues that limit scalability

The major user complaints with the eRourke were: 1) Poor integration of ill-baby and well-baby care documentation in EMRs. EMR interfaces treat the eRourke as a ‘form’ that must be exited to view other parts of the record, limiting users’ ability to view ill-baby and well-baby records simultaneously. 2) Poor integration of the immunization module and the eRourke. Data has to be entered in the immunization module for reminders and queries to work properly, but that data did not get sent to the eRourke. If a provider wishes to know the patient’s immunization status in future when viewing the eRourke, they have to re-enter the immunization information in the eRourke form, creating a burden of double data entry. 3) Poor integration of a Parent reporting tool and eRourke. Currently, providers must exit the eRourke to view the parent-reported information; both cannot be viewed at the same time, causing fragmentation of information and increased cognitive overhead.

Table 2 categorizes the implementation issues identified during on-site visits. These issues were reported to the EMR vendors as soon as they were detected. Most were fixed within a reasonable time frame.
Table 2. eRourke implementation issues

<table>
<thead>
<tr>
<th>Type of Issue</th>
<th>No.</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coding Error</td>
<td>3</td>
<td>Clicking on check box in one column selects box in another column</td>
</tr>
<tr>
<td>Specification not met</td>
<td>2</td>
<td>Breast feeding should have 4 states, but only 3 captured in the form</td>
</tr>
<tr>
<td>Usability</td>
<td>18</td>
<td>Immunization text boxes too small</td>
</tr>
<tr>
<td>Integration with EMR</td>
<td>2</td>
<td>Difficult to view both ill and well-baby care at the same time</td>
</tr>
<tr>
<td>Technical</td>
<td>1</td>
<td>The scroll wheel on the mouse was behaving as a left button</td>
</tr>
<tr>
<td>Unit Conversion</td>
<td>2</td>
<td>Age of patients displayed in years, even in infants</td>
</tr>
<tr>
<td>Maintainability</td>
<td>2</td>
<td>When eRourke is updated, previous data should be imported</td>
</tr>
<tr>
<td>Spelling Error</td>
<td>1</td>
<td>Pneumococcal was spelled as pneumococal</td>
</tr>
<tr>
<td>Exclude</td>
<td>3</td>
<td>Ruled out as issue after investigation</td>
</tr>
</tbody>
</table>

Total: 34

Key informants were asked whether they preferred check boxes or radio buttons for data input. Most users preferred the data input method that they had used during the study; a small minority had no preference for either method.

2.3. Data Quality

Quality of data extracted from the eRourke was very good and far surpassed what was possible with the old forms. The older forms had not allowed extraction of any data, let alone standardized data from multiple EMRs. Minor issues did remain, such as a few records that mixed metric and imperial units and some types of information was not routinely filled, such as family history, APGAR scores and other risk factors, although there was a trend to increasing use of those fields over the course of the study. Developmental status and other check list information, which was structured and standardized in the eRourke and formed the bulk of the data collected was clean and easy to analyze. Researchers were able to quickly analyze the data to identify trends in the data –something they had not been able to do previously. These clinical data will be reported elsewhere.
3. Discussion

Overall, the quality of information captured in the eRourke is higher than previous versions in the EMR and the data extracted is clean and easy to analyze. The eRourke also increased the perceived quality of information collected and most of the providers found the eRourke acceptable for use in their practice. There are several unrealized opportunities to improve the usability of the form by improving the integration of the eRourke with other parts of the EMR, including better integration with the immunization module; better integration of ill baby and well-baby visits and better integration of the patient reported form. We conclude that the eRourke is scalable to all providers in Ontario if the three major usability issues are resolved.

The approach to development of the eRourke is transferrable to other diseases and forms. Development and implementation of electronic versions of forms requires iterative development to identify residual usability and user satisfaction issues. To ensure widespread uptake of forms, vendors and technology implementers need to pay attention to integrating disparate elements of the EMR to increase usability and value to front line clinicians.

References


Patient Perspective Paper
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What is Missing from this Picture?
Empowering the Health Consumer

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Abstract As patients, we are told that we own all of our personal medical information, but we do not necessarily have it, control it or have immediate access to it. It is not portable enough to be carried in a pocket or purse or to take it with us when we travel. It is not readily accessible when we move to a new town, need to visit a new medical practitioner and are required to fill out yet another paper “Intake Form” when we hope to remember all of the answers to the questions but likely don’t! Moreover, we do not want the government being a "Big Brother” controlling our personal medical information, storing it on the “Cloud” and ultimately transferring its management to a U.S. based Company as has happened with other personal medical related services. It is time we, as owners and prospective patients, are not only empowered, but trusted to manage and be responsible for storing our own health records.

Empowering the Health Consumer

Personal Health Records Include All Health-related Providers……

While there is a trend developing slowly towards the use of computers by medical practitioners during consultations and the conversion of some practitioners’ paper medical records into digital, the majority of medical records be they physician, physiotherapist, dentist, chiropractor and the like are not yet in digital format. Converting them to digital on an individual basis is not a huge task if done progressively.

Current plans by governments to digitise and centralise personal medical information require major investment, long implementation periods as well as careful scrutiny by the Privacy Commissioner in B.C. One approach to accelerate results is to partition some of the responsibilities to individuals to offload the valuable resources within the healthcare sector. A portion of funds could then be redirected towards improving medical care by training more doctors, improving working conditions for medical practitioners and in hospitals, on new equipment or for advancing health research.

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Responsibilities of Individuals for Record Keeping

Because of personal experiences, this concept of government centralised medical records had been a serious topic of conversation with several colleagues. Why not empower an individual or the person responsible for them to take control of managing their medical history? We manage our personal finances, education, and children, so why is it difficult to believe that we can also manage our own health records? Are our historical medical records so much more important that we cannot be trusted to manage them?

The 18-Month Window

Medical professionals consulted locally and in the USA all indicated that, unless there was a serious or chronic medical condition present, patient historical data for the past 18 months was the most useful. Especially in the case of a doctor taking on a new patient, being able to see specialist’s and hospital reports as well as image copies of X-rays MRI’s, ECG’s etc. was seen as an added bonus. This 18 month window indicates that for many patients the paper records that could be turned into digital are not necessarily a high volume.

Equipping Individuals to Take Responsibility for Historical Records

The average person/patient expects to receive the best possible medical care when needed. Therefore they should have an investment in being able to provide as much and as accurate a medical history as possible when needed. Is there any reason why it would not be possible or practical for an individual to update a personal medical record by making a note of the latest treatment, medication prescribed or by attaching a report or image file? And yes, this assumes that one would be using an electronic personal health record.

The technology to have a personal electronic health record already exists. Its ultimate use is just being approached from the wrong perspective. Rather than funding a government controlled personal health record system, why not focus on having all of those paper records digitized at no cost for the various medical practitioners?

With the availability of high speed scanners able to deal with thousands of paper pages in short order, this would not cost nearly as much as is currently being spent and the outcome would be the first practical step towards facilitating personal health records management into the hands of the owner - the patient or their designated care giver. There are no privacy implications when the owner is responsible for care and control of their own records. Some of the more progressive medical practitioners are already providing their patients with electronic copies of data from their appointments. Hospital and pharmacy records are already available on request and some are provided as digital files.

Engaging the Millennials in the Next Generation of Care Records

The questions of computer access or interest in controlling the storage of one’s own medical information are easily addressed. The majority of the population according to Statistics Canada do have access to a computer at home and this is increasing. The speed at which the “Baby Boomer” sector of the population is embracing leading edge
technology is outstripping that of their children, while tomorrow’s adults know only the
digital world and will utilise technology to its highest extent in their daily lives. If
responsibility for the electronic management of their personal medical records is part
of their future, it is not going to be any kind of challenge for them.

**Portability of Health Records**

A credit card sized device has long been seen as practical for other uses. With
appropriate software on board, it can carry huge amounts of data and images and is
eminently portable.

**Benefits of Portable Records (EMT and Intake)**

A typical personal health record can include but not be limited to carrying a
comprehensive range of related health information such as medical conditions and
treatment, travel history, insurance policy details, life instructions like “DNR”, be able
to instantly produce a medical summary of the file contents and produce the equivalent
of an “Intake Form” when visiting a new medical practitioner. It must also be able to
carry actual X-Ray, MRI, CAT scan, ECG files and the like, and not just copies of
written reports. It could also be extended to include personal records of exercise data,
health improvement or goals achieved.

**Tackling Handoffs between Providers**

Many of us can cite examples of how having control of personal health care
information could have helped in the treatment of ourselves, friends or family
members. Two hospitalisations of my own, and in observing the process when,
following a fall at home, an elderly aunt was admitted to hospital with broken bones
and concussion. The only questions asked with regard to the Aunt concerned what
medication she was currently taking. Then there was a hunt to find her pills and her
Medical Insurance card. These two issues seem to be the key matters requiring
attention by emergency responders. But there was no question asked about any other
current diagnosis, future scheduled hospitalisation appointments or treatment at another
institution either then or once she was in the E.R.

In fact, two days later she was due to attend the B.C. Cancer Agency to begin
radiotherapy for a stomach tumor. This information did not “pop up” when her name
was entered into the hospital computer on admission. Why? Because there are still
silos of unconnected data held by individual medical practitioners and institutions
throughout the country.

**The Empowered Health Consumer**

Even so, with very little effort, we can do more to improve the quality of care we
receive as patients or for those family members for whom we may be responsible by
having control and management of our medical records.
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