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Electronic Falls Reporting System Implementation: Evaluating Data Collection Methods and Studying User Acceptance

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ELECTRONIC FALLS REPORTING SYSTEM IMPLEMENTATION: EVALUATING DATA COLLECTION METHODS AND STUDYING USER ACCEPTANCE

A Thesis Presented

by

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ABSTRACT

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In this research, we detail the development of a novel, easy-to-use system to facilitate electronic patient falls reporting within a long-term residential care facility (LTRCF) using off-the-shelf technology that can be inexpensively implemented in a wide variety of settings. We report the results of four complimentary system evaluation measures that take into consideration varied organizational stakeholders' perspectives: 1) System-level benefits and costs, 2) System usability, via scenario-based use cases, 3) A holistic assessment of users' physical, cognitive, and marcoergonomic (work system) challenges in using the system, and 4) User technology acceptance. We report the viability of collecting and analyzing data specific to each evaluation measure and detail the relative merits of each measure in judging whether the system is acceptable to each stakeholder.

The electronic falls reporting system was successfully implemented, with 100% electronic submission rate at 3-months post-implementation period. The system-level benefits and costs approach showed that the electronic system required no initial investment costs aside from personnel costs and significant benefits accrued from user time savings. The usability analysis revealed several fixable design flaws and demonstrated the importance of scenario-based user training. The technology acceptance model showed that users perceived the reporting system to be useful and easy to use, even more so after implementation. Finally, the holistic human factors evaluation identified challenges encountered when nurses used the system as a part of their daily work, guiding further system redesign. The four-pronged evaluation framework accounted for varied stakeholder perspectives and goals and is a highly scalable framework that can be easily applied to Health IT (Information Technology) implementations in other LTRCFs.

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INTRODUCTION AND LITERATURE REVIEW

1.1 Background

Patient falls are a costly and common problem in a variety of healthcare settings. They are the leading cause of unintentional injury and death among older adults (age 65 years and over) [1] and are the largest single category of self-reported incidents in acute care facilities [2]. Statistics show that over 10,300 elderly deaths resulted from falls in the year 2000 costing approximately $179 million in incidence and medical costs [3]. Furthermore, non-fatal injuries caused by falls cost $19 billion annually [3]. In addition to taking lives and causing acute injuries, “Falls result in disability, functional decline and reduced quality of life. Moreover, fear of falling can cause further loss of function, depression, feelings of helplessness, and social isolation” [4].

Falls occur more frequently in older adults who suffer more often from muscle weakness, walking or gait problems, reduced vision, medication side effects and environmental hazards. One recent study found that individuals aged 70-to-99-years comprise 58% of all falls [5]. The 2008 US Census estimated that 39 million older adults are living in the US, accounting for 12.3% of the country’s population [6]. Of the 39 millions older adults, 1.4 million elderly Americans are living in 15,711 long-term residential care facilities (LTRCFs) [7]. Additionally, the US Census Bureau reports that the aging population is projected to double within the next 25 years and that an estimated 1 in 5 Americans will be age 65 or older by that time [8]. This increase in the 65 and older population creates an escalating demand for LTRCFs. Given the current frequency and cost of falls, and the growth of the older adult population, we need methods to reduce patient falls and reduce the negative consequences of falls that do occur.

Patients who fall may require extended stays in hospitals, more tests, additional procedures, and extra monitoring. Care-providing institutions now have significant monetary incentive to reduce falls. The Centers for Medicare and Medicaid Services (CMS) incorporated falls as a category under the 2008 Hospital Acquired Condition (HAC) regulations, a move that restricts payment to hospitals for treating injuries caused by falls that occur on hospital property. A patient falling from his/her bed incurs, on average, approximately $24,962 in injuries sustained by the fall, a cost that now must often be paid by the hospital [9].

Because of the high prevalence of patient falls, the associated adverse outcomes in at-risk patient populations, and the cost of treating injuries resulting from falls, national organizations recognize the need to study and better understand the characteristics and prevalence of falls within healthcare facilities, especially LTRCFs. This knowledge can then inform the development of interventions that reduce the number of falls and their consequences. Several organizations recognize this need for further study. The Joint Commission emphasizes the need to reduce the risk of patient injuries from falls in their National Patient Safety Goals. Additionally, the American Nurses Association's Magnet Recognition program includes falls as one of the core indicators of nursing performance. Such measures "have a strong ideological connection to quality nursing care" [10] and are used to monitor performance within units at the facility level.

1.1.1 Importance of Falls Reporting

Patient falls reporting helps organizations study the characteristics and prevalence of falls within their healthcare facilities and ultimately serves several purposes. First, organizations can examine the causes of a fall. This examination helps organizations to take preventive measures against future falls and to improve patients' quality of care and quality of life, thereby reducing future patient falls-related costs not covered by CMS. In addition, organizations may recoup, though not from CMS, insurance claims for medical expenses incurred by the fall. A third reason to have systems to record and analyze falls is to reduce the agencies' liability insurance costs. The organizations can use this structured data to track falls-related trends in individual patients and patient populations across facilities and organizational units. As mentioned in *Lippincott's Nursing Procedures*, one should "complete a detailed incident report to help track frequent patient falls so that preventive measures can be used with high-risk patients" [11]. Completing a detailed incident report helps nurse leaders and quality improvement personnel to determine the causes of the fall so that they may plan for future prevention efforts. For example, if a fall is caused by medication side effects, the staff can communicate with the patient's doctor about the possibility of switching medications. Detailed quality improvement efforts used to reduce falls will be discussed in the next subsection.

1.1.2 Quality Improvement Efforts Used to Reduce Falls

Quality improvement (QI) personnel in hospitals, nursing homes, and other care facilities are working hard to develop falls prevention programs to reduce the number of falls in their organizations. The Joint Commission had published a book entitled *Reducing the risk of falls in your healthcare organization* to guide healthcare organizations in falls prevention and reduction activities. According to the Joint Commission, “the first step in reducing falls is correctly and completely assessing and reassessing and individual’s risk of falling.” [2] Typically, the initial nursing assessment is done upon the patient’s admission to the facility. Assessment techniques included observation of the patient’s emotional state and physical range of movement, communication with the patient’s doctor, caregiver, and family, and review of the patient’s medical history, including medications. Comparing the assessment with a risk assessment tool (a set of criteria developed by organization leaders) helps to determine the patient’s risk level for falling.

Another quality improvement effort to reduce patient falls is making sure the environment is safe for the patient. The Joint Commission developed an environmental checklist to identify fall risks, including: adequate lighting, minimized glare, clean and dry floors free of clutter, visible and secure handrails near the toilet, and equipment in good repair [2].

1.1.3 Using Technology for Falls Reporting and Quality Improvement

The current paper-based falls reporting process has many drawbacks, including requiring a great deal of manual data entry. Further, the incident reports exchange many hands throughout the organization, requiring subsequent manual processing of the form data into aggregate analyses. Forms also may be lost, resulting in incomplete quality improvement data. As Health IT progresses, hospitals and large healthcare delivery systems are increasingly using technology to improve the delivery of healthcare. While Health IT has yet to fully diffuse into LTRCFs and other non-acute care facilities ([12], [13], [14], and [15]), successful Health IT implementations may pave the way for tools that can improve healthcare for various vulnerable populations including the elderly [16]. Yet, these settings face many barriers in their attempt to adopt Health IT. Resnick et al. [17] state that these barriers include "lack of access to capital by providers, high initial costs with uncertain payoff, complex systems, and lack of data standards that permit exchange of data, privacy concerns, and legal issues."

In the research described here, we focus on three significant barriers to Health IT adoption: financial limitations [18], the technology readiness of users [19], and the lack of a standard evaluation framework [20]. A study by Keshavjee et al. [18] showed that only 20% of interviewed Canadian family physicians – another low-technology, understudied setting – are willing to invest in electronic medical records. Despite the fact that US hospitals are provided with financial incentives to use Health IT [9], other sectors of healthcare such as LTRCFs do not have strong adoption incentives.

The technology readiness of a given workforce – such as nurses – also affects Health IT adoption. In 2009 Yu et al. [19] surveyed 134 caregivers from 15 long-term care facilities in Australia and found that 66.4% of the participants are *potentially capable* of Health IT adoption *with adequate training and support*. The authors concluded that the caregivers' computer skills directly influenced their adoption of new Health IT applications, making it essential to provide sufficient training and support [19].

Unfortunately, Health IT implementation evaluations are often conducted in large hospital settings, while evaluation in elder care settings is understudied [21]. These institutions need structured means to evaluate the financial impacts of Health IT and potential system efficiencies resulting from Health IT, which together will comprise a value proposition for administrators. Additionally, institutions must be able to evaluate how the system might change users' workflow, including whether the system supports the cognitive abilities of users and the usefulness and ease of use of the system – all factors potentially affecting Health IT adoption [22]. According to Castle et al. [23], "Nurses are looking towards IT to streamline work and reduce unnecessary and redundant activities, which may in turn allow them to spend more time with patients and have higher job satisfaction." Yet, Health IT often does not fulfill this hope.

While the evaluation of Health IT is difficult due to the complexity of the evaluation project, and the institutional motivation for evaluation, LTRCFs badly need a robust Health IT evaluation framework to address the aforementioned barriers to adoption [20].

1.2 Objectives

The objectives of this study are to develop an inexpensive electronic patient falls reporting system in a long-term care facility serving older adults in Western Massachusetts and to test a Health IT evaluation framework that can be easily used by other LTRCFs. The electronic patient falls reporting system uses off-the-shelf technologies currently available within the organization. The system requires basic computer knowledge, and allows nurses to document patient falls and to submit their reports electronically, allowing quality improvement personnel and administrators to access and aggregate falls data immediately. A schematic overview of the system is shown in Figure 1.

We report the results of four complimentary system evaluation measures that take into consideration varied organizational stakeholders' perspectives: 1) System-level benefits and costs, 2) System usability, via scenario-based use cases, 3) User technology acceptance, and 4) A holistic assessment of users' physical, cognitive, and marcoergonomic (work system) challenges in using the system. We report the viability of collecting and analyzing data specific to each evaluation measure and detail the relative merits of each measure in judging whether the system is acceptable to each stakeholder. We document how these evaluation measures can inform the refinement and/or redesign of the system to improve the system's fit with users and their workflows

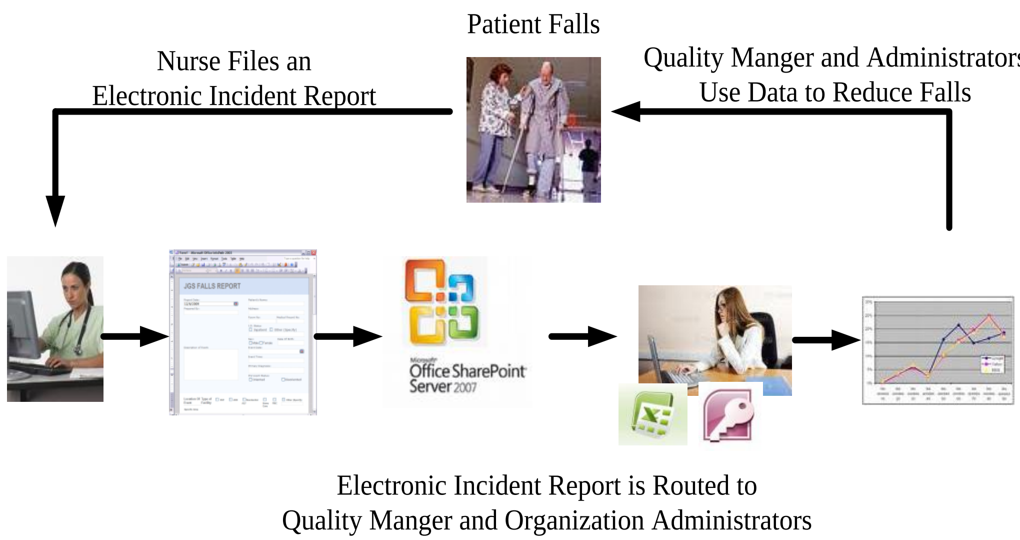

Figure 1: Patient Falls Reporting System Schematic

In short, we describe how this project uses the electronic exchange of health information (via the patient falls reporting system) to improve quality of care (specifically patient falls). This project focuses on using Health IT to improve the quality of care provided to a priority population, the elderly, in an understudied setting (LTRCFs). The system uses Health IT to generate informative data, and aggregate data for ongoing quality improvement initiatives. The results of this study will inform the transference of the developed system to other applications and settings, as shown in Figure 2.

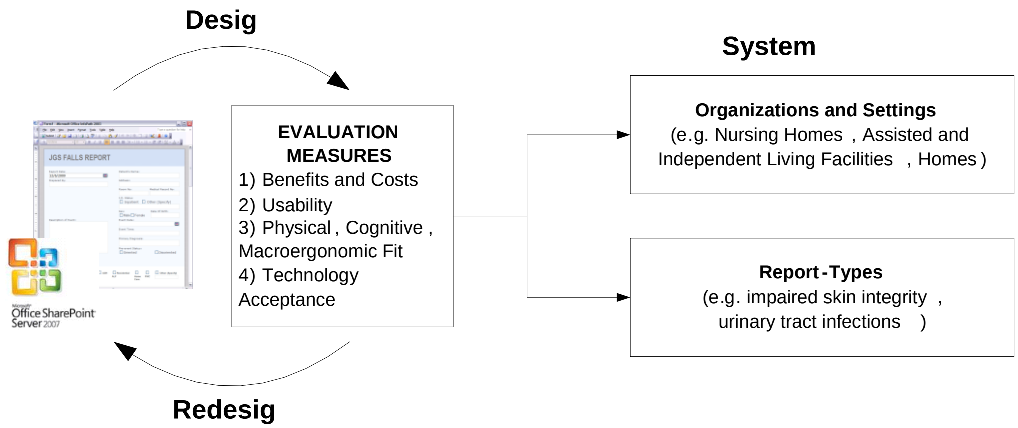

Figure 2: Scalability of the Falls Reporting System and Evaluation Framework

1.2.1 Study Site

The organization of study is a non-profit LTRCF in Western Massachusetts, which is composed of six independent programs, each providing specialized services to elderly adults. The Health IT system described here was implemented in the facility's 78-bed assisted living facility. The staff at the assisted living facility includes four nurses, one of whom serves as the quality improvement manager who keeps records of falls data. The work described here was approved by the Institutional Review Board at the University of Massachusetts Amherst. The LTRCF implemented an e-mail system approximately one year ago, but the four nurses have limited work-related computer usage and are generally not utilizing the e-mail system as a source of communication and information sharing. Currently, the nurse who serves as a quality improvement manager manually counts the number of falls at the end of each month and inputs the data into computer-based organizational reports. She does not perform any data aggregation or analysis using computer applications or software.

1.2.2 User-Oriented Falls Reporting System Design

After meeting with quality improvement personnel to understand their needs, as well as the needs of the organization and its staff, the research team took a user-centered design approach to create a low-cost falls reporting system at the LTRCF. This project addressed the four evaluation concepts (system-level benefits and costs, usability of the falls reporting system interfaces, continued adoption, and fit with users' work) throughout the initial system design cycle.

To be attractive to the organization, the proposed falls reporting system must require low capital costs and reduce future labor costs. As budget is always one of the primarily concerns in projects, especially in health information technology implementation, this project aimed to provide a solution for the LTRCF that required little capital. By using their readily available applications Microsoft SharePoint and Microsoft InfoPath to create the electronic falls reporting system, the organization incurred no extra development costs. The research team also focused on decreasing labor costs by making the falls reporting process more efficient.

All system interfaces must be intuitively understandable to end users to ensure that they use the system as intended with minimal errors. To address the usability of system interfaces, the research team focused on simplifying the electronic falls reporting form to mimic the forms currently in place at the LTRCF. The research team also elicited feedback on the form design from stakeholders in the respective LTRCF programs.

If the falls reporting system is to be successful, users must perceive it to be both useful and easy to use, with these factors influencing their adoption of the system. To ensure continued adoption of the system, the research team worked with the quality improvement personnel in the LTRCF to encourage buy-in at the program level. The research team also met with the Chief Nursing Officer to ensure buy-in at the organizational level.

In addition, focusing on a design of a falls reporting system that “fits” the users is very important for two reasons. First, the system must be compatible to the users’ physical and cognitive abilities. Second, according to Dixon [24], the implementation of a technology intervention creates a change in user workflow, and ignoring the ‘fit’ of the technology to the users’ work system can lead to their rejection of the technology. The research team captured users’ work processes through interviews with key stakeholders.

1.2.3 Data Collection Approach

This project aims to evaluate the relative merits of an evaluation framework consisting of three traditional technology implementation data collection techniques and one additional approach: a holistic human factors evaluation approach. When implementing a new technology, three existing and commonly used measures of system worth, as previously mentioned, include: system-level benefits and costs, usability analysis via cognitive task analysis (CTA), and technology adoption. The holistic human factors evaluation approach is guided by Zayas-Cabán et al. [25] and Marquard et al. [26] in their studies to monitor and mediate physical, cognitive, and macroergonomic design flaws in a consumer health informatics intervention system. By identifying the flaws, it provides opportunity to redesign the system to enhance the “fit” of the system to users’ work patterns [25].

The proposed falls reporting system will initially be deployed at the LTRCF’s assisted living facility. Having nurses at the assisted living facility test the electronic falls reporting system will help identify design flaws. The data collected will enable the researchers to guide system redesign at the assisted living facility, and redesign and training before deployment in other programs at the LTRCF.

1.3. Literature Review

1.3.1. Cost of fall among Older Adults

Stevens et al. [3] conducted a detailed study on the cost of fatal and non-fatal falls among adults aged 65 and over. The authors used various sources to analyze the cost of falls since there is no national database that provides information on the incident and medical costs of falls. In the study, the authors divided the cost of falls into fatal and non-fatal falls.

The cost of fatal falls were estimated by the place of death, which were categorized as death-on-scene/at home, death-on-arrival to the hospital, death at the ED, death at the hospital after inpatient admission, and death at a nursing home [3]. Depending on the place of death, the cost incurred can be estimated by considering factors such as cost of transportation to the ED (Emergency Department), cost of inpatient admission, and cost of nursing home services. The total cost of fatal deaths among 10,300 fatal fall injuries in the year 2000 was $179 million [3]. Furthermore, Stevens et al. examined and compared the cost of fatal falls between age group, sex, and types of fatal injuries. The first age group, 65-74 year- olds, accounted for 17% of the total cost of fatal falls; ages 75-84 accounted for 36%; and ages 85 and over accounted for 47% of the total cost of fatal falls [3]. From the data, the authors concluded that the cost of fatal falls increased with age. When examining the cost between females and males, the authors found that the cost of fatal falls for women is 20% higher than for men [3]. Moreover, the study further investigated the causes of death due to falls, and reported that 44% of the deaths were from fracture, followed by injured internal organs (29%) [3].

The second category of the cost of falls that Stevens et al. studied was non-fatal fall costs. Non-fatal fall costs included costs of services in the hospital and nursing home, costs of medical supplies and equipments, and other service costs such as home health and hospice [3]. The study estimated 2.6 million non-fatal fall injuries in a year which brings the total annual cost of non-fatal fall to $19 billion. Once again, the authors examined and compared the cost of non-fatal falls between age group, sex, and types of injuries. Data shows that costs increased with age: ages 65-74 accounted for 25%; ages 75-84 and ages 85 and over accounted for 38% of the total cost of non-fatal fall injuries [3]. For women, the proportion of falls-related costs is significantly higher than men: 67% compared to 32%, respectively [3]. According to the authors this difference is due to women having higher sustainable rates for hip fractures than men and also that fractures were the most expensive type of non-fatal fall injury (32% of the total non-fatal fall cost) [3].

By implementing a falls reporting system that decreases the time between the moment a fall occurs and the time by which quality improvement personnel have information about the fall, more timely and appropriate interventions by quality personnel can be put into place, thus reducing the costs associated with falls.

1.3.2. Health Information Technology Costs and Failures

Health IT has received significant attention since President Obama signed the Recovery Act of 2009 in February, 2009. As part of the Recovery Act, Congress approved more than $20 billion for Health IT to improve the US healthcare system [27]. Furthermore, Medicare and Medicaid provide Health IT incentives and support for adoption. Beginning in 2011, Medicare and Medicaid will start one incentive program by giving bonus payments to hospitals and professionals for adopting and using certified electronic health records [9]. Professionals and hospitals who fail to adopt the use of certified electronic health records will be penalized beginning in 2015 [9].

The benefits of Health IT from the Health Information Technology for the Future of Health and Care website include:

- Improved healthcare quality
- Prevention of medical errors
- Reduced healthcare costs
- Increased administrative efficiencies
- Decreased paperwork
- Expanded access to affordable care [28]

However, a recent study by Kaplan and Harris-Salamone [29] identified the difficulties and failures of implementing Health IT. According to Kaplan and Harris-Salamone, in a study of 214 IT projects, in which 18 projects came from the healthcare sector, 65% of the failed projects failed because of inadequate management practices, and 35% of the failures were caused by technical problems such as “poor or inappropriate requirements, design, development tools, user documentation, test planning, and technical support" [29]. A detailed study of Health IT failures is valuable for learning and training, but publication of Health IT failures are limited because the failures are often covered up, ignored, or rationalized [29].

Even though data on medical errors due to Health IT failure are limited, the Joint Commission examined around 180,000 medication error records in the U.S. Pharmacopeia MEDMARX database in the year 2006 and classified 25% of those errors are directly or indirectly related to Health IT [30]. In an article published by Elizabeth S. Roop, Roop reports that 5% of those medical errors are from mislabeled bar codes on medications, that 2% come from poor information management systems, and that 1.5% result from unclear or confusing computer screen displays [30].

By taking a user-centered design approach to the creation of the falls reporting system, and evaluating system-level benefits and costs, usability of the system, continued adoption of the system, and the fit between the system and users' work, the research team aims to mitigate known factors leading to high Health IT costs and rates of failure.

1.3.3. Information Technology and Users' Work

Health IT applications are often built in a way that focuses on automating paper-based forms or tasks without considering the users' capability of using the application [25, 31]. The National Research Council reports that Health IT applications "provide little support for the cognitive tasks of clinicians or the workflow of the people who must actually use the system" [31]. As a result of poor designs, Health IT can increase workload instead of reducing it and create new forms of medical error [31].

A well-designed Health IT system must account for all three human factors domains relevant to the user: physical, cognitive, and macroergonomic. In a study by Zayas-Cabán et al. [25], the authors assessed the physical, cognitive, and macroergonomic challenges encountered by users when using a consumer health informatics (CHI) intervention. The authors observed three students using the intervention which consisted of CHI devices (a blood pressure monitor and glucometer) and a CHI application (Microsoft HealthVault). Two undergraduate industrial engineering students performing the roles of patients were put to the task of using the CHI devices to send their glucose readings electronically through the CHI application. For the nursing PhD student performing the role of nurse, the task was to monitor and alter the patients' medication using the CHI intervention. Over a ten day period, the acting-patients identified 49 human factors domains challenges, and the acting-nurse identified 8. An example of a physical challenge identified by one of the students is "difficulty securing the USB plug to a computer in an inaccessible location" [25]. A cognitive challenge recognized by a student was the fact that an error message did not explain what caused the error. A macroergonomic challenge observed by the student who performed the nursing role was that the system does not address how the nurse documents glucose readings that merit a change in medication. The authors concluded that by identifying the physical, cognitive, and macroergonomic challenges, "it is then possible to re-design and/or supplement an existing CHI intervention, making the intervention more closely fit end-users' work" [25].

The holistic human factors evaluation approach supplements usability evaluation by assessing the fit of the proposed falls reporting system with users' work in addition to users' ability to navigate specific system interfaces.

1.3.4. Information Technology and Shared Work

Technologies are built to support specific cognitive activities and "off-load" a part of the user's workload [32]. In the article "Wearable Technology for Crime Scene Examination: distributed cognition and naturalistic decision making," Barber provides an example of taking a photograph of a crime scene. The photograph supports a specific cognitive activity: helping the user to remember the scene by capturing the crime scene on film. This example illustrates that cognitive work is shared by both the user and technology, creating a relation between the two known as "distributed cognition" or "shared work." Barber further explains: "a primary assumption of 'distributed cognition' is that objects-in-the-world play a role in supporting, structuring and aiding the activities of cognition" [32].

When designing a technology, one must understand the tasks that the technology will undertake and what pieces of information each user will need to complete their task. In a complex environment such as healthcare, it is challenging to design a technology that supports a specific cognitive activity. However, if successfully designed, the technology will be extremely valuable to the users. In an article, Yan Xiao [33] mentions that there are two characteristics of healthcare that make information technology more difficult to deploy than in other industries. He states that "first, healthcare is a prime example of collaborative work. In hospitals, multiple people provide care to each patient and bring to bear their expertise and efforts" and "healthcare work is often non-routine, so it is difficult to pre-schedule events and activities" [33].

In his study, Xiao examined the use of whiteboard in managing six operation rooms and how it supports the collaborative work between the staff members and the ways in which staff use the board to support their work environment. The whiteboard is located in an area that is accessible by all staff members and displays information such as staff schedule and surgery room status. Having a public whiteboard where all staff can see all the information "encourages communal management of activities in the operating rooms" [33]. Furthermore, "they [staff] also exploit different arrangements of objects to convey changes in status (often subtle) in response to the changing environment, such as staffing shortages or patient volume increases" [33]. Another example given in his study is the relationship between electronic schedules and the user, who in this case is the clinician. Information technology stores and organizes a schedule of patients for the clinician while the clinician uses the information technology to print out the list of patients in order to write notes and reminders to support his or her work environment. The above examples show how information technology can support distributed work, albeit often in unintended ways.

The proposed falls reporting system will support the shared work of nurses, nurse managers, quality improvement personnel, and organizational administrators as they document and file falls reports, assess information about individual falls and trends in falls, and make decisions about patient falls and quality improvement interventions.

1.3.5. Types of Data Collection and Relative Merits

This project aims to evaluate the relative merits of traditional technology implementation data collection techniques and an additional approach: a holistic human factors evaluation approach. When implementing a new technology, three previously mentioned existing and commonly used measures of system worth are: system-level benefits and costs, usability analysis via cognitive task analysis (CTA), and technology adoption. A brief summarization of each data collection technique and their relative merits are discussed in the next few subsections.

1.3.5.1. System-level Benefits and Costs

Several literatures have evaluated Health IT interventions through an economic perspective, because cost is one of the primary burdens preventing an institution from implementing Health IT. Wang et. al [34] performed a cost-benefit analysis of using electronic medical records (ERM) at a physician office. In their study, the authors estimated two categories of costs incurred while implementing ERM: system costs and induced costs. System costs included software costs, which are $1600 per provider per year, initial software purchase cost, estimated to be $2500-$3500 per provider, as well as maintenance and support fees of 12% to 18% per year [34]. Induced cost consisted of an implementation cost of $3400 for the first year, maintenance and support costs of $1500 per provider per year, and hardware costs of $6600 per provider for three computer workstations every three years [34]. Wang et. al analyzed categories of cost benefits and one example is a monetary savings of $5 per medical chart pull which included the time and cost of staff to retrieve and re-file a medical chart [34]. The authors suggest that using an EMR can reduce approximately 600 chart pulls annually [34]. Another cost savings included a 15% reduction in total drug costs annually by using alternative, less-expensive drugs suggested by the EMR system [34]. Overall, results showed that in a 5-year cost-benefit analysis model, a total benefit of $86,400 per provider can be achieved using the EMR [34]. Based on the analysis, the authors concluded that "implementing an ambulatory electronic medical record system can yield a positive return on investment to healthcare organizations" [34].

Another study by Poissant et. al [35] focused on the time efficiency of medical staff after implementing Health IT. Specifically, the authors reviewed literature and previous studies to determine the time efficiency of physicians and nurses using Health IT. The study reported that in each shift, nurses saved 24.5% of their overall time on documentation using bedside terminals [35]. However, in the case of physicians, results show an increase of 17.5% in documentation time using bedside or point-of-care computer systems [35]. The authors explained that nurses and physicians document different types of information, thus resulting in different outcomes of using Health IT [35]. Nurses' documentation is often in standardized format, whereas physicians do not have a standardized template for documentation [35].

In the above examples, both studies evaluated Health IT in a system-level benefits and costs approach: monetary costs-benefits and time efficiency. Using system-level benefits and costs largely takes administrative interests into consideration. This data collection approach lacks the assessment of individual work practices, which may result in differences between expected and actual benefits and costs, evidenced by the documentation time differences for doctors and nurses.

1.3.5.2. Usability Assessment through Cognitive Task Analysis

Cognitive task analysis, as defined by Schraagen and Chipman, "is the extension of traditional task analysis techniques to yield information about the knowledge, thought processes, and goal structures that underlie observable task performance" [36]. The data collection methods of CTA are primarily observation and in-depth interviews. According to Militello and Hutton, "these interviews focus on gaining information about the cognitive strategies used to accomplish the task including situation assessment strategies, identification and interpretation of critical cues, metacognitive strategies, important perceptual distinctions, etc" [37]. The strength of cognitive task analysis is that it "aid[s] experts in articulating knowledge that is generally difficult to verbalize," however, the tradeoff is that the analysis requires extensive time and resources to conduct [37]. Additionally, CTA is task-focused rather than work-focused, so it may not capture the fit of the technology with users' workflow.

1.3.5.3. Technology Adoption and Acceptance

There are vast varieties of technology adoption and acceptance models developed by different researchers. Some models' measuring approach focuses on the individual's level of acceptance of technology according to its usage intention or usage [38]. Other models focus on the organization level such as implementation success and task-technology fit [38]. Venkatesh et al. provides a list of individual technology acceptance models and theories which include: Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), Motivational Model (MM), Theory of Planned Behavior (TPB), Model of PC Utilization (MPCU), Innovation Diffusion Theory (IDT), and Social Cognitive Theory (SCT) [38].

The widely accepted and used technology adoption and acceptance model is Davis' Technology Acceptance Model (TAM). Davis' Technology Acceptance Model is composed of two main components: perceived usefulness and perceived ease of use. Davis defined perceived usefulness as "the degree to which a person believes that using a particular system would enhance his or her job performance," and perceived ease of use as "the degree to which a person believes that using a particular system would be free of effort" [39]. In Davis' study, questionnaires were given to 120 users to rate the perceived usefulness and perceived ease of use of an electronic mail system and electronic file editor application. Participants were then asked to self-report their usage of both systems. Statistical analysis showed that both perceived usefulness and perceived ease of use are significantly correlated with usage rate [39]. The TAM utilizes questionnaires to ask users to rate items based on perceived usefulness and perceived ease of use to predict the users' usage of the technology. The TAM provides information predicting and measuring adoption but does not provide guidance on how to improve the human-technology interaction. Additionally, the TAM may not adequately explain which aspects of the technology support or inhibit adoption, or why.

1.3.5.4. Holistic Human Factors Evaluation

Recent studies show promise in utilizing a holistic human factors approach to aid in the design of consumer health informatics (CHI) interventions. Marquard evaluated CHI interventions with respect to three domains of human factors: physical ergonomics, cognitive ergonomics and organizational ergonomics (or macroergonomics) [26]. Physical ergonomics take into account the physical ability of the individual and the physical environment in which the individual performs work. Marquard suggested that designers of CHI interventions assess the user's physical ability to interact with CHI interventions [26]. Cognitive ergonomics is concerned with the individual's cognitive ability such as perception, memory, and decision making. By understanding the users' cognitive ability and how users perform tasks, designers of CHI interventions greatly benefit, as many CHI interventions are designed to aid users on executing these tasks [26]. Finally, Marquard and Zayas-Cabán synthesize existing macroergonomics literature, stating that "macroergonomics not only addresses the type of work individuals might engage in, but the domain also addresses workflow (i.e. the flow of information, people, and artifacts across space and time) and the work system (i.e. the social, workflow, organizational and environmental conditions under which work is performed)" [26]. Marquard concluded that all three human factors domains contributed to how users perform the work and how decisions are made about adoption and use.

Another study by Zayas-Cabán et al. [25], mentioned in the previous subsection, identifies all three human factors domain challenges encountered when users actually engage with the CHI interventions. Using a holistic human factors approach to evaluate Health IT enables researchers and designers to identify challenges within all three human factors domains and allows them to come up with mediation strategies for each challenge [25]. The holistic human factors evaluation approach is work-focused and takes into account all stakeholders as users, the tasks they perform in completing their work, the tools and technologies that aid them in completing their work, their physical environment, and their organizational environment [40].

1.4. Research Contribution

1.4.1. Evaluation Framework

This study tests a four-pronged evaluation framework which consists of system-level benefits and costs, usability analysis, technology acceptance, and holistic human factors evaluation. The relative merits of each of the four approaches are evaluated based on the acceptability of the system to each stakeholder: nurses, quality manager, and administrators of the LTRCF. By identifying the needs and goals of each stakeholder, the system will be redesigned to fit the users and enhance the acceptance of the Health IT.

1.4.2. Initial Falls Reporting System Implementation

The pilot test of this method is an initial system implementation at a LTRCF in Western Massachusetts. The electronic patient falls reporting system is the first step in converting paper-based quality performance data collection into electronic data collection. The pilot testing includes nurses at the LTRCF's assisted living facility. Once the falls reporting system is fully deployed, nurses and staff in the whole organization (i.e. nursing home and home care) will be able to access and use the electronic falls reporting system.

1.4.3. Future System Implementation

Other quality performance measures important to the LTRCF include patient satisfaction, infection reporting, and pressure ulcer reporting, which can be converted to electronic data collection once this falls reporting system is successfully implemented. The 4-pronged evaluation framework will help guide the patient falls reporting system design and implementation and the design and implementation of other reporting tools at the LTRCF as well as other nursing homes and healthcare facilities.

1.4.4. Benefit of the Falls Reporting System

The electronic patient falls reporting system is a low-cost system designed with off-the-shelf computer applications: Microsoft InfoPath and Microsoft SharePoint. If the study is successful, the low-cost falls reporting system and method for design and evaluation will be highly scalable. Small healthcare organizations with low budgets such as nursing homes will be able to implement this electronic system.

CHAPTER 2

METHODS

2.1. Introduction

The falls reporting system aims to support shared work and is being developed through a user-centered design process. The following sections outline the research questions of the study, the system design and data collection approach, and the data analysis approach.

2.2. Research questions

The aim of this research is to answer these two research questions:

Q1: What are the relative merits of each of the four evaluation approaches (system-level benefits and costs, usability analysis, technology acceptance, and holistic human factors evaluation)?

Q2: What factors contribute to the acceptability of the falls reporting system for each user group?

2.2.1. Relative Merits of Data Collection Methods

This research will outline the relative merits of each data collection method: system-level benefits and costs, usability analysis, technology adoption, and the proposed holistic human factors approach. The analysis will be concentrated on the data collection methods' abilities to evaluate and inform the design of a falls reporting system that supports shared work.

2.2.2. Falls Reporting System Acceptability to Each Stakeholder Group

This research will also outline the contributing factors to falls reporting system acceptability by each stakeholder group, specifically the users of the tool (nurses) and those who use the information from the tool in their decision making (quality improvement personnel and LTRCF administrators). Each stakeholder group plays an important role in the system's implementation and determines the system's success.

2.3. Falls Reporting System Design

2.3.1. System Design

To be attractive to organizational leadership, the electronic patient falls reporting system must require low capital costs and/or reduce labor costs. As costs are primary barriers for Health IT adoption, this system provides a solution for the LTRCF requiring little capital costs. By using the existing and available applications Microsoft InfoPath and SharePoint to create the electronic patient falls reporting system, the organization incurred no capital costs and low personnel costs.

At the organizational level, it is also important that the system not become obsolete. The LTRCF desires to keep the proposed patient falls reporting system separate from their clinical information systems. Thus, the system will not interfere with any future plans to implement an Electronic Health Records (EHR) system. In sum, the electronic patient falls reporting system is a low-cost and low-risk approach to gain organizational buy-in for other electronic systems.

Like many LTRCFs, this facility has a low level of technology adoption. Currently, only email is used for organizational communication. To account for the nurses' limited computer background, all system interfaces were designed to be intuitively understandable to end users, which ensures that they use the system as intended with minimal errors. The system is designed so that only a basic knowledge of computers is required for use: locating the icon to open the form, typing information into the form, using radio buttons and drop-down menus, and clicking the submit button to submit the report. To address the usability of system interfaces, the research team focused on simplifying the paper-based incident report currently in place at the facility. By eliciting feedback on the form design from end users, the research team determined which data fields in the patient falls reporting form were commonly used and which were rarely used. For example, in the assessment section of the incident report, there were 26 choices on the paper-based form (e.g. abrasion/contusion, anaphylaxis, bite, brain damage, burn/scald, cardiac arrhythmia, etc.), but the users identified only 4 commonly-used choices. In the electronic report, the research team designed the assessment section to include the 4 commonly used choices (no apparent injury, abrasion/contusion, fraction/dislocation, and skin tear) along with one "other" choice, which was followed by a text box so the users can enter in a specific assessment. With a reduced amount of text, the electronic form appears much cleaner while still preserving essential data fields. Figure 3 displays side-by-side the original paper-based incident report and the re-designed electronic form.

To make it easy for users to locate the form, the research team created a desktop shortcut to the electronic patient falls reporting form on all nurses' computers. This shortcut is only available when a nurse logs into his/her computer, and is only available to approved nurses. Once a nurse completes the report, (s)he clicks on the "submit" button to submit the form electronically. A pop-up message box stating "the form was submitted successfully" appears so the nurse has confirmation that the form has been submitted. In addition, if a nurse is interrupted while filling out the incident report, (s)he can save the report and complete and submit it at a later time.

Once an incident report is submitted through Microsoft InfoPath, the form is sent to the organization's Microsoft SharePoint server where all the reports are stored. For security and privacy reasons, only authorized personnel are able to submit, view, and edit the reports. Moreover, SharePoint has the capability of sending email alerts immediately to notify administrators and quality improvement personnel of new reports, and further, can aggregate selected data from all submitted reports. This function reduces the manual processing of paper-based forms done by the quality improvement personnel. In sum, with these capabilities, the quality improvement personnel can be notified immediately of new reports, can make timely quality improvement assessments, and can easily create data-driven reports.

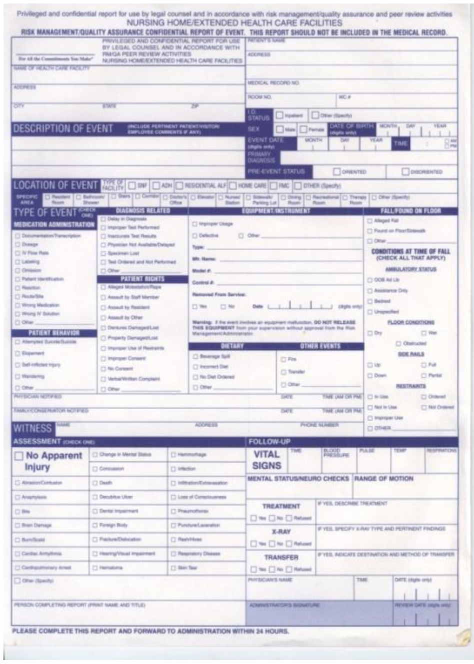

Figure 3: Paper and Electronic Falls Reporting Forms

2.3.2. Shared Work at the LTRCF

With the falls reporting system as the focus of system implementation, the next step is to identify the shared work the system will support at the LTRCF. This knowledge will then identify the tasks for which each stakeholder will need the system, and moreover, the pieces of information each will need to complete their tasks. Each of the quality improvement personnel for each LTRCF program outlined the process of submitting a fall report at their respective program. The falls reporting process can be generalized into the following steps:

First, whenever a fall occurred, the staff member who first found the patient had to file an incident report. The incident report consisted of data fields that asked the staff member to identify the patient, the date, time, and place of the fall, the health condition of the patient before and after the fall, the environment condition of the place of fall, etc. Any witnesses to the incident had to fill in and sign the witness section of the report.

Once the incident report was completed, the staff member submitted it to the quality manager. The quality manager reviewed the report and determined if any procedures needed to be done to prevent the patient from future falls. After, the quality manager manually entered some data fields into the computer to keep a database of information such as number of patient falls monthly, quarterly, and yearly, number of fractures and number of skin tears resulting from falls. From the data entered, the quality manager created monthly, quarterly, and yearly aggregated reports to review with the LTRCF's administrators to evaluate the organization's performance. The quarterly reports are also required to submit to the MDS (Minimum Data Set) nurses for reporting to the government.

From this understanding of the process, the research team identified the needs of each stakeholder. The staff needs the falls reporting system to be able to submit the incident report. The electronic falls reporting system must include all the data elements in the paper-based incident report. However, to reduce the complexity of the electronic falls reporting system, the quality improvement personnel and research team decided to not include the witness section of the report. Likewise, the quality improvement personnel need the system to be able to notify them whenever a report is submitted. The system also has to be capable of maintaining a database of various data fields automatically so the quality improvement personnel can perform quality performance reviews.

2.4. Data Collection Approach

2.4.1. Data Collection Introduction

Each data evaluation approach has its own strengths and weaknesses. By presenting an evaluation framework consisting of all four approaches and accounting for a variety of stakeholders' perspectives, the research team was able to evaluate and redesign the system to improve the fit of the technology for the users. We are confident that this four-pronged evaluation framework is highly scalable; it can be easily transferred to programs within this LTRCF, to other types of organizational reporting, and to other LTRCFs. The following sections highlight the use of these evaluation approaches at each stage of the system implementation. Table 1 summarizes the evaluation measures, and the framework component corresponding to each measure.

2.4.1.1. Pre-implementation Stage

In this study, we defined system-level benefits as decreases in report turnaround time and decreases in workers' time to complete relevant tasks. We defined system costs as capital costs (none in this study) and estimated personnel costs to develop, implement, and maintain the system. In order to evaluate the system-level benefits, the research team gathered data on the efficiency of the paper-based incident report and electronic patient falls submission processes. The nurses recorded the time it took them to file each paper-based incident report over the course of a two month period in a logbook. Within the nurse's logbook, there was a form where the nurse recorded the date of the incident report and the time it took him/her to complete the report. Similarly, whenever an incident report was received, the quality improvement (QI) manager recorded the date the incident report was filed and the date that she received the report on the QI manager's logbook.

This information was used to determine the report turnaround time. In addition, the QI manager also recorded the amount of time she spent manually entering data fields into the computer to aggregate the paper-based reports at the end of each month. In order to assess the system cost, we estimated time spent to develop, train, and maintain the system at a rate of $50 per hour.

2.4.1.2. Training Stage

To further increase the nurses' acceptance of the new patient falls reporting system, we created training sessions in which nurses practiced submitting trial scenarios and then were encouraged to ask questions about the system. The trial scenarios can be found in **Error! Reference source not found.**. During these training sessions, the nurses were given a tutorial packet and were asked to review it with a team member so as to fully understand the process of submitting a report through the electronic system. Then, nurses were given training incident reports for three different patient fall scenarios to enter into the computer and were asked to submit them using the electronic patient falls reporting system. The training incident reports had varying patient demographic information, locations of events, environmental conditions, and patient injury statuses. Our research team also used screen capture videos to detail the process by which each nurse completed the form. While the nurses were entering and submitting the training incident reports with the electronic system, a research team member observed and documented the length of time it took each nurse to submit each report as well as any difficulties the nurses encountered. Furthermore, the nurses were asked to use the think-aloud protocol in which they verbalized their thoughts so the research team member could document challenges not detectable by observation [41].

Following the training sessions, the nurses were given a survey (APPENDIX B

TECHNOLOGY ACCEPTANCE SURVEY) based on Davis's technology acceptance model (TAM) [39]. Multiple studies ([42], [39], and [19]) have concluded that a user's perceived usefulness and perceived ease of use of a technology are determinants of user acceptance and usage. The TAM survey consisted of 20 questions tailored to the patient falls reporting system that asked the nurses to rate on a 7-point scale the extent to which they agreed or disagreed with each statement. The survey aimed to assess each nurses' perceived usefulness and perceived ease of use of the electronic patient falls reporting system. This data was then used to analyze the nurses' acceptance of the new technology prior to implementation.

2.4.1.3. Implementation Stage

After the electronic patient falls reporting system was implemented, the nurses continued recording the amount of time that they spent completing the paper-based and electronic reports. Likewise, the QI manager continued logging the time she spent aggregating the paper-based and electronic-based reports. At the same time, the users (the nurses and QI manager) were asked to journal all the challenges they encountered when using the electronic system in their logbooks. The research team then sorted those challenges into three different categories: physical, cognitive, and macroergonomic (work-related). By identifying the challenges, the research team could regularly review the challenges with users and identify strategies to resolve the challenges.

2.4.1.4. Post-implementation Stage

The implementation stage was estimated to be a three-month period in which the users continued to record all challenges to the use of the system. After using the electronic system for three months, the users were again asked to complete the technology acceptance survey. By comparing the results of the pre-implementation and post-implementation survey, the research team could determine the changes in the users' technology acceptance levels and predict their continued use of the system.

The data collected during this project were analyzed using descriptive statistics and qualitative analysis methods. We provide descriptive statistics for the results of the technology acceptance measures, nurse and QI manager time to file reports, report turnaround times, and percentage of reports filed electronically (in the results section). We qualitatively describe the system design process, the challenges found during the scenario-based training sessions, the challenges found during the holistic human factors evaluation process, and the design strategies used to mediate these challenges.

Table 1: Summary of Evaluation Measures

Stage	Evaluation Measures	Framework Component	Most Affected Stakeholder(s)
Pre-Implementation	• Nurse logbooks of time to complete reports	• System-level Benefits and Costs	• Administration • Nurses
	• QI Manager logbook of report turnaround time (time of receipt by QI manager – time of fall)	• System-level Benefits and Costs	• Administration • QI Manager
	• QI Manager time to consolidate reports	• System-level Benefits and Costs	• Administration • QI Manager
Training	• Scenario-based user training, think-aloud protocol	• Usability	• Nurses • QI Manager
	• Technology acceptance survey (TAM)	• Technology Acceptance (Intention to adopt)	• Nurses • QI Manager
Implementation	• Nurse logbooks of physical, cognitive, and macroergonomic challenges	• Holistic Human Factors Evaluation	• Administration (macroergonomic challenges) • Nurses
	• QI Manager logbooks of physical, cognitive, and macroergonomic challenges	• Holistic Human Factors Evaluation	• Administration (macroergonomic challenges) • QI Manager
Post-Implementation	• Nurse logbooks of time to complete reports	• System-level Benefits and Costs	• Administration • Nurses
	• QI Manager logbook of report turnaround time (time of receipt by QI manager – time of fall)	• System-level Benefits and Costs	• Administration • QI Manager
	• QI Manager time to consolidate reports	• System-level Benefits and Costs	• Administration • QI Manager
	• Technology acceptance survey (TAM)	• Technology Acceptance (Intention to continue using system)	• Nurses • QI Manager
Other	• Estimated time/salary of developer	• System-level Benefits and Costs	• Administration
	• Estimated time/salary of maintainer	• System-level Benefits and Costs	• Administration

2.5. Analysis Approach

2.5.1. Analysis Approach: System-level Benefits and Costs

The system-level benefits and costs approach is composed of these elements: time efficiency for the nurses and QI manager; report turnover time; and the costs to develop, train, implement, and maintain the system. For the time efficiency component, both the nurse's logbook and QI manager's logbook will be analyzed. The time data, the time it takes the nurse to fill out each paper based incident report, and the time it takes to submit each electronic incident report, all collected from the nurse's logbook, will be used to compare the time difference between completing the paper based form and the electronic based form. The QI manger's logbook will be used to analyze two time efficiency measurements. The first measurement is the time the QI manager spends on manually entering the paper-based data fields into the computer. The second measurement is the time it takes for the QI manager to receive the incident report (i.e. the report turnaround time). Evaluating both the time efficiency and the report turnover time can assess the trade-offs between paper-based reports and electronic reports. Furthermore, any time difference between the nurse's work and the work of the QI manager will be investigated and documented in detail.

The costs are assessed by the research team's estimated time spent on developing, training, implementing, and maintaining the system at a rate of $50 per hour. The analysis will justify to the organization the system-level benefits and costs of the electronic falls reporting system.

2.5.2. Analysis Approach: Usability Analysis

Usability analysis will be performed through carefully reviewing the observation data on the challenges that the nurses encountered while using the electronic falls reporting system. Having data on how the nurses entered different incident report scenarios will help to identify challenges specifically due to the system design. For example, in a scenario where the environmental condition is not listed as one of the choices, the nurse has to check the "other" option and key into the blank space the specific condition. The nurse might have difficulty keying in the condition due to the text box being too small. This information will help in the redesign of the system to make the interface more user-friendly. Furthermore, the observation data can also help to determine the system's usability among the nurses: how the nurses use the electronic form, the common errors, the challenges, and how the nurses circumvent those challenges. Those challenges will be investigated to determine their cause and ways to resolve them so that any redesign "fits" the users and their work.

In addition, our research team used a novel technique – process visualizations – for assessing the order in which users of electronic reporting systems complete the electronic forms. The process visualizations are based on Markov Chains. In a recent study, Zheng et. al. demonstrated how Markov Chains could be used to generate visualizations that help designers understand the process by which users navigate an electronic health record system[43]. Marquard et. al. have also used Markov Chain-based visualizations and eye tracking data to understand nurses' surveillance patterns when they verify patients' identities. Markov Chain-based visualizations show promise as a way to explore human-in-the-loop processes, whether individuals completing clinical tasks or individuals interacting with electronic systems. Figure 4 shows an example of a Markov Chain-based visualization.

Our research team used Graphviz open source graph visualization software initiated by AT&T Research Labs to draw the visualizations, specified in Dot-script [44]. The development process for the visualizations is shown in Figure 4. In the context of this research, we define a Markov state as a specific section of the falls reporting form, and a state change occurs when an individual transitions from entering or reviewing data in one area of the form to another. A Markov Chain transition matrix (probabilities of transitioning from entering or reviewing data in one area of the form to another) is used to generate Dot-script, which is then used by Graphviz to create the visualizations. To support automatic generation of Dot-script from the transition matrix, we developed a Java Dot-script generator. The Graphviz tool generates visualizations based on the attributes of the graph, and specified nodes and edges in the Dot-script file. The attributes control the graphic features of visualizations including node sizes and shapes, line widths, arrow shapes, text labels, object colors, node and edge placement, etc. Based on this knowledge, designers can validate the design of the forms, informing their subsequent redesign. By thoughtfully designing the reporting forms, designers can positively impact the larger process within which submitting the form occurs.

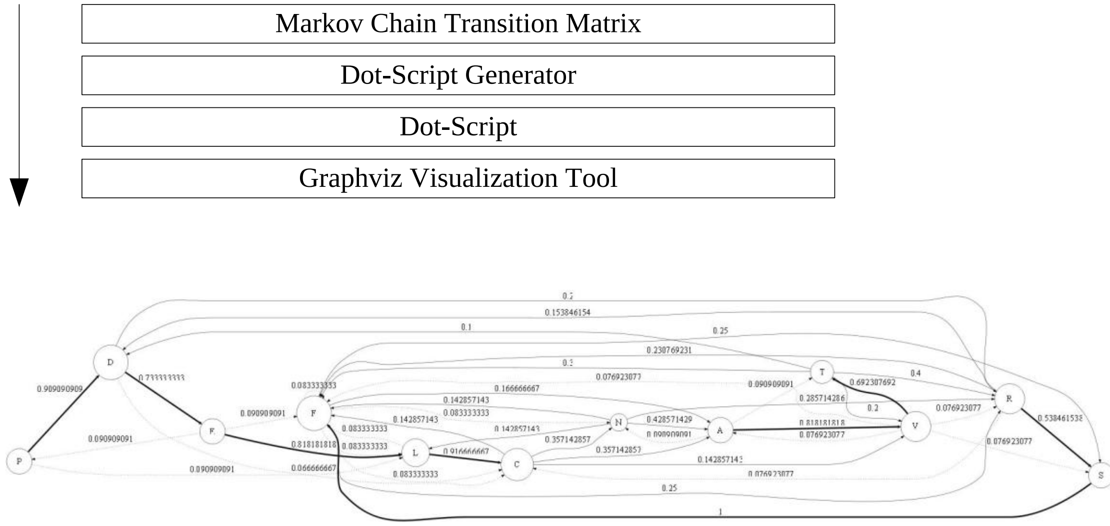

Figure 4: Visualization Development Process

2.5.3. Analysis Approach: Technology Adoption

The TAM survey results collected from the users before training and after implementation will be used to evaluate the users' technology adoption level during the pre-implementation and post-implementation stages. The adoption level is evaluated by the users' perceived usefulness and perceived ease of use of the falls reporting system before and after the implementation. For example, one of the nurses might rate "strongly disagree" on the item "I find it easy to get the electronic falls reporting system to do what I want it to do" during the pre-implementation survey, and then change to "agree" on the same item during the post-implementation survey. This change shows an improvement in the nurse's technology acceptance of the system. Overall, the results will help to understand how acceptable the system is for the nurses.

2.5.4. Analysis Approach: Holistic Evaluation

Journaling the three human factors domain challenges - physical, cognitive, and macroergonomic - as experienced by both the users and the researcher, will enable the researcher to review those challenges with the users and work with them to mediate strategies. For example, nurses may identify difficulty in locating the submit button. Designers can redesign the electronic form layout so the submit button is located at the end of the report and is easy to see can help to resolve this issue. For challenges that are not possible to resolve by redesigning the layout of the system, designers can create walk-through training manuals to aide users in resolving these difficulties. One example consists of a QI manager having difficulty exporting the database into an Excel spreadsheet. A future falls reporting system re-designed by the holistic evaluation approach will take into account all stakeholders and their respective human factors challenges. This data collection approach also identifies how work is shared between the users and the system.

CHAPTER 3

RESULTS

In this section, we present the results of the four-pronged evaluation framework. We refer to the four nurses as Nurse A, B, C, and D when discussing details about each nurse. Within the first three months utilizing the patient falls reporting system, there were 24 patient falls of which all 24 incidents (100% submission rate) were reported electronically. Of the 24 submissions, Nurse A submitted 0 reports, Nurse B submitted 11 reports, Nurse C submitted 3 reports, and Nurse D submitted 10 reports.

3.1. System-level Benefits and Costs

From a system-level benefits and costs approach, the electronic patient falls reporting system was designed and developed using existing software which required no up-front investment to the organization. The research team estimated a total of 532 hours will be required to develop, train, implement, and maintain the electronic patient falls reporting system at a site with 50 nurses. Table 2 below details the projected amount of time spent at each stage of the system implementation. The total cost is calculated to be $26,600 at a rate of $50/hour. This is favorable to organizational administrators because they can trial the system, and if the technology is not successful, the organization will not lose a significant monetary investment.

Table 2: Estimated Costs to Develop, Train, Implement, and Maintain the Electronic Patient Falls Reporting System at a 50-nurse Site

Task	Estimated Hours Spent
Pre-Development Stage	
• Meetings with program managers to understand the process of patient falls reporting	**10**
Development Stage	
• Learning to use Microsoft InfoPath and SharePoint and server configuration	**10**
• (Re)Designing the electronic patient falls form	**8**
• Meetings to elicit feedback on the initial form design	**4**
• Redesigning the form based on feedback	**4**
Training Stage	
• Creating training tutorials	**8**
• Generating training scenarios	**4**
• Training session with each nurse (2 hours each)	**100**
• Analyzing training data and captured video (1.5 hours for each nurse's data)	**75**
• Technology Acceptance Model Survey and Analysis (1.5 hours per nurse)	**75**
Implementation Stage	
• Configuring each nurse's computer to access SharePoint (0.5 hour per computer)	**25**
• Meeting with nurses to collect and discuss reported challenges (1 hour per nurse)	**50**
• Redesigning the form and system to resolve the reported challenges	**16**
Post-Implementation Stage	
• Technology Acceptance Model Survey and Analysis (1.5 hours per nurse)	**75**
• Creating InfoPath and SharePoint training tutorial and 'troubleshooting common errors' tutorial	**8**
• Training the IT personnel to support the system	**8**
• Estimated time to maintain the system at 1 hour per week for one year	**52**
Total time spent	**532**
Total cost at $50/hour	**$26,600**

Out of 24 falls submissions only 5 times were recorded for the length of time it took the nurse to complete the paper-based and electronic reports due to the highly interruptive nature of the nurses' work. The nurses commented that they often were interrupted in the middle of completing the incident report and once the interruption was handled, they sometimes lost track of the time or forgot to log the time. The average time spent completing each paper-based incident report was 11 minutes, whereas the electronic report took 5.4 minutes to complete. Even though the sample size of 5 is relative small, we statistically analyzed the difference in completion times. To test for a difference in the mean time spent completing the paper-based and electronic incident reports, we utilized the paired t-test. The null hypothesis assumed the two means were the same, in other words, that there was no time difference between completing the paper-based and electronic reports. The P-value of the two tailed paired t-test is .00073363. This extremely low P-value leads to the rejection of the null hypothesis and concludes that there is a significant difference in the mean values for the paper-based and electronic reporting completion times.

Table 3: Paper-based and Electronic Report Completion Time and T-test Results

Date of Report	Paper-based Time (min)	Electronic Time (min)
11/7/2009	10	5
11/11/2009	15	7
11/17/2009	10	5
11/22/2009	10	5
12/18/2009	10	5
Average	11	5.4
Standard Deviation	2.236067977	0.894427191
Difference in mean	5.6	
Paired t-test result		
Two-tailed P value		0.00073363

The time savings results from the computer's capability of memorizing commonly entered information such as the nurse's name and the facility's address, relieving the nurses from having to repetitively type in this information. The simplicity of the form also creates time savings in filing reports. Another time savings in filing reports is due to the simplicity of the electronic form. The options are reduced to commonly selected choices; it is faster to find the choice that the nurse is looking for among 5 options than among 26 options.

Nurse B said that:

> *It takes longer to write compared to just going to the computer and clicking.*

Nurse C commented that:

> *The electronic form flows nicely. It is set up just like the paper form, easy to follow and one less thing on my desk.*

In addition, the QI manager stated that in terms of report turn-over time, the paper report takes anywhere from a few days to as long as a week to reach her. According to Nurse C, after completing a paper report, she walks to the nurse manager's office to submit it. Then, after the nurse manager reviews the report, the report is directed to the QI manager for data collection. However, sometimes reports are lost. The electronic-based report simultaneously goes to all the administrators and the QI manager immediately after it is submitted. The instantaneous report turn-around time enables the administrators and QI personnel to review the incident and take preventive actions days to a week earlier.

Nurse D stated about the electronic form:

> *It is less paperwork, less reasons it could be lost. Once the electronic report is finished, it is submitted right away so that's the date of submission. Whereas, with paper-based, sometimes it sits on my desk and I forget to submit right away. There's no delay with electronic submission.*

Furthermore, the QI manager reported that the process of gathering and going through the submitted paper-based reports for the month took her 45 minutes to 1 hour before she could start writing her monthly falls report. The electronic database stores all reports and automatically keeps track of data. In summary, the electronic reporting system required a relatively small cost to the organization to implement but resulted in time savings on non-nursing tasks so the nurses could spend more time on direct care related tasks.

3.2. System Usability

We gained three key insights about the efficacy of the scenario-based training method as a way to assess system usability:

1. *The system has a learning curve, so training is necessary.* For each nurse, the first training scenario took the longest time to submit – approximately 10 minutes on average *(*Appendix C). After the first training scenario, the nurses became familiar with the interface and thus took less time completing the second and third training scenarios (approx. 6 minutes). This improvement in time to complete the reports gave the nurses confidence, supporting research that shows that training is important to the users' acceptance of a new technology [19].
2. *We can identify fixable usability challenges using scenario-based training.* Several small usability challenges arose during the scenario-based training sessions, and were subsequently fixed. For example, the form included an optional drop-down calendar tool to select the date of when the event occurred, and then automatically inputted the date (month/day/year). Instead of using the calendar, all of the nurses typed in the month, day, and year of the event. After the research team member showed the nurses the calendar icon, the nurses began using the calendar. After two nurses completed the last data field in the bottom of the form, both asked how and where to submit the form. This shows that they did not see any button to submit or instruction

on how to submit the form, which in turn shows that the location of the submit button was not well designed. The location of the submit button, on the top left corner of the application, required the nurse to look up from the bottom of the form where they completed the last data field and search for the submit button. To alleviate this confusion, the research team redesigned the bottom of the form to give instruction after the last data field that reads “Please review the report and then click the button below to submit;” a submit button was also added to the bottom of the form (see Figure 5 below).

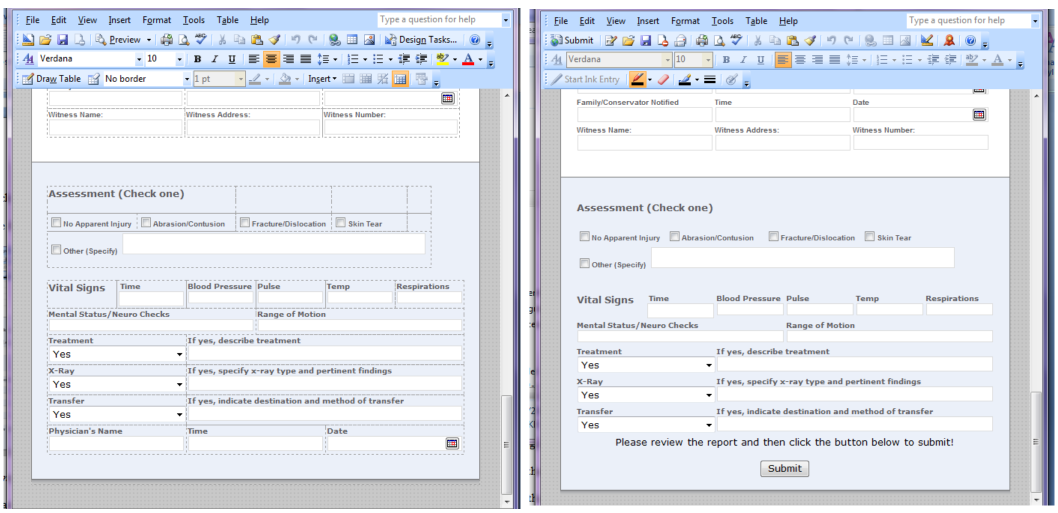

Figure 5: Before (left) and After (right) Re-design of the Form

3. *Users feel comfortable using the system after a small number of scenarios.* After three training scenarios, the research team member asked the nurses how comfortable they felt using the electronic patient falls reporting system and if they wanted to complete more training scenarios. All nurses reported that they felt comfortable using the system and that the three training scenarios were sufficient. Three of the four nurses commented that the electronic system is “easy to use”. One of the nurses commented:

I feel very comfortable using it, it's very easy. For someone like me who doesn't know much about computers, I found it easy to use. It follows or mimics the paper-based form so I know where to fill in the information

Moreover, the Markov Chain-based visualization provided information that can help designers uncover usage patterns that may not be evident via other usability methods, thus aiding form redesign. Figure 6 displays the first version of the electronic falls reporting form (without the extra submit button added on the bottom of the form), with the Markov Chain visualization overlaid on the form. The size of the nodes indicate the relative frequencies with which nurses entered, reviewed, or changed information in a specific section of the form. The arcs between the nodes distinguish the nurses' transitions from one section of the form to another. Only transition probabilities at or above 0.2 are shown in Figure 6. A transition probability of 0.2 means that if a nurse is currently entering, reviewing, or changing information in a specific section of the form, (s)he has a 20% chance of transitioning immediately to another specific section of the form. The solid arcs indicate transition probabilities at or above 0.5. By overlaying the nodes and arcs on the form and removing low-probability transitions, we can easily see the users' navigation patterns.

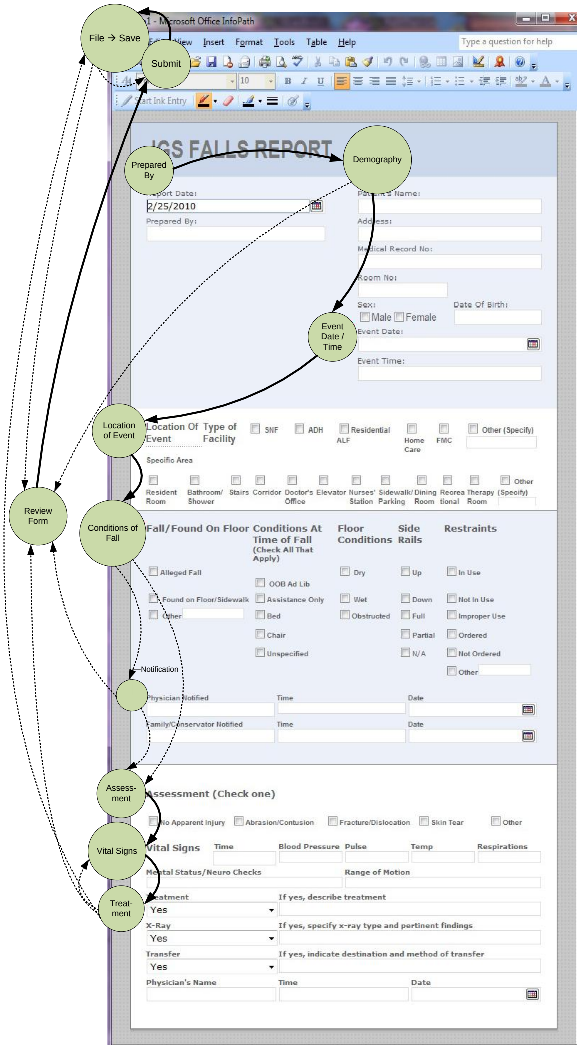

Figure 6: Electronic Form w/ Markov Chain Overlay

The Markov Chain visualizations are valuable for two main reasons: they are a highly efficient and scalable form of analysis, and they can aid designers in uncovering users' navigation patterns that may not be obvious using qualitative observations. The visualizations can help designers see common and/or unusual usage patterns. These patterns may provide clues as to why different form designs cause users to be more or less efficient. As is evident in Figure 6, our initial form design generally supports users' patterns of work, but also encourages the users to review their entries before submitting the form, as evidenced by their transition to reviewing the form before submitting the form. This usage pattern was weighed against adding the submit button to the bottom of the form in the final design. However, the extra submit button was added to the bottom of the form in the final design because the users (nurses) viewed it as inconvenient to move the mouse back to the top of the form to submit after reviewing the report. Also, for future new users, adding the extra submit button on the bottom of the form reduced the confusion of searching for the submit button.

3.3. Technology Acceptance

Four nurses completed the pre-implementation technology acceptance survey but only three completed the post-implementation survey due to the fact that Nurse A did not need to submit any patient falls reports over the course of the 3-months implementation period. Thus, Nurse A's technology acceptance data is excluded. The technology acceptance survey consisted of 20 questions from Davis's (1989) [39] study; the first 10 questions addressed factors related to the usefulness of the system (e.g. improves job performance, accomplishes more work) and the last 10 questions addressed factors related to ease of use (e.g. ease of learning, mental effort required). The nurses rated each statement on a 7 point-scale: 1 as strongly disagree, 2 as moderately disagree, 3 as slight disagree, 4 as neutral, 5 as slightly agree, 6 as moderately agree, and 7 as strongly agree.

The nurses completed the pre-implementation survey after the training sessions and the results are shown in the dark grey bars in Figures 7 and 8. The two highest ratings on usefulness factors were "the system makes my job easier" and is "useful" which the nurses rated on average 6.3 points (moderately agree). The two highest rated usefulness factors were "the system makes my job easier" and "useful" which the nurses gave on average 6.3 points (moderately agree). The lowest rated usefulness factor was that the system “allows me to accomplish more work” which the nurses rated on average 4 points (neutral). As for the ease of use factors, the nurses gave the highest rating, 6.67 points (moderately to strongly agree), to “the system is easy to learn”. Likewise, the nurses slightly to moderately disagree (2.33 points) that “the system requires a lot of mental effort” and is “cumbersome”.

Three months after the system implementation, the nurses completed the post-implementation technology acceptance survey; results are shown in the light grey bars in Figures 7 and 8. The highest rated usefulness factor was still “useful” with an average rating of 6.67 points (compared to 6.33 points on the pre-implementation survey). The second highest rated usefulness factor was that the system “helps me work more quickly” which had an average rating of 6 points (moderately agree). The lowest rated usefulness factor was the same as the pre-implementation survey that the system “allows me to accomplish more work” but the average rating was 4.33 points instead of 4 points. Results on the ease of use factors showed that the highest rated factor was still “the system is easy to learn,” which maintained a rating of 6.67 points. All three nurses strongly disagreed that “the system requires a lot of mental effort”, which received 1 point from all three nurses.

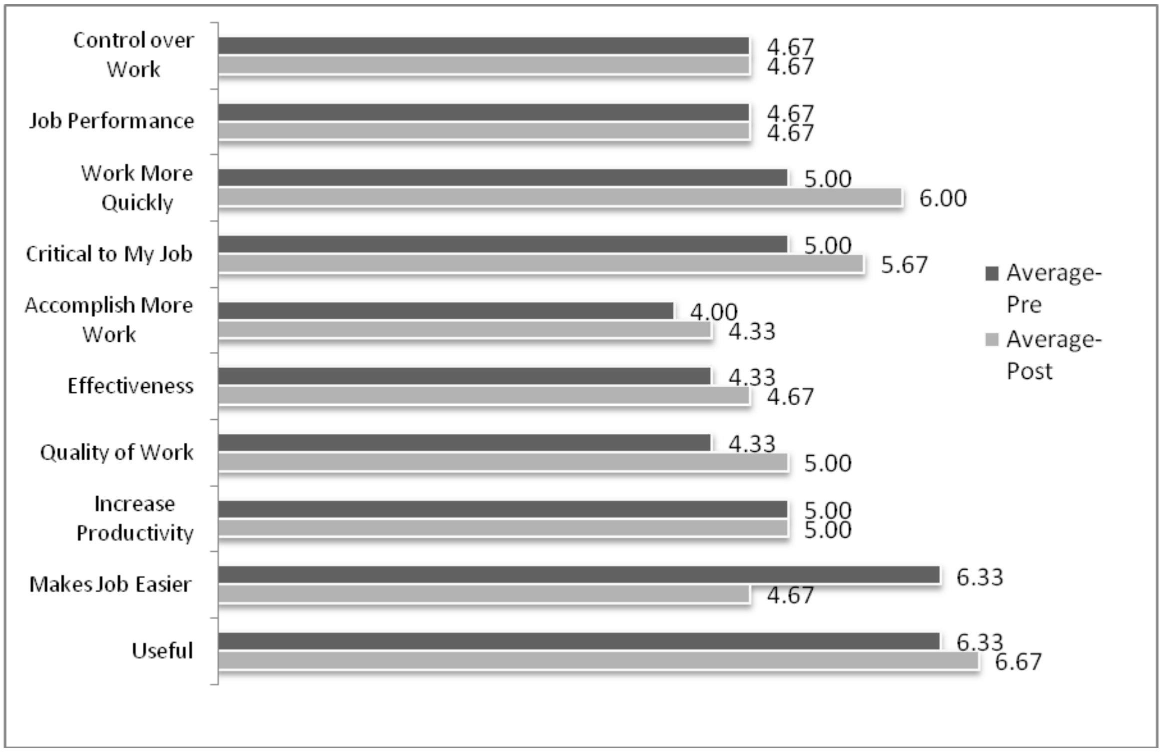

Figure 7: Pre- and Post-Implementation Usefulness Ratings

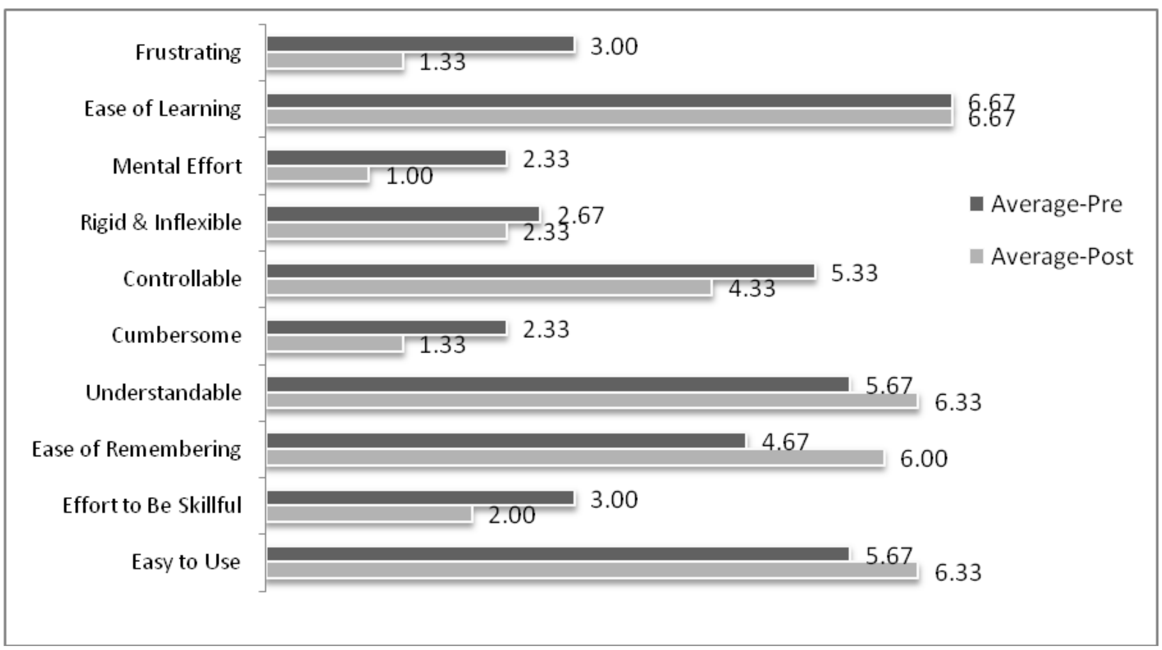

Figure 8: Pre- and Post-Implementation Ease of Use Ratings

The results from the pre-implementation and post-implementation surveys showed that all the nurses rated the 10 factors of usefulness at least 4 points (neutral) or greater (which are slightly, moderately, and strongly agree). Therefore, we can conclude that the nurses perceived the electronic patient falls reporting system to be useful. For the complete data please refer to Appendix D. On both the pre and post-implementation survey, the lowest rating of the usefulness factors is on "accomplishes more work". Moreover, nine out of ten usefulness factors' average rating either remained the same or increase after the system was implemented. The only usefulness factor whose rating decreased was "the system makes my job easier". These results may be explained by the fact that the pilot testing of the electronic system required the nurses to complete both the paper-based and electronic reports. This adds extra work for the nurse instead of reducing it. However, once the electronic system is implemented in the organization, the paper-based report will be fully replaced by the electronic report so nurses only need to complete one report.

The 100% electronic submission rate (all 24 incidents were successfully submitted electronically) is consistent with the nurses' technology acceptance ratings.

3.4. Holistic Human Factors Evaluation

During the system implementation, the research team gleaned key insights from the nurses' and QI manager's journals of work-related system challenges. For example, two nurses identified the same problem with the "Description of Event" textbox. The text floats in one single line so when reviewing the form before submitting, the nurses have to scroll back to the beginning of the text to view and make changes. Research team members cannot always be present to observe nurses using the system as falls are, by nature, unexpected events. Had a nurse not recognized this issue during his/her daily work, the research team would not know about this problem, because the research team did not correctly anticipate the length of the phrases the nurses use for descriptions of events. After identifying this problem, the research team redesigned the textbox to "wrap" so text floats to the next line.

Additionally, one nurse's computer was running very slowly when loading the electronic form, which increased the amount of time she spent submitting each report. This challenge caused an increase in her workload as well as a general frustration with using the computer. The organization became aware of this issue and replaced the nurse's computer. The support of the organization is important to a user's adoption. As mentioned in Aggelidis and Chatzoglou's study [42], "*facilitating conditions, such as new personal computers, support during the information system usage and financial rewards, are crucial concerning users' decision-making with respect to usage.*" Overall, the holistic human factors evaluation enabled the research team to identify and categorize challenges and to take immediate action to resolve the challenges.

Table 2 outlines specific system challenges, the number of nurses that encountered the challenge, the challenge type (physical, cognitive, and macroergonomic), and the mediation strategy.

Table 4: System Challenges

Task Name	Description	# of Nurses	Type	Mediation Strategy
Input event description	Description of Event box - all text floats in one single line so it is hard to read and make changes	2	C	Changed the property of the text box to "wrap" so now the entire text displays in the text box.
Opening the form	Slow computer increased waiting time and nurse’s time complete the report	1	M	Discussed challenge with administrators. The organization invested in a computer upgrade.

CHAPTER 4

DISCUSSION

4.1. Discussion of findings

That the pilot system was accepted in this low-technology setting demonstrates the viability of using such a system in organizations with higher technology usage. Additionally, the successful simplification of the form, the process by which nurses submit the form, and the process by which QI personnel and administrators view and use the form data can directly inform system implementations in other settings.

This system improved this LTRCF's ability to track falls electronically – a technical capability they did not have and could not afford. The proposed system used existing technologies available within the LTRCF and similar institutions, so this approach can be easily scaled to other organizations. This LTRCF expects to implement an EHR approximately 5 years from now. Thus, implementing the patient falls reporting system serves two purposes. First, it readies the staff in a low-risk way for the full EHR system implementation. By the time the EHR is implemented, the staff will be familiar with electronic documentation, whereas now they are only somewhat familiar with responding to work-related email. Second, we posit that implementing this type of patient falls reporting system will, in a variety of LTRCFs, reduce Health IT failures related to technology readiness. Yet, this patient falls reporting system will not interfere with the EHR implementation. This LTRCF, like other institutions, intends to keep their falls patient reporting system separate from their clinical EHR, so that the patient falls reporting system can still be used post-EHR implementation. Additionally, this patient falls reporting system will be the first in a series of similar electronic reporting tools to be implemented at this LTRCF. Other high risk problems such as impaired skin integrity and urinary tract infections are also amenable to reporting via this type of system.

The falls reporting system improved clinical practice by providing a means to collect falls data efficiently. This falls data can then be used to facilitate collaboration across the individuals in the organization who review falls data and make quality improvement decisions. QI personnel and administrators are notified via email of a patient fall immediately after a nurse files an incident report. This system improves coordination across the organization, reducing the chances of lost forms and the burden of routing the forms through the institution. The system allows QI personnel to quickly analyze falls data for a particular patient or set of patients, for a single incident, and for trends over time. While this type of analysis was previously possible, it required substantial efforts by the QI personnel to manually input data into an analyzable format.

This system is innovative in that there is a gap in the current research regarding how to measure Health IT adoption in LTRCFs. The evaluation framework is intended to be holistic, in that it addresses the needs and perceptions of a variety of stakeholders. While the approach builds on and refines existing, well-developed evaluation methods, the approach aims to evaluate the system's worth to all the stakeholders, and uses different evaluation schemes to take into account the different stakeholders' values and perspectives.

4.2. Limitations

There are several limitations in this study that can be addressed in future studies. First, the data were collected from four nurses, a limited sample size on which to fully judge the evaluation outcomes. Second, patient falls in an assisted living facility occur less often than in a nursing home due to a more able, smaller resident population. Hence, each of the four nurses submits fewer patient falls reports than do nursing home nurses, for instance. Third, each LTRCF operates differently, meaning special attention must be paid to the extension of the system to these programs to ensure that the electronic system supports the workflow of all the nurses.

4.3. Answering to Research Question 1

Q1: What are the relative merits of each of the four evaluation approaches?

Each of the four evaluation approaches focused on specific stakeholders (nurses, QI manager, and administrators) to evaluate the system based on their goals and values. The system-level benefits and costs approach justifies the benefit (time savings) of the electronic reporting system over its cost (low-cost due to using existing off-the-shelf technology). However, this evaluation method is not capable of identifying what factors contribute to the time saving and how to further improve the efficiency of the system. Using cognitive task analysis (CTA) as a usability method during the training scenario sessions enabled researcher to observe how the users are using the system and identified design flaws. This evaluation approach was helpful during the training stage so researchers could resolve cognitive challenges, usually by redesigning the system, before the system was implemented. CTA is focused on users, but it lacks the capability of assessing the users' technology acceptance level. Moreover, it does not take cost into account. On the other hand, the technology acceptance model (TAM) predicts the nurses' intention of use and adoption of the new Health IT through evaluating the nurses' perceptions of the usefulness and ease of use of the electronic patient falls reporting system. The limitation of the TAM is that it doesn't provide details on explaining why and how to improve the ease-of-use and usefulness of the system. This evaluation approach also does not take cost into consideration. Lastly, the holistic human factors evaluation methodology – having nurses log challenges during their daily work – encouraged nurses' involvement so they could take part in expressing their ideas on how to redesign the system to resolve those challenges. Resolving those challenges led to an increase in the usefulness and ease of use of the system. The TAM has lacked guidance on how to improve these two factors. The limitation of the holistic human factors evaluation is that it is incapable of predicting the nurses' adoption and acceptance of the technology before and after the redesign, and relies on the nurses to proactively log the challenges. Like the CTA and TAM, the holistic human factors evaluation does not address the cost of implementing and maintaining the system. Thus, each data evaluation approach has its own strengths and weaknesses. By presenting an evaluation framework consisting of all four approaches, researchers are able to evaluate and redesign the system to increase the fit between the technology and the users as well as take into account of all the stakeholders' goals. Table 5 summarizes the four evaluation approaches' strengths and weaknesses.

Table 5: Summary of the Strengths and Limitations of the Evaluation Approaches

Evaluation Approach	Strengths	Limitations
System-level benefits and costs	• Justifies the benefits (time saving in report submission and report turnover) over the costs	• Not capable of identifying what factors contribute to time saving and possible ways of further system improvement
Usability Via Cognitive Task Analysis	• Training scenarios enabled researcher to observe how the users are using the system and identified design flaws	• Lack of consideration to the cost of the system • Not capable of determining the user's acceptance level of the technology
Technology acceptance	• Assesses the users' technology acceptance level before and after implementation • Provides understanding about how the users perceived the system	• Lack of consideration to the cost of the system • Gives no information on "why" and "how" to improve the interaction between the user and the technology
Holistic human factors evaluation	• Identifies physical, cognitive, and macroergonomical challenges and possible solutions	• Lack of consideration to the cost of the system • Not capable of predicting the user's acceptance level of the technology

4.4. Answering to Research Question 2

Q2: What factors contribute to the acceptability of the falls reporting system for each user group?

Through the 4-pronged evaluation scheme, factors contributing to the acceptability of the electronic patient falls reporting system for each user group are identified. The system-level benefits and costs method pointed out that the low system implementation cost is attractive to the administrators/organization. Furthermore, logging the amount of time spent on completing the paper-based and electronic patient falls report showed the time savings to the nurses and the QI manager. The nurses agreed that it is faster to complete the electronic report than the paper-based one. The QI manager also emphasized that the electronic database automatically compiled all the submitted reports, a feature that reduced the users' time anywhere from 45 minutes to 1 hour per month – the amount of time it took them to compile the paper forms manually. The usability approach acknowledged that training has a positive effect on encouraging nurses to use the system. After the three training scenarios, the nurses felt comfortable on using the electronic system. Usability analysis also enables nurses to identify design flaws so the researcher can redesign the system to fit the nurses' use of the form. Thus, nurses are likely to use the system because it is designed based on their needs. The electronic patient falls reporting system's ease-of-use and usefulness are two important factors that determined the users' acceptability level of the technology. This was also confirmed by the nurses, as 3 out of the 4 nurses that used the system commented after the training that the system was "easy to use". Lastly, the holistic human factors evaluation identifies the physical, cognitive, and macroergonomical challenges encountered by the users while performing their daily tasks. By resolving those difficulties, the redesign not only improves the fit between the users and the technology, it also eliminated the time and frustrations spent troubleshooting errors. The factors considered and stakeholders benefited are summarized in Table 6 below:

Table 6: Acceptability Factors and Stakeholder Benefited

Evaluation Approach	Factors	Stakeholder Benefited
System-level benefits and costs	• Low cost • User time saving	• Admin/ organization • Nurses • QI Manager
Usability Via Cognitive Task Analysis	• Importance of scenario based user training • Involvement with identifying design flaws and solution suggestions	• Nurses
Technology acceptance	• Easy to use • Useful	• Nurses
Holistic human factors evaluation	• Minimal difficulties/errors when using the system	• Nurses • QI Manager • Admin/ organization

CHAPTER 5

CONCLUSION

Based on stakeholders' feedback and the success of the system implementation, we are confident that the system and evaluation framework are highly scalable and transferrable to other programs of the organization as well to other LTRCFs. The four-pronged evaluation framework accounted for different stakeholder perspectives in evaluating the fit between the electronic patient falls reporting system and the system users. The system-level benefits and costs approach showed that the electronic system required no initial investment costs aside from personnel costs and significant benefits accrued from user time savings. The usability analysis revealed several fixable design flaws and demonstrated the importance of scenario-based user training. The technology acceptance model (TAM) showed that users perceived the reporting system to be useful and easy to use, even more so after implementation. Finally, the holistic human factors evaluation identified challenges encountered when nurses used the system as a part of their daily work, guiding further system redesign. The four-pronged evaluation framework accounted for varied stakeholder perspectives and goals and is a highly scalable framework that can be easily applied to Health IT implementations in other LTRCFs. By using an evaluation framework consisting of all four approaches, the research team was able to evaluate and redesign the system taking into account of all the stakeholders' goals.

APPENDIX A

TRAINING SCENARIOS

Scenario 1

You were walking down the hall and heard someone cry "help". You realized the voice came from Room 132. You opened the door and went in the room. The resident, Mrs. Green, was not in her bed, and the bathroom door is open. You immediately checked the bathroom and found the resident on the floor. Mrs. Green appeared to have no significant injuries so you helped her to get up and then walked her to her bed. You asked her if she feels any pain or injury. She said "no". You examined her and saw only a minor skin tear on her right hand. You asked her how she fell. She said she was about to take a shower and the floor was slippery. You went to the bathroom and checked. The floor had some water spills and there was a partial side rail near the shower tub. You looked at your watch and it was 8:45 PM. Then, you checked Mrs. Green's vital signs. After, you pulled Mrs. Green's medical chart to obtain her information to fill out the incident report. The patient's full name is Michelle Green, her date of birth is August 29, 1928, and her medical record number is 1384572.

Scenario 2

You were at the corridor when you heard some noise that sounded like someone fell. Quickly, you ran to the rest area where you believed the noise came from. When you arrived, you saw the resident on the floor next to the sofa. You recognized it is Jane Smith from Room 218 who fell. Immediately, you asked her if she feels any pain or injury. She answered "no". You helped her get up and examined her. She has no apparent injury. Then, you asked her how she fell. She said she was getting up from the sofa to go back to her room but fell. It was approximately 2:15 PM when the incident happened. Afterward, you pull out her information to fill out the incident report. The patient's full name is Jane Smith, her date of birth is January 12, 1931, and her medical record number is 1847276.

Scenario 3

You were in Room 261 administrating medicine to the resident around 9:05 AM and suddenly heard a loud noise from the next room. You ran to the next room which is Room 262 to see what happen. You saw the resident, John McCarthy, on the floor. You asked him if he feels any pain or injury. He said he felt pain on his backbone. You checked his backbone for bone cracks and fractures. You helped him to get up and immediately called the doctor to examine him. Meanwhile, waiting for the doctor to arrive, you asked him how he fell. He answered that he was trying to get up from his bed and fell. You observed the floor and it's not wet or slippery. There is a full side rail next to his bed. The doctor arrived and examined him. The doctor said the patient probably has a bone fracture, so he suggested getting the patient to the hospital for a complete check. After, the hospital confirmed that the patient's backbone has a minor bone fracture. In the afternoon, you fill out the incident report. The patient's full name is John McCarthy, his date of birth is May 4, 1925, and his medical record number is 1280433.

APPENDIX B

TECHNOLOGY ACCEPTANCE SURVEY

	1 = strongly disagree	2 = moderately disagree	3 = slightly disagree	4 = neutral	5 = slightly agree	6 = moderately agree	7 = strongly agree
1. Using the electronic falls report gives me greater control over my work.	1	2	3	4	5	6	7
2. Using the electronic falls report improves my job performance.	1	2	3	4	5	6	7
3. The electronic falls report enables me to accomplish tasks more quickly.	1	2	3	4	5	6	7
4. The electronic falls report supports critical aspects of my job.	1	2	3	4	5	6	7
5. Using the electronic falls report allows me to accomplish more work than would otherwise be possible.	1	2	3	4	5	6	7
6. Using the electronic falls report enhances my effectiveness on the job.	1	2	3	4	5	6	7
7. Using the electronic falls report improves the quality of the work I do.	1	2	3	4	5	6	7
8. Using the electronic falls report increases my productivity.	1	2	3	4	5	6	7
9. Using the electronic falls report makes it easier to do my job.	1	2	3	4	5	6	7
10. Overall, I find the electronic falls report system useful in my job.	1	2	3	4	5	6	7
11. Interacting with the electronic falls report system is often frustrating.	1	2	3	4	5	6	7
12. Learning to operate the electronic falls report system is easy for me	1	2	3	4	5	6	7
13. Interacting with the electronic falls report system requires a lot of my mental effort.	1	2	3	4	5	6	7
14. The electronic falls report system is rigid and inflexible to interact with.	1	2	3	4	5	6	7
15. I find it easy to get the electronic falls report system to do what I want it to do.	1	2	3	4	5	6	7
16. I find it cumbersome to use the electronic falls report system.	1	2	3	4	5	6	7
17. My interaction with the electronic falls report system is easy for me to understand.	1	2	3	4	5	6	7
18. It is easy for me to remember how to perform tasks using the electronic falls report system.	1	2	3	4	5	6	7
19. I find it takes a lot of effort to become skillful at using the electronic falls report	1	2	3	4	5	6	7
20. Overall, I find the electronic falls report system easy to use.	1	2	3	4	5	6	7

APPENDIX C

TRAINING TIME

		Time	Comments
Nurse A	Training 1	11:23:00	showed her how to use the calendar function, she said it makes a lot of sense to have the ability to save and go back to the form later on, asked about where to select "yes/no" in the X-ray, asked about where is family notify, she said "that saves a lot of time"
	Training 2	9:37:00	showed her that InfoPath auto save some information such as name and address so she doesn't need to enter in again, asked if she has to complete all the data field in order to submit I said she just enter whatever filled out in the written form
	Training 3	10:26:00	12 min 26 sec was adjusted because the computer became slow took almost 2 minutes to open InfoPath and temporary freezes once a while
		10:28:40	she said "the form is well designed, it's easy to use and simple" "you don't need to know much, just know the basics, opening the form, and able to use this form, she likes the idea of the electronic form to reduced the amount of paper work to submit to various personnel
Nurse B	Training 1	8:22:00	showed her how to use the calendar function, asked if there's a place to input description of event, asked where to submit the form
	Training 2	5:48:00	reminded her to use the calendar
	Training 3	7:54:00	longer time due to the scenario which took her some time to think what to fill in
		7:21:20	she feels the form is "easy to use" she feels better with the electronic form than the paper-based form, she thinks it's faster to complete than writing
Nurse C	Training 1	10:23:00	some delay due to computer loading slow, showed her how to use the calendar function, she said they normally don't take the temperature and if she leave it blank can she move forward, at the end she said "it's so nice, maybe one day can replace the paper form"
	Training 2	6:29:00	she felt good that InfoPath has memory of her information so it will show her name, address
	Training 3	7:39:00	she forgot to enter the room number and MRN and I reminded her before she click on submit
		8:10:20	she said "I feel very comfortable using it, it's very easy, for someone like me who doesn't know much about computer found it easy to use, it follows or mimic the paper-based form so I know where to fill in the information" "all you need to know is know how to type to use it"
Nurse D	Training 1		was interrupted, showed her how to use the calendar function, asked how to submit
	Training 2	4:31:00	after completing the form, she review it very carefully, she hopes the system will prompt her to review it before submitting
	Training 3	7:56:00	she pointed it out they don't have MRN
		6:13:30	she pointed out various fields that should be included: description of event, ID status, primary diagnose, pre-event status, medication admin, patient behavior, diagnosis related, patient rights, also in the "other" in assessment, leave room to type in specific
Average time	Training 1	10:02:40	
	Training 2	6:36:15	
	Training 3	8:28:45	

APPENDIX D

SURVEY RESULTS

	Nurse B -Pre	Nurse B -Post	Nurse C -Pre	Nurse C -Post	Nurse D -Pre	Nurse D -Post	Average-Pre	Average-Post
Control over Work	5	6	4	4	5	4	4.67	4.67
Job Performance	4	5	6	5	4	4	4.67	4.67
Work More Quickly	4	6	7	6	4	6	5	6
Critical to My Job	6	7	4	4	5	6	5	5.67
Accomplish More Work	4	5	4	4	4	4	4	4.33
Effectiveness	4	6	4	4	5	4	4.33	4.67
Quality of Work	4	6	4	4	5	5	4.33	5
Increase Productivity	4	6	7	4	4	5	5	5
Makes Job Easier	6	6	7	4	6	4	6.33	4.67
Useful	6	7	7	7	6	6	6.33	6.67
Frustrating	4	1	1	1	4	2	3	1.33
Ease of Learning	6	6	7	7	7	7	6.67	6.67
Mental Effort	3	1	1	1	3	1	2.33	1
Rigid & Inflexible	3	1	1	2	4	4	2.67	2.33
Controllable	5	4	7	6	4	3	5.33	4.33
Cumbersome	2	1	1	1	4	2	2.33	1.33
Understandable	5	6	7	7	5	6	5.67	6.33
Ease of Remembering	4	5	6	7	4	6	4.67	6
Effort to Be Skillful	4	2	1	1	4	3	3	2
Easy to Use	5	6	7	7	5	6	5.67	6.33

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