UNDERSTANDING NURSES’ PERCEPTIONS OF ELECTRONIC HEALTH RECORD USE IN AN ACUTE CARE HOSPITAL SETTING

by

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A thesis submitted in conformity with the requirements for the degree of

Doctor of Philosophy

Graduate Department of Nursing Science

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2017

ABSTRACT

As Canadian healthcare organizations implement electronic health records (EHRs), nurses are expected to use the technology in their practice. Findings of a literature review suggest that usability (ease of use, functionality, navigation and impact on workload), the organizational context (support from leadership, level of training, level of on-going support, physical environment and implementation process) and individual nurse characteristics (sex, age, nursing unit, years of experience as a registered nurse, country of nursing education, years of experience using an EHR, previous EHR use and formal informatics training) influence nurses’ use of these systems. Thus, the purpose of this doctoral research was to better understand the relationships between the variables that make up usability, organizational context, individual nurse characteristics, and nurses’ perceptions of EHR use.

This study was conducted using a sequential mixed methods design with two phases. Phase One consisted of a cross sectional survey that was piloted and then
administered to nurses in an acute care teaching hospital in Toronto, Canada. The aim of the survey was to obtain information about nurses’ perceptions of the usability of the EHR, the organizational context, their individual nurse characteristics and their use of the system. Phase two involved focus groups to better understand the findings identified in the survey.

Multivariable and hierarchical linear regression was conducted. A multivariable model made up of the variables ease of use, navigation and impact on workload, explained 13% of the variance in nurses’ perceptions of EHR use, however navigation was the only significant predictor in the model. In the data from the focus groups, nurses described how they navigated through the EHR, and which functionalities supported or hindered their use of it. Results of this study provide insights into factors that may influence nurses’ use of EHRs in an acute care hospital setting that have implications for research, nurse leaders, vendors, healthcare settings and nursing practice.
ACKNOWLEDGEMENTS

There are a number of people that I would like to acknowledge for their contributions to my doctoral studies. First, I would like to thank my supervisor, Dr. Linda McGillis Hall, for the advice and guidance she has provided me as her student. I am grateful to have had a supervisor who has challenged me to become a better writer and researcher over the last four years. I would like to thank my committee member, Dr. Lynn Nagle, who inspired me to pursue research in nursing informatics. I am also grateful to Dr. Patricia Trbovich for her contributions as a committee member, and her constant encouragement at every meeting. To my internal examiner, Dr. Lisa Cranley, and my external examiner, Dr. Suzanne Bakken, thank you for your thoughtful questions and suggestions. I would also like to acknowledge the financial support I received during my doctoral degree, including the University of Toronto, the Registered Nurses’ Foundation of Ontario, Nursing Leadership Network and the Canadian Nurses’ Foundation/Dr. Kathryn J. Hannah Nursing Informatics Scholarship.

I am lucky to have had a wonderful group of women to experience the doctoral program with, and who have been a source of inspiration over the years. These women include: Alex Harris, Leigh Chapman, Dr. Jacqueline Galica, Robin Enns, Ruth Rodney, Vida Ghodraty Jabloo, and Sanja Visekruna. I also want to thank Dr. Richard Booth, Mike Villeneuve, Dr. Nicholas Hardiker, Dr. Rani Srivastava, Dr. LaRon Nelson, Dr. Kristin Cleverley, Dr. Michelle Lalonde, Jen Robinson, Libby Dror, Emy Eduque, and Tsega Eyasu. Each of you know the support that you have provided me, and I am honoured to have received it. To my colleagues at the Centre for Addiction and Mental
Health, and former colleagues at Kuwait Cancer Control Center, thank you for your constant encouragement and willingness to discuss nursing informatics on a regular basis.

Most importantly, to Achin and my Mom, Dad and Dana, thank you for the countless ways that you have supported me over the last four years. Although I could never list them all, some of my most memorable experiences have included our cross country skis to Tanney cabin (or the picnic table for Dad), Winnipeg visits, time with the Chugh/Idnani/Sabharwal family, and weekends at the lake (all while you patiently listened to the exciting moments and challenges of the doctoral program).
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CHAPTER I: INTRODUCTION

Electronic health records (EHRs) have been increasingly implemented in healthcare environments globally (Stone, 2014). Reports indicate that as of 2014, 83.2% of hospitals in the United States (US) have installed the technology (Charles, Gabriel & Searcy, 2015). In 2011, 97% of Swedish hospitals and all Swedish primary care clinics reported using EHRs for clinician documentation, computerized provider order entry (CPOE), and electronic prescribing (Gray, Bowden, Johansen & Koch, 2011). Similarly, in New Zealand and Denmark, all acute care hospitals have some form of an EHR in place (Gray et al., 2011). Between 2006 and 2014, the Canadian federal government contributed 1.2 billion dollars towards EHRs through Canada Health Infoway (CHI), a not-for-profit organization, which aims to increase the adoption of digital health platforms in the country (CHI, 2014). As of 2016, it was estimated that more than half of Canadian health professionals (doctors, nurses, pharmacists and allied health) used EHRs in their practice (CHI, 2016).

With such permeation of the technology in acute care hospital settings around the world, studies have investigated the impact of the technology on health professional (Poissant, Pereira, Tamblyn & Kawasumi, 2005; Wong et al., 2003) and patient outcomes e.g. length of stay (Hessels, Flynn, Cimiotti, Bakken & Gershon, 2015). Several researchers have identified that simply installing and implementing an EHR does not necessarily equate to its success and achievement of intended outcomes (Gephart, Carrington & Finley, 2015; Koppel, Wetterneck, Telles & Karsh, 2008; Patterson, Rogers, Chapman & Render, 2006). The ability of an EHR to support safe and effective healthcare may be realized when important functions of the technology are consistently
and effectively used by health professionals (Simon et al., 2007). For example, in organizations with barcode medication administration systems in place, outcomes related to safety may be achieved when health professionals demonstrate a high level of adoption and use (Higgins et al., 2010; Savage, Titus, Manns & Lee, 2014). In doing so, studies have shown that medication errors during the administration process may be decreased (Ching, Williams, Idemoto & Blackmore, 2014; Paoletti et al., 2007; Poon et al., 2010).

Given that nurses make up the largest group of health professionals globally (World Health Organization, 2013) and may be the largest user group of EHRs (Kutney-Lee & Kelly, 2011), there have been a number of studies aimed at better understanding outcomes associated with this group’s use of the technology (Dowding, Turley & Garrido, 2012; Gephart et al., 2015; Kutney-Lee & Kelly, 2011). In 2015, Gephart, Carrington and Finley conducted a review of the literature and identified a number of unintended consequences of EHRs for nurses including changes to nurses’ workflow, difficulty finding information to inform nursing care, and the continuous adaptation of nursing work patterns to conform to technology requirements. As well, limited studies have demonstrated that anticipated benefits of EHRs have been realized for nurses (Menachemi & Collum, 2011; LeBlanc, Gagnon & Sanderson, 2012; Zhang, Yu & Shen, 2012). In a 2012 study by Dowding, Turley and Garrido, nurses’ use of an EHR was significantly associated with improved documentation rates for hospital acquired pressure ulcer risk, and a 13% decrease in hospital acquired pressure ulcers. The electronic documentation that nurses completed related to pressure ulcers generated a risk level, and identified appropriate nursing interventions and alerts that allowed this reduction to be achieved. However, the authors did not find similar results when they reviewed
documentation of fall risks and rates. Other organizational interventions to reduce falls during the time of the study may have accounted for the difference obtained from EHR use between the two nursing sensitive patient outcomes (pressure ulcers and fall rates).

Research has also demonstrated that there is great variability in how nurses use EHRs even in the same organization with the same vendor (Lanham, Leykum & McDaniel, 2012) due to a number of influencing variables. If benefits of EHR systems are to occur on a consistent basis, it has been argued that nurses and other health professionals need uniformly high levels of acceptance (Holden & Karsh, 2010) and use (Lanham et al., 2012). Thus, this doctoral study aims to increase what is known about the factors that influence nurses’ use of EHRs, and how they relate to nurses’ perceptions of their use of the technology.
CHAPTER II: LITERATURE REVIEW

Introduction

EHRs have had significant uptake in Canadian healthcare environments given their potentially extensive benefits to health professionals, patients and organizations (CHI, 2016; Khangura, Grimshaw & Mosher, 2013). With over 296,000 nurses in Canada (Canadian Institute for Health Information, 2014), nurses play an important role as one of the main users of this technology in ensuring that these benefits are realized. In order to do so, nurses need to use EHRs to their full functionality. As a part of the nursing process, nurses also need to be able to enter, find, and utilize information in an EHR to document, and make decisions related to planning and implementing appropriate care. A number of studies have indicated that there are barriers that nurses have to overcome to use EHRs. Therefore, the aim of this literature review was to identify the barriers to, and facilitators of EHR use by the largest group of health professionals in Canada, nurses.

Methods

This literature review was conducted using a narrative methodology. This is an appropriate approach as it aligns with the purposes of the review, which are to provide a comprehensive overview of the literature, highlight gaps, and discuss areas for further research (Cronin, Ryan & Coughlan, 2007). Understanding the broader context in which EHRs are situated is an important part of comprehending this topic, given that the use of this specialized technology by nurses occurs within busy and complex healthcare environments. In addition, as the use of EHRs requires the use of computers, research on nurses’ relationships with computers was also searched. From the 1980s to more recently,
literature informing what is known about nurses’ use of both computers and EHRs has been reviewed.

For the purpose of this review, EHRs were defined as a repository of secure computerized patient specific information, accessed by multiple health professionals (International Organization for Standardization, 2005). Examples of some of the functions included in this definition are electronic medication administration, CPOE, clinical documentation, as well as diagnostic results reporting and viewing. In some studies, EHRs with these and other functions were present, whereas other studies used a more simplistic electronic system. Due to the broad definition of EHRs, literature that utilized terminology such as “electronic medical record”, “digital medical record”, “hospital information system”, “computerized patient record”, “electronic patient record”, “computerized medical record”, or “clinical information system”, were also included if the system met the pre-determined EHR definition. “Personal health records”, were excluded as they were often defined in the literature as a repository of information accessed and controlled by the patient, and not by health professionals (Hayrinen, Saranto & Nykanen, 2008).

Relevant literature was identified through four methods. First, a search was conducted through three electronic databases. Second, a scan of reference lists was also completed, given that “indexing in bibliographic databases is imperfect” (Grimshaw, 2013, p. 16), and there may be important work that is missed if electronic databases are solely relied upon. Third, influential studies and authors were identified through subject matter experts. The Canadian Institutes of Health Research considers this search strategy an important part of conducting a thorough synthesis of the literature (Grimshaw, 2013).
Lastly, a Google™ search was done to uncover relevant grey literature. Although the latter three strategies are not always completed during traditional literature reviews, these methods are supported in the knowledge synthesis literature (Cronin et al., 2007; Grimshaw, 2013).

The following electronic databases were searched: Ovid/MEDLINE®, PubMed, and the Cumulative Index to Nursing and Allied Health Literature (CINAHL). Keywords utilized were “nurse”, “electronic health record”, “clinical information system”, “electronic medical record” and “electronic patient record”. To be included in the review, articles were required to be in English. No article was discarded due to being of poor quality. Instead, the quality of the research methods in the articles was evaluated using tools developed by the ‘Critical Appraisal Skills Programme’ (CASP) (CASP, 2013). CASP is a program that provides assessment tools for the appraisal of clinical and health-related research, and was a valuable resource for conducting this review.

Results

Three distinct historical periods of knowledge generation that focus on understanding the barriers to, and facilitators of effective EHR use by nurses, emerged from this review. The initial period began in the mid-1980s, approximately 20 years after the first known EHR was implemented in a hospital in Mountain View, California (Staggers, Bagley Thompson & Snyder-Halpern, 2001). During this period, a number of researchers studied and wrote about nurses’ attitudes towards computers, and how nurses’ attitudes may have influenced their use of the technology. In the 1990s, another body of literature emerged in which researchers studied and wrote about nurses’ prior experience and knowledge of computers. These attributes were thought to influence nurses’ ability to
use a computer in a clinical environment. The third and most recent body of literature (from 2000 to present) has garnered the greatest amount of study, and has largely focused on nurses’ use of EHRs rather than computers. During this recent period, articles have been published about EHR usability, the organizational context and individual nurse characteristics. Literature from these three time periods has been synthesized and is discussed in the following sections.

*The 1980s: Nurses’ Attitudes*

In the 1980s, researchers studied and wrote about nurses’ attitudes towards computers (Brodt & Stronge, 1986; Schwirian, Malone, Stone, Nunley & Francisco, 1989; Stronge & Brodt, 1985; Thomas, 1988). Bagby (1985) stated that, “As nursing departments computerize more and more of their operations, how completely the nursing staff accepts the idea, and how well the staff uses the programs becomes ever more important” (p. 30). Several authors wrote about strategies that could be employed to ensure a smooth transition from paper-based records to computerized systems. Suggestions included ensuring that nurses were a part of the implementation process, reinforcing the advantages of the new system to the frontline nursing staff, having realistic expectations of the computers, and including nurses on design teams (Beckman, Cammack & Harris, 1981; Happ, 1983; Waterstradt, 1981).

During this decade, computerization in healthcare environments became increasingly common particularly in hospital settings. Nurses were beginning to see computers and clinical applications appear in their respective environments and become a part of their everyday work (Edmunds, 1982; Romano, 1984). Research on this topic began with several studies being conducted on nurses’ attitudes towards computers.
It may be that the authors of these studies were influenced by a growing body of literature outside of the healthcare sector that focused on the attitudes of the end users of technology. It was in the 1980s that Davis adapted Fishbein and Ajzen’s Theory of Reasoned Action (Fishbein & Ajzen, 1975) to create the Technology Acceptance Model (TAM), which garnered support in the business and information technology (IT) fields (Davis, 1989; Davis, Bagozzi & Warshaw, 1989). In the TAM, an end users’ attitude directly predicts their intention to use the technology. Within the field of nursing, researchers began to investigate the attitude of nurses towards computers as a way of better understanding how potential benefits of computers could be achieved through effective use (Brodt & Stronge, 1986; Schwirian et al., 1989; Stronge & Brodt, 1985; Thomas, 1988).

The Nurses Attitudes Toward Computers Questionnaire (NATC) (Stronge & Brodt, 1985) was developed to measure the attitudes of nurses toward computers. This questionnaire focused on the general beliefs of nurses, their concerns with computer use, and their willingness to use the technology. Questionnaire statements were generated via findings from a review of the literature, and were developed for the following themes: job security, legal ramifications, quality of patient care, capabilities of computers, willingness to use, and benefit to the institution. Nurses’ attitudes were thought to act as either barriers or facilitators to their computer use depending on how the nurses scored on the measure.

A study by Stockton and Verbey (1995) was conducted to examine the psychometric properties of the NATC. The questionnaire was administered before and
after the implementation of a computerized information system, and factor analysis was completed. Factor loadings for both administrations of the questionnaire were found to be the same as those discovered by its developers, and the instrument was found to be reliable with a Cronbach’s alpha of 0.92.

As well, the same authors who created the instrument used it in a mid-western community hospital. Results showed that medical/surgical nurses, and nurses who had less than 10 years of experience, had less favourable attitudes towards using computers (Brodt & Stronge, 1986). Additionally, no statistically significant results were found related to the age of nurses and their attitudes towards computers.

Schwirian et al., (1989), adapted the NATC to reflect the attitudes of both nurses and nursing students. The researchers found that students had more positive attitudes towards computers than practicing nurses. The authors also found that study participants who were more experienced in using the technology held more positive views than those with less computer experience.

In the following decade, McBride and Nagle (1996) also used the NATC among nurses and nursing students. Four factors different than those identified in the original instrument were found among the students. These were: nurses’ work, barriers, organizational issues and efficiency issues. This study also discovered that previous computer use was related to more favourable attitudes towards computers among practicing nurses. Differences discovered between the groups (students and practicing nurses) may be due to students having a higher level of computer comfort and understanding, as the students reported more experience using a computer.
Non-empirical articles (discussion and editorial papers) were written as well (Bagby, 1985; Edmunds, 1982, Reeves & Underly, 1982; Waterstradt, 1981). These articles tended to focus on observed experiences and potential benefits without measuring any specific outcomes. Authors wrote about possible improvements in the quality and accuracy of patient records; structured charting formats that aided nurses in ensuring relevant details of the patient’s care were documented; improved legibility of patient records (Beckman et al., 1981); as well as a reduced need for transcription leading to less clerical work for nurses and fewer errors (Reeves & Underly, 1982). Several authors suggested that benefits not obtained by the computer systems may be due to ineffective computer use by nurses as a result of poor acceptance or attitude towards the technology (Bagby, 1985; Schwirian et al., 1989). Authors of one article stated, “the attitudes of nurses who use automated information systems (computers) are as important as the technology itself” (Schwirian et al., 1989, p. 168).

*The 1990s: Nurses’ Knowledge and Experience*

Although researchers in the 1990s continued to study nurses’ attitudes towards computers (McBride & Nagle, 1996; Scarpa, Smeltzer & Jasion, 1992), the experiences and knowledge that nurses had with the technology were also explored (Arnold, 1998; Carter & Axford, 1993; Van Dover & Boblin, 1991). Computer experience and knowledge were viewed as important factors influencing nurses’ use of computers in their practice. Chu and Spires (1991) suggested that taking courses to improve computer knowledge could help to alleviate anxiety nurses may have felt about using computers at work. In 1994, an instrument was designed specifically to measure nurses’ experiences with computers (Staggers, 1994). The instrument consisted of items that represented
knowledge of general computer applications, knowledge of health information systems, role participation, and role knowledge. Despite there being interest in this topic in the nursing community around the time of its development, there were no known applications of the instrument.

During the 1990s there were several studies that explored how to prepare nursing students with the computer experience and knowledge required of clinical practice environments. In a study by Saranto and Leino-Kilpi (1997), a Delphi survey technique was used to identify and describe the computer skills required in nursing, in an effort to determine what topics should be taught in nursing education in Finland. Participants agreed that knowing the basic components of a computer, being able to use windows, detect viruses, and use a database, were important skills for nurses to know and be able to complete in their clinical work environment. Additionally, it was suggested that nursing informatics topics be integrated into the curriculum for nursing education.

In a study by Birx, Castleberry and Perry (1996), the integration of laptops into nursing education was explored. The authors argued that knowledge consisting of basic computer terminology and experience with applications such as email, word processing and library searches, were important predictors of nursing students’ attitudes toward computers. The authors developed a survey using these concepts to assess attitudes, and then students were divided into groups. One group received a laptop and nine hours of training, and the other group did not receive a laptop or training. No significant differences were discovered between the groups with regards to computer knowledge. This may have been due to students in both groups having previous knowledge and
experience with computers in their personal life, or an inadequacy of the provided training.

Also during the 1980s, a new way of thinking about nurses’ use of computers and EHRs was developed through the creation of the Staggers and Parks Nurse-Computer Interaction Framework (Staggers & Parks, 1993). This framework showed that nurses’ attitudes toward computers, as well as experiences and previous knowledge, needed to be situated within a broader context. Staggers and Parks' framework was developed to address the intersection of human-computer-interaction, nursing informatics, and developmental psychology, as a way of organizing information obtained from previous and forthcoming related research. The developers of the framework described it as portraying “nurses and computers interacting in a system of mutual influences with information as the medium of exchange between them” (p. 284). Thus, this dyad (computers and nurses) was argued to exist within the nursing context/environment. A series of framework elements were established including nurse behaviors and computer interface actions; the task information exchange process; nurse and computer characteristics; nursing context; and the nursing informatics development trajectory. The authors explained that the success of the interaction between the nurse and the computer cannot be simplified to one of these elements alone, but must be placed into the entire context whereby all of these framework elements are simultaneously shaping the nature of the nurse-computer interaction.

The 2000s: EHR Usability, Organizational Context and Individual Nurse Characteristics

An increasing amount of literature has been published on nurses’ use of EHRs in the 2000s, which coincides with the rising number of system implementations and
additional investments from governments since the 1980s and 1990s (CHI, 2014; Staggers et al., 2001). EHR usability, the organizational context and individual nurse characteristics are themes present among the articles published since the year 2000 and are discussed in the following sections.

**EHR Usability.** Usability factors are those that influence how easy the EHR is for the nurse to use, how much effort it takes to use the technology, whether its functionalities support use, and how easy it is to navigate (Boone, 2010; Flanagan et al., 2011). Usability factors are sometimes referred to as ‘human factors’ (Harris & North, 2012). In the US, an analysis of the Manufacturer and User Facility Device Experience database has shown that there are a number of usability issues with EHRs, and in some cases these issues have led to adverse or unintended outcomes (Harris & North, 2012). For example, Harris and North (2012) reported that a health professional documented critical patient information in the wrong record without knowing that they had done so. Although this error was identified, there could have been serious implications to patients as a result of incorrect or missing information in the record.

Given the known EHR usability challenges, there has been nursing specific research conducted on the topic. Alexander and Staggers (2009) describe how many of these studies focus on EHR design, however other usability topics such as satisfaction, effectiveness and efficiency of the technology, are also important. As well, Nielsen’s (1994) usability heuristics have been drawn upon often to support EHR screen and interface evaluation. Findings from several studies that highlight suggestions to improve EHR design, along with those identified by Nielsen (1994), are described below.
Staggers and Kobus (2000) conducted a study to determine if any differences existed between nurses’ use of text-based interfaces, as compared to graphical user interfaces. Results showed that graphical user interfaces that included pictures and colours were preferred by nursing staff, and also allowed for quicker navigation. Boone (2010) further suggested the use of effective information presentation strategies in terms of the appropriate density of information, and the thoughtful use of colour.

An EHR workflow analysis was completed by Lowry and colleagues (2014). The authors identified a number of desired organizational and system modifications that would enhance health professional use of the technology. Such an analysis could be done in organizations implementing an EHR. In a study incorporating nurse workflow into an EHR design, nurses demonstrated high levels of acceptance and satisfaction once the design was implemented (Page & Schadler, 2014). A workflow analysis may also highlight the need for strategies to support use such as the incorporation of specific functions or devices, such as a barcode scanner. In two studies, nurses identified that having the ability to document at the bedside was advantageous (Rogers et al., 2013; Whittaker, Aufdenkamp & Tinley, 2009). Devices to best support nurses in being able to do so (e.g. a laptop), could be discussed during a workflow analysis (Hurley et al., 2007).

Strategies to support overall ease of use and end user navigation are advised by Nielsen (1994). One suggestion that Nielsen (1994) offers is that the system status be visible. Nurses should be able to easily identify their progress on a given task. Feedback and information pertinent to these tasks should be clear, simple and easy to find. As well, the language and tasks embedded in the system need to be congruent with that of the end user (Nielsen, 1994). This could come in the form of nursing terminology being used, and
the system being designed to carry out functions of importance to nursing work e.g. being able to document a nursing assessment. Appropriate terms should be used in the EHR to accurately describe the clinical care being documented in the words that nurses use, and terminology and labels need to remain consistent throughout the system. End users of the technology should have a degree of freedom to undo or modify information within it (Nielsen, 1994), as nurses may not be able to complete their documentation all at once, and may need to add content at a later time.

Recognition rather than recall can be established through a series of standardized reminders and documentation screens (Nielsen, 1994). For example, a nurse can be reminded of best practices related to assessing a peripheral intravenous site, or performing wound care, and an asterisk (or other visual indicator) could be present where nurses are required to fill out mandatory fields. As well, a colour can be used to signify when a medication is past due (Staggers, Kobus & Brown, 2007). These are a few of the many design suggestions offered in the literature.

Other influential usability factors discovered in the literature include nurses’ perceptions of a number of aspects of the system including the usefulness of the EHR (Aggelidis & Chatzoglou, 2009; Ketikidis, Dimirovski, Lazuras & Bath, 2012; Lu, Hsaio & Chen, 2012), how easy it is to use (Aggelidis & Chatzoglou, 2009; Carayon et al., 2011; Ketikidis et al., 2012; Lu et al., 2012), workload (Poissant et al., 2005), the quality of the information in the system (Lu et al., 2012), and the quality of the overall system (Lu et al., 2012). Lau and colleagues (2010) argue that having end users involved in the development of the EHR may mitigate usability issues.
Organizational Context. Several articles that discussed organizational context were discovered in the literature review. In these articles, suggested tactics and strategies for successful EHR implementations in hospital settings were explored and explained.

Leonard (2004) describes how EHRs dramatically change the environment in which health professionals’ work, and thus the author suggests that strategies to successfully manage these changes need to be employed. Engaging nurses in implementation activities were thought to have improved the attitudes of nurses toward the EHR in a study by Carayon and colleagues (2011), however the specific engagement strategies used by the authors were not discussed.

Nagle and Catford (2008) recommend that hospital administrators communicate to staff before, during and after the implementation of the EHR about the goals of the EHR implementation, anticipated changes to practice, changes to policy, important dates, help and support availability, successes, and how and where to provide feedback. This would entail hospital administrators having a deep understanding of the workflow changes required of nurses, and developing strategies to manage these that can be communicated to staff (Leonard, 2004; Saletnik, Niedlinger & Wilson, 2008). Nagle and Catford (2008) also highlight that health professionals should feel that they are supported in using the EHR by their organization’s leadership. Huryk (2010) describes how nurse managers play an important role in supporting nurses’ use of the technology e.g. through scheduling EHR training for staff.

It was also mentioned that organizations should provide consistent, effective and centrally created training for nursing staff, and that expectations for EHR use be communicated during this time (Geibert, 2006; Lee, 2004; Nagle & Catford, 2008).
Training and ongoing support have been noted by several authors as being valuable in supporting nurses’ use of EHRs (Lium, Laerum, Schulz & Faxvaag, 2006; Saletnik et al., 2008). In a study by Whittaker and colleagues (2009), the timing of training, too much information presented in one session and an inability to obtain help when needed, were barriers to being able to effectively complete clinical documentation.

It has also been suggested in the literature that organizations engage in ongoing evaluations of the EHR, where required changes can be acted upon quickly (Nagle & Catford, 2008; Saletnik et al., 2008). During an evaluation, fine-tuning that better supports nurses’ ability to use the EHR appropriately can be identified and implemented.

The physical environment has also been identified as a potential barrier or facilitator to nurses’ EHR use. In a 2004 study by Moody, Slocumb, Berg and Jackson, nurses did not have enough space in patients’ rooms to be able to access the EHR, and there was an insufficient supply of computers in other areas. Organizations also need to ensure that there is an adequate power supply, a sufficient speed of internet/connectivity, and plans developed for how to manage any times when the EHR is “down”.

*Individual Nurse Characteristics.* Individual nurse characteristics were discussed in the literature as having the potential to influence nurses’ use of EHRs. In the 1980s and 1990s, multiple studies explored attitude, knowledge, and experience with computers as possible individual factors that influence computer use. In the 2000s, several studies have also explored demographic variables such as seniority (Chan, 2007), prior computer experience (van der Meijden, Tnage, Troost & Hasman, 2001; Whittaker et al., 2009), education (Alquiriaini, Alhashem, Shah & Chowdhury, 2007; Chan, 2007), and personality (Kuo, Liu & Ma, 2013). In one study, nurses with higher levels of seniority
and advanced levels of education had more positive attitudes towards EHRs (Chan, 2007). In another study, nurses who had been educated internationally had high levels of anxiety about using the technology (Edwards & Davis, 2006). As well, it has been suggested in the literature that formal training in nursing informatics could allow nurses to better understand and use related technologies in their practice (Saba, 2001; Staggers, Gassert, & Curran, 2002).

Strengths and Limitations

One of the strengths of the reviewed literature is the quantity of research done on this topic, which indicates that there is an interest in better understanding nurses’ use of EHRs. Researchers have looked outside of the nursing field and applied principles from other disciplines (e.g. the TAM, and Nielsen’s usability heuristics), sometimes modifying them to best meet the unique needs of nurses. In recent years, there has been a shift in the way nurses are viewed in relation to EHRs. Initial work published in the 1980s, and 1990s explored strategies that appeared to focus on overcoming nurses as barriers to successful computer or EHR implementations. As there seems to be a knowledge trajectory in this field, in which studies have been built upon previous work, researchers in the 2000s have focused on broader factors that influence nurses’ ability to use EHRs such those related to EHR usability, the organizational context and individual nurse characteristics. Recent studies have therefore been more supportive of the end users of the technology.

Several gaps have been identified in the literature. Despite EHR usability, the organizational context and individual nurse characteristics being explored in the 2000s, no one study has combined these factors together. How these factors relate to one another
and to what extent they may be able to predict a nurses’ use of an EHR, is unknown. As well, the availability of adequate infrastructure such as an appropriate power supply, speed of Internet connection, physical space and number of computers to access the EHR was only minimally discussed in the literature despite their obvious implications on a nurse’s ability to utilize an EHR. Future studies should ensure that these variables are included.

A limitation discovered in the literature is the general lack of definitions provided for some of the commonly utilized terms such as ‘attitude’, ‘acceptance’ or ‘use’. It is unclear whether the studies included in the review used similar definitions in their research. Future studies that use these concepts should be clear with regards to the specific definition(s) used. As well, literature reviewed from the 1980s and 1990s primarily focused on computers, rather than EHRs specifically. Applying what was learned during these decades to EHRs today should be done with caution, as both the computer systems and end user knowledge of technologies, has likely evolved.

Conclusion

The findings of this literature review show that nurses’ use of EHRs in clinical practice settings is highly dependent on a number of different variables. In the 1980s, nurses’ attitudes towards computers was studied. During the 1990s, studies were completed on nurses’ computer experience and knowledge, and how nursing students would obtain this knowledge so that they were prepared to enter clinical practice environments with computers present. As well, Staggers and Parks introduced a new way of thinking about nurses’ use of computers by introducing a framework that took into account a number of other variables and contextual factors. The results of more recent
studies examined suggest that the main factors influencing nurses’ use of the EHRs specifically are EHR usability, the organizational context and individual nurse characteristics. No study to date has examined how these factors combined influence nurses’ perceptions of their EHR use. As such, a study that addresses this gap in the literature is proposed.
CHAPTER III: FRAMEWORK

Four approaches have been predominantly used in the health IT literature to study nurses’ perceptions of their use of EHRs. These are the Diffusion of Innovation Theory (DOI) (Rogers, 1995), the Staggers and Parks Nurse-Computer Interaction Framework (Staggers & Parks, 1993), the DeLone and McLean Model for Information System (IS) Success (DeLone & McLean, 1992; DeLone & McLean, 2003), and the TAM (Davis, 1989; Davis et al., 1989); each are detailed below. These approaches were reviewed to inform the way the findings from the literature could be organized within a broader context in this study.

Diffusion of Innovation Theory

Rogers developed the DOI in the early 1960s to explain how innovations are spread (Rogers, 1995). This theory proposes that innovation occurs through a five-stage process over time, and that individuals are influential in the dissemination process. The first stage is knowledge, followed by persuasion, decision, implementation, and confirmation. Rogers’s theory has been applied to studies implementing EHRs to date, however only minimally (Hsu, Liu, Weng & Chen, 2013).

In the DIT, individuals become aware of an innovation such as an EHR, and rely on past experiences, current needs, innovativeness, social norms, and individual factors to form an opinion of it. In the knowledge stage, factors that play an important role include socio-economic characteristics, personality, and communication behaviours. During the persuasion stage, the individual becomes engaged in learning more about the innovation, and assesses the technology for its relative advantage, compatibility, complexity, trialability and observability. This is when an individual’s attitude toward an innovation
is formed, and may be influenced by a number of barriers, and/or facilitators to its adoption. In the decision stage, one evaluates the innovation and makes a decision to either accept or reject it. In doing so, the individual can adopt it immediately/later, or discontinue/continue to reject the technology. During the implementation phase, use of the technology is initiated. Previous to this stage, no physical use of the technology has occurred. Re-invention, where modifications are made to the innovation may occur at this time. The final stage of the process is one of confirmation in which individuals’ terminate the technology acceptance process, and may look to others for reinforcement about their decision to use it (Rogers, 1995).

Although the DOI is utilized in health IT literature, the application of the theory to nurses’ perceptions of their use of EHRs may be limited due to nurses not having a choice in whether they use it or not. Additionally, the DOI does not explicitly account for the organizational context or EHR usability, as were identified as important influencers of EHR use in the literature review. As such, the DOI in its original form will not be utilized in this study.

Staggers and Parks Nurse-Computer Interaction Framework

The Staggers and Parks Nurse-Computer Interaction Framework was developed as a way of describing the context in which nurses’ relate and interact to computers (Staggers & Parks, 1993). In the framework, information is considered the medium exchanged between nurses and the computer over time within a nursing context, and nurses’ behaviours are influenced by their individual characteristics, as well as attributes of the computer (made up of both computer characteristics and its interface). Staggers
and Parks (1993) designed the framework to organize literature and research conducted in this field.

Although the Staggers and Parks Nurse-Computer Interaction Framework offers insight into how nurses’ perceptions of their use of EHRs may be understood, it has had limited uptake within the published literature. For example, there are only two known studies using this framework; one is a qualitative study investigating the barriers to electronic documentation by nurses in a rural US hospital (Whittaker et al., 2009). In this study, nurses identified computer-related, nurse-related and contextual barriers and facilitators to their ability to document electronically. The other study compares two user interfaces for nurses’ response time, satisfaction, and errors (Staggers & Kobus, 2000).

The framework aligns with the findings from the literature review in that it includes elements of usability (computer characteristics), the organizational context (nursing context) and the individual nurse (nurse characteristics) and thus has been drawn upon in this doctoral study (Staggers & Parks, 1993).

**DeLone & McLean Model for Information System Success**

DeLone and McLean have developed a model to understand the net benefits of a technology (DeLone & McLean, 1992, DeLone & McLean, 2003). The model posits that the success of an information system (e.g. an EHR) can only be realized if end users are satisfied with, intend to use, and do use a particular technology. In turn, the benefits of the technology influence the satisfaction and intentions of the end users. In the case of EHRs, success is argued to be dependent on the use, and not just the installation of the technology in clinical environments.
In the DeLone and McLean model, intention to use a technology, and user satisfaction, are predicted by three main variables: information quality, system quality and service quality. A high degree of information quality suggests that the technology provides appropriate and useful information to the end user (DeLone & McLean, 2003). In an EHR, this would be indicated by information that is up to date, accurate, and that there is enough information captured in the record to allow it to be used by health professionals.

System quality reflects the functionality of the technology within the environment in which it is used (DeLone & McLean, 2003). In the case of EHRs, the integration of clinical documentation with physician orders, pharmacy dispensing systems, laboratory results, as well as other related systems, would allow for a high degree of system quality. The usability (ease of use) of the system is a component of system quality (DeLone & McLean, 2003).

Service quality is defined as the supports provided to end users to enhance their ability to utilize the technology appropriately (DeLone & McLean, 2003), and are elements of the organizational context. In the case of EHRs, this support could be in the form of education for the clinical staff on how to use the EHR, or technical support available for managing difficulties that may arise while using it.

To date, three known studies have utilized the DeLone and McLean Model for IS Success to examine nurses’ use of EHRs (Bossen, Jensen & Udsen, 2013; Lu et al., 2012; Palm, Colombet & Sicotte, 2006). Findings from these studies indicate that the model in its original form is unable to explain how net benefits of the technology can be achieved. Two additional studies combined the DeLone and McLean model with the TAM and
found the combination of the models accounted for a better understanding of the phenomena (Lu et al., 2012; Palm et al., 2006).

The DeLone and McLean Model for IS Success does not examine individual nurse characteristics, which were found to be important predictors of EHR use by nurses in the literature review. As this gap exists, the DeLone and McLean Model for IS Success in its original form will not be used, however elements of it will be drawn upon to inform the development of a framework for this study.

Technology Acceptance Model

One of the most widely adopted models utilized in the health IT literature is the TAM (Bagozzi, 2007). This model has been applied in research with health professionals as the end users of related technologies (Aggelidis & Chatzoglou, 2009; Holden, Brown, Scanlon & Karsh, 2012; Schnall & Bakken, 2011). The TAM is based on the Theory of Reasoned Action (TRA), a theory developed originally by Fishbein and Ajzen. In the TRA, behavioural intention is predicted by an individual’s attitude and subjective norms (Fishbein & Ajzen, 1975; Sheppard, Hartwick, & Warshaw, 1988). In turn, behavioural intention is believed to be an accurate predictor of actual behaviour (Chau & Hu, 2002). As the TAM emerges from the Theory of Reasoned Action, it also posits that behavioural intention is a direct predictor of real behaviour.

The TAM was originally developed by Davis as a way of explaining the intentions of employees required to use electronic mail (email) as a part of their job (Davis, 1989, Davis et al., 1989; Davis, 1993). In the model, behavioural intention is directly predicted by a person’s attitude, and indirectly predicted by the perceived usefulness, and ease of use of the technology. Perceived usefulness is defined as “the
prospective user’s subjective probability that using a specific application system will increase his or her job performance within an organizational context” (Davis et al., 1989, p. 985). Perceived ease of use is defined as “the degree to which the prospective user expects the target system to be free of effort” (Davis et al., 1989, p. 985). The TAM is used to predict acceptance of a technology, and it is assumed that actual use will follow acceptance (Davis, 1989, Davis et al., 1989).

Six known studies have used the TAM to better understand nurses’ acceptance of EHRs in hospital settings in the last decade (Aggelidis & Chatzoglou, 2009; Ketikidis et al., 2012; Kuo et al., 2013; Lu et al., 2012; Palm et al., 2006; Stocker, 2010). Much like the studies conducted with the DeLone and McLean Model for IS Success, this research has suggested that the TAM in its original form cannot fully predict nurses’ acceptance of EHRs. Added variables that have improved the models’ ability to predict acceptance are self-efficacy, training, facilitating conditions (Aggelidis & Chatzoglou, 2009), job relevance, subjective norms (Ketikidis et al., 2012), personality (Kuo et al., 2013) and sex (Palm et al., 2006).

Several of the variables added to the TAM were also identified in the literature review for this doctoral work, however not all barriers or facilitators to EHR use have been tested in previous applications of the TAM. For example, individual nurse characteristics were investigated through the addition of sex (Palm et al., 2006) and personality variables (Kuo et al., 2013). Furthermore, organizational context was measured through the addition of training, facilitating conditions (Aggelidis & Chatzoglou, 2009) and job relevance (Ketikidis et al., 2012). However, not all individual
nurse characteristics and organizational context variables have been comprehensively examined in the research to date using TAM.

Given that the original and modified versions of TAM do not include all of the potential variables discovered in the literature review that may influence nurses’ use of EHRs, the model was not applied in its original form in this study. Instead, TAM was used to inform the development of the framework for this doctoral study, and to support the assessment of nurses’ perceptions of their use of the technology, rather than actual use.

Proposed Framework

In summary, the approaches discussed in their current forms were shown to be incomprehensive in their ability to fully explain EHR use by nurses based on the findings from the literature review. Therefore the framework that guided this study consisted of relevant elements from each, as well as important variables identified from published research (Figure 1).

Literature has suggested that EHR usability, the organizational context and individual nurse characteristics are groups of variables that influence nurses’ use of EHRs. The DIT, Staggers and Parks Nurse-Computer Interaction Framework, DeLone and McLean Model for IS Success, and the TAM have provided insight into the possible relationships that may exist between the potential variables found in the literature, and nurses’ perceptions of EHR use. How each approach contributes to the proposed framework, is discussed below.

Although, the DOI focuses on the innovation process rather than factors that contribute to use, it does hold the role of the individual in the innovation diffusion
process as critical to success (Rogers, 1995). As well, the persuasion stage in the innovation-diffusion process may be particularly influenced by the barriers and/or facilitators identified in the literature review. Rogers asserts that individual characteristics influence whether an innovation is adopted, and at what rate. The terms innovators, early adopters, early majority, late majority or laggards are given to individuals depending on when adoption occurs. The DOI suggests that adopter behaviour toward the innovation is influenced by unique characteristics of the individual as well. As EHRs are considered in this study to be an innovation that diffuses throughout a hospital, individual nurses’ perceptions associated with the technology use are seemingly important, as are the behaviours of nurses toward the technology. As such, the individual nurse will be the unit of analysis in the proposed framework.

The specific individual nurse characteristics included in this study were informed by those found in the literature, and were included as moderators as suggested by Ifinedo (2016). These are sex, age, nursing unit, years of experience as a registered nurse (RN), country of nursing education, years of experience using an EHR, previous experience using an EHR, and formal informatics training. In the current study, the DOI was drawn upon to inform how individual nurse characteristics relate to nurses’ perceptions of EHR use.

The Staggers and Parks Nurse-Computer Interaction Framework was designed to organize research and literature to gain a greater understanding of how to optimize nursing behaviors associated with computer use (Staggers and Parks, 1993). This framework acknowledges the influence of the computer system, individual nurse characteristics and nursing context over a period of time. The proposed framework for
this dissertation will draw upon and enhance the Staggers and Parks Nurse-Computer Interaction Framework by adding the concepts of organizational context and EHR usability, which extend beyond the nursing context and influence of the computer system respectively. Organizational context is a broader concept than nursing context in that it captures variables that may influence nurses’ perceptions of their use of EHRs beyond nursing. In acute care, nurses operate in complex settings in which social, physical and structural variables influence their behaviours. As such, this expansion of the concept of nursing context is expected to provide a better understanding of nurses’ perceptions of EHR use. Additionally, EHR usability is an expansion of the concept of the influence of a computer system. The computer system itself is the means in which the EHR is accessed. By understanding the ease of use, functionality, navigation and workload of the current EHR software, nurses’ perceptions of EHR use may be better understood (Flanagan et al., 2011).

The DeLone and McLean Model for IS Success is focused on understanding how net benefits of a technology are achieved (DeLone & McLean, 1992, DeLone & McLean, 2003). In this model, end user satisfaction with the technology is suggested to influence any net benefits, and service quality, information quality and system quality positively relate to end user satisfaction. Service quality is proposed as a component of organizational context, and information and system quality are proposed as components of EHR usability in this research. As well, level of training and level of on-going support are proposed as aspects of service quality, and included in the proposed framework. Additionally, ease of use, functionality, navigation and workload are aspects of information and system quality, and are also included in this study.
Lastly, the TAM proposes that technologies that are easier to use are more likely to be viewed as beneficial, and end users are more likely to intend to use them (Davis, 1989, Davis et al., 1989). Thus, ease of use is included as a component of the concept of EHR usability in this doctoral study. As well, the TAM supports the measurement of nurses’ perceived EHR use rather than actual use. Figure 1 shows the proposed framework for understanding nurses’ perceptions of EHR use as developed from the DIT, Staggers and Parks Nurse-Computer Interaction Framework, the DeLone and McLean Model for IS Success, the TAM and relevant literature.
Figure 1. Proposed framework for understanding nurses’ perceptions of EHR use.
Problem Statement

Canadian healthcare organizations have invested heavily in the implementation of EHRs in the last decade (CHI, 2014). Nurses working in all care areas across the country with EHRs present are required to use the technology in their work (Abdrbo, Zauszniewski & Hudak, 2010; CHI, 2014). A literature review investigating the barriers to, and facilitators of EHR use by nurses found that EHR usability, the organizational context and individual nurse characteristics were groups of variables that influence nurses’ perceptions of their use of the technology. One of the gaps in the literature is that no known study has investigated these variables together, and how they relate to nurses’ use of EHRs.

Purpose

The purpose of this study is to a) determine whether perceived EHR usability and the organizational context are related to acute care nurses perceptions of their use of EHRs, b) examine individual nurse characteristics as possible moderators to this relationship, and c) understand if a combination of these factors is associated with acute care nurses’ perceptions of their use of EHRs.

Research Questions

The research questions were:

RQ1: Do nurses’ perceptions of their ability to use an EHR improve when the technology usability (i.e. ease of use, functionality, navigation, workload) is optimal?

RQ2: Do nurses’ perceptions of their ability to use an EHR improve, when the organizational context (i.e. support from leadership, level of training, level of on-going support, physical environment, implementation process) is favourable?
RQ3: Are nurses’ perceptions of their ability to use EHRs when the technology usability (i.e. ease of use, functionality, navigation, workload) is optimal moderated by individual nurse characteristics (i.e. sex, age, nursing unit, years of experience as a registered nurse, country of nursing education, years of experience using an EHR, previous experience using an EHR, formal informatics training)?

RQ4: Are nurses’ perceptions of their ability to use EHRs when the organizational context conditions (i.e. support from leadership, level of training, level of on-going support, physical environment, implementation process) are favourable moderated by individual nurse characteristics (i.e. sex, age, nursing unit, years of experience as a registered nurse, country of nursing education, years of experience using an EHR, previous experience using an EHR, formal informatics training)?

RQ5: Does an optimal level of EHR usability (i.e. ease of use, functionality, navigation, workload), a favourable organizational context (i.e. support from leadership, level of training, level of on-going support, physical environment, implementation process), and a unique set of individual nurse characteristics (i.e. sex, age, nursing unit, years of experience as a registered nurse, country of nursing education, years of experience using an EHR, previous experience using an EHR, formal informatics training), together, contribute to higher perceptions by nurses of their ability to use EHRs?
CHAPTER IV: METHODOLOGY

Design

This study used a sequential mixed methods design with two phases (Creswell & Plano Clark, 2011). Phase One consisted of a quantitative cross-sectional self-administered nurse survey comprised of instruments that have been used in previous research (Abdrbo et al., 2010; Flanagan et al., 2011; Saleem et al., 2011) and adapted for use in this work. Phase Two consisted of two qualitative focus groups with nurses that were conducted in an effort to further interpret the survey results.

Setting

The setting for this dissertation study was medical, surgical and cardiology units at a large teaching hospital in Toronto, Canada which had implemented modules of Cerner Corporation’s™ EHR solution (Anonymous, 2015). The hospital is located in the downtown core of the city of Toronto. At the time of study planning, this site was a 472-bed acute care academic teaching hospital affiliated with the University of Toronto, with 337-beds dedicated to medical, surgical and cardiology units (Anonymous, 2015). During the course of the study, the cardiology unit was closed leaving the hospital with 442-beds (Anonymous, 2016).

The hospital has a comprehensive EHR called Powerchart™ in place with CPOE, an electronic medication administration record (eMAR) at the bedside, clinical documentation, and diagnostic and laboratory results viewing on the medical, surgical and cardiology units. Nurses on these units are required to use Powerchart™ in their daily practice. Clinical documentation for nurses was first implemented in some clinical areas at the hospital in 2002 and since this time there have been additional modules
added, such as CPOE and eMAR (Nurse leader, personal communication, February 3, 2015). Nurses receive Powerchart™ training when they are first hired to the organization. The student conducting this study had been trained, and had experience using this particular EHR in clinical practice.

The hospital was selected as the site for sampling for several reasons. First, it has a comprehensive EHR in place with functionalities that surpass most hospitals in the province. These functionalities were expected to be implemented in a number of organizations in Canada in the future, and thus some results from this study may be generalizable to those settings. Second, the student had a familiarity with both the EHR and the hospital, as she was employed as a nurse at the site for two years ending in 2010. Finally, at the time of study planning the hospital employed enough nurses in its medical, surgical and cardiology units (Nurse leader, personal communication, April 1, 2015) to meet the sample size requirements for this study.

Nurses work in a variety of different clinical settings at the hospital including medicine, surgery, cardiology, oncology, intensive care, maternity, emergency, psychiatry and neonatal intensive care (Anonymous, 2015), however only those that worked on medical, surgical and cardiology inpatient units (10N, 10S, 11th floor, 12S, 14N, 14S, 16th floor) were included in this study. These units were chosen as they represented a relatively homogenous group of units due to their similar working patterns, and implemented modules of the EHR. Medical, surgical and cardiology units have had an EHR present for several years, whereas some of the specialty units (e.g. labour and delivery) have had a more recent implementation of the technology, or aspects of it (Nurse leader, personal communication, November 13 2014).
Sample

The sample of participants in this study consisted of RNs who worked on medical and surgical inpatient units at the hospital (10N, 10S, 11th floor, 12S, 14N, 14S, 16th floor). Given the closure of the cardiology unit during the study, nurses from the 16th floor were unable to participate. The inclusion criteria for this study was: a) RNs who have used Powerchart™ for a minimum of one year, b) the EHR must be used in the nurse’s routine practice (for clinical care), and c) the nurse will have worked in his or her current clinical environment for at least one year. A study by Casey, Fink, Krugman and Propst (2004), indicates that nurses can take up to twelve months to feel comfortable practicing in a new setting. As such, nurses with less than a year of experience using Powerchart™, or working on one of the study units, were excluded from the study. Nurses who did not use the EHR in their routine practice (for clinical care), such as nurse educators and managers, were excluded from the study. The student screened each nurse participant for the inclusion criteria prior to participation in the study.

Sample Size

Survey

Using Cohen’s power analysis calculation (Cohen, 1988; Cohen, 1992), it was determined that 130 participants were required for Phase One of this study (Appendix A). A number of different factors influenced the calculation of sample size using this approach including effect size (medium), the number of independent variables (n= 8), level of significance (0.05), and the study power (0.80) (Cohen, 1988; Shi, 2008). Based on the variability of reported response rates in previous research, a conservative response rate of 35% was utilized to calculate the sample size requirements. Oversampling was
planned as a mechanism of ensuring that enough nurses participated in the study to achieve power. As such, the student planned to approach 371 (130/371 = 35%) nurses to participate in the research.

Past survey research examining EHR usage within nursing populations has reported varying response rates. Urban settings have shown high response rates, ranging from 75.74% (Kuo et al., 2013) to 84.5% (Ketikidis et al., 2012). One study had a response rate of 83.5% among urban hospitals, and a very low rate among rural hospitals thus lowering the overall response rate of the study to 13.5% (Song, 2013). An Ohio study investigating nurses’ satisfaction with an information system using a mail-in survey approach, received a 45.93% response rate (Abdrbo, Hudak, Anthony & Douglas, 2011). Locally, a survey of nurses at the study hospital investigating an unrelated topic generated a 30% response rate among nurses (Mehta et al., 2007). In the Mehta et al. 2007 study, a survey was placed inside of each of the nurse’s mailboxes on two separate occasions.

Focus Groups

Typically, focus groups are comprised of between four and twelve people, and more than one focus group is conducted so that the researcher can compare and contrast data from the various groups (Kitzinger, 1995; Krueger & Casey, 2009). In this study, the goal of the focus groups was to gain a deeper understanding of the findings from the Phase One survey. The student planned to conduct two focus groups with between six and twelve participants present to be able to obtain enough information to meet this goal.

Ethics

Ethical Approval
Ethical approval was first received from the hospital site’s Research Ethics Board in September 2015. An administrative review was subsequently obtained by the Health Sciences Research Ethics Board at the University of Toronto in October 2015. The hospital site investigator acted as the conduit between the research ethics board at the site and the student. A data transfer agreement between the hospital and the University of Toronto was completed in October 2015 so that study materials could be transferred from the hospital to the university for data analysis. No recruitment took place until all of these approvals had been received.

*Ethical Considerations*

This study was considered low risk as participants were not considered to be vulnerable, and the research risk to the participant was low. The original paper surveys and audio recording transcriptions of the focus groups were kept in a locked filing cabinet in a locked room at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto. Once the focus groups were transcribed, the original audio recordings were destroyed. Numbers were given to participants in the focus group transcripts and no identifying information was collected or transcribed in the documents. Computer files containing data collected from the study were stored on a secure server at the university. Only the student and the dissertation committee members have access to the data. Aggregated data will be utilized in the dissemination of the study results.

*Informed Consent*

As obtaining written consent is not necessary for surveys at the study site, an introductory paragraph introducing the study purpose, data collection methods, participant expectations, any benefits or risks, voluntary nature, privacy and
confidentiality, and the students contact information, was provided for both the pilot and main survey. Implied consent was assumed for all participants who completed the survey. This acted as a means of maintaining the anonymity of the participants. The student was available on the unit on a daily basis should any potential participants have had any questions.

Informed consent was obtained in writing from all nurses participating in the focus groups. The consent letter, which was provided to all participants in the Phase Two focus groups, explained the purpose of the study, data collection methods, participant expectations, any benefits or risks, voluntary nature, privacy and confidentiality, as well as the students’ contact information (Appendix B). Participants had as much time as they needed to review the letter of information and consent form, and ask any questions before giving consent.

Data Sources

Survey

This study used several instruments and items to measure the variables included in the research. The definitions of the variables, as well as their measures are described below in Appendix C. The eight independent variables included in this study have been categorized into two groups: 1) EHR usability (ease of use, functionality, navigation and impact on workload) and 2) organizational context (support from leadership, level of training, level of on-going support and physical environment). Implementation process was not included as a variable in this study as at the time of the research, the EHR had been in place at this hospital for approximately a decade.
The EHR usability group of variables was made up of nurses’ perceptions of ease of use, functionality, navigation and impact on workload. Navigation was defined as “how logically information is organized and how easily information is located” (Flanagan et al., 2011, p. 428) as perceived by the nurse. Functionality refers to nurses’ perceptions of the extent to which the EHR “has tools or operations available to complete tasks that are necessary” (Flanagan et al., 2011, p. 429). Ease of use was defined as “how easy or hard it is to use the information system”, and impact on workload is the “degree to which the computer system increases the amount of effort” (Flanagan et al., 2011, p. 429) for the nurse.

A modified version of the Workflow Integration Survey (WIS) was used to measure all variables included in the EHR usability group (Flanagan et al., 2011). The WIS was developed to measure how an electronic clinical decision support tool was integrated into the workflow of physicians and nurse practitioners (Flanagan et al., 2011). The instrument consists of twelve statements related to ease of use, functionality, navigation and impact on workload. Participants were asked to answer to what extent they agreed with the statements on a five-point Likert scale ranging from one (strongly disagree) to five (strongly agree). The scale also included a “don’t know” response option. Psychometric testing of the instrument showed an internal consistency of 0.93 (Flanagan et al., 2011).

The clinical decision support tool used in Flanagan et al.’s 2011 study is a component of an EHR. The instrument was used in a study in US Veterans Affairs Medical Centers during a simulation exercise (Flanagan et al., 2011). For the purpose of this doctoral study, minor modifications were made to the WIS. Where the clinical
decision support tool was referred to specifically, the wording was changed to the name of the EHR at the hospital (Powerchart™). All additional wording remained as close to the original as possible. Pilot testing of the modified WIS was conducted.

The organizational context group of variables was made up of support from leadership, level of training, level of on-going support, implementation process and the physical environment related to EHRs. Support from leadership was defined as nurses’ perceptions of their Nursing Unit Administrators’ (NUA) support for their use of the EHR. Examples of the kind of support NUAs could provide nurses include providing results from documentation audits, preparing nurses for EHR ‘down-time’, and organizing for additional training for staff when appropriate. Level of training was defined as how nurses perceive their current level of EHR training. The level of on-going support was defined as nurses’ perceptions of the current level of support (Help Desk) provided to them for use of the EHR. Physical environment was defined as the physical space in which computers were located on the unit, as well as the power supply and network speed available. Finally, implementation process was defined as nurses’ perceptions of how the EHR was implemented, however was not measured in this study.

Several measurement tools exist in the literature for assessing organizational context; however, none do so using all of the concepts identified in this study. Additionally, the unit of analysis in this study is the individual nurse. Many of the existing instruments are to be utilized at the nursing unit (meso) or organization level (macro). As such, a combination of previously developed, and new items were used to measure organizational context variables in this study.
Level of training and level of on-going support were measured using one item per variable from the ‘service quality’ section of the CHI System and Use Assessment Survey (CHISUAS) (CHI, 2012). The items in the CHISUAS were developed from the DeLone and McLean Model for IS Success (DeLone & McLean, 2003), a model that was drawn upon to create the framework utilized in this study.

Support from leadership was measured using the item, “nursing unit administrators support nurses use of Powerchart™”. The item was developed by the student based on the literature suggesting a relationship exists between support from leadership, and health professional use of EHRs (Nagle & Catford, 2008; Pringle & Nagle, 2009; Whittaker et al., 2009).

Additionally, the following items were developed to measure the physical environment: “there are enough computers on my unit to access Powerchart™”, “computers are located in convenient spaces on my unit”, and “the speed of the network connection is appropriate.” These items were also added by the student, based on the literature suggesting that the physical environment may influence nurses’ perceptions of their use of EHRs (Edwards, Chiweda, Oyinka, McKay & Wiles, 2011).

The dependent variable in this study is nurses’ perceptions of EHR use, and was conceptualized as the extent to which the EHR supports nursing tasks as a part of the nursing process. The nursing process consists of an assessment, nursing diagnosis, planning, implementation, and evaluation (Ammenwerth et al., 2001). It is a framework used to guide the work that nurses do in clinical settings (Goossen, 1996), and is recognized throughout the world (Habermann, 2005). It is possible that nursing tasks associated with each component of the nursing process may be supported by an EHR.
In 2010, the Information System Use Instrument (ISUI) was developed to measure nurses’ perceptions of their use of an EHR using the nursing process (Abdrbo et al., 2010). Seven items (assessment, searching, planning, implementation, communication, documentation and administrative tasks) were created to reflect how nurses perceive an EHR to support the nursing process. A five-point Likert scale ranging from zero (never/almost never) to four (always/almost always) was used to assess the frequency in which nurses used the EHR to complete the tasks required to complete the nursing process. The instrument was tested on 570 hospital nurses, and an internal consistency (Cronbach’s alpha) of 0.82 was found. Scoring of the original ISUI allows for a summative score to be calculated between zero and twenty-eight. Higher scores indicate that a nurse has a higher perception of their EHR use.

For this study, the ISUI was modified to provide more specific information related to how nurses at this hospital can use Powerchart™ to complete the nursing process. As such, “searching” was replaced with “searching for information”, “implementation” was replaced with “clinical decision-making”, and “documentation” was expanded to the specific ways that nurse’s document at the site. The items that are related to documentation are “medication administration”, “documentation of assessments through standardized forms”, and “narrative notes”. Additionally, the Likert scale was changed so that it could be scored more similarly to the other scales utilized in the survey to enhance survey ease of use. In the modified scale, one represents “never”, and five represents “always”. The scale also includes a “don’t know” response option. Given these changes, the student planned to calculate a summative score between nine and forty-five for each
participant. Like the original scale, higher scores indicate that a nurse has a higher perception of EHR use.

Individual nurse characteristics are variables that may act as moderators by changing the strength and/or direction of the relationships found between EHR usability, organizational context and nurses’ perceptions of EHR use. Potentially moderating variables collected in this study were sex, age, nursing unit, years of experience as a RN, country of nursing education, years of experience using an EHR, previous experience using an EHR, and formal informatics training. Demographic questions, including employment status (full time, part time or casual status), were asked through a series of questions at the end of the survey, and were also used to better understand the study participants.

The pilot survey and main survey are shown in Appendix D and E respectively.

*Focus Groups*

Once the results of Phase One were available, the student developed focus group questions aimed at asking participants whether they agreed or disagreed with the study findings. As well, participants were asked to provide examples from their practice of how significant variables identified in the survey influenced their use of Powerchart™. See Table 1.
Table 1. Focus Group Questions

<table>
<thead>
<tr>
<th>Question 1: ‘Navigation’ is how logically information is organized in Powerchart, and how easily information is located.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Can you share with me your experiences ‘navigating’ through Powerchart?</td>
</tr>
<tr>
<td>• Study participants who found Powerchart easier to ‘navigate’ indicated that they used it more. Would the same apply to you?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 2: ‘Functionality’ is the extent to which Powerchart has tools or operations available to complete necessary tasks.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Participants in this study provided a wide range of comments related to ‘functionality’, with no specific functionality issue being identified</td>
</tr>
<tr>
<td>• Can you tell me about, or describe your experiences with the ‘functionalities’ of Powerchart?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 3: Participants provided a number of comments related to ‘repetitive’ and ‘double/triple’ charting within the Powerchart system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Do any of you want to comment on any experiences you have had of this nature?</td>
</tr>
<tr>
<td>• Have you found this to be the case, and if so, where specifically?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question 4: There were a number of comments from participants about the documentation and assessment screens in Powerchart, and their ability to capture nursing assessments and care provided.</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Can you tell me about or describe your experiences with the documentation and assessment screens in Powerchart?</td>
</tr>
</tbody>
</table>
The first question asked during the focus group was related to navigation. This question was developed as results from the survey indicated that navigation was significantly related to nurses’ perceptions of their EHR use. The second question posed to participants during the focus group was about the EHR functionality. Due to a poor Cronbach’s alpha (0.55), functionality was not included in any statistical analyses of the survey data. However, since comments related to the variable were present on the respondent surveys, a question about functionality was asked of focus group participants. Question three was related to repetitive or double/triple charting, and question four asked participants about how they perceived the current documentation and assessment screens. These questions were asked as a number of participants had written comments on their returned surveys about these topics.

The student’s dissertation committee members provided feedback related to the students’ initial draft of the focus group guide, which allowed for further refinement of the questions. The focus group guide is shown in Appendix F.

Procedures for Data Collection

Initial Contact with the Study Site

Communication with the hospital regarding study logistics was initiated in May 2015 when the study proposal was approved by the thesis proposal examination committee at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto. The study ethics proposal specific to the hospital, study objectives and data collection plans were discussed with the site investigator, who was a senior nursing leader at the organization.
Once ethical approvals were obtained, the site investigator introduced the student to the NUAs from participating units. For each study unit, the student generated a list of all eligible nursing staff with the assistance of the NUA or their designate. This was done to ensure that an approximately equal number of surveys were distributed to each unit in an attempt to ensure that the study had equal representation by unit, and to improve the generalizability of the study findings.

**Pilot Study of Survey**

Pilot testing of the survey was done prior to undertaking the main study to ensure its clarity, face validity and feasibility, and to determine the length of time required for survey completion. Five nurses were asked to participate in pilot testing, and were informed of the study objectives and requirements of participating in the research (Appendix G). RNs were eager to participate in the study, and the student did not find it difficult to recruit the pilot participants. Participants were given the survey (Appendix D), and a feedback form (Appendix H). As a token of appreciation, a small snack was also provided. The student then arranged to collect the completed surveys at a later time, either on the same day or the following day. The participants left the completed surveys in a sealed envelope in a dedicated space on the unit for the student to collect.

**Recruitment and Data Collection**

During Phase One, the student met with the nursing staff during regular staff meetings and unit safety huddles to explain the study and the sampling procedure. Times when the student could attend these meetings to reach the optimal number of potential RN participants was coordinated with the NUAs. The student also provided the survey packages to potential participants on weekends, evenings and in the early morning by
coming to the units while the night and weekend staff were present, to maximize study recruitment. Participants were provided with a letter of information about the study (Appendix I), a copy of the survey (Appendix E), envelope labeled with the student researcher’s name on it, and an invitation to participate in a focus group (Appendix J).

The survey was available to participants in paper form. Participants were instructed to place the completed paperwork in the envelope, seal it, and place it in a pre-determined ‘drop’ location point on their unit. The student visited the clinical units on a daily basis to pick up completed surveys, as well as to directly recruit additional nurses to participate in the study. Participants received a small snack as a thank you for participating in the study. This was provided to participants when they received a copy of all study materials regardless of whether they completed the survey. Data collection occurred over a five-week period during November and December 2015.

Nurses who completed the survey in Phase One of this study were asked if they would be interested in participating in focus groups during Phase Two. Potential participants were provided with a one-page document reviewing the purpose of Phase Two and inviting them to participate in the focus groups (Appendix J). This information was included in the original survey package that was provided to each eligible nurse. Nurses were asked to provide their contact information on a separate paper if they were interested in being contacted in the future by the student researcher regarding possible participation. An envelope, which could be sealed, was also provided. Each day the student collected the envelopes from pre-determined designated ‘drop’ locations on each study unit.
The student researcher worked with the NUAs on each unit to determine times and dates that would be appropriate to hold the focus groups. The units from which the focus group sample was obtained, schedule nurses to work twelve hour shifts either commencing or terminating at 7:30 or 19:30. It was recognized that it would be challenging for nurses to participate in the focus groups while they were working, and that during their lunch break or after their shift ends, may work best. Thus, two focus groups were scheduled with one being held at noon, and the other being held at 20:00. As well, some NUAs indicated that on Wednesdays, there are sometimes more nurses working given their current schedules and that it could potentially be easier for nurses to attend the focus group during their lunch on this day. Given this information, both focus groups were scheduled for Wednesdays.

Focus groups took place at the hospital in classrooms, which were located close to the clinical units where the participants worked. These classrooms were chosen in an effort to create a quiet and comfortable environment, free from the distractions of the clinical unit e.g. call bells and phone calls. Chairs were set up in a circular manner to facilitate discussion and interaction between members. The focus groups began by the student researcher instructing all members to take a seat. Participants were welcomed and thanked for agreeing to participate in the study. They were then told the purpose of the research, were notified of the audio recording of the focus group, and were reminded that the discussions would be kept confidential. After written consent was obtained, the student researcher led the participants through a series of four questions and prompted participants when further information was required or if a member of the group had not yet contributed to the discussion. The student researcher utilized a guide (Appendix F) to
facilitate the discussion. After the last question was asked and participants had provided their final response, the student researcher thanked the attendees for their participation in the study. Last, participants were provided with a light meal, and $5 gift card to a coffee shop. The first focus group was held in July 2016, and the second was held in August 2016. Each focus group lasted approximately one hour and three participants were present in each session.

Data Analysis

Surveys

All survey data was entered into SPSS® Version 21 for data analysis. Descriptive statistics (means, standard deviations, frequencies and percentages) were generated to describe the sample (Plichta Kellar & Kelvin, 2013). The reliability of each of the instruments (WIS and ISUI) was determined using Cronbach’s alpha (Cohen, Cohen, West & Aiken, 2003). Research questions were examined using multivariable linear regression and hierarchical linear regression (Cohen et al., 2003; Tabachnick & Fidell, 2013). A chunkwise approach was used to determine which individual nurse characteristics should be included in models as potential moderating variables (Kleinbaum, Kupper, Nizam & Rosenberg, 2014).

Assumptions of regression were examined through a variety of different statistical tests. Assessing for multicollinearity was completed by conducting either a Pearson or Spearman correlation, as well as by reviewing tolerance and variance inflation factors (Cohen et al., 2003). Outliers were examined by reviewing Mahalanobis distances (Pallant, 2016), and scatterplots were used to determine if a linear relationship existed between the independent and dependent variables. Homoscedasticity, normality and
linearity of the residuals were reviewed by conducting a normal probability plot, histogram and scatterplot of the standardized residuals (Cohen et al., 2003; Pallant, 2016).

*Focus Groups*

Once focus groups were completed, the recordings were transcribed verbatim and verified for accuracy. A directed content analysis technique (Hsieh and Shannon, 2005) was used for data analysis given that focus group questions were developed from the findings from Phase One of the study. This approach is considered deductive in nature (Elo and Kyngas, 2007).

Coding categories were determined based on the framework used in this study. As such, passages from the focus group transcripts were matched to either one of the usability variables (ease of use, functionality, navigation, impact on workload) or one of the organizational context variables (support from leadership, level of training, level of on-going support, physical environment). Where there was no obvious fit between a passage and a pre-determined coding category, a new category called “other” was assigned. As suggested by Hsieh and Shannon (2005), all data that populated the “other” category was then analyzed to identify if any new categories needed to be developed. As well, all data contained in each of the pre-determined categories was reviewed, and subcategories were developed where required.

The student attempted to employ strategies during the analysis process that would ensure the trustworthiness of the findings (Shenton, 2004). For example, the student and her dissertation supervisor each read the transcripts and assigned categories to the text separately. Afterwards, the categories were compared and consensus was obtained.
through discussion. Graneheim and Lundman (2004) describe this technique as an effective way of improving the internal validity of the categories and subcategories assigned to the text. As well, authentic citations were selected to demonstrate the various categories and subcategories, while maintaining the anonymity of the participants. This transparency improves trustworthiness by allowing readers to make their own assessment of the fittingness of the data to the category (Sandelowski, 1993).
CHAPTER V: RESULTS

This chapter presents the results of Phase One and Phase Two of this doctoral dissertation research.

Pilot Test

A pilot test of the survey was conducted over a two-week period in November 2015 to determine the length of time it took for nurses to complete it, as well as to assess its clarity, face validity and understandability. The survey was distributed to five RNs working on different medical and surgical units at the study site and not included in the larger study. All five RNs who were approached to participate in the pilot test returned completed surveys.

The results of the pilot test demonstrated that all participants understood the survey directions as they provided answers to all questions by indicating their answer through a corresponding number in the appropriate column. Participants reported that the survey took approximately five minutes to complete, the length was appropriate, and the instructions and items were clear and easy to understand. One participant proposed a ‘comments’ section, and a different participant suggested there be questions developed to inquire about nurses’ perceptions of the adequacy of the current EHR assessment screens.

The survey was modified to include a ‘comments’ section at the end of the second page. The feedback regarding capturing information from RNs about their perceptions of the adequacy of the EHR assessment screens was discussed with the student’s dissertation committee, and the decision was made to consider incorporating it into the focus group question guide.
Phase One: Survey Results

Response Rate

As a result of the sample size calculation, the student planned to ask 371 nurses to participate in the survey. A senior nursing leader at the study site verified that there were enough staff to meet the sample size requirements. However, when the student reconciled the number of eligible participants by collecting the number of full time, part time and casual staff from the NUAs, a discrepancy of 42 nurses was discovered, as there were 329 nurses employed on the study units. As well, the administration of surveys to the cardiology unit was not possible due to its closure after the study was underway, eliminating a further 44 nurses. As such, 285 nurses remained eligible for the study. Appendix K shows a summary of the eligible participants.

A total of 212 survey packages were handed out, and 139 survey packages were returned. Six of the returned surveys were ‘blank’. As such, 133 usable surveys remained. The response rate was calculated using the definition by Fowler (2014) which states that the numerator is the number of people who completed the survey, and “the denominator includes all people in the study population who were selected but did not respond for whatever reason: refusals, language problems, illness, or lack of availability” (p. 43). Therefore, the response rate for this study was 40.4% (133/329). Appendix K includes a summary of the sample attained.

Data Preparation

All usable surveys were entered into SPSS® Version 21. The student went through each survey to verify the accuracy of data entry into the statistical software. Fourteen surveys (approximately 10%) were then selected using a random number
generator and again double-checked for accuracy. Discrepancies discovered during the double-checking process were addressed.

Age was computed by subtracting year of birth from the year the survey was distributed (2015). Country of nursing education was coded as either “Canadian educated” or “internationally educated” due to limited variability in responses. Scores for each of the usability variables (ease of use, functionality, navigation and impact on workload) were calculated by summing the three item scores that made up each subscale in the WIS. Six of the items within this scale were reversed scored and a computed variable using the reverse of this score was created and used in the calculation of the subscales. Three of the organizational context variables (support from leadership, level of training and level of ongoing support) used Likert responses from the modified CHISUAS (CHI, 2012). These scores were individually used in any analyses. Physical environment was measured using three items from the modified CHISUAS, and the mean score was calculated to represent this variable. Nurses’ perceptions of EHR use, was measured by summing the Likert responses for the entire Nurses ISUI.

Prior to the main analysis, all variables were examined for missing data. Where scale scores were generated from summing a number of items together, mean imputation was used provided that only one item had a missing value. Listwise deletion was used in all other cases. Item level missing data ranged from 0-7.5% for the independent variables, 0-18% for the dependent variable, and 0-14.3% for demographic information. Thirty-three of the overall survey items had less than 10% missing data. Only three items had more than 10% missing data. These were: ‘what year were you born?’ (14.3% missing), ‘in which country did you complete your nursing education?’ (10.5% missing) and, how
often nurses reported using Powerchart™ to complete ‘administrative tasks’ (18% missing). Enders (2003) described that it can be common in some studies to have a 15-20% rate of missing data. Dong and Peng (2013) further reported that the ways in which missing data is managed is as important as the amount of missing data in a study. Missing data in this study was considered acceptable given the amount of missing data, and the way it was managed (mean imputation and listwise deletion).

Description of the Sample

Nurses from four surgical and three medical units participated in the study. Initially participants from the cardiology unit were to be asked to participate in the study; however, due to the closure of this unit during the study period, RNs employed on the cardiology unit were not asked to participate in the pilot survey or main survey. Participants in the study were predominantly female (n= 121, 91%), educated in Canada (n= 109, 82%), and did not have informatics training (n= 113, 85%). In comparison, the Canadian Institute for Health Information (CIHI) reported 92.4% of RNs nationally as female (CIHI, 2015). Approximately half of the participants worked on medical units (n= 66, 49.6%), and the other half on surgical units (n= 67, 50.4%). Close to two thirds of the sample reported that they did not have experience using an EHR other than the version used at the study site e.g. Powerchart™ (n= 83, 62.4%). For the remaining participants that reported having experience with a different EHR (n= 47, 35.3%), they described using ‘Meditech™’, ‘PointClickCare™’, and student placements at other organizations with EHRs in place. Over three quarters of the study participants were employed full time (n= 106, 79.7%), while 18% (n= 24) worked part time and a small number (n= 2, 1.5%) were employed in a casual status. The average age of nurse participants was 35.2 (SD= 
9.7) with 10.9 (SD= 8.8) years of nursing work experience and an average of 6.8 (SD= 3.8) years of experience using an electronic heath record. CIHI reports the average age of RNs in Canada as 44.6, and 46.3 in Ontario (CIHI, 2015).

Reliability of the Measures

The WIS measuring EHR usability, and the ISUI measuring nurses’ perceptions of EHR use, were assessed for internal consistency. The Cronbach’s alpha for the WIS overall scale was appropriate at 0.90, which is similar to the scale reliability reported by the instrument developers at 0.93 (Flanagan et al., 2011). No Cronbach’s alphas were reported for the individual subscales by the original instrument developers. In this study, ease of use, navigation and impact on workload had acceptable Cronbach’s alphas of 0.81, 0.78 and 0.81 respectively, however functionality demonstrated poor internal consistency with a Cronbach’s alpha of 0.55. Due to the poor internal consistency of the functionality subscale, this variable could not be used in further analyses for any of the research questions. The Cronbach’s alpha for the ISUI was 0.80, similar to that reported by the instrument developers of 0.82 (Abdrbo et al., 2010).

Qualitative Comments

In the final section of the survey, participants were able to provide written comments. An analysis of these comments revealed that most were related to the topics of functionality, repetitive charting and the adequacy of the assessment screens. These comments were used to develop the focus group discussion guide for phase two of this study.
Findings Related to the Research Questions

The research questions in this study were answered using multivariable linear regression and hierarchical linear regression.

**Research Question One**

*Do nurses’ perceptions of their ability to use an EHR improve when the technology usability (i.e. ease of use, functionality, navigation, impact on workload) is optimal?*

Usability is made up of four variables (ease of use, functionality, navigation, impact on workload) and is measured using the four subscales of the WIS. Since the functionality subscale showed poor internal consistency (0.55), it could not be used in the analysis of RQ1.

Tests of the assumptions of regression were conducted and reviewed. Multicollinearity was tested using Pearson’s correlation coefficient, and by inspecting both the tolerance and variance inflation factor of the collinearity diagnostics (Cohen et al., 2003; Harrell, 2015). None of the bivariate correlations were above 0.7 indicating that it is appropriate to include the variables in the regression analysis (Pallant, 2016; Tabachnick & Fidell, 2013). As well, all tolerance and variance inflation factor scores were acceptable. Outliers were examined by reviewing a matrix scatterplot, and the Mahalanobis distances in relation to the critical chi square value, as indicated by the number of independent variables in the regression model (Pallant, 2016; Tabachnick & Fidell, 2013). No obvious outliers were evident from the matrix scatterplot, and all Mahalanobis distances generated in the analysis were less than the critical chi square value at the $\alpha = 0.001$ level indicating the absence of significant outliers. Scatterplots of
the bivariate relationships between each usability variable and nurses’ perceptions of EHR use showed linear relationships (Plichta Kellar & Kelvin, 2013). Homoscedasticity, normality and linearity of the residuals were verified by inspecting the normal probability plot, and both a histogram and scatterplot of the standardized residuals (Pallant, 2016; Plichta Kellar & Kelvin, 2013; Tabachnick & Fidell, 2013). All tests completed showed that the data was appropriate for a regression analysis.

A multivariable model with three usability independent variables (ease of use, navigation and impact on workload) was developed with nurses’ perceptions of EHR use as the dependent variable. Results indicate that the model explains 13% of the variance in nurses’ perceptions of EHR use. Navigation was the only variable significantly associated with the dependent variable as evidenced by the significant β value (β = 0.38, p = <0.01). Ease of use and impact on workload variables were not significant. See Table 2.

Table 2. Coefficients of Multivariable Regression for Usability Variables Predicting Nurses’ Perception of EHR Use

<table>
<thead>
<tr>
<th>Variable</th>
<th>R</th>
<th>R²</th>
<th>Adjusted R²</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
</tr>
</thead>
<tbody>
<tr>
<td>*p=&lt;0.01</td>
<td>0.38</td>
<td>0.15</td>
<td>0.13*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Use</td>
<td></td>
<td></td>
<td></td>
<td>0.15</td>
<td>0.28</td>
<td>0.07</td>
</tr>
<tr>
<td>Impact on Workload</td>
<td></td>
<td></td>
<td></td>
<td>-0.24</td>
<td>0.20</td>
<td>-0.13</td>
</tr>
<tr>
<td>Navigation</td>
<td></td>
<td></td>
<td></td>
<td>0.92</td>
<td>0.25</td>
<td>0.38*</td>
</tr>
</tbody>
</table>
Research Question Two

Do nurses’ perceptions of their ability to use an EHR improve, when the organizational context (i.e. support from leadership, level of training, level of on-going support, physical environment, implementation process) is favourable?

Organizational context is made up of four variables (support from leadership, level of training, level of on-going support and physical environment). These variables were measured using one item each from the modified CHISUAS, except for physical environment that was measured using the mean of three items from the same modified survey. As the multivariable regression analysis was conducted, assumptions of multicollinearity, linearity, homoscedasticity, normality and linearity of the residuals were confirmed using the techniques described for RQ1. Spearman’s correlation coefficients were calculated instead of Pearson’s correlation coefficients, as some of the variables in RQ2 were measured using single item Likert responses. All but one Mahalanobis distance was smaller than the critical chi square value at the $\alpha = 0.001$ level indicating that there was one outlier. The analysis was completed despite this outlier, as it can be appropriate to conduct a regression analysis if the number of outliers is small (Pallant, 2016), as it was in this case. All other assumptions of regression were met.

A multivariable model with the four organizational context independent variables was developed with nurses’ perceptions of EHR use as the dependent variable. Results of the regression analysis indicate that the model was not statistically significant ($p = 0.51$). The results of the regression analysis can be found in Appendix L.

Research Question Three
Are nurses’ perceptions of their ability to use EHRs when the technology usability (i.e. ease of use, functionality, navigation, impact on workload) is optimal moderated by individual nurse characteristics (i.e. sex, age, nursing unit, years of experience as a registered nurse, country of nursing education, years of experience using an EHR, previous experience using an EHR, formal informatics training)?

To determine which individual nurse characteristics to include as potential moderators between usability variables and nurses’ perceptions of EHR use, a chunkwise approach was used in model building. This approach is a way of selecting which variables to include in subsequent models by reviewing the $f$ change statistic and its significance when variables are added to a model (Kleinbaum et al., 2014). For RQ3, all continuous usability variables (ease of use, navigation and impact on workload) and individual nurse characteristics (age and years of experience using an EHR) were first mean centred to decrease the potential for multicollinearity arising from the creation of interaction terms. Interaction terms were developed between each usability variable (ease of use, navigation and impact on workload) and each individual nurse characteristic (years of experience using an EHR, other EHR use and age) included in the model.

Years of experience using an EHR, other EHR use and age were the only individual nurse characteristics with both theoretical significance and enough variability in participant responses to be included as possible moderators in this analysis. Since years of experience using an EHR and age demonstrate multicollinearity above 0.7, they could not be included in the same model and thus two chunkwise models were developed for each of the three usability variables (see Appendix M). In the first version of the model (Model A), years of experience using an EHR, and other EHR use were entered
along with one of the usability variables in the first step. Interactions between these variables were entered in the second step. In the second version of the model (Model B), age and one of the three usability variables was entered in the first step, and the interaction term was entered in the second step. Models A and B for each of the usability variables (ease of use, navigation and impact on workload) were then examined by reviewing the $f$ change statistic and its significance.

All chunkwise models developed, met the assumptions for multicollinearity, and homoscedasticity, normality and linearity of the residuals. None of the models displayed a significant $f$ change statistic suggesting that individual nurse characteristics did not have a moderating effect on any of the relationships between usability variables (ease of use, navigation and impact on workload) and nurses’ perceptions of their EHR use. Therefore no interaction terms were retained as possible moderators in RQ3. Given these findings, a final model with all usability variables and moderators was not developed.

Research Question Four

Are nurses’ perceptions of their ability to use EHRs when the organizational context conditions (i.e. support from leadership, level of training, level of on-going support, physical environment, implementation process) are favourable moderated by individual nurse characteristics (i.e. sex, age, nursing unit, years of experience as a registered nurse, country of nursing education, years of experience using an EHR, previous experience using an EHR, formal informatics training)?

RQ4 was answered using the same approach as RQ3 where two chunkwise models (Model A and Model B) were developed for each organizational context variable. All models were then examined by reviewing the $f$ change statistic and its significance, as
well as tests for assumptions of regression. Individual nurse characteristics did not have a moderating effect on the relationship between any of the organizational context variables (support from leadership, level of training, level of on-going support, physical environment) and nurses’ perceptions of their EHR use. As none of the interaction terms were significantly associated with nurses’ perceptions of EHR use, a final model with all organizational context variables and interaction terms was not developed. See Appendix N.

Research Question Five

Does an optimal level of EHR usability (i.e. ease of use, functionality, navigation, impact on workload), a favourable organizational context (i.e. support from leadership, level of training, level of on-going support, physical environment, implementation process), and a unique set of individual nurse characteristics (i.e. sex, age, nursing unit, years of experience as a registered nurse, country of nursing education, years of experience using an EHR, previous experience using an EHR, formal informatics training), together, contribute to higher perceptions by nurses of their ability to use EHRs?”

Hierarchical linear regression was used to answer RQ5. In the first block of predictors, years of experience using an EHR and other EHR use were entered into the model. Age was not included in this model due to multicollinearity with years of experience using an EHR.

The second block of predictors consisted of usability variables (ease of use, navigation and impact on workload), and the third block of predictors entered into the model were organizational context variables (support from leadership, level of training,
level of on-going support and physical environment). Using the techniques outlined in RQ1, assumptions of regression were verified. All assumptions of regression were confirmed and thus the appropriateness of the statistical technique was confirmed as well.

Results of the hierarchical linear regression analysis indicated that only the second block of predictors had a significant change statistic, and that the model contributed to 8% of the variance in nurses’ perceptions of EHR use. Navigation was the only variable that was statistically significant (β = 0.30; P = <0.05). Results of model testing are shown in Table 3.
Table 3. Summary of Hierarchical Regression Analysis for Variables Predicting Nurses' Perceptions of EHR Use

<table>
<thead>
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Phase Two: Focus Group Results

This portion of the results chapter provides the findings from the analysis of the focus groups in three main sections. The first section describes the results from the first focus group question, which asked participants to comment on their experience navigating through the EHR. Next, the findings of the second question asked during the focus groups on the topic of functionality are presented. The third section reviews findings related to the organizational context. Finally, the fourth section describes other results, which emerged through the third and fourth questions in the focus groups, and any other findings that could not be categorized as an aspect of navigation or functionality. The focus group guide showing all questions asked of participants, and prompts, is shown in Appendix F.

Navigation

Navigation was defined in this study as how information is organized in the EHR and how easily information can be located within it. Participants provided comments about their experience navigating through Powerchart™ and described two main aspects of navigation. These were: 1) design related documentation issues, and 2) information seeking challenges.

Design Related Documentation Issues. As clinical information is stored in a variety of different areas of the EHR, nurses reported that it can be cumbersome to document their nursing assessments, and consequently difficult to find information. System design issues were discussed as being the probable cause for this navigational challenge. For example, participants described that in some cases there are multiple places within Powerchart™ to document the same clinical information. This can make it
confusing for nurses to know where certain data should go, or in which part of the record this information may be viewed by other health professionals. One participant described an area in the EHR where double documentation occurs in relation to wound care:

There’s like wounds skin integrity, and they ask is there anything abnormal, where is it, the location, but then you have to do documentation of their wound dressing change, it’s there again. It’s like why are you, again, why are you doing it twice, in a way? And who’s looking at which one? What, what one’s actually… people are actually looking to? Are we just documenting to document, or is it actually of need or kind of like of use? (Focus Group 1, Participant 1)

Nurses reported that since the EHR had been implemented, a number of additional Power Forms™ (structured nursing documentation templates) had been added to the system. Some of the more recently added Power Forms™ required that nurses document information that they had already charted elsewhere in the record, thus creating double or triple documentation.

As well, participants in both focus groups identified a problematic recent design change to the eMAR that reversed the way in which the timing was displayed on the screen.

In terms of navigation, one thing that really stuck out to me…was one of the things that they made more recently with the MAR, the timing of, um, medications to give. I think, before they made the changes, it was from left to right, um, like earliest time for medication onto, um, a later time for medication. Now, currently on Powerchart, from right to left, it’s earliest to, um, more later time for medications. So, in a sense, that was kind of confusing…to navigate through, like what medications are given and what times (Focus Group 2, Participant 3)

Nurses had become used to navigating the eMAR screen in a certain way; however, the change in orientation meant that nurses had to navigate the screen in a new way. Focus group participants found it frustrating that they were required to make this change, and did not understand the rationale for the new design.
Information Seeking Challenges. Participants wondered how other health professionals (e.g. physicians, pharmacists and other nurses) might find their documentation, given that EHR users may have to look in multiple places within the record to find it. They described the process for finding information as challenging, and worried about missing important patient information.

Focus group participants further explained how those seeking information were required to open one item at a time and review the content to determine whether it contained what they were looking for. If what they are looking for was not present, they would need to close the item before being able to open a new one. One nurse described it in the following way:

It’s painful. It’s like click, close it, click, close it. Yeah. (Focus Group 1, Participant 3)

Another participant said:

… you have to keep going in and out to try and find anything (Focus Group 1, Participant 1)

Nurses reported that other health professionals also struggle with finding information within Powerchart™ and that this sometimes impacts nurses. For example, one nurse explained that as a result of a physician being unable to locate important clinical data within the electronic record, the physician interrupted her from patient care activities to ask for information she had already documented.

Functionality

In this study, functionality was described as the tools and operations available in Powerchart™ that allow nurses to complete necessary tasks. Participants provided comments about their experience with the functionalities of the EHR, and described six
aspects of functionality. These were: 1) functions that supported nursing practice, 2) data visualization and interoperability, 3) challenges with obtaining complete patient information, 4) hybrid systems, 5) alerts, and 6) forced functions.

*Functions that Supported Nursing Practice.* Several nurses commented on the functions of the EHR that they believe supported their practice. For example, one nurse reported:

One of the functions that Powerchart offers is… those tabs at the top where you can also say missing dose and it pops up, um, a window on where you can communicate with pharmacy to bring down a certain medication that’s not available at the time… it’s really good for that communication for pharmacy…to get medications that are missing at the time. (Focus Group 2, Participant 3)

Other examples of useful functions of Powerchart™ discussed by participants were a calculator, an electronic reference manual for drug and clinical information, clinical documentation screens, and a referral form for homecare and/or rehabilitation. These were described as aspects of the EHR that supported nurses in being able to complete their clinical work.

Structured documentation templates (Power Forms™) were explained as prompting nurses to document certain aspects of an assessment and/or care related to the particular fields indicated on the forms. This was discussed as being useful when a nurse initially forgets to document an aspect of an assessment and/or care, and is then reminded through the prompt to do so. However, several of the nurses reported that these prompts make some nurses feel that they need to document in every field, which may not always be appropriate, and may also be time consuming.

*Data Visualization and Interoperability.* Participants expressed that they preferred documentation and viewing functions of the EHR system that allowed them to see
patterns in clinical data over a period of time. The design of the current EHR system was described as supporting this type of data visualization for specific kinds of patient information, such as a patient’s capillary blood glucose (CBG). Nurses described how a patient’s CBG was automatically populated into Powerchart™ due to the glucometer technology being interoperable with the EHR. One participant explained:

If you upload, um, the CBG machine onto the dock, it automatically pops up…the patient’s blood sugar, so you can see the trends in the blood sugar and, um, in their chart. (Focus Group 2, Participant 3)

Nurses reported that being able to see trends in clinical data helped them to better understand the patients’ health status and make clinical decisions.

Challenges with Obtaining Complete Patient Information. Nurses did not always feel that the functions of Powerchart™ were effective in providing a comprehensive picture of the patient. Participants informed the investigator that there are many different places where patient information can be located in the system, and that this made it difficult to obtain a complete understanding of the patient. One nurse stated:

You’re not getting a full picture of the patient…the nurse has to…get a good picture, a story…well, you’re not getting it, because you’re using chop, chop the stories…(Focus Group 1, Participant 1)

As well, patient data being captured electronically on one unit, and on paper on other units (e.g. emergency department and intensive care unit) created a disjointed patient story. As a result of the hybrid environment at this hospital, some documentation was contained in online fields and forms, while other information was scanned into the record from a paper source. Nurses reported that it was important for them in their clinical practice to obtain complete information about their patients, and that the current
system design and available functionality throughout the hospital hindered their ability to gain this perspective.

*Hybrid Systems.* Given that the various functions of Powerchart™ have not yet been uniformly implemented across the organization, nurses reported a number of challenges transferring patients between paper based and electronic based clinical units. For example, one focus group participant said the following:

> Why isn’t ICU online? Like, it is really frustrating to get ICU transfers and… the orders are frozen online or you have to get them re-suspended and re-ordered (Focus Group 2, Participant 2)

In this case, duplicate documentation is created when paper orders are transcribed into the electronic record, potentially resulting in an increased workload for the transcriber and the potential for transcription errors. Given that patients on medical and surgical units have often received care or transitioned from other units that predominantly rely on paper, not all relevant clinical information may be available in Powerchart™.

One participant commented on recent changes that have improved access to important information:

> In the last little while, Emerg has been scanning the… triage notes and… now uploads; whereas, before, we didn’t have that….And so, if they’ve never been admitted before and I don’t know anything about this patient, that’s one place I can go and look to find out a little bit more about why the patient’s here, what their baseline function is (Focus Group 2, Participant 1)

Although some paper-based information is now available electronically, there are limitations with respect to finding this information, as it is not easily searchable in the EHR. As well, not all nurses were aware that some scanned notes from clinical areas that primarily rely on paper, were available in Powerchart™.
Alerts. Focus group participants also commented on the CPOE function embedded in the EHR. Although nurses agreed that CPOE was useful, they were concerned about missing new orders or learning about new orders too late. In the current system, a nurse is notified of a new order only if he or she has Powerchart™ open, or if the ordering provider tells the nurse either in person or by phone. However, ordering providers use different approaches to notify nurses about new orders entered into Powerchart™. As well, there is no audible sound or ‘pop up’ to alert the nurse when a provider creates a new order; instead, a symbol representing an unviewed order becomes visible on the screen. Given the nature of nursing work, nurses do not always have Powerchart™ open and are not always in front of a computer. Therefore, nurses may not see new orders for several hours at a time. One focus group participant stated the following:

One thing we had asked for is…when a new order or suggest order comes, like when you first open that chart, it pops up. We asked because a lot of times we’ll get stat orders and no one calls us to tell us and if you haven’t checked it for a while, then you don’t know, it’s like been a couple of hours…Because, then the doctors complain that …the stat order wasn’t given right when they ordered it and somebody didn’t call me and it’s like back and forth. (Focus Group 2, Participant 1)

Nurses were concerned about their ability to provide timely care related to new orders, and identified enhancements e.g. a ‘pop up’ notification to alert them of a new order. Focus group participants discussed this system design change, as they believed it would further enhance their ability to care for patients.

Forced Functions. Comments related to forced functions were made by participants in the focus groups particularly related to the signing of late medications within the eMAR. It was explained that if a medication is not documented as administered at the time it is due, it is highlighted in red. This function is present to alert
the nurse that the medication has not been given and to act either by administering it or by documenting the rationale for why it was not given. Focus group participants reported that the system does not allow for the nurse to document the correct time that the medication was given after a medication has been overdue for 30 minutes. One nurse stated:

So once you sign on to it, and you try to put in when you actually gave it, if it’s past 30 minutes, they don’t let you….I don’t know why, but it, it won’t let you put to the time it actually is given, because it’s past a certain timeframe. They said, well, it’s overdue, blah, blah, blah. Well, what do you want me to do? Like, that’s when they took it….Yes and you try to reschedule a med, but you can’t reschedule it (Focus Group 1, Participant 1)

This example highlights that the rigidity of the eMAR system and its design does not align with nursing practice, or the realities of their clinical practice environments. The participants suggested that a system, which was designed to be more flexible in rescheduling or documenting medications, would better suit their needs.

Organizational Context

Despite there not being any significant findings from the statistical analyses, participants in the focus groups provided a few comments that suggested that organizational context variables may have influenced their use of the system. For example, nurses described how their formal training did not adequately prepare them to use the EHR in their practice, and that informal training on their clinical unit provided them with more direction. As well, nurses described challenges of working in a hybrid environment; system performance and response time issues; not knowing what was expected of them in relation to their use of the EHR; poor communication related to system enhancements (e.g. paper triage notes from the emergency department were
recently being scanned into the system, however some nurses were not aware of this); and
not being consulted in relation to system changes (e.g. eMAR screen orientation). It
therefore appears that organizational context variables do play a role in nurses’ use of the
EHR even after it has been in place for many years.

Other Findings

Several topics related to nurses’ use of the EHR system that were not directly
related to its functionality or navigation were also discussed in the focus groups. These
were: 1) organizational standards, 2) documentation workload, and 3) issues of system
performance and response time. As well, additional system design issues were identified.

Organizational Standards. As a result of the multiple places to document the
same information in the record and other design related issues, focus group participants
requested a set of standards from the organization to support a uniform way to document
within the record. One participant explained that:

…there’s so many options to put things… there’s no standard of where to put the
information…(Focus Group 1, Participant 1)

Another participant reported that nurses document information in areas of the
EHR where they have observed a preceptor or mentor do so, and not necessarily how the
organization has specified. It was explained that however a nurse learns to document in
Powerchart™ is usually how he or she continues to document from that point on, and
that due to this practice, there is great variability in where nurses document within the
EHR. Nurses reported that they expected guidance from the hospital regarding EHR
documentation standards. Nurses also felt that by creating standards, issues of
documentation workload may be partially resolved.
**Documentation Workload.** Despite the limited direction nurses reported receiving from the organization about where and what to document in Powerchart™, participants stated that they were being asked to do more documentation each year. For example, as additional Power Forms™ were added, nurses felt that they were expected to document within them; however focus group participants also described how tasks and forms were never removed from the system. Nurses in the focus groups expressed issues of documentation workload, indicating that both the volume of documentation and the time they spent doing it had increased.

It just seems to me … that every year there’s more expected to chart from nurses, like, they add in, like, confusion assessment, but that wasn’t there…five years ago. There’s, um, like things that are, I would… they are important, but like, it just seems like okay you have to do, like, five different Powerchart things in the first year and then next year they come up with, okay, you have to do these two more assessments in addition to your charting and the next year after that, oh, another assessment that they add to Powerchart… And it just seems… it will get overwhelming or it is already overwhelming the amount of stuff that we have to chart (Focus Group 2, Participant 3)

Another nurse described how much time documentation takes, and the proportion of this to patient care activities. This nurse believed that the lack of documentation standards at the hospital might have contributed to the ambiguity that nurse’s feel about where and what to enter into Powerchart™.

We have a plateful of stuff and then they’re giving us more than, I don’t want to say than we can handle, but like… where’s the line that we draw in terms of, like for example, charting. That’s just one aspect of nursing….that’s not even what the patients see, right. And then, so, yeah, I see some of my colleagues staying even after shift just to finish charting and it shouldn’t be that way (Focus Group 2, Participant 3)
Focus group participants voiced their concerns about the increasing documentation workload, and that repercussions of not being able to complete this work during a regular shift resulted in having to stay late.

*System Performance and Response Time.* Focus group participants discussed issues of EHR system performance and response time. They described certain functions that seemed to suspend system response. Participants in both focus groups reported that they often experienced this when documenting within the Bates-Jensen Wound Assessment Tool (BWAT). One participant described this experience:

> Freezes for, like, a good ten seconds, because there’s just so much information that it loads up and then you only, like, for sometimes if you’re charting on a wound, you’re only charting, like, to small portion of that (Focus Group 2, Participant 3)

This nurse described that due to his familiarity with Powerchart™, he is usually able to get into a ‘rhythm’ when he documents care provided for his patients. However, when the system stops responding, it disrupts his ‘rhythm’ and he has to restart the process. He described this disruption as both time consuming and frustrating.

> Other participants commented on the system “freezing” at inopportune times such as when the nurse has been called away to attend to something else.

> Um, I’m frozen. Like I’m in the middle of writing a nurse assessment…a patient calls…you can’t predict that, right. You’re right in the middle of doing something, and you’re, like, “Arghhh! What do I do? Do I leave the Powerchart completely open so you don’t lose your note, because you’re not even finished it… or you just erase it all and re-write it, and you hope to remember it again? (Focus Group 1, Participant 1)
In this case, given limitations of the system design and functionality in being able to save partially completed documentation, nurse’s comments reflected a feeling of frustration in having to potentially re-do their documentation.

Summary

Through focus groups, participants provided valuable insights into their use of Powerchart™. In relation to system navigation, nurses described areas of Powerchart™ where they were required to double document or where the same information could be entered in multiple fields or forms due to the design of the system. As well, challenges with finding information with the EHR were described.

Participants also explained the various functions that they found useful, and how data visualization facilitated through an interoperable system, was helpful. Issues in being able to obtain complete patient information were described. Working at an organization that has not uniformly implemented an EHR with similar functionalities in all departments was reported as a challenge given that patients often transition through several care areas during their stay in hospital. Participants made suggestions about functionality and design changes that would support their role and enhance their use of the system, such as the introduction of alerts when new orders are created. As well, forced functions related to the eMAR were described as being inflexible and incongruent with the realities of their current clinical practice environment.

Nurses also voiced their concerns related to not knowing exactly what was expected of them by the organization, and the impact this had on their documentation workload. Focus group participants suggested that organizational standards be developed
related to their expected use of the EHR. Lastly, system performance and response time was reported to be a challenge, especially when nurses are documenting on the BWAT.
CHAPTER VI: DISCUSSION

Results of this study indicate that challenges with navigation have influenced nurses’ perceptions of their Powerchart™ use in this setting almost a decade after its implementation. Other usability variables (ease of use, functionality, and impact on workload), organizational context variables (support from leadership, level of training, level of on-going support and physical environment) and individual nurse characteristics (years of experience using an EHR, other EHR use, age) did not significantly influence nurse perceptions of EHR use, however some of these variables were discussed during the focus groups. The findings related to usability, organizational context and individual nurse characteristics from both phases of the study are discussed below.

Usability Variables

Ease of Use

Although there were no statistically significant relationships discovered between ease of use and nurses’ perceived EHR use in any of the quantitative data analyses, nurses discussed the variable during the focus groups. Powerchart™ was described as not being ‘user friendly’. These comments align with other studies that have discovered ease of use challenges when examining health professionals’ perceptions of EHRs (Garavand et al., 2016; Harrington, 2015; Likourezos et al., 2004).

In this study, focus group participants described how they had developed ways to manage system use challenges through workarounds where nurses interacted with the system in unintended ways. For example, participants described how they would log into two separate computers so that they could view multiple screens at the same time. The presence of these workarounds suggests that the EHR design does not support end user
practice (Debono et al., 2013). Several studies have examined nurse workarounds as a result of system usability challenges (Carrington & Effken, 2011; Debono et al., 2013; Edwards, Moloney, Jacko & Sainfort, 2008; Schoville, 2009). These studies demonstrate that workarounds may improve ease of use for the nurse, however are sometimes unknowingly at the expense of patient safety (Koppel et al., 2008). It may be that workarounds serve as opportunities for EHR vendors to consider design changes in areas of the record in which they often occur. In making these modifications, nurses’ use of the EHR may improve through its enhanced ease of use.

**Functionality**

Functionality could not be examined in any statistical analyses due to measurement issues, however focus group participants did provide examples that demonstrated how system functionality influenced their use of Powerchart™. Nurses described how certain documentation forms were useful; how they appreciated being able to look up drug information through an electronic manual; how communication with pharmacy to obtain missing doses was helpful; and that the auto-population and trending function of capillary blood glucose facilitated by interoperable systems was useful. Each of these functions in Powerchart™ were described as supporting the completion of nursing tasks or functions.

Nurses made several suggestions about system functionality that they believed would support further use. These suggestions included adding alerts when new orders were created, establishing a reduced number of fields in the record to put the same information (decreasing incidence of double documentation), allowing more flexibility in documenting within certain areas of the record (e.g. medications could be documented...
‘late’ or be rescheduled), and implementing Powerchart™ in areas of the hospital that still use paper.

Research examining alerts embedded in EHRs have indicated that in some scenarios they may support improved documentation, assessment or EHR use. For example, in a study aimed at understanding the effectiveness of clinical alerts on routine childhood immunizations, an increase in captured immunization opportunities was found (Fik, Grundmeier, Biggs, Localio & Alessandrini, 2007). As well, in a study that provided nurses with depression screening reminders via a personal digital assistant, nurses completed the screening in more than half (52.5%) of the encounters when the reminder was in place (Schnall et al., 2010). However, nurses at this study site suggested a different kind of alert where they would be notified of new orders. Previous research has found that when too many alerts occur on a regular basis, alert fatigue may ensue where these alerts may be inadvertently ignored or not taken seriously (Carspecken, Sharek, Longhurst & Pageler, 2013). Given the number of new orders that occur on a daily basis on the medical and surgical units at the study site, embedding alerts for all new orders may lead to alert fatigue. As nurses in the focus groups requested alerts in relation to their concerns about providing timely care, alerts could be considered for orders that were ‘urgent’ or ‘stat’. Through the consideration of a number of added, enhanced or modified functionalities, such as alerts, nurse’ use of the EHR may be improved.

Navigation

Given that nurses access various sections of the EHR to obtain and document information on a regular basis, it is not surprising that those who found Powerchart™
easier to navigate reported higher perceived levels of use. Focus group participants validated this finding, and provided examples of their experience navigating through Powerchart™. Design related documentation issues, and information-seeking challenges were described by focus group participants. For example, it was explained that in situations where access to multiple windows within the EHR may be helpful to review important patient information or to support documentation, nurses were required to open and close each window separately. Some nurses described this as challenging, especially in scenarios when they were completing documentation and needed to access other areas of the EHR but did not want to risk losing information already entered. Nurses would have to then decide whether to log on and access the information on a separate computer, or close their current session, and in doing so, lose information they already entered. This may be an example of ‘working as designed (WAD)’, where a nurse is working within the parameters of an EHR in which the design specifications may not be appropriate for their role. As well, nurses reported that the current design of Powerchart™ contributed to information-seeking burden. With multiple fields in the record to document the same clinical information, focus group participants reported that time was spent opening and closing sections that were not relevant in an attempt to find the appropriate information.

Results related to navigation are congruent with previous research findings, which have shown that when health professionals struggle to retrieve information from EHRs as a result of poor system navigation, their use of the technology to complete necessary tasks is reduced (Christensen & Grimsmo, 2008). For example, in a study examining medical students’ use of an EHR, poor system navigation contributed to students missing critical information (Yudkowsky, Galanter & Jackson, 2010). As well, in a 2012 study by
Sockolow and colleagues, poor system navigation was described as a barrier to nurses being able to maximally use an EHR in two community care settings. To overcome these challenges, nurses reported spending time finding information and reviewing it prior to patient visits, as they did not want to waste time doing this when with their patients. In another study, the researchers aimed to identify how health professionals use EHR search functionalities, and found that navigational searches (e.g. typing in the medical record number of a patient to switch to another patient record) made up 14.5% of all queries (Natarajan, Stein, Jani & Elhadad, 2010). This example demonstrates a creative way that EHR users have learned to work around system navigational challenges.

Although nurses in this study described several ways that they manage issues of EHR navigation (e.g. through creative workarounds), these challenges continue to influence their use of the record many years after its implementation. Solutions to the problems described by focus group participants would be best addressed by system design changes that were completed before implementing the technology in clinical practice settings.

**Impact on Workload**

Impact on workload was not significantly related to nurses’ perceived EHR use in any of the statistical analyses, however it was discussed during the focus groups. Participants reported that some nurses had to stay beyond their shift in order to complete documentation, and that each year documentation requirements increased as new Power Forms™ were added to the system. Nurses voiced concerns about their documentation workload, and indicated that this may be the result of unclear organizational expectations of their use of the EHR, and the additive approach to new Power Forms™. Double and
triple documentation may have also contributed to nurses’ perceiving that they had a higher than necessary documentation workload as the same information may be entered in multiples areas within the EHR.

Findings from this study align with those from previous research. For example, results of a systematic review on the time efficiency of physicians and nurses using an EHR indicate that in many cases more time is spent documenting and using an EHR in comparison to paper based systems (Poissant et al., 2005). As well, findings from a study of primary care physicians in the US show that younger physicians may initially experience an increase in workload, and a decline in patient volume with the implementation of an EHR (Bae & Encinosa, 2016). Furthermore, Stokowski (2013) describes how EHRs were originally touted as being able to “free up nurses to spend more time with patients” and that instead, “documentation is taking longer than ever” (p. 3). Reasons for this increased documentation workload were suggested to have several origins including logging in and out of the EHR many times in a nursing shift, slow systems, duplicate documentation, increasing mandatory documentation, and poor navigation (Stokowski, 2013). In this study it appears that the reasons for a high documentation workload are also multifactorial, and include those related to the system design, ambiguous EHR expectations, and an additive approach to new Power Forms™. Documentation workload mitigation strategies will therefore need to be varied if they are to be effective in reducing workload for nurses.

Organizational Context Variables

No significant relationships were found between the organizational context variables included in this study, and nurses’ perceptions of their EHR use in any of the
statistical analyses. There are several reasons why this may have occurred. First, a lack of variability in participants’ responses related to their perceptions of the organizational context variables may be one reason why no significant findings were present. This may be the result of centrally created and delivered EHR training, on-going support (help desk) that is the same for each of the study units, and clinical units that have a very similar physical layout to one another. As well, unit level leadership is generally comprised of a NUA who is a master’s prepared nurse with clinical experience at the hospital, who reports to the same director as the other NUAs whose units are represented in this study. It may be that the NUAs offer a similar level of EHR support to their staff as a result of direction received from their director and/or the clinical informatics team at the study site.

Another reason why organizational context variables may not have been significant in this study is that the influence of these variables may not have been as influential at the time of the study in comparison to other times since the technology was implemented. It may be that conditions of the organizational context are most instrumental at certain points in time e.g. when the EHR is first implemented. Nurses at the study site may not have had training, required on-going support (help desk), or support from their manager in a long period of time, given that Powerchart™ was implemented approximately a decade ago. Thus, it may be that the influence of these variables on the use of the EHR years after the system has been implemented may be lower than when it was immediately installed, or when a nurse initially began interacting with it.
Past research suggesting that organizational context variables may influence nurses' use of EHRs, has been predominantly conducted immediately after system implementations. For example, in a study by Whittaker and colleagues (2009), nurses were interviewed between thirty and sixty days post-implementation of an EHR. At that time, nurses reported requiring assistance from their organization in using the technology. It may be that nurses were still learning to use the system at this point and required support from their organization in doing so. After the system had been in place for several years, it may be that a lesser number of supports would be required to sustain nurses’ use of it.

As well, there is a lack of validated tools and instruments to measure the various organizational context variables within a health IT context. In this study, the CHISUAS (CHI, 2012) was modified to measure training, on-going support, support from leadership, and the physical environment. As such, it is possible that a type two error occurred where the organizational context did influence nurses’ use of the technology, but was not found to be significant in this study due to reasons associated with its measurement. Future research that examines this tool, and other methods for quantitatively evaluating organizational context variables may be considered.

Individual Nurse Characteristics

Chunkwise methods of model building were used to determine which interaction terms should be included in subsequent models for RQ3 and RQ4. However, since none of the chunkwise models identified significant interaction terms, final models for these research questions were not developed. It may be that individual nurse characteristics act as moderators when the system is first implemented, but after the EHR has been in place
for a number of years, users establish a level of comfort using the system regardless of their years of experience using an EHR, other EHR use, or their age.

Implications for Research

This study has several implications for future research. Specifically, those related to measurement, training, context and the guiding framework, will be discussed.

Measurement

Future research related to the measurement of usability and organizational context variables may be of value. Specifically, further psychometric testing of the WIS (Flanagan et al., 2011) should be done, given that the functionality subscale demonstrated poor internal consistency, and that it has had limited use in other studies to date. The Cronbach’s alpha for functionality in the WIS was 0.55, while ease of use, navigation and impact on workload were 0.81, 0.78 and 0.81 respectively.

Issues of subscale reliability may stem from poor construct validity for functionality and navigation. In conducting further instrument testing, the theoretical and operational definitions of functionality and navigation should be examined, as findings from the focus groups suggest that they may overlap. For example, nurses described issues navigating through Powerchart™ as a result of elements of its functionality. In the case of medication administration, if the record could be used at the same time as a documentation screen, nurses would have an easier time navigating through the system. Further research should investigate this potential overlap in the context of further development of the WIS. This would be valuable to the field of health informatics given that there are a limited number of ways to measure usability through surveys. Other usability instruments such as the System Usability Scale (Bangor, Kortrum & Miller,
have been determined by the Agency for Healthcare Research and Quality (AHRQ) to be inadequate for the study of EHRs in their current state (AHRQ, 2011).

As well, given the limited instruments available to measure organizational context variables in relation to health IT, further testing and development of measurement tools for this topic may be of value. Specifically, developing an instrument that is applicable to EHR adoption immediately after implementation, as well as several years afterwards would be useful. This may entail completing further research to determine which organizational context variables are most important at different points in time in nurses’ adoption of the technology.

Training

Another research implication stemming from this study would be to investigate how or if, informal training may influence nurses’ use of the EHR. Although in this study formal Powerchart™ training was not associated with nurses’ perceptions of their EHR use in any statistical analysis, focus group participants reported that nurses currently use the system in the way that they were taught by a more experienced nurse when they first started working on their unit. It may be that formal centralized training provides nurses with an overview of the system, and unit level orientation gives nurses more specific direction about how and when to use it. As a result, non-standard EHR documentation and use practices may have developed across the organization.

A doctoral student at the University of California noted that informal learning from ones colleagues may maximize health professionals’ use of the EHR (Graetz, 2012), and may be sought out to address gaps in formal training. Furthermore, a study by
Furlong (2016) investigating nurses’ EHR learning found that “when (nurses) started working with the EHR, the real learning begins” (p. 42), implying that formal training is not enough for nurses to be able to adequately use the technology. During the period of informal learning, workarounds to circumnavigate system design issues (if present) may be developed without nurses understanding the potential consequences to patient safety (Furlong, 2015; Furlong, 2016). Informal learning of non-healthcare specific information technologies (e.g. desktop computing) has been identified as important for continued and sustained uptake by users (Robey, Boudreau & Rose, 2000). Given that limited research has been conducted on informal EHR training to date within the health sector, further study may allow for a better understanding of how and what kind of information is shared during informal training and how informal training influences nurses’ EHR use. As well, research to investigate how to optimize formal EHR training for nurses should also be considered.

**Context**

This study differed from others in that it examined EHR adoption by nurses almost a decade after its implementation, rather than immediately afterwards (Carayon et al., 2011; Ketikidis et al., 2012; Kuo et al., 2013). It is unknown if barriers to, and facilitators of nurses’ use of the technology vary at different points in time (e.g. within the first year or several years after implementation). Research to date has suggested that nurses are more accepting of the technology after its been implemented for a longer period of time, versus when it is first implemented (Carayon et al., 2011). Longitudinal research which aims to explore how various factors affect use over longer periods of time would be useful, as this would help organizations determine how to best support their
staff in being able to use the technology at various points in time in their EHR implementation journey.

As this study measured variables specific to the system (those related to usability) and the organization (those related to the organizational context), it would be helpful to understand if or how different systems and organizations influence nurses’ use of the technology. Many different EHR vendor solutions are currently available for healthcare organizations to purchase. These systems vary considerably in terms of design and use. Gaining a better understanding of the usability of each one may support organizational decision-making regarding the procurement of new systems, potential customization and effective approaches to train their staff to use them. Similarly, organizations can choose to implement these systems and support them thereafter in many different ways. In the future, studies that examine how various barriers to, and facilitators of EHR use in other organizations, should be conducted to determine specific aspects of the organizational context that are most valuable in supporting technology adoption by nurses immediately after and during its implementation.

Guiding Framework

Lastly, findings from this research may contribute to the guiding framework used to understand nurses’ perceptions of their EHR use in this study. This guiding framework was informed by the literature, the DOI (Rogers, 1995); Staggers and Parks Nurse-Computer Interaction Framework (Staggers & Parks, 1993); the DeLone and McLean Model for IS Success (DeLone & McLean, 1992; DeLone & McLean, 2003); and the TAM (Davis, 1989; Davis et al., 1989). Findings of the statistical analyses support navigation as being an important aspect of the guiding framework, however it was
through the focus groups that elements of EHR usability and the organizational context emerged. Individual nurse characteristics were not found to be related to nurses’ perceptions of their EHR use in either the statistical analyses, or the focus groups. This finding suggesting that the guiding framework may not need to include individual nurse characteristics. However, future research that examines the guiding framework in a different context may be helpful in determining if individual nurse characteristics should be removed.

In summary, this study has several implications to future research that if pursued may allow for a better understanding of nurses’ use of EHRs. These areas of future research include investigating measurement techniques, training approaches, contextual considerations and the further testing of the guiding framework.

Implications for Nursing Leadership

There are several implications for nursing leadership as a result of this study. These include developing nursing specific expectations and standards for use, advocating for the standardization of user interfaces and forms, selecting an appropriate approach to EHR training, and communicating implications of system modifications to nursing staff.

Expectations and Standards for Use

Participants in this research identified that they were unsure of how they were expected to use Powerchart™, and thus a shared mental model related to their EHR use did not appear to exist. Given the numerous sections of the EHR to input information, nurses identified that this may have facilitated a system that was difficult to use, and in some cases may have contributed to nurses feeling the need to provide narrative notes that duplicated other documentation (e.g. assessments in Power Forms™). Nurses
reported compensating for unclear expectations related to their use of the EHR by completing additional documentation (e.g. narrative notes), which led them to experience increased documentation burden.

Nursing leaders can advocate for the development of standards for use (developed with practicing nurses) in organizations implementing EHRs to ensure that nurses use the technology in a consistent and uniform manner throughout the organization. This point is supported by the findings of a 2011 study, which found that having clear standards for health IT use contributes to the development of a shared mental model among users (Hysong et al., 2011). Furthermore, results of more recent research in which nurses were engaged in the development of standards for use of BCMA technology, indicate that high nurse adoption can be achieved (Ching et al., 2014).

*Standardizing User Interfaces and Forms*

Another way that nursing leaders can support the consistent and uniform use of EHRs amongst nurses is through advocating for the development of standard user interfaces, and documentation screens. In this study, participants reported that they regularly completed duplicate documentation as a result of the various templates and fields requiring the same or similar information to be entered. As a result, nurses reported a high documentation workload.

Zhang and Walji (2011) report that a minimalistic design may support end user navigation within the EHR. As stated by the authors, “A system is fully useful if it includes the domain and only the domain functions that are essential for the work” (p. 1057). Implications of a minimalistic design include having a limited number of places where clinical information can be documented or found, which may improve system
navigation particularly during the information retrieval process. By standardizing the number of documentation forms, and the fields within these forms, there may be an opportunity to reduce duplication and the amount of time nurses spend documenting. As well, the reduction in fields within the EHR where nursing documentation is located may support improved navigation, as finding information may become easier. The information-seeking burden that nurses and other health professionals currently face when trying to locate information within the EHR, may therefore be reduced. Nursing leaders can work with both frontline nurses and those with technical expertise at their organizations to achieve standardized user interfaces and forms (when possible) that minimize duplicate documentation.

Approaches to Training

In a study by Han and Lopp, (2013), physicians who struggled with navigating the EHR had higher perceived training needs. Thus, the authors suggest developing navigation specific training that may occur before general EHR training given the “complex non-linear structure” (p. 18) of EHR systems. As well, findings from this study suggest that centralized EHR training that nurses have received to date may not have been sufficient to allow nurses to use the record in their practice. Nurses therefore spoke about informal training methods (e.g. through a peer on their clinical unit) that provided them with more direction related to how to use and incorporate the EHR into their practice. Nursing leaders should consider evaluating their current EHR training programs, and looking for opportunities to enhance both formal and informal training. This may include navigational training prior to other forms of training such as communicating expectations and standards of EHR use.
Communicating Implications of System Modifications

Nursing leaders should evaluate which modes of communication are most effective in providing frontline nurses with information related to implications of system modifications. In this study, several of the nurses in the focus groups were not aware that triage notes from the emergency department were scanned into the EHR. Thus, identifying appropriate communication strategies is important given the value that focus group participants stated that the triage notes were to their care of patients, and the frequent updates that need to be communicated to frontline staff when these systems are in place.

In summary, nursing leaders can play an important role in supporting nurses’ use of EHRs. Results of this study show that nursing leaders can do so by developing expectations and standards for use, standardizing user interfaces and forms, evaluating approaches to training, and effectively communicating implications of system modifications to frontline nursing staff.

Implications for EHR Vendors

Findings from this study have implications for EHR vendors in relation to design considerations, and nurse engagement in the pre-market design of the system.

Design Considerations

Focus group participants identified a number of design related issues of the EHR that influence their use of the system. Rather than to provide nurses with additional training to make up for the shortfalls of a design, EHR developers should create systems that minimize a number of the issues identified in this study. For example, if a nurse is documenting using a Power Form™ and then wants to review information in another
area of the chart, he or she has to close each Power Form™ that is currently open. Given limitations in the way partially completed work is saved, nurses reported that if interrupted they usually have to re-start their documentation from the beginning at a later time. There are substantial implications of this design to nursing workload, and patient care. In this study, focus group participants identified creative ways to manage some of the challenges they faced in relation to designs that did not support nursing practice. In the example stated above, nurses reported that they would sometimes log onto another computer to be able to access other areas of the record, so that they would not lose their documentation. This workaround, and others described by participants, may serve as opportunities for EHR vendors to determine potential design modifications that may enhance the technologies ability to support nursing practice (Azad & King, 2008).

Other design related considerations and issues discussed by focus group participants in this study included: forcing functions in areas of the record where it is incongruent with practice norms (e.g. not being able to sign medication late in the eMAR); having multiple places within the EHR where the same information can be documented; and not being able to save partially completed charting with the intent of returning back at a later time to finish it. The Institute for Safe Medication Practices (1999) has described forcing functions and constraints as “the most powerful and effective error prevention tools” (p.2). However, in this study it appears that the forced functions within Powerchart™ related to the eMAR documentation may have not been the most appropriate mechanism for ensuring medication safety. This may have been due to the misalignment between the use of the forced function (only being able to document
medication within a specific timeframe) and the realities of the clinical practice setting (patients may be at a test, or prefer to have a medication at a later or earlier time).

*Nurse Engagement in Pre-Market Design*

One way that an optimal EHR design can be achieved is by incorporating feedback and insights from end users into the design (Rose, Schnipper, Park, Poon, & Middleton, 2005), or by including practicing nurses on EHR design teams before the system is implemented in healthcare organizations (Monegain, 2016). The authors of a study evaluating the impact of an EHR in Spain, stated that including end users in the design of the technology would have allowed for a system to be developed that better met their needs (Gascon et al., 2013). In incorporating pre-market end user feedback, issues such as those identified in this study may be discovered and addressed before the EHR is implemented.

In summary, this study has highlighted two major implications to EHR vendors that could allow for the development of health IT systems that better meet nursing practice needs. These include specific design considerations identified in this study, and engaging nurses in the pre-market design of EHRs.

*Implications for Healthcare Settings*

This study has several implications for healthcare settings that have or wish to implement EHRs. These include considering the effects of hybrid systems and interoperability, assessing EHR infrastructure, engaging nurses in system modifications, and re-evaluating procurement practices.

*Hybrid Systems and Interoperability*
One of the challenges that nurses in this study faced when accessing information within the EHR was poor system interoperability given that nurses at this hospital site use a hybrid health record. While the nurses in this study predominately used an electronic system, they frequently received patients from other clinical units where paper documentation was present. Only some of the nurses in the study were aware that paper documentation forms from other clinical units were often scanned into the electronic record. Nurses described how issues of interoperability and hybrid systems made it difficult to obtain complete information about a patient. As well, challenges were described regarding having to obtain new orders when patients were transferred between units where one used paper and the other used the EHR. Organizations should be aware of the impact that interoperability and hybrid environments may have on clinical care when EHRs are implemented using a phased approach (some clinical areas e.g. emergency department, or functions e.g. medication administration, may still be done on paper for a period of time), versus a ‘big bang’ approach. These implementation approaches may also have an impact on patient safety.

*EHR Infrastructure*

A number of participants in this study reported issues with the performance of the system such as non-responsive screens, “freezing” and slow response times. Organizations should recognize the impact of poor system performance on nurses’ use of the EHR, and ensure that adequate EHR infrastructure is in place.

*Engaging Nurses in System Modifications*

In this study, participants described system modifications that were made that influenced their practice, however they felt the decisions were made without their
engagement and feedback. For example, several nurses reported that a recent modification had made it more challenging for nurses to use the eMAR function of the electronic record. Ensuring that frontline nurses are involved in the decisions regarding system design modifications may allow for the most appropriate modification to be incorporated, and more easily adopted by end users (Schwartz, 2012). Consideration should also be taken for how best the modification and rationale for it, could be best communicated to frontline nurses.

**Procurement Practices**

Organizations procuring an EHR may consider having end users trial each potential EHR solution, and assess ease of navigation (and other aspects of EHR use) as a standard component of system assessment and selection. This method was utilized in the choice of barcode medication administration devices in an acute care hospital in the US. Results of this engagement showed a significant decrease in medication errors once the system was implemented as devices selected reflected those that nurses could best use (Ching et al., 2014).

Once an EHR solution has been selected, usability assessments where nurses are observed interacting with the technology before implementation across an organization may be valuable (McCartney, 2014). This assessment can allow organizations to identify opportunities to obtain customizations aimed at enhancing use, or to develop targeted educational strategies to support adoption (Rojas & Seckman, 2014). While issues of use may not be feasibly resolvable through technical solutions, standards for use may be developed, and training delivered.
In conclusion, the findings from this study suggest that nurses’ use of EHRs may be facilitated through a number of actions taken by organizations with the technology in place. These include addressing issues of hybrid systems and interoperability, ensuring EHR infrastructure is present, engaging nurses in system modifications, and including frontline nurses during health IT procurement.

Implications for Practice

This study has identified a number of issues that nurse’s face when using Powerchart™ in their clinical practice. Although nurses recognize the influence that these challenges have on their practice, they may feel powerless in being able to make any meaningful changes. Nurses know that they are required to use the system, and that given the cost of the technology, the organization is unlikely to make significant changes to the current system that would be needed for it to best support their role.

Despite frontline nurses not having power to make some of the changes they suggested in this study, there are a few implications of this research to clinical practice. First, nurses should take note of system issues and challenges and escalate these to the appropriate leaders within the organization who may be able to act on them. These issues may be related to deficits in training, modes and methods of communication that are best for advising nurses of system updates or modifications, patient safety related concerns or issues of system performance. Second, frontline nurses should advocate for being included in decision making related to health IT at the organization such as during the procurement of new systems, EHR updates or modifications, the development of standards for use, and efforts to streamline certain elements of the record e.g. documentation screens.
Nurses should be prepared to be engaged in these conversations by being knowledgeable about nursing and health informatics, and what value it could bring to patients, and the profession. This may be facilitated by nurses obtaining formal nursing informatics education (e.g. courses and degrees) and through participation in organizations such as the Ontario Nursing Informatics Group (Ontario Nursing Informatics Group, 2017), or the Canadian Nursing Informatics Association (Canadian Nursing Informatics Association, 2017). It is through the engagement of frontline nursing staff that organizations using EHRs and vendors of these systems, will be able to develop and best implement health IT systems that support nurses in the future.

Limitations of the Study

This study had several limitations that should be considered when reviewing the findings. First, given that the study was done at a single site with one EHR software present, the generalizability of the study findings may be limited. As well, both focus groups that were conducted were small (n= 3). Despite the repetition of similar topics and themes during both focus groups, it is possible that there is additional information that was not communicated during the focus groups that would allow for a better understanding of nurses’ use of the electronic system. Additionally, one of the planned study units (cardiology) was closed during the study and therefore sampling could not be done on this unit. This closure resulted in a reduced number of eligible participants. The number of survey respondents was therefore likely smaller than if the nurses on this unit were able to participate in the research.

Another possible limitation of this study is the timing in which it occurred. Most other studies that have reviewed health professional use, acceptance or attitude towards
an EHR, do so within a year of its implementation (Bossen et al., 2013; Carayon et al., 2011; Ketikidis et al., 2012; Kuo et al., 2013). In this study, the EHR had been in place for approximately a decade hence it is unknown if the findings are applicable to organizations in earlier stages of EHR adoption. During the initial implementation of an EHR, results of evaluations should be reviewed with an understanding that it takes time to learn and become comfortable using the technology. Results of these evaluations may reflect the frustrations or excitement of end users as they compare their current situation with previous methods of working. As such, evaluations conducted within a year of technology implementation may yield different results than those done several years after adoption.

At the time of this study, elements of Powerchart™ had been present for approximately ten years, with the eMAR and CPOE functionality being implemented in the last six to seven years. It may be that certain independent variables are more important at different stages in the adoption and lifespan of the technology. For example, perhaps organizational context variables, such as training or on-going support, are most important during the implementation and initial use of the technology by nurses. However, this study used a cross sectional approach and therefore it was not possible to capture potential changes over time as to how different variables may have influenced nurses’ use of the EHR.

Last, it is possible that nurses in this study are more proficient at using health IT than the general RN population in Canada and therefore generalizing the results of this study to other parts of the country should be done with caution. This may be due to the age of the nurses in the study (younger than the average Canadian RN), the number of
years that the EHR has been present (approximately a decade), and the number of nurses who have used other EHRs (35.3%). Several studies have highlighted that younger nurses may feel more accepting of EHRs (Alquraini et al., 2007; Chan, 2007; Kaya, 2011), with the explanation often provided of the ubiquity of technologies used in their lives since a young age. Given that nurses in this study were younger than the national RN average, it may be expected that nurses at the study site have an easier time using the technology than their counterparts in other areas of the country.

As well, it appears that nurses at this study site may have more experience using an EHR (either at the study site or another organization) than other nurses nationally. According to the Canada EMR Adoption ModelSM, only 37.2% of Canadian hospitals used an EHR for clinical documentation in 2014 (Healthcare Information and Management Systems Society, 2014). Thus, nurses at this hospital may have an enhanced knowledge and comfort using the technology in comparison to nurses working in other organizations and settings in Canada that do not yet use the technology.

Conclusion

The purpose of this research was to better understand how a number of variables identified in the literature influenced nurses’ perceived use of an EHR in an acute care hospital setting. Researchers investigating the various barriers to, and facilitators of nurses’ use of EHRs have indicated that system usability (Ammenwerth, Ehlers, Hirsch & Gratl, 2006; Carayon et al., 2011; Carrington & Effken, 2011; Lu et al., 2012), the organizational context (Mailet, Mathieu & Sicotte, 2015; Saleem et al., 2015; Whittaker et al. 2009), and individual nurse characteristics (Infenedo, 2016; Yontz, Zinn & Schumacher, 2015) may influence nurses’ use of the technology. A framework was used
in this study, and was based on the results of the literature review, the Diffusion of Innovation Theory (Rogers, 1995), the Staggers and Parks Nurse-Computer Interaction Framework (Staggers & Parks, 1993), the DeLone and McLean Model for IS Success (DeLone & McLean, 1992; DeLone & McLean, 2002), and the TAM (Davis 1989; Davis et al., 1989).

Relationships were explored between EHR system usability, organizational context variables, and nurses’ perceptions of Powerchart™ use while taking into account potential individual nurse characteristics that may influence the strength and/or direction of these relationships. Results of this study demonstrate that EHR navigation can influence nurses’ perceptions of their use of the system, even when the technology has been in place for more than ten years. Findings of the statistical analyses did not support the hypothesis that other usability or organizational context variables may influence nurses’ use of Powerchart™, however during the focus groups participants shared experiences where these variables may have been present.

This doctoral research contributes to the literature by being the first known study to investigate the influence of a number of variables on nurses’ use of an EHR several years after it has been implemented. Previous research on the topic has either examined a limited number of potentially influencing variables, or has done so immediately after technology implementation when nurses are likely to still be learning how to use the system. Thus, findings from this study suggest that after several years of EHR use, nurses may need to be supported in different ways than when the technology is first implemented, and that poor system design may continue to influence their EHR use.
REFERENCES


Appendix A.

Sample Size Calculations

Alpha = 0.05
Power = 0.80
Effect size ($f^2$) = 0.15
$R^2 = 0.13$

Number of independent variables ($u$) = 8

Degrees of freedom of the denominator of the F ratio = $v$

Noncentrality parameter = $\lambda$

$\lambda = f^2 (u + v + 1)$

A trial value for $v$ is set at 120 with $\lambda = 19.35$

$n = \frac{\lambda (1-R^2)}{R^2}
\begin{align*}
n &= \frac{19.35 (1-0.13)}{0.13} \\
n &= 129 \text{ (interpolated)}
\end{align*}$

$v = n - u - 1
\begin{align*}
v &= 129 - 8 - 1 \\
v &= 120
\end{align*}$

$\lambda = 19.35 + \frac{1}{120} - \frac{1}{120} (19.35 - 15.9) = 19.35$

$N = \frac{19.35 (1-.13)}{.13} = 129.5 \text{ (round up to } n=130 \text{ participants)}$

Response rate was expected to be 35%.
Therefore, the student planned to ask 371 ($130/371 = 35\%$) nurses to participate in Phase One of the study.
Appendix B.

Consent to Participate in Focus Groups

**Title:** Nurses’ Perceptions of their Use of Electronic Health Records Pilot Study

**Investigator:** Gillian Strudwick, RN, MN, PhD Student

You are being asked to participate in a pilot research study by Gillian Strudwick, RN, MN, PhD Student, under the supervision of Linda McGillis Hall, RN, PhD, FAAN, FCAHS, Professor at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto.

The purpose of the study is to better understand nurses’ perceptions of using an electronic health record in an acute care setting. If you agree to participate in this study, you will be asked to participate in a focus group lasting approximately 60-90 minutes. This will be audio recorded. Your participation in this study is voluntary. You are free to withdraw from the study without risk to your employment. There are no anticipated risks or direct benefits to you participating in the study. If there is a question you do not want to answer, you can refuse to answer it. You will receive a $5 Tim Horton’s or Indigo Gift Card and a light meal as a thank you for your participation. All participants are asked not to disclose anything said within the context of the focus group discussion to others outside this group. All participation in this study will be kept confidential. No identifying information will be collected, and all data will be destroyed after five years. No one at [study site] will have access to the data collected from the survey. Study findings may be shared through publications in journals and/or presentations at conferences.

If you have any questions or concerns, please contact Gillian Strudwick Gillian.strudwick@mail.utoronto.ca or Dr. Linda McGillis Hall at research.nursing@utoronto.ca. If you have any questions about your rights as a research participant, please contact [contact at study site]. The REB is a group of people who oversee the ethical conduct of research studies. These people are not part of the study team. Everything that you discuss will be kept confidential. You can also contact the Research Oversight and Compliance Office- Human Research Ethics Program at ethics.review@utoronto.ca or 416-946-3273.

Regards,

Gillian Strudwick, RN, MN, PhD Student

**Consent**
This study has been explained to me and my questions have been answered. I know that I may choose not to participate in this study at any time. I agree to take part in the study.

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<th>Participants Name</th>
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My signature means that I have explained the study to participant named above. I have answered all questions.

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### Appendix C.

Variables, Definitions and Operationalization

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition</th>
<th>Operationalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Navigation</td>
<td>How logically information is organized and how easily information is located</td>
<td>Workflow Integration Survey</td>
</tr>
<tr>
<td>Ease of Use</td>
<td>How easy or hard it is to use the information system</td>
<td>Workflow Integration Survey</td>
</tr>
<tr>
<td>Functionality</td>
<td>Extent to which the EHR has tools or operations available to complete necessary tasks</td>
<td>Workflow Integration Survey</td>
</tr>
<tr>
<td>Workload</td>
<td>Degree to which the computer system increases the amount of effort</td>
<td>Workflow Integration Survey</td>
</tr>
<tr>
<td>Support from leadership</td>
<td>Nurses’ perceptions of NUAs’ support for their use of the EHR</td>
<td>Item: “Nursing unit administrators’ support nurses use of Powerchart™”</td>
</tr>
<tr>
<td>Level of training</td>
<td>How nurses’ perceive their current level of training</td>
<td>Canada Health Infoway System and Use Assessment Survey</td>
</tr>
<tr>
<td>Level of ongoing support</td>
<td>Nurses’ perceptions of the current level of support (Help Desk)</td>
<td>Canada Health Infoway System and Use Assessment Survey</td>
</tr>
<tr>
<td>Physical environment</td>
<td>Physical space in which computers are located on the unit, as well as the power supply and network speed available</td>
<td>Items: “There are enough computers on my unit to access Powerchart™”, “Computers are located in convenient spaces on my unit”, “The speed of the network connection is appropriate”</td>
</tr>
<tr>
<td>Implementation process</td>
<td>Nurses’ perceptions of how the EHR was implemented</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>
Appendix D.

Pilot Survey

Dear Registered Nurse,

You are being asked to participate in a pilot research study by Gillian Strudwick, RN, MN, PhD Student, under the supervision of Linda McGillis Hall, RN, PhD, FAAN, FCAHS, Professor at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto.

The purpose of the pilot study is to test a survey that was developed to better understand nurses’ perceptions of using an electronic health record in an acute care setting. If you agree to participate in this study, you will be asked to complete a survey and feedback form that is expected to take approximately 25 minutes. Your participation in this study is voluntary. You are free to withdraw from the study without risk to your employment. There are no anticipated risks or direct benefits to you participating in the study. If there is a question you do not want to answer, you can refuse to answer it. You will receive a small snack as a thank you for your participation.

All participation in this study will be kept confidential. No identifying information will be collected, and all data will be destroyed after five years. No one at [study site] will have access to the data collected from the survey. Study findings may be shared through publications in journals and/or presentations at conferences.

If you have any questions or concerns, please contact Gillian Strudwick Gillian.strudwick@mail.utoronto.ca or Dr. Linda McGillis Hall at research.nursing@utoronto.ca. If you have any questions about your rights as a research participant, please contact [contact at study site]. The REB is a group of people who oversee the ethical conduct of research studies. These people are not part of the study team. Everything that you discuss will be kept confidential. You can also contact the Research Oversight and Compliance Office- Human Research Ethics Program at ethics.review@utoronto.ca or 416-946-3273.

Regards,

Gillian Strudwick, RN, MN, PhD Student
A: ELECTRONIC HEALTH RECORD USABILITY:
Instructions: Please enter the number in the right hand column, the extent you agree with the below statements.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

1. Patient information is easy to find in Powerchart.
2. Powerchart has all of the functions needed to complete patient care.
3. Powerchart is challenging to use.
4. Using Powerchart adds effort.
5. Patient information is easily accessed with Powerchart.
6. Powerchart helps you perform the tasks you need to complete.
7. Powerchart is easy to use.
8. Using Powerchart increases workload.
9. With Powerchart, it is difficult to search for patient information.
10. The same information is entered into Powerchart multiple times.
11. Powerchart is frustrating to use.
12. Powerchart helps you to complete your work efficiently.

B: ORGANIZATIONAL CONTEXT:
Instructions: Please enter the number in the right hand column, your level or agreement or disagreement with the statements below.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Disagree</th>
<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

1. The current level of ‘Powerchart’ training is acceptable.
2. The level of on-going support (Help Desk) provided is acceptable.
3. Nursing unit administrator’s support nurses use of Powerchart.
   *Examples of support may include providing results from documentation audits, preparing nurses for EHR ‘down-time’, and organizing for additional training for staff as needed
4. There are enough computers on my unit to access Powerchart.
5. Computers are located in convenient spaces on my unit.
6. The speed of the network connection is appropriate.
C: NURSES’ PERCEPTIONS OF EHR USE:
Instructions: Please enter the number in the right hand column, how often you use Powerchart to accomplish the following nursing activities?

<table>
<thead>
<tr>
<th></th>
<th>Never</th>
<th>Almost Never</th>
<th>Sometimes</th>
<th>Almost Always</th>
<th>Always</th>
<th>Don’t Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>9</td>
</tr>
</tbody>
</table>

1. Assessment
2. Searching for information
3. Care planning
4. Clinical decision-making
5. Communication
6. Documentation
   a. Medication administration
   b. Documentation of assessments through standardized forms
   c. Narrative notes
7. Administrative Tasks

D: DEMOGRAPHICS:

1. Sex: Male ☐; Female ☐
2. What year were you born? _______
3. Please indicate how many years you have been practicing as a Registered Nurse: ______
4. Have you had any formal training in informatics? Yes ☐; No ☐
   If you answered yes, please explain: __________________________
5. In which country did you complete your nursing education? ___________________
6. Please indicate your primary nursing unit: medicine ☐; surgical ☐; cardiology ☐
7. How many years of experience have you had using an electronic health record? ______
8. Have you had experience using an electronic health record other than Powerchart? Yes ☐; No ☐
   If you answered yes, please explain: __________________________
9. Please indicate your employment status: full time ☐; part time ☐; casual ☐

Thank you for your participation in this survey.

Please place your survey in the envelope provided, seal it and return it to the designated return area.
Dear Registered Nurse,

You are being asked to participate in a pilot research study by Gillian Strudwick, RN, MN, PhD Student, under the supervision of Linda McGillis Hall, RN, PhD, FAAN, FCAHS, Professor at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto.

The purpose of the study is to better understand nurses’ perceptions of using an electronic health record in an acute care setting. If you agree to participate in this study, you will be asked to complete a survey and feedback form that is expected to take approximately 15 minutes.

Your participation in this study is voluntary. You are free to withdraw from the study without risk to your employment. There are no anticipated risks or direct benefits to you participating in the study. If there is a question you do not want to answer, you can refuse to answer it. You will receive a small snack as a thank you for your participation.

All participation in this study will be kept confidential. No identifying information will be collected, and all data will be destroyed after five years. No one at [study site] will have access to the data collected from the survey. Study findings may be shared through publications in journals and/or presentations at conferences.

If you have any questions or concerns, please contact Gillian Strudwick Gillian.strudwick@mail.utoronto.ca or Dr. Linda McGillis Hall at research.nursing@utoronto.ca. If you have any questions about your rights as a research participant, please contact [contact at study site]. The REB is a group of people who oversee the ethical conduct of research studies. These people are not part of the study team. Everything that you discuss will be kept confidential. You can also contact the Research Oversight and Compliance Office- Human Research Ethics Program at ethics.review@utoronto.ca or 416-946-3273.

Regards,

Gillian Strudwick, RN, MN, PhD Student
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12. Powerchart helps you to complete your work efficiently.

B: ORGANIZATIONAL CONTEXT:
Instructions: Please enter the number in the right hand column, your level or agreement or disagreement with the statements below.

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<th>Neutral</th>
<th>Agree</th>
<th>Strongly Agree</th>
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</table>

1. The current level of ‘Powerchart’ training is acceptable.
2. The level of on-going support (Help Desk) provided is acceptable.
3. Nursing unit administrator’s support nurses use of Powerchart.
   *Examples of support may include providing results from documentation audits, preparing nurses for EHR ‘down-time’, and organizing for additional training for staff as needed
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5. Computers are located in convenient spaces on my unit.
6. The speed of the network connection is appropriate.
C: NURSES’ PERCEPTIONS OF EHR USE:
Instructions: Please enter the number in the right hand column, how often you use Powerchart to accomplish the following nursing activities?

<table>
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<th>Sometimes</th>
<th>Almost</th>
<th>Always</th>
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</tr>
</thead>
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4. Clinical decision-making
5. Communication
6. Documentation
   a. Medication administration
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7. Administrative Tasks

D: DEMOGRAHICS:

1. Sex: Male ☐; Female ☐
2. What year were you born? _______
3. Please indicate how many years you have been practicing as a Registered Nurse: ____
4. Have you had any formal training in informatics? Yes ☐; No ☐
   If you answered yes, please explain: ______________________
5. In which country did you complete your nursing education? ___________________
6. Please indicate your primary nursing unit: medicine ☐; surgical ☐; cardiology ☐
7. How many years of experience have you had using an electronic health record? _____
8. Have you had experience using an electronic health record other than Powerchart? 
   Yes ☐; No ☐ If you answered yes, please explain: ___________________________
9. Please indicate your employment status: full time ☐; part time ☐; casual ☐

E: COMMENTS:

Thank you for your participation in this survey.

Please place your survey in the sealed envelope provided, seal it and return it to the designated return area.
Appendix F.

Focus Group Guide

<table>
<thead>
<tr>
<th>Date and time of focus group</th>
<th>Location</th>
</tr>
</thead>
</table>

Welcome and thank you for agreeing to participate in this study.

The purpose of this doctoral research is to better understand nurses’ perceptions of their use of electronic health records (Powerchart). During phase one of this study, nurses on medical and surgical floors filled out a survey about their use of Powerchart. This is now phase two which consists of focus groups.

During this focus group, you will be asked to share your perspective related to the findings of phase one. Please do not discuss anything that was said today outside of this focus group session as to protect the privacy of those who are participating. As well, this focus group will be audio recorded, however no identifying information such as your name, will be transcribed from the recordings.

Do you have any questions before we begin?

**Focus Group Questions**

**Question 1:**

_Preamble:_ ‘Navigation’ is how logically information is organized in Powerchart, and how easily information is located.

Can you share with me your experiences ‘navigating’ through Powerchart? Study participants who found Powerchart easier to ‘navigate’ indicated that they used it more. Would the same apply to you?

_Prompts:_ What about anyone else? Does anyone who did not find Powerchart easy to use have anything else to say?

**Question 2:**

_Preamble:_ ‘Functionality’ is the extent to which Powerchart has tools or operations available to complete necessary tasks.

Participants in this study provided a wide range of comments related to ‘functionality’, with no specific functionality issue being identified.
Can you tell me about or describe your experiences with the ‘functionalities’ of Powerchart?

Prompts: What about anyone else? Does anyone have anything else to say?

Question 3:

Preamble: Participants provided a number of comments related to “repetitive” and “double/triple charting” within the Powerchart system.

Do any of you want to comment on any experiences you have had of this nature? Have you found that to be the case, and if so, where specifically?

Prompts: What about anyone else? Does anyone have anything else to say?

Question 4:

Preamble: There were a number of comments from participants about the documentation and assessment screens in Powerchart, and their ability to capture nursing assessments and care provided.

Can you tell me about or describe your experiences with the documentation and assessment screens in Powerchart?

Prompts: What about anyone else? Does anyone have something to add? Are there any other comments you would like to share with me about your use of Powerchart?

Thank you for participating in this focus group. Everything that was said today will remain confidential.
Dear nursing colleague,

My name is Gillian Strudwick, RN, MN, PhD Student and I am a doctoral student at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto conducting my dissertation research. I am working under the supervision of Dr. Linda McGillis Hall, RN, PhD, FAAN, FCAHS, Professor at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto.

You are being asked to participate in a pilot study. The purpose of the pilot study is to test a survey that was developed to better understand nurses’ perceptions of their use of electronic health records in an acute care setting. Your participation involves completing a survey, and then a feedback form. The survey and feedback form is expected to take 25 minutes of your time. Your participation in the pilot study is voluntary and no personal information about you will be collected. You can refuse to answer any questions, and you can withdraw from the pilot study at any time without consequence.

If you have any questions or concerns, please contact Gillian Strudwick Gillian.strudwick@mail.utoronto.ca or Dr. Linda McGillis Hall at research.nursing@utoronto.ca. If you have any questions about your rights as a research participant, please contact [contact at study site]. The REB is a group of people who oversee the ethical conduct of research studies. These people are not part of the study team. Everything that you discuss will be kept confidential. You can also contact the Research Oversight and Compliance Office- Human Research Ethics Program at ethics.review@utoronto.ca or 416-946-3273.

Thank you.

Regards,

Gillian Strudwick, RN, MN, PhD Student
Lawrence S. Bloomberg Faculty of Nursing
University of Toronto
155 College Street, Suite 130
Toronto, Ontario M5T 1P8
416-946-3977
Gillian.strudwick@mail.utoronto.ca
Appendix H.

Pilot Feedback Form

Thank you for participating in the “Nurses’ Perceptions of their Use of Electronic Health Records Pilot Research Study”. Please use this sheet to provide feedback about the survey you just completed.

1. How long did it take you to complete the survey?

2. Do you have any comments on the length of the survey?

3. Were the survey instructions clear and easy to understand?

4. Were any of the items (survey questions or statements) difficult to understand? If so, which ones?

5. Were any of the response scales difficult to understand? If so, which ones?

6. Are there any missing items (survey questions or statements)?

7. Please provide any additional comments about the survey.
Appendix I.

Invitation to Participate in Main Survey

Dear nursing colleague,

My name is Gillian Strudwick and I am a doctoral student at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto conducting my dissertation research. I am working under the supervision of Dr. Linda McGillis Hall, Associate Dean, Research and External Relations at the Lawrence S. Bloomberg Faculty of Nursing at the University of Toronto.

You are being asked to participate in a study. The purpose of the study is to better understand nurses’ perceptions of their use of electronic health records in an acute care setting. Your participation involves completing a survey. The survey is expected to take 15 minutes of your time. Your participation in the study is voluntary and no personal information about you will be collected. You can refuse to answer any questions, and you can withdraw from the study at any time.

If you have any questions or concerns, please contact Gillian Strudwick Gillian.strudwick@mail.utoronto.ca or Dr. Linda McGillis Hall at research.nursing@utoronto.ca. If you have any questions about your rights as a research participant, please contact [contact at study site]. The REB is a group of people who oversee the ethical conduct of research studies. These people are not part of the study team. Everything that you discuss will be kept confidential. You can also contact the Research Oversight and Compliance Office- Human Research Ethics Program at ethics.review@utoronto.ca or 416-946-3273.

Thank you.

Regards,

Gillian Strudwick, RN, MN, PhD Student
Lawrence S. Bloomberg Faculty of Nursing
University of Toronto
155 College Street, Suite 130
Toronto, Ontario M5T 1P8
416-946-3977
Gillian.strudwick@mail.utoronto.ca
Appendix J.

Invitation to Participate in Focus Groups

Dear nursing colleague,

You are being invited to participate in phase two of this dissertation research study on Nurses’ Perceptions of their Use of Electronic Health Records. Phase two consists of focus group discussions. Please indicate below if you are interested in participating in a focus group aimed at understanding and validating the results of this survey. Your participation would involve participating in a recorded discussion lasting approximately 60-90 minutes. Your participation in the study is voluntary and no personal information about you will be collected. You can refuse to answer any questions, and you can withdraw from the study at any time.

Participants in the focus group will receive a $5 gift card to Tim Hortons’s or Indigo and a light meal. Focus groups will be held at [study site] before or after nursing shifts. Are you interested in participating in a focus group?

☐ Yes, you may contact me at a later time to participate in a focus group.
☐ No, please do not contact me.

If you answered yes, please provide the following additional information:

Name: _________________________________________________________

Contact information: _____________________________________________

*Please note that Focus Group participants will be randomly drawn from the group of eligible consenting participants. Depending on the random draw, you may or may not receive an invitation to participate in the Focus Group.

Place this form in the envelope provided, seal it and return it to the designated return area.

If you have any questions about your rights as a research participant, please contact [contact at study site]. The REB is a group of people who oversee the ethical conduct of research studies. These people are not part of the study team. Everything that you discuss will be kept confidential. You can also contact the Research Oversight and Compliance Office- Human Research Ethics Program at ethics.review@utoronto.ca or 416-946-3273.

Regards,

Gillian Strudwick, RN, MN, PhD Student
Lawrence S. Bloomberg Faculty of Nursing
University of Toronto, 155 College Street, Suite 130
Toronto, Ontario M5T 1P8, 416-946-3977
Gillian.strudwick@mail.utoronto.ca
Appendix K.

Summary of Eligible Participants and Survey Responses

Target Sample Size based on Power Calculation (n = 371) → Reconciliation of eligible participants (n = 42)

Eligible Participants (n = 329) → Cardiology Unit Closure (n = 44)

Remaining Eligible Participants (n = 285) → Unable to Hand Out (n = 73)

Surveys Handed Out (n = 212) → Unreturned (n = 73)

Returned Surveys (n = 139) → Returned blank (n = 6)

Usable Surveys (n = 133)
Appendix L.

Coefficients of Multivariable Regression for Organizational Context Variables Predicting Nurses’ Perceptions of EHR Use (RQ2)

<table>
<thead>
<tr>
<th>Variable</th>
<th>$R$</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
<th>B</th>
<th>SE B</th>
<th>$\beta$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Support from leadership</td>
<td>0.17</td>
<td>0.03</td>
<td>-0.01</td>
<td>0.37</td>
<td>0.66</td>
<td>0.06</td>
</tr>
<tr>
<td>Level of training</td>
<td></td>
<td></td>
<td></td>
<td>-0.63</td>
<td>0.75</td>
<td>-0.09</td>
</tr>
<tr>
<td>Level of ongoing support</td>
<td></td>
<td></td>
<td></td>
<td>0.86</td>
<td>0.77</td>
<td>0.13</td>
</tr>
<tr>
<td>Physical environment</td>
<td></td>
<td></td>
<td></td>
<td>0.25</td>
<td>0.68</td>
<td>0.04</td>
</tr>
</tbody>
</table>
## Appendix M

### Chunkwise Models for Usability Variables and Interaction Terms (RQ3)

<table>
<thead>
<tr>
<th>Model</th>
<th>Variable</th>
<th>Interaction Terms</th>
<th>$R$</th>
<th>$R^2$</th>
<th>Adjusted $R^2$</th>
<th>$R^2$ Change</th>
<th>F Change</th>
<th>Sig. F Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a</td>
<td>Ease of Use</td>
<td>None</td>
<td>0.23</td>
<td>0.05</td>
<td>0.03</td>
<td>0.05</td>
<td>2.26</td>
<td>0.09</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Years of Experience using an EHR, Other EHR use</td>
<td>0.23</td>
<td>0.05</td>
<td>0.01</td>
<td>0.00</td>
<td>0.02</td>
<td>0.98</td>
</tr>
<tr>
<td>1b</td>
<td>Ease of Use</td>
<td>None</td>
<td>0.24</td>
<td>0.06</td>
<td>0.04</td>
<td>0.06</td>
<td>3.23</td>
<td>0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age</td>
<td>0.24</td>
<td>0.06</td>
<td>0.03</td>
<td>0.00</td>
<td>0.01</td>
<td>0.96</td>
</tr>
<tr>
<td>2a</td>
<td>Navigation</td>
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<td>0.01</td>
</tr>
<tr>
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<td></td>
<td>Years of Experience using an EHR, Other EHR use</td>
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<td>0.12</td>
<td>0.09</td>
<td>0.01</td>
<td>0.06</td>
<td>0.94</td>
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<tr>
<td>2b</td>
<td>Navigation</td>
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<td>0.11</td>
<td>0.10</td>
<td>0.11</td>
<td>7.14</td>
<td>0.01</td>
</tr>
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<td></td>
<td></td>
<td>Age</td>
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<td>0.12</td>
<td>0.09</td>
<td>0.01</td>
<td>0.39</td>
<td>0.54</td>
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<tr>
<td>3a</td>
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<td>0.02</td>
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<td>0.02</td>
<td>0.86</td>
<td>0.46</td>
</tr>
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<td>Years of Experience using an EHR, Other EHR use</td>
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<td>0.01</td>
<td>0.30</td>
<td>0.74</td>
</tr>
<tr>
<td>3b</td>
<td>Impact on workload</td>
<td>None</td>
<td>0.11</td>
<td>0.01</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.71</td>
<td>0.50</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Age</td>
<td>0.12</td>
<td>0.01</td>
<td>-0.01</td>
<td>0.01</td>
<td>0.11</td>
<td>0.74</td>
</tr>
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Appendix N

Chunkwise Models for Organizational Context Variables and Interaction Terms (RQ4)

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