IMPACT OF HEALTH INFORMATION TECHNOLOGY ON DELIVERY AND QUALITY OF PATIENT CARE

by

AMANDA JANE HESSELS

A Dissertation submitted to the

Graduate School-Newark

Rutgers, the State University of New Jersey

in partial fulfillment of the requirements

for the degree of

Doctor of Philosophy

Graduate Program in Nursing

written under the direction of

Linda Flynn, PhD, RN, FAAN

and approved by

_____

_____

_____

_____

_____

Newark, New Jersey

May, 2014

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

ABSTRACT OF THE DISSERTATION

Impact of Heath Information Technology on Delivery and Quality of Patient Care

By AMANDA JANE HESSELS

Dissertation Director:

Linda Flynn, PhD, RN, FAAN

Adverse events in hospitalized patients are catastrophic and costly to individuals, hospitals and society. The use of electronic health records (EHR) is one promising system-level initiative that may improve provider performance, interdisciplinary communication, reduce adverse patient events, improve the overall quality of patient care, and ultimately improve patient satisfaction with hospital care. The study purpose was to examine the relationships among: (1) EHR adoption stage, (2) missed nursing care and (3) nursing practice environment, on hospitalized patient adverse outcomes and satisfaction.

This secondary analysis of cross sectional data was compiled from four sources: (1) the State Inpatient Database, (2) Healthcare Information and Management Systems Society Dorenfest Institute database of EHR adoption, (3) Hospital Consumer Assessment of Healthcare Providers and Systems Survey, and (4) a survey of New Jersey hospital-based nurses. The analytic approach used ordinary least squares and multiple regression models to estimate the effects of EHR adoption on the delivery of nursing care and patient outcomes, controlling for characteristics of patients, nurses, and hospitals. Robust procedures with Huber-White sandwich variance estimators and clustered means

were used to account for the clustering of patients within hospitals. The final analytic sample consisted of 854,258 patients and 7,679 nurses in 70 New Jersey hospitals.

Significant findings from this study indicate positive relationships between nursing practice environment and patient satisfaction, and inverse relationships between: (a) advanced EHR adoption and adverse outcome of prolonged length of stay, (b) nursing practice environment and missed nursing care and (c) missed nursing care and patient satisfaction. Among the subscales of the nursing practice environment tested, staffing and resource adequacy was the strongest predictor of missed nursing care and patient satisfaction.

Further, findings indicate strong, significant relationships among staffing and resource adequacy, missed nursing care and patient satisfaction, and that these strong relationships are not confounding the effects of EHR adoption stage on patient satisfaction. These important findings suggest that sufficient staffing and resources is essential for advanced EHR adoption and patient reported outcomes of satisfaction. These findings may also signify that the patient benefits of advanced technology will only be realized in context of sufficient human resources.

Acknowledgements

I will begin by gratefully acknowledging the funding and data sources that made this project possible. This includes the statement: "This project was supported by grant number R36HS021988 from the Agency for Healthcare Research and Quality. The content is solely the responsibility of the authors and does not necessarily represent the official views of the Agency for Healthcare Research and Quality." I gratefully acknowledge the support of this research provided by my Chair, Dr. Linda Flynn, for sharing The Nurse Survey Data, funded by research grant #053071 awarded to Dr. Flynn from the Robert Wood Johnson Foundation. Finally, I wish to acknowledge that the State Inpatient Databases (SID), Healthcare Cost and Utilization Project (HCUP), Agency for Healthcare Research and Quality provided patient data and the HIMSS Analytics ™ Dorenfest Institute provided data on EHR adoption.

The story these data tell would not be evident without the expert guidance, consultation and mentoring from my team of committee members. I would like to express my deepest gratitude to my chair Dr. Linda Flynn, whose support throughout the years has helped me develop professionally as well as personally. She provided exemplary instruction in research process, methodology, content, writing and role socialization through her scholarship, patience, and mentorship throughout my evolution in becoming a nurse scientist.

I am immensely appreciative of my committee members, including Dr. Jeannie Cimiotti who helped me refine the conceptualization of this study in a novel way, and whose enthusiastic and expert insight and editing made this project more rigorous. I am greatly thankful to Dr. Edna Cadmus for her acumen and guidance in considering

perspectives and factors important to healthcare administrators and policy makers. I am deeply appreciative of the participation of my external committee members, including Dr. Robyn Gershon whose mentoring over the years and expertise in Public Health and Biostatistics always added a unique and valuable perspective, and Dr. Suzanne Bakken who without hesitation joined my committee to offer her expertise in Biomedical Informatics, helping me to make sense of both the data and implications. I also express my gratitude to Dr. Alex Kiss whose statistical expertise was invaluable. Finally, I gratefully acknowledge the support, consultation and assistance of the faculty and staff at Rutgers, the State University of New Jersey; College of Nursing, New Jersey Collaborating Center, and Center for State Health Policy, in particular Jose Nova who provided critical assistance in managing the SIDS data.

I wish to acknowledge the support of my professional development by the many organizations that provided awards, serving to build my confidence and inspire me to continue through the challenges of doctoral study, including: Rutgers University, Meridian Health, New Jersey State Nurses Association, New Jersey Healthcare Information and Management Systems Society, and Sigma Theta Tau, International Honor Society of Nursing. Finally, I appreciatively acknowledge my colleagues and mentors at Meridian Health who provided inspiration, support and flexibility throughout this journey, allowing me to keep my feet grounded in practice while I reached for the stars.

Dedication

This work is dedicated to the many people behind the numbers who suffer or succumb to preventable harm and bring this issue home, including my Grandfather Gizzi and Uncle Andy, and those who care for them, personally and professionally, experiencing dissatisfaction with the state of healthcare. This is also dedicated to the efforts and accomplishments of the many in healthcare who aim to mitigate this harm, it is my hope the new knowledge this study brings will inform your important work.

I also dedicate this to my parents, Kerry and Bill, who early in my training instilled the knowledge there is no such thing as "just" a nurse, my sisters and brothers, nieces and nephews who each invariably had just the right words of motivation, humor and reality to keep me going, and my in-laws Carole and John who always provided a unique perspective. Your flexibility with my abilities to join numerous family events throughout these past four years was heartfelt and instrumental, you selflessly always reminded me this was the most important thing I needed to be doing at the moment. Finally, this study was possible because of the love, support and incredible adaptability of my husband, Sam. He was eternally present through the many challenges and celebrations of this most recent adventure; his belief in me was unwavering, as it has been for the past 28 years. I could not have done this without you! It is my sincere hope this work contributes to a safer and more satisfied tomorrow for us all.

CHAPTER I

The Problem

The current state of patient outcomes indicates that patients are not safe in U.S. hospitals; they are at worst dying and at best dissatisfied with their health care experience. Generating widespread attention and galvanizing broad action, the 1999 landmark report from the Institute of Medicine (IOM) estimated that up to 98,000 people die annually in hospitals due to preventable adverse patient events. Subsequently, there has been a growing awareness of the need to reduce preventable adverse patient events and thereby improve patient safety (Buerhaus et al., 2007; Leape, et al., 2009).

Disturbingly, recent reports and study findings indicate that despite national attention and substantial resource allocation, there has been no substantive reduction in the incidence of preventable adverse inpatient events over the last several years (Leape, et al., 2009; IOM, 2012; Wachter, 2010a, 2010b). Recent figures from Department of Health and Human Services (DHHS) suggest that each year approximately 13.5% of hospitalized Medicare beneficiaries experience an adverse event during their hospitalization. Moreover, 44% of these adverse events are reported to be preventable (DHHS, 2010a). Further, in a recent study, the rate of preventable harm to patients was found to remain relatively stable at 40.2 adverse events per 1,000 patient days over the study period covering the years 2002–2007 (Landrigan et al., 2010). These sustained rates of inpatient adverse events are detrimental to individuals, hospitals and society, costing our healthcare system more than 4.4 billion dollars per year (DHHS, 2010a).

Tolerance with this status quo is waning. Payers, regulators, insurers and consumers are demanding the delivery of safe healthcare with positive outcomes. In

addition to increased morbidity and mortality, the toll of preventable adverse events on inpatients, their families and caregivers through emotional strain, loss of income and impaired household and societal functioning is incalculable (IOM, 2004; Wachter, 2010a, 2010b). Consumer concern became evident in a seminal 2006 national survey of public perspectives on ways to improve health care in which 42% of respondents reported experiencing inefficient, poorly coordinated or unsafe care in the prior two years (Schoen, How, Weinbaum, Craig & Davis, 2006). Concern remains evident in a 2011 international survey in which up to 25% of U.S. respondents reported experiencing an actual error in care (Schoen, Osborn, Squires, Doty, Pierson & Applebaum, 2011). Importantly, a theoretically and empirically supported consequence of low quality healthcare and poor work environments also includes decreased patient satisfaction (Kutney-Lee et al., 2009; Mitchell & Shortell, 1997; Schubert et al., 2008).

There is substantial evidence to support the associations among nursing care processes, the nursing practice environment, adverse patient events, and patient satisfaction (Aiken et al., 2010; Aiken, Cimiotti, Sloane, Flynn & Neff, 2011; Aiken, Smith & Lake, 1994; Ashton & Wray, 1996; Kutney-Lee et al., 2009; Meurier, 2000; Sovie & Jaward, 2001). Furthermore, the electronic health record (EHR) is a promising system initiative aimed at improving clinical communication, reducing time spent in redundant documentation, supporting clinical decision making, providing reminders or cues regarding care activities that need to be performed, and reducing adverse patient events (Bates & Gawande, 2003; Buntin, Burke, Hoaglin, & Blumenthal, 2011; Jamal, McKenzie, & Clark, 2009; Kelly, Brandon, & Docherty, 2011; Kutney-Lee & Kelly, 2011; Waneka & Spetz , 2010). Moreover, EHR has been linked to an increase in the

amount of time hospital-based nurses spend in direct patient care, as well as to nurses' perceptions of providing higher quality care (DesRoches, Miralles, Buerhaus, Hess, & Donelan, 2011; Kutney-Lee & Kelly, 2011).

Thus, it is generally believed that EHR is effective in reducing missed nursing care, defined as necessary nursing care that is omitted, either in part or whole, or delayed (Kalisch, Landstrom, & Hinshaw, 2009). The reduction of missed nursing care is one mechanism through which EHR may reduce adverse events and enhance patient satisfaction. These potential benefits of EHR warrant further investigation since missed nursing care is a growing phenomenon that threatens patient safety, patient satisfaction, and positive outcomes (Aiken et al., 2012; Bittner & Gravlin, 2009; Jha, Orav, Zheng & Epstein, 2008; Kalisch, Landstrom, & Hinshaw, 2009; Lucero, Lake, & Aiken, 2010).

Unfortunately, there is no evidence to support these assumptions as there have been no studies that have tested the theorized relationships among levels of EHR adoption, characteristics of the practice environment, and missed nursing care, on patient outcomes such as adverse patient events and patient satisfaction in acute care hospitals. Despite the potential benefits, most studies involving EHR have been conducted in a small sample of hospitals, have not considered the effects of differing levels of EHR adoption, and have not included factors such as the nursing practice environment (Shekelle, Morton, & Keeler, 2006). Highlighting these gaps, an evidence report published by the Agency for Healthcare Research and Quality (AHRQ) concluded that there are too few studies linking organizational structures and care processes with outcomes when examining the positive effects of EHR (Shekelle et al., 2006). Moreover,

the AHRQ evidence report further specified that the effects of EHR across differing practice environments remain unknown.

Although it has been several years since AHRQ released the evidence report, these major gaps in the evidence persist. A recent report by the IOM (2012) continues to identify a critical knowledge gap in understanding the impact of health information technology, including EHR, on patient safety in context of the care processes and workflow and organizational factors such as work environment (IOM, 2012). To date, there have been no multi-site studies that have disentangled the complex relationships among EHR, the practice environment, missed nursing care and the inpatient outcomes of preventable adverse events and satisfaction with inpatient care.

Theory and conceptual models posit the positive effects of the practice environment, technology, and quality nursing care practices on patient outcomes (Mitchell, Ferketich & Jennings, 1998). Theory and conceptual models also propose a positive relationship between advanced information technology, such as an EHR, and the quality of communication and decision-making (Huber, 1990; Powell-Cope, Nelson & Patterson, 2008). Moreover, theory and conceptual models specifically propose negative relationships between quality communication and the absence of a reasonable action that should be taken, such as missed nursing care, an indicator of poor quality nursing care, and between decision-making and missed nursing care (Kalisch, 2006; Kalisch, Landstrom & Hinshaw, 2009; Kalisch, Landstrom & Williams, 2009).

Guided by theoretical synthesis, the purpose of this study is to address these gaps by testing propositions in a sample of inpatients and nurses via the examination of relationships among: (1) levels of EHR adoption, (2) missed nursing care, (3) features of

the nursing practice environment, (4) adverse patient events, and (5) the patient-centered outcome of satisfaction with inpatient care.

Statement of the Problem

What are the relationships among EHR adoption, the nursing practice environment and missed nursing care on patient outcomes such as adverse events and patient satisfaction in acute care hospitals?

Sub–problems.

1. Is the use of EHR inversely related to occurrence of adverse patient events in acute care hospitals?
2. Is the use of EHR positively related to patient satisfaction in acute care hospitals?
3. Is a supportive nursing practice environment inversely related to occurrence of adverse patient events in acute care hospitals?
4. Is a supportive nursing practice environment positively related to patient satisfaction in acute care hospitals?
5. Is the use of EHR inversely related to missed nursing care in acute care hospitals?
6. Is a supportive nursing practice environment inversely related to missed nursing care in acute care hospitals?
7. Is missed nursing care positively related to occurrence of adverse patient events in acute care hospitals?
8. Is missed nursing care inversely related to patient satisfaction in acute care hospitals?

9. Will missed nursing care mediate the relationship between the nursing practice environment and adverse patient events?
10. Will missed nursing care mediate the relationship between EHR adoption and occurrence of adverse patient events?
11. Will missed nursing care mediate the relationship between EHR adoption and patient satisfaction?

Definition of Terms

The following will detail the theoretical and operational definitions of the four dependent and three independent variables.

Adverse patient events.

An adverse patient event is theoretically defined, overall, in this study as unintended harm to an inpatient, including prolonged hospitalization that is most likely caused by clinical management or the health care delivery system rather than an underlying disease or condition (Brennan, et al., 1991; DHHS, 2012; Hunt, et al., 2005). Three categorical indicators of adverse events will be examined in this proposed study: (1) a nurse-sensitive subset of adverse inpatient events identified, measured, and labeled by AHRQ as patient safety indicators (PSIs); (2) a hospital readmission within seven days of discharge; and (3) a prolonged length of stay. Each category of adverse events is theoretically and operationally defined, and will be detailed in the following section.

AHRQ Patient Safety Indicators.

The AHRQ Patient safety indicators (PSIs) are theoretically defined as a set of specific quality indicators which reflect the quality of care provided in hospitals with a focus on patient safety. These indicators screen for adverse events in hospitals following

surgeries, procedures and childbirth that patients may experience as a result of exposure to the healthcare system, and that are likely amenable to prevention by changes at the system and provider level (McDonald et al., 2002). Selected nurse-sensitive PSIs that will be examined in this proposed study include: (1) death in low-mortality DRG's (PSI 2); (2) failure to rescue (PSI 4); (3) postoperative sepsis (PSI 13); (4) central venous catheter-related blood stream infection (PSI 7); and (5) postoperative hip fracture (PSI 8). Each indicator is operationally defined by selected diagnosis or procedure codes derived from the *International Classification of Diseases, 9th edition, Clinical Modification* (ICD-9-CM) that suggests the occurrence of an adverse event. The measure of each event will be calculated based on guidelines from the AHRQ Guide to Patient Safety Indicators that specifies the method by which each measure is calculated, the DRGs, ICD-9-CM codes included in each measure, and appropriate risk-adjustment methodologies.

Hospital readmission.

Early hospital readmissions will be defined as the readmission of a patient who was recently discharged following a hospitalization (CMS, 2012a). Theoretically, the shorter the duration of time between discharge and readmission, the more likely it is that the care process during the previous stay played a role in the current readmission (Ashton & Wray, 1996). For this reason, readmission will be operationally defined as an all-cause admission to the same New Jersey hospital facility from which the patient was discharged within seven days of discharge (HCUP, 2012a, 2012b). Patients with select PSIs of death and death due to failure- to- rescue will be excluded from the risk pool for readmission.

Prolonged length of stay (PLOS).

The concept of PLOS is theoretically defined as the beginning of the deceleration in the rate of patient discharge from a hospital (Silber et al., 1999; Silber, et al., 2009). PLOS is deduced from empirical observations that after daily discharge rates peak there is a certain distribution point at which the discharge rate declines (Silber, et al., 2009). PLOS will be operationalized as the number of hospitalization days by which a patient's stay is considered prolonged by identifying the prolongation point. The prolongation point for hospital discharges will be computed as described by Silber et al. (1999, 2003, 2009), and defined as the day after the deceleration point of the discharge rate. The patient's hospital stay is therefore considered prolonged if it exceeds the prolongation point.

Patient satisfaction.

Patient satisfaction with health care will be theoretically defined as the patient's perception of care and rating of their satisfaction with their hospital experience (CMS, 2012a; Donabedian, 1966, 1988). Patient satisfaction will be operationally defined as the hospital level average "top box" score from the *Hospital Consumer Assessment of Healthcare Providers and Systems* (HCAHPS) overall hospital rating measure (CMS, 2012a). "Top- Box" is defined as the most positive response to the HCAHPS survey questions, including the response "9" or "10" for the overall hospital rating item (CMS, 2012a). Individual patient responses are aggregated to the hospital level by HCAHPS following risk-adjustment for patient mix and mode of administration.

Independent variables.

The following section will detail the theoretical and operational definitions of the three independent variables: (1) EHR adoption, (2) nursing practice environment and (3) missed nursing care.

EHR adoption.

Electronic health record (EHR) will be theoretically defined as the level of EHR capabilities that has been implemented within the hospital environment (HIMSS, 2008; IOM, 2012). EHR adoption will be operationally defined as a hospital's total cumulative score on the Electronic Medical Record Adoption Model scale (EMRAM), (HIMSS, 2008).

Nursing practice environment.

Nursing practice environment is theoretically defined as "the organizational characteristics of a work setting that facilitate or constrain professional nursing practice," (Lake, 2002, p.178). The nursing practice environment will be operationally defined as a composite score on the Practice Environment Scale of the Nursing Work Index (PES-NWI), (Lake, 2002).

Missed nursing care.

Missed nursing care will be theoretically defined as necessary nursing care that is omitted, either in part or whole, or delayed (Kalisch, Landstrom, & Hinshaw, 2009). Missed nursing care will be operationally defined as the composite score on Tasks Left Undone measure; a 12 item scale that asks nurses to identify patient care activities on their last shift that were necessary, but left undone.

Control variables.

Theoretical and empirical literatures indicate that several other factors are associated with adverse patient events and patient satisfaction with inpatient care. Therefore, the relationships between these factors and the dependent variables of interest will be explored in this proposed study, and their effects will be controlled if indicated. Additionally, relationships between these factors, or control variables, and the study's predictor variables will be assessed for multicollinearity prior to model testing. These control variables will include: (1) nurse staffing levels, operationally defined as the ratio of patients to registered nurses in each hospital; (2) hospital size, operationalized as less than or equal to 100 beds, 101 to 250 beds, or greater than or equal to 250 beds; (3) teaching status, operationalized as the trainee-to-bed ratio, (number of medical residents and fellows) and categorized as minor teaching (less than 1:4 residents to trainee ratio) or major teaching (greater than 1:4 ratio); (4) high technology status, operationally defined as facilities with open-heart surgery, major organ transplant, or both; (5) hospital geographic categories, operationally defined based on United States rural-urban continuity codes (Rural-Urban Continuum Codes) of the county where the hospital is located; and (6) nurse education, operationally defined as the percentage of staff RNs with a baccalaureate degree in nursing or higher. Additionally, patient risk adjustment covariates used in this study include ICD9-CM primary and secondary diagnosis codes, age, sex, race, and insurance type, operationalized using the AHRQ risk adjustment method, based on the Elixhauser method, including a comprehensive set of 30 comorbidities (Elixhauser, Steiner, Harris & Coffey (1998). Finally, clustering of patients within hospitals will be statistically controlled.

Delimitations

This study will leverage and merge the following existing datasets: (1) the State Inpatient Databases (SIDS) available from AHRQ will be the data source for mortality and non-mortality adverse events; (2) Data from the New Jersey Department of Health and Senior Services (NJDHHS) will provide metrics on hospital structural characteristics (e.g. bed size, teaching status and technology); (3) Healthcare Information and Management Systems Society (HIMSS) Dorenfest Institute database will be the source of data on EHR adoption; (4) Centers for Medicare and Medicaid Services data from the Hospital Consumer Assessment of Healthcare Providers and Systems Survey (HCAHPS) will provide measures of patient satisfaction; and (5) the database from the New Jersey nurse survey will be the source of metrics on staffing, organizational climate, and details on the delivery of nursing care. Therefore, there is no need for the recruitment of subjects. Women and minorities are represented similarly to their population distribution and no genders, racial or ethnicity groups will be excluded.

The existing nurse survey dataset delimits the hospital sample to nonfederal general acute care hospitals for the year 2006 in New Jersey. Veterans Affairs hospitals were not included in the original parent study as these hospitals do not report the discharge data of interest to the state. General acute care hospitals are included as these have the discharge patient outcomes of interest; psychiatric and non-acute care hospitals are not included in the dataset. The sample of hospitals is comprised of 72 New Jersey hospitals including large and small hospitals, teaching and non-teaching hospitals, from a variety of geographic settings that differ in terms of the level of technology, as well as in terms of the nursing characteristics of interest (i.e., staffing, nurse education).

The sample for the existing 2006 nurse survey data was further delimited to registered nurses (RNs) licensed and residing in New Jersey, who practice in acute hospitals providing inpatient care at the bedside. To maintain anonymity of nurse respondents and obtain reliable data, hospitals with less than 10 nurse survey respondents were excluded from the original sample recruited in the parent study, the majority of which were small hospitals (Aiken, et al., 2010; Aiken, Sloane, Cimiotti, Flynn, Neff, & Smith, 2011). The final nurse and hospital samples include approximately 7,000 RN's from 72 New Jersey acute care hospitals.

The State Inpatient Database (SID) from the Healthcare Cost Utilization Project (HCUP) contains inpatient discharge abstracts from New Jersey hospitals. The existing NJ 2006 SIDS dataset will be examined in this study and includes all patients discharged from NJ hospitals. The SID contains more than 100 clinical and nonclinical data elements such as: facility identification number, patient demographics, admission and discharge information, payment source, total charges, and length of stay. In addition, *International Classification of Diseases, 9th edition, Clinical Modification* (ICD-9-CM) codes are recorded for both the principal diagnosis and principal surgical procedures. Importantly, each PSI measure defines the "at risk" population of patients, based on procedures and diagnoses, and excludes cases where the adverse event is inherently less likely to reduce the likelihood of false positive cases (Freidman, Ecinosa, Jiang, Mutter, 2009; HCUP, 2012a).

This patient sample will be delimited as follows: individuals under the age of 21 will be excluded from this study as the research topic to be studied examines adult patients who are typically older than 21 years of age. Of the 20 PSIs, a subsample of

patient's with the following select nursing sensitive PSIs will be constructed: (1) death in low-mortality DRG's (PSI 2); (2) failure to rescue (PSI 4); (3) postoperative sepsis (PSI 13); (4) central venous catheter-related blood stream infection (PSI 7); and (5) postoperative hip fracture (PSI 8). The measures included will be calculated based on guidelines from the AHRQ *Guide to Patient Safety Indicators* that specifies the method by which each measure is calculated, the DRGs, ICD-9-CM codes included and excluded in each measure, and appropriate risk-adjustment methodologies.

Data on EHR adoption will be obtained from the existing 2006 HIMSS Analytic Database. HIMSS is the most comprehensive national collection of information technology currently available providing data on sub-acute care, home health, ambulatory, free standing and acute care facilities, and has been used in previous research on health information technology (Kazley & Ozcan, 2008; McCullough, Casey, Moscovice, & Prasad, 2010). Data is extensive and includes hospital characteristics and market segmentation, EHR purchase and utilization plans, and software, hardware and infrastructure installed in all participating facilities. HIMSS annually surveys U.S. nonfederal acute care hospitals, including independent hospitals and those that are part of a health care delivery system, in 2006 5,082 acute care facilities submitted data. This study will leverage the existing dataset and delimit the sample to NJ hospitals that voluntarily submitted data to HIMSS in 2006.

Data on patient satisfaction will be derived from the existing HCAHPS dataset, which is the first national, standardized database of patient's perceptions of their experience in acute care hospitals. Hospitals voluntarily participate and the data are publically available through the Hospital Compare website. This dataset includes 42 NJ

hospitals that participated in 2006. The dataset will be limited to patients surveyed in the six month period of 2006 available from the reporting period of October 2006-June 2007. While this data is not entirely contemporaneous with the patient safety outcome datasets, it does correspond with the survey data for nursing practice environment and missed nursing care.

Significance of the Study

A recent report by the Institute of Medicine (IOM, 2009) identified the top 100 healthcare research priorities for the nation. Leading the list of priorities is research aimed at improving patient safety and the quality of care. Yet, despite an increased focus on patient safety since the release of the IOM report *To Err is Human* (IOM, 2001), there has been minimal improvement in patient safety (Leape et al., 2009; Wachter, 2010a, 2010b).

Although there is a growing body of evidence quantifying the benefits of EHR adoption on patient outcomes, some major gaps in the evidence remain (Elnahal, Joynt, Bristol & Jha 2011; Himmelstein, Wright & Woolhandler, 2010; Kazley, Diana, Ford & Menachemi, 2012; Kutney-Lee & Kelly, 2011). By leveraging existing databases, this study will address these gaps in the evidence in a sample of 72 acute care hospitals in New Jersey. Findings from this study will inform a technologically based, multi-faceted approach to reducing inpatient adverse events and enhancing patient satisfaction. This study is aligned with AHRQ's strategic research goal to reduce harm from health services by promoting the delivery of appropriate care that achieves the best quality outcomes. This study is also aligned with the National Institute for Nursing Research (NINR)

Innovation research strategy to develop new knowledge to apply to the implementation of EHR (NINR, 2012).

This intersection of priorities speaks to the recognition of a patient safety as a core value of nursing. Preventing adverse patient events and promoting patient satisfaction with health care are core priorities of nursing (Hughes, 2008). These values and priorities are rooted in the nursing metapardigm concepts of person, environment, nurse and health, and are increasingly visible in context of the transformation of US healthcare (Reed & Shearer, 2009; IOM, 2011). Nursing science is integral to the advancement of health promotion and health protection practices as related to the concept of patient safety. As such, patient safety has an important, historic, and iterative relationship with nursing.

Nurses are at the frontline of healthcare delivery, compromising the largest sector of the healthcare workforce (Page, 2004). There are over 2.7 million RN's and over 700,000 licensed practical and vocation nurses in the U.S (Bureau of Labor Statistics, 2012). A central role of nurses in keeping patients safe is surveillance, therapeutic nursing interventions, and coordination of care and services (Page, 2004). Nurses, therefore have the direct ability to promote, ameliorate or prevent adverse patient events improve patients' satisfaction with care. The important role of nurses in promoting patient safety and satisfaction with care is exemplified by the work of Florence Nightingale, the founder of modern nursing and a renowned statistician. In 1863 she noted:

> In attempting to arrive at the truth, I have applied everywhere for information, but in scarcely an instance have I been able to obtain hospital records for any purposes of comparison. If they could be obtained…they would show subscribers how their money was being spent, what amount of good was really being done with it, or whether the money was doing more mischief than good… and the truth thus ascertained would enable

> us to save life and suffering, and to improve the treatment and management of the sick (Nightingale, 1863, p. 176).

This was a harbinger of the promise of EHR to improve nursing care and patient outcomes.

In 2011, the consequential IOM report *The Future of Nursing: Leading Change, Advancing Health* asserted that the US healthcare system has a unique opportunity to transform itself, and that nurses are essential to lead this transformation. Presently, technology is permeating the healthcare environment and radically changing how care, including nursing care, is delivered (IOM, 2012). A key finding of the *Health IT and Patient Safety* report by the IOM (2012) is that health technology can improve patient safety. Importantly, this technology cannot be viewed in isolation, but as part of the ecosystem of hospital healthcare, as the integration of EHR in health systems is not the end, but a possible means to the end of improved patient safety and satisfaction. However, significant knowledge gaps remain in the literature. These gaps include explicating the nature of the relationships among EHR, contexts and processes of nursing care, and patient outcomes. Therefore, this proposed study is highly relevant to the discipline and science of nursing, and is urgently needed to advance nursing knowledge.

This innovative study addresses significant empirical gaps in the patient safety literature and advances the important nursing research goal to improve patient safety outcomes. It is the first study to examine the effects of EHR adoption on missed nursing care. Secondly, findings will be disseminated through a comprehensive plan to inform key healthcare executives and policymakers to render better decisions regarding valuable healthcare resources. Thereby, evidence-based recommendations resulting from study findings will have the potential to directly influence organizational, state and national

policy decisions. This information will be relevant to construct and deploy efficient mixes of health care material and human resources that will support the provision of safe, error free care. Thus, findings from this study will inform a technologically based, multi-faceted approach to reduce inpatient adverse events and enhance patient satisfaction. Lastly, it is anticipated that the findings from this study will add to a growing body of knowledge in nursing health services research that identifies modifiable system factors and hospital-level determinants that may be modified through broader alternative strategies to reduce adverse patient events and improve patient safety.

CHAPTER II

Review of the Literature

This proposed research investigates the relationships among: (1) EHR adoption; (2) the nursing practice environment; (3) missed nursing care; and (4) the patient outcomes of adverse events and satisfaction with inpatient care in a large sample of patients from acute care hospitals in New Jersey. Theoretical and empirical literatures relevant to these relationships are presented in this chapter. The first section presents the theoretical literature relative to the dependent variable patient outcomes, which in this study will be indicated by adverse patient events and patient satisfaction with care. Secondly, the theoretical literature related to the primary predictor of EHR adoption will be presented, as well as the empirical support for the relationships among EHR, nursing care processes and patient outcomes. Next, the theoretical literature related to the secondary predictor, the nursing practice environment, will be presented, followed by empirical support for the relationship between the nursing practice environment and patient outcomes. Finally, a review of the theoretical literature of missed nursing care, as well as empirical support for the relationships among the nursing practice environment, missed nursing care, and patient outcomes will be presented. Lastly, gaps in the empirical literature will be synthesized, the theoretical rationales for the research questions summarized, and the study hypotheses outlined.

Theories of Patient Outcomes

Patient outcomes include both negative and positive effects of nursing care (Donabedian, 1988; Mitchell & Lang, 2004). These outcomes have typically been

categorized as the "five Ds": death, disability, dissatisfaction, discomfort and disease (Lohr, 1988, p 38).

Donabedian's Structure-Process-Outcomes Model (1966, 1988) theorizes that a better structure is positively related to the likelihood of better processes of care, and that these better processes are positively related to better patient outcomes. The structure is conceptualized as the attributes of the settings in which patient care occurs, including human and material resources and attributes of organizational structure. Processes are theoretically defined as "what is actually done in providing and receiving care," (Donabedian, 1988, p. 1745). Quality care processes include both quality technical and quality interpersonal care (Donabedian, 1980). Patient outcomes are conceptualized as the effects of care on the health status of a patient, and specifically include patient satisfaction under the broad definition of health status (Donabedian, 1988).

The Quality Health Outcomes Model (QHOM), (Mitchell, Ferketich, & Jennings, 1998; Mitchell & Lang, 2004) is an elaboration and extension of Donabedian's (1966; 1988) original model (Figure 1). In contradistinction to the linearity of Donabedian's explanation, the QHOM explains that the relationships among structure, process, and outcomes are dynamic with feedback loops that occur among these three essential factors. The QHOM posits that the quality of nursing care and the outcomes of that care are affected by characteristics of the system in which care is delivered. Patient outcomes reflect a dynamic and interactive process between system characteristics, patient characteristics, and interventions (Mitchell et al., 1998). The QHOM further posits that system factors such as nurse staffing and characteristics of the practice environment have a direct effect on patient outcomes. Importantly, the model specifically proposes that the

adoption of advanced technology that supports nursing staff in their work will contribute to higher quality care and better patient outcomes. Therefore, this theoretical model proposes a direct and positive relationship between system factors, including: (a) a supportive practice environment, (b) adequate nurse staffing, and (c) technology adoption and quality nursing care processes and favorable patient outcomes. Conversely, an inverse relationship between these system/process factors and adverse patient outcomes is proposed.

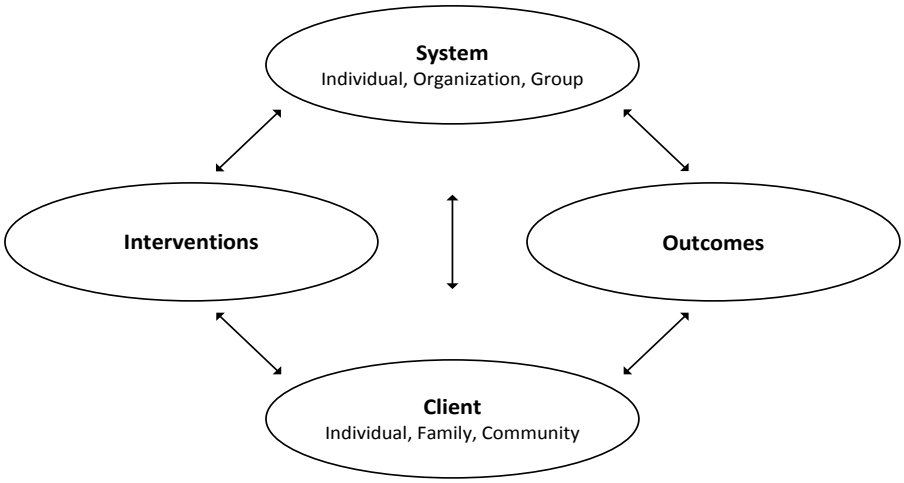


Figure 1. Quality Health Outcomes Model, by P. Mitchell, S. Ferketich, and B.M. Jennings, 1998, Quality Health Outcomes Model, *Journal of Nursing Scholarship, 30*(1), p.44

The Nursing Role Effectiveness Model is also an elaboration of Donabedian's Structure-Process-Outcomes model that provides a theoretical explanation of nurses' contribution to patient outcomes (Irvine, Sidani & McGillis-Hall, 1998). The model posits that high quality, independent nursing care, or that care such as assessment, intervention, and follow-up that falls within the purview of independent nursing practice, has a direct and positive effect on patients' clinical outcomes as well as their satisfaction with care. Conversely, the model proposes that high quality nursing care has an inverse

effect on adverse patient events, prolonged hospital stays, and readmissions to the hospital.

Ashton and Wray (1996) propose an explanation that explicates predictors of the adverse patient event of an unscheduled, early hospital readmission. The authors define early hospital readmission as an unscheduled hospital admission that occurs within 31 days of the index hospital discharge (Ashton & Wray, 1996, p. 1535). The conceptual framework explains that suboptimal inpatient care, including nursing care, can negatively affect the health status of the patient, the patient's preparation for discharge, or can lead to a premature hospital discharge. The conceptual framework explains that ultimately suboptimal inpatient care processes can lead to hospital re-admission. Thus, the conceptual framework proposes a positive relationship between substandard inpatient care processes, including substandard nursing care processes, and early hospital readmission.

In summary, conceptual frameworks and models propose that system-level factors, such as the structural characteristics in which is care is provided, affect both the processes of care and the outcomes of care (Donabedian, 1966; 1988). Moreover, conceptual frameworks and models specifically propose that the adoption of technology is a system-level characteristic that has a positive, direct effect on the quality of nursing care, and a positive, direct effect on patient outcomes (Mitchell, Ferketich, & Jennings, 1998). Additionally, there is substantial theoretic support that high quality processes of care, including nursing care, have a positive, direct effect on patient outcomes (Donabedian, 1966: 1988; Irvine, Sidani &McGillis-Hall, 1998) including the prevention of an early hospital readmission (Ashton and Wray, 1996).

Theories of Electronic Health Records (EHR)

Huber's (1990) theory of advanced information technology explains operant mechanisms through which health technology can contribute to better patient outcomes. Huber (1990) posits that the use of advanced information systems results in more rapid and accurate communication. Within the context of nursing practice, theory suggests that advanced information systems should decrease the amount of nursing care omitted by providing cues for nurses to do the important work that needs to be done (Huber, 1990). That is, the use of technology assisted communication and decision support will lead to more rapid and higher quality provider decisions, thus promoting positive outcomes (Huber, 1990). Organizationally, this technology can support managers in improving provider autonomy by fostering the decentralization and organizational units' ability to clarify and respond to problems in a more rapid and significant manner (Huber, 1990). Therefore, theory suggests EHR is directly and positively related to the quality of nursing care delivered, and this better quality of nursing care is directly and positively related to patient outcomes.

Powell-Cope, Nelson and Patterson (2008) present a conceptual model for Technology, Nursing, and Patient Safety. This model proposes that the presence and utilization of technology, such as EHR, is used by nurses to provide direct and indirect nursing care, provide protection from harm, perform patient assessment, monitoring, surveillance and provide assistance and allow for communication and patient identification. The model explains that workplace factors of: (a) organizational arrangements, (b) social factors, (c) physical environment, and (d) technology affect the initial and continued use of technology by nurses (Powell-Cope et al., 2008). This

technology is categorized as: (a) direct care delivery technology, (b) indirect nursing care technology, (c) communication technology, (d) patient and nurse protective devices, (e) patient assessment, (f) monitoring and surveillance, (g) patient assistive devices, and (h) continued learning and pattern identification (Powell-Cope et al., 2008). Importantly, communication technology includes EHRs.

The model posits that well designed technology allows nurses to focus on caregiving functions. These nursing processes are in turn predictive of the patient outcomes of improved satisfaction with care and fewer adverse events (Powell-Cope et al., 2008). Moreover, the relationship between the EHR and nursing processes is mediated and moderated by factors such as resources, practice environment, characteristics of the nurses, such as education, and patient characteristics, such as age and co-morbidities (Powell-Cope et al., 2008). Therefore, the model suggests the adoption of communication technology, such as EHR, will directly and positively affect quality nursing care processes and favorable patient outcomes.

EHR, care processes, and patient outcomes: Empirical support.

A review of the empirical literature indicates that evidence to date has largely been mixed. More recent studies, however, have demonstrated associations among EHR, improved provider performance, and patient outcomes.

Poissant, Pereira, Tamblyn and Kawasumi (2005) performed a systematic review of studies on the impact of EHR on the time efficiency of nurses and physicians. Importantly use of EHR (such as bedside terminals and centralized station desktops) reduced documentation times by 24.5% and 23.5% during a shift (Poissant et al., 2005). Researchers concluded that reduced documentation time allows more time for clinicians

to care for patients. The researchers also concluded that the impact of EHR on patient outcomes such as hospital readmission is an important area of future research (Poissant et al., 2005).

In a four year observational study examining the impact of EHR on organizational culture and quality improvement in hospitals, Nowinski et al., (2007) tested the hypothesis that enhanced information flow and ease of information retrieval related to EHR adoption would positively relate to quality indicators, including patient satisfaction. The one year results post EHR implementation did not support the hypothesis. Though not statistically significant, authors did find the movement in the expected direction of improved quality of care following the adoption of EHR in that decreased falls rates were found for all patients and an increased testing and prescribing of medications for congestive heart failure patients (Nowinski al., 2007).

Jamal, McKenzie and Clark (2009) conducted a systematic review of the impact of EHR on the quality of clinicians' processes of care in a broad mix of setting including medical centers, and surgical facilities and preventive health facilities. These studies largely included primary provider outcomes of drug dosing, drug selection, patient education, and provider compliance with a number of measures. The major effect of EHR was found by 14 of 17 studies that demonstrated a positive improvement in provider adherence to evidence based guidelines. However, there were limited studies that evaluated the impact on patient outcomes (Jamal, McKenzie & Clark, 2009).

Himmelstein, Wright and Woolhandler (2010) performed a secondary analysis of linked data from 4,000 U.S. hospitals using the Healthcare Information and Management Systems Society (HIMSS), Medicare Cost Reports (both 2003-2007) and Dartmouth

Health Atlas quality data (2001-2005) to test the relationships of HIT, including EHR, on costs and quality outcomes. These data include quality process measures related to the management of congestive heart failure, acute myocardial infarction, pneumonia outcomes, and an overall composite, as reported through the CMS. Hospitals that had higher overall adoption of health information technology, including EHR had slightly better quality scores (parameter estimate=2.365, p = .013), (Himmelstein et al., 2010).

DesRoches, Miralles, Buerhaus, Hess and Donelan (2011) tested the theoretical relationships among hospitals adoption of EHR, perception of the impact on daily work, quality of care rendered, and time spent on documentation, and time spent in patient care, in a survey of 532 RN's who worked in direct care in 2010. The RNs perceived the impact of EHR on quality of care and on their daily work as positive; 63% reported that the use of information technology improved quality of care, and RN's reported more time spent on patient care and less on documentation at the highest and lowest levels of information technology adoption, with approximately 50% reporting information technology, specifically, EHR, their daily work easier (DesRoches et al., 2011). Additionally, RN's working in settings with the highest levels EHR adoption and information technology rated the quality of care higher than those in lower level settings (DesRoches et al., 2011).

Evidence for the theoretical relationship between EHR and better nurse-reported quality of care and EHR and fewer adverse outcomes was found by Kutney-Lee and Kelly (2011). This cross-sectional secondary analysis included 16,352 nurses in 316 hospitals from 4 states. Significant findings indicate that nurses who worked in hospitals with EHRs reported less patient safety problems and fewer indications of poor quality

care. Respondents indicated that less than 10% of hospitals had fully implemented basic EHRs. Nurses who worked in hospitals with fully implemented basic EHR (clinical documentation, demographics, problem list, medication lists, discharge summaries, laboratory, radiographic and diagnostic results and computer physician order entry (CPOE) process installed) reported significantly less patient safety problems. Specifically, these nurses were 14% less likely to report "things fell between the cracks," (p <0.5), 25% less likely to report hospital management actions indicate patient safety was a low priority (p=0.001), 18% less likely to give their unit a poor safety grade (p < .05), and 17% less likely to report they were not confident their patients were ready for discharge (p < .05), (Kutney-Lee & Kelly, 2011, p. 470).

At the hospital level, Elnahal, Joynt, Bristol and Jha (2011) examined 1,637 U.S. hospitals using 2009 American Hospitals Association Health Information Technology (HIT) survey data and 2006 Hospital Quality Alliance data, and found that high-quality hospitals were more likely to have higher levels of adoption of EHR clinical decision support functions than low-quality hospitals. Important findings include high quality hospitals more often had electronic nursing notes when compared to intermediate and low quality hospitals (81% vs. 73% and 68%, p = .04) and medication lists (89% vs. 79% and 73%, p < .01), (Elnahal et al., 2011). This study provides empiric support for the theorized relationship between EHR and higher quality patient outcomes.

Most recently, a study by Kazley, Diana, Ford and Menachemi (2012) tested the theoretical relationship between EHR and patient satisfaction. EHR was found to be positively associated with measures of patient satisfaction. Specifically in a sample of 2,836 acute care general hospitals in the U.S., without propensity strata the coefficients

are: (a) staff providing information for recovery at home ($R^2 = 0.57$, $p < .01$), (b) patient rating the hospital as a 9 or 10 ($R^2 = 0.67$, $p < .01$); and (c) patient recommending the hospital ($R^2 = 0.48$, $p < .01$), (Kazley et al., 2012).

In summary, these studies support the theorized relationships and a main effect of EHR in that technology enhances communication and decision making and positively impacts provider performance and a variety of patient outcomes. These studies also indicate that as the levels of EHR adoption increase there may an increase in improvements in patient outcomes. Each of these studies, however, is limited in scope and did not include the multiple factors affecting patient outcomes. Therefore, research that explicates and quantifies the unique and cumulative effects of EHR adoption, characteristics of the practice environment, and nursing care processes on patient outcomes, while controlling for nurse staffing levels and other hospital characteristics, is needed.

Theories of Nursing Practice Environment

A review of the theoretical literature regarding the nursing practice environment will be presented. Following, will be the empirical support for the relationship between the nursing practice environment and patient outcomes.

Aiken, Sochalski and Lake (1997) developed the Nursing Organizations and Outcomes Model (NOOM) that explains the relationship between organization support for nursing care, processes of care and nursing and patient outcomes. The conceptual framework has origins in the theories of organizations and professions (Aiken, 2002). Hospitals are described as structures that have both bureaucratic and professional properties. Nurses intersect both domains and accordingly have dual demands and

desires that must be balanced (Aiken, 2002; Flood & Fennell, 1995). Thus, the level of organizational support impacts what the nurse does or does not do. Organizational support for professional nursing practice specifically includes modifiable core traits of a supportive nursing practice environment. These traits include the 5 dimensions of: (1) supportive front line manager; (2) adequate resources; (3) foundations for quality care; (4) nurse participation in organizational decision and (5) collaborative relationship with physicians.

Aiken et al., (1997) theorized the relationship between the practice environment and outcomes can be explained indirectly through nursing processes. Specifically, the model posits a positive relationship among the nursing practice environment, nursing care processes and patient outcomes. Greater levels of organizational support enhance nurse autonomy, control over clinical resources and nurse-physician relationships that in turn lead to improved patient outcomes (Aiken, Sochalski & Lake, 1997, p. NS9).

The Nursing Worklife Model explains how the practice environment influences the work of nurses and patient safety outcomes. Five modifiable work-life factors that comprise the practice environment are identified: (1) effective nursing leadership, (2) staff participation in organizational affairs, (3) adequate staffing for quality care, (4) support for a nursing model of care, and (5) effective nurse physician relationships. Although these environmental factors are similar to those proposed by Aiken, the theorists differ in their explanation of how these factors affect nurses. These theorists explain that these factors interact and affect patient outcomes through nurses' engagement processes within their organization (Laschinger & Leiter, 2006; Manojlovich & Laschinger, 2007). The theorists explain that better, empowered practice environments

positively relate to work effectiveness and group processes, and in turn improved patient outcomes (including patient satisfaction), (Purdy, Laschinger, Finegan, Kerr & Olivera, 2010). Leadership is the main component of the professional practice environment and directly relates to staffing adequacy, policy involvement, and nurse-physician relationships. These factors in turn predict the use of a nursing model of care.

This model posits that the higher quality practice environment, specifically using a nursing model of care, are related to less exhaustion and depersonalization and higher levels of personal accomplishment, and in turn, less adverse patient events (Leiter & Laschinger, 2006, Laschinger & Leiter, 2006). Thus, this model posits that factors that enhance the practice environment of nurses will improve nursing care processes and patient outcomes. Importantly, this model specifically proposes that these work-life factors are related to patient outcomes, such as falls, healthcare associated infections, and medication errors.

Nursing practice environment and patient outcomes: Empirical support.

According to the Institute of Medicine (2004) *"Keeping Patients Safe: Transforming the Work Environment of Nurses,"* (Page, 2004) there is amassing evidence that indicates the practice environment of nurses is an important factor in improving patient safety. That is, an unsupportive nursing practice environment contributes to lapses in nursing care; conversely, a supportive practice environment facilitates nurses important work of preventing adverse events, thereby keeping patient safe (Page, 2004). This relationships among the nursing practice environment, patient and nurse assessed quality of care, and outcomes, is empirically supported in the literature (Purdy et al., 2010).

A study by Aiken, Clarke and Sloane (2002) tested the theoretically positive relationships among nurse staffing, organizational support for nursing care, and nurse assessed quality of patient care. The sample included 10,319 staff nurses who worked in medical-surgical units in 303 hospitals in the U.S., Canadian provinces of Ontario and British Columbia, England and Scotland (Aiken et al., 2002). Nurse staffing was measured by nurse survey, and calculated as the average number of patients per day shift medical-surgical staff nurse (Aiken et al., 2002). Organizational support was measured using a subscale of a modified Nursing Work Index. Quality of hospital care was measured using a four item tool that ascertained: (a) nurse rated quality on the unit in general and on last shift worked, (b) confidence patient could manage care at discharge, and (c) whether unit quality of care had changed in the past year (Aiken et al., 2002). Consistent with the conceptual framework, nurse staffing and organizational support had a significant effect on nurse-reported quality on unit, whether analyzed individually or simultaneously. Results indicate that when organizational support is controlled for nurses in the worst staffed hospitals are 1.3 times as likely (*OR*= 1.3, 95% CI [1.11, 1.54], $p <$ .0001) to rate the unit quality of care as fair or poor than those on the best staffed units (Aiken et al., 2002). However, a stronger association was evident in adjusted models for nurses in settings with the lowest support levels who were 2.4 times as likely (*OR*= 2.44, 95% CI [2.05, 2.91]), $p < .0001$) to rate quality as fair or poor than those working in the best supported settings (Aiken et al., 2002). Thus, consistent with the conceptual framework, it was empirically demonstrated that organizational structure and staffing are both directly and independently related to nurse rated quality of care**.**

Advancing this knowledge, higher degrees of nurse autonomy, physician collaboration and nurse manager support have also been associated with better patient outcomes including failure to rescue, infections, mortality and pressure ulcers (Boyle, 2004). A positive practice environment was found to be associated with fewer nursing concerns about the quality of care, and lower risk of mortality and failure to rescue (Aiken, Clarke, Sloane, Lake & Cheney, 2008). Nurse practice environment factors of participation in hospital affairs, foundations for quality care, nurse management leadership and support, staffing and resource adequacy and collegial nurse-physician relationships have also been correlated with quality of care and adverse events in a novel construct measuring nurse surveillance capacity (Sochalski, 2009). More recently, nurse practice environment factors of workgroup cohesion, nurse-physician relationships, procedural justice, and organizational and physical constraints were found to be correlated with nurses' assessment of patient care quality (Djukic, Kovner, Brewer, Fatehi & Cline, 2011).

Most recently, Flynn, Liang, Dickson, Xie and Suh (2012) examined the relationships among the nursing practice environment, nursing processes of intercepting medication errors, and medication error rates. The sample included 686 nurses from 82 medical–surgical units from 15 N.J. hospitals. The nursing practice environment was measured using the PES-NWI scales: (a) nurse participation in hospital affairs, (b) nursing foundations for quality care, (c) collegial nurse-physician relationships, (d) nurse manager competence and support, and (e) staffing and resource adequacy. Support for the theorized relationships was demonstrated by the positive association with four of the subscales (all but resource and staffing adequacy) and the nursing process of intercepting

medication errors, that is, the higher quality environment was associated with higher quality care. Additionally, support for the theoretical linkages among the nursing practice environment, nursing processes and patient outcomes was supported by the outcome of fewer medication adverse events (β = -0.19, p = 0.15), (Flynn et al., 2012).

Finally, the quality of the practice environment has also been linked to patient satisfaction, in diverse populations and settings, in that the better the care environment the more satisfied the patients (Aiken et al., 2012; Brooks-Carthon, Kutney-Lee, Sloane, Cimiotti & Aiken, 2011; Kutney-Lee et al., 2009; Gardner, Thomas-Hawkins, Fogg, & Latham, 2007).

In summary, these empirical studies tested and support the theorized relationship between the nursing practice environment and patient outcomes, including satisfaction, in diverse samples of nurses and patients a variety of settings. The relationship between nursing practice environment and patient outcomes of prolonged length of stay and readmissions has not been tested.

Theories of Missed Nursing Care

Savitz, Jones, and Bernard (2005) identified that process measures under the purview of nursing standards are rarely reported in the nursing sensitive outcomes literature. It is suggested that important measures to be considered include: (a) unfinished care, (b) use of standard technique, (c) prudent monitoring of invasive devices (such as IV's), (d) skin inspection, cleaning and positioning, and (e) adherence to protocols (Savitz, Jones & Bernard, 2005, p. 380). These authors specifically call for research of indicators that are sensitive to broader aspects of nursing care, such as missed nursing care as it relates to patient safety (Savitz, Jones & Bernard, 2005).

The Missed Nursing Care Model is a theoretical framework that explains the relationships among features of the practice environment, nursing processes, and patient outcomes (Kalisch & Williams, 2009). Missed nursing care is conceptualized as a process measure directly related to patient outcomes in that the quality of care is reduced when nursing care that is needed is not completed (Kalisch et al., 2011). Antecedents of missed nursing care include demands for patient care, practice environment features of material resource allocation (including needed medications, supplies and functioning equipment) and labor resource allocation (including number and type of nurses, nurse competencies, education level), inter-professional relationships, communication, and teamwork (Kalisch, Landstrom & Hinshaw, 2009). The model posits that decreased quality of communication and teamwork among and between nurses, physicians, and ancillary personnel is related to increased missed nursing care.

An important theorized antecedent to missed nursing care is priority decision making. Theorists explain that when nurses determine the elements of care that are needed for patients they incorporate available knowledge and assessments based on patient's conditions and needs and then decide and prioritize aspects of care rendered or omitted (Kalisch, Landstrom & Hinshaw, 2009). These judgments and decisions are also made in context of the practice environment, in that the changing environment influences decisions to render or omit needed patient care. The model specifically proposes that the decision and subsequent act of missing care leads to negative patient outcomes. In summary, the model posits a direct, positive relationship between missed nursing care and poor patient outcomes, and negative relationships between a supportive practice

environment and missed nursing care, enhanced communication and missed nursing care, and timely decision making and missed nursing care.

Missed nursing care, nursing practice environment and patient outcomes: Empirical support.

The nursing practice environment can influence whether needed nursing care is provided (Kalisch et al., 2009). A limited number of studies have provided early support that the relationship between nursing practice environment and improved patient outcomes are in part explained by nursing processes.

An important study by Sochalski (2004) tested the relationship between missed nursing care and patient safety outcomes. The quality of nursing care was measured by a single item measure that asked nurses to describe care they delivered on their unit on the last shift (Sochalski, 2004). Patient workload, reflective of a practice environment factor, was a measure of patients cared for by nurse respondent on their last shift. Missed nursing care was measured by a seven item RN survey that indicated if a nursing task was left undone on last shift because of time constraints. Patient safety problems was operationalized by a two item (medication errors and patient falls with injury) measure that asked the frequency of patient events while under the RN respondents care in the past year (Sochalski, 2004). Findings indicate an average of two tasks was left undone at the end of a shift (Sochalski, 2004). Quality of nursing care demonstrated the strongest independent correlation with missed nursing care, operationalized as tasks left undone, ($r = .634$, $p < 0.001$), (Sochalski, 2004, p. II-71). The structure and processes of care were related as workload was significantly associated with patient safety problems ($r = .337$, $p < 0.001$) and tasks undone and ($r = .284$, $p < 0.001$), (Sochalski, 2004). The most

variance in quality of care ratings was explained by the three predictor model (R^2 = .4340); and though patient workload (b = -.025, SEb = .002) and patient safety problems (b = -.043, SEb = .003) were significant at $p < .001$, tasks undone explained most of the variance (b = -.208, SEb = .004), (Sochalski, 2004). Notably, workload is associated with both the quality of care and tasks undone, though tasks undone exhibited a stronger relationship with the quality assessment than workload (Sochalski, 2004).

Schubert et al. (2008) extend and test the theoretical framework by explicating a care process of implicit rationing of care. The purpose was to explore the association between implicit rationing of nursing care and patient outcomes, controlling for organizational variables of nurse practice environment, staffing and workload (Schubert et al., 2008). The relationship was tested on a convenience sample of nurse and patients in eight acute care hospitals in Switzerland between 2003 and 2004 (Schubert et al., 2008). The response rate for both patients and nurses was 65%, yielding 779 and 1338 participants, respectively. The most significant finding was that higher levels of rationing care were associated with nurse reported adverse outcomes of nosocomial infections, patient falls, pressure ulcers and medication errors in both adjusted and unadjusted models. An increase in rationing by 0.5 points in unit level scores increased the odds that nurses would report the occurrence of an adverse event in the past year by 10% to nearly three times (OR= 1.10, 95% CI [1.04, 1.17]), p = 0.002), (OR= 2.81, 95% CI [1.65, 4.78]), $p < 0.001$), (Schubert et al., 2008). The NWI-R Resources subscale (which specifically includes nurse autonomy and resources) was a significant predictor in the unadjusted models of four of the five adverse events, as well as the patient outcome of satisfaction. The collaboration subscale was statistically significantly associated with one

outcome, critical incidents (*OR* = .18, 95% CI [.06, 48], *p* = .001) in the unadjusted models, (Schubert, 2008, p. 233). These findings empirically support the relationships tested in that nursing environment factors of enhanced collaboration, nursing resources and autonomy are related to improved patient outcomes that are in part explained by lower levels of missed nursing care (Schubert et al., 2008).

Al-Kandari and Thomas (2009) tested the relationship between the nursing practice environment factor of workload and elements of nursing care left undone. The study was performed in five hospitals Kuwait, using a modified questionnaire developed from the International Hospital Outcomes Consortium survey, 780 nurses participated. Important findings indicate that nursing and non-nursing workload (conducted by nurses) contributed to task incompletion. Specifically, nursing interventions of bathing, dressing changes, routine Foley care, starting or changing IV fluids and oral hygiene were more often left incomplete when the nurse workload increased (Al-Kandari & Thomas, 2009). Significant negative correlations were found between nurse-patient load and task completion. Total workload was statistically negatively associated with provision of routine foley care (r = -.11, p <= 0.005), oral hygiene (r = -.11, p <=*0.005*), starting and changing an IV (r = -.08, p <=0.05) and dressing changes (r = -.1, p <=0.005), (Al-Kandari & Thomas, 2009).

Lucero, Lake and Aiken (2010) further advanced this knowledge by empirically establishing the association between nurse's reports of unmet nursing needs, as an indicator of quality of nursing care, and adverse event outcomes. The secondary analysis of 1999 data from 168 Pennsylvania hospitals included a sample of 10,184 RN's and administrative data from 232,342 general, vascular and orthopedic surgical patients

(Lucero et al., 2010). Nursing care quality was measured by nurse report of seven nursing care needs unmet in the last shift due to time constraints; it was aggregated at the hospital level (Lucero et al., 2010). Adverse events included: (a) patient receipt of wrong medication or dose, (b) nosocomial infection or (c) patient fall with injury, measured by RN survey, categorized based on frequency of occurrence, and calculated as a proportion per hospital (Lucero et al., 2010, p. 2189). Analysis at the hospital level indicates 26% to 74% of necessary nursing care needs were unmet (Lucero et al., 2010). Multivariate regression analysis was performed to explain the evident variance in unmet nursing care needs and adverse events. This is the first empiric support for the relationship tested in that unmet nursing care needs had a risk adjusted (patient factors and care environment) effect on all reported AE's: (a) nosocomial infections (adjusted $R^2 = 0.53$); (b) patient falls with injury (adjusted $R^2 = 0.41$); and (c) wrong medication or dose (adjusted $R^2 = 0.23$), (Lucero et al., 2010). Authors suggest it may be common that 28% or greater care is left undone by nurses in hospitals, and this in turn can increase adverse events (Lucero et al., 2010).

Missed nursing care, as an indicator of inferior nursing care practices is theoretically and empirically associated with adverse patient events **(**Lucero et al., 2010; Schubert et al., 2008; Sochalski 2004; Thomas-Hawkins, Flynn & Clarke, 2008). A number of studies have demonstrated that missed nursing care processes in hospitals is both prevalent and portends certain outcomes including higher occurrence of infections and falls, new onset delirium, pneumonia, increased length of stay, delayed discharge, increased pain and discomfort, and malnourishment (Kalisch, Tschanen, & Lee, 2011; Lucero et al., 2010). This significant amount of nursing care processes missed in

hospitals spans all nursing care responsibilities including assessment (44%), interventions and basic care (73%), and planning (71%), (Kalisch, Landstrom & Williams, 2009).

Thus, though few in numbers, this early and novel line of research is beginning to suggest an explanatory mechanism between the practice environment and patient outcomes. These few studies have provided a foundation for further research; though have a common limitation of using nurse reports of adverse outcomes. Notably, there are no studies that explore the relationship between missed nursing care and outcomes of prolonged length of stay and early hospital readmissions. Further, there is a paucity of research that has specifically tested the relationship between the nursing practice environment and missed nursing care. In summary, these studies provide empirical support for the theoretical main effects that increased missed nursing care is related to increased patient adverse outcomes and decreased patient satisfaction. However, there is limited empiric support for the theoretical relationship that missed nursing care mediates the relationship between the nursing practice environment and patient outcomes.

Gaps and Limitations

In summary, the empirical literature to a large extent supports the theorized relationships among EHR adoption, the nursing practice environment, missed nursing care and patient outcomes. There is substantial evidence linking preventable adverse events to nurses and features present in their practice environment (Aiken, Smith & Lake, 1994; Meurier, 2000; Mitchell & Shortell, 1997; Sovie & Jaward, 2001). There is also evidence that nursing processes are linked to adverse outcomes and patient satisfaction.

However, significant gaps in the empirical literature exist. Across the studies the majority of outcomes are provider reports of quality care. Reasonable actions that may

mitigate, though not necessarily eliminate, the occurrence of an adverse event, reflect both provider and organizational decisions and processes, are understudied. Currently, there is limited evidence that EHR is linked to improved patient outcomes and no studies that link EHR to PLOS or early readmissions. There is some evidence that EHR is associated with improved guideline adherence and decreased documentation time, however, there are no studies that evaluate the impact of EHR on specific nursing care processes. Moreover, the relationship between missed nursing care and EHR, and evaluation of missed nursing care as an operant mechanism by which EHR relates to patient outcomes and satisfaction is untested.

There have been no studies that have tested the full model in a sample of acute hospital registered nurses and acute hospital adult inpatients. The purpose of this proposed study is to address this important gap in the empirical literature by determining the relationships among nursing practice environment, EHR utilization and functionality, and missed nursing care on patient adverse outcomes (PSIs, readmissions, and prolonged length of stay) and satisfaction.

Theoretical Rationale

This study bridges disciplines of nursing, biomedical informatics, and healthcare systems and quality; it is interdisciplinary in nature and as such the research should be based upon theoretical models that link and integrate these disciplines (Aboelela, Larson, Bakken…et al., 2007). The overarching conceptual framework that guides this study is the Quality Health Outcomes Model (Mitchell Ferketich, & Jennings, 1998; Mitchell & Lang, 2004). Outcomes models postulate a positive relationship among organizational structure, processes of care and patient outcomes. That is, higher quality nursing care

processes when rendered, are theorized to be an important operant mechanism that explains the relationship between the organizational structure and decreased occurrence of adverse events, decreased readmissions, decreased length of stay, and increased patient satisfaction.

Consistent with the QHOM, Huber's (1990) theory of advanced information technology also posits that technology can contribute to better outcomes. As early as 1990, Huber explains that the use of advanced information systems results in more rapid and accurate communication and more rapid and higher quality decisions, thus promoting positive outcomes. Nursing practice environment models propose that factors that enhance communication and improve the worklife of nurses will improve the role effectiveness of nurses, and in turn result in positive patient outcomes (Aiken et al., 2002, Laschinger & Leiter, 2006).

Nearly fifteen years after this model was presented there is a call that near misses (an act of omission or commission that could harm a patient but did not) should be examined in context of nursing processes and the technology that can prevent near misses (Bakken, 2006). Nearly fifteen years following this call, the Missed Nursing Care Model (Kalisch, Landstrom, & Williams, 2009) specifically explains the importance of good communication and decision-making processes to high quality nursing practice, proposing that the absence of these crucial factors contributes to missed or omitted nursing care. At the same time, the conceptual model for Technology, Nursing, and Patient Safety further indicates that nursing processes that are supported through EHR will result in improved patient outcomes (Powell-Cope et al., 2008). A significant gap in

the empiric literature persists as these theoretical relationships remain untested, despite remaining salient over time.

This study will broaden significantly the empirical testing of elements of the QHOM, which guides this work. Derived from a synthesis of theoretical propositions and adapted to the QHOM model, Figure 2 details the system, intervention and outcome features that will be examined.

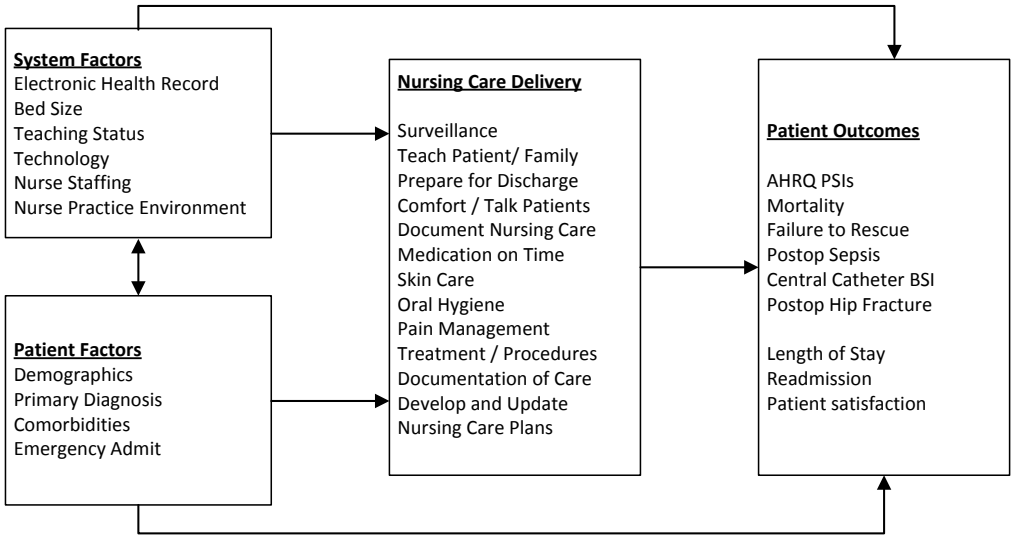


Figure 2. Conceptual model guiding this study. Adapted from "Quality Health Outcomes Model," by P. Mitchell, S. Ferketich, and B.M. Jennings, 1998, Quality Health Outcomes Model, *Journal of Nursing Scholarship, 30*(1), p.44

In summary, conceptual models propose positive relationships among the practice environment, technology, quality nursing care practices, and positive patient outcomes (Mitchell, Ferketich & Jennings, 1998). Theory and conceptual models also propose a positive relationship between advanced information technology, such as an EHR and quality nursing care processes (Huber, 1990; Powell-Cope et al., 2008). Conceptual models explain that EHR, through the enhancement of communication and more timely decision processes, reduces missed nursing care, thus supporting a negative relationship

between EHR and missed nursing care (Kalisch, 2006; Kalisch, Landstrom & Hinshaw, 2009; Kalisch, Landstrom & Williams, 2009). Significant gaps in the literature persist, importantly testing missed nursing care as a mediating factor between EHR adoption, nursing practice environment and patient outcomes will add to the empirical literature. Therefore, derived from the theoretical and empirical literatures this study will test the following hypotheses.

Hypotheses

1. The use of EHR is inversely related to the occurrence of adverse patient events in acute care hospitals.
2. The use of EHR is positively related to patient satisfaction in acute care hospitals.
3. A supportive nursing practice environment will be inversely related to occurrence of adverse patient events in acute care hospitals.
4. A supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals.
5. The use of EHR is inversely related to missed nursing care in acute care hospitals.
6. A supportive nursing practice environment is inversely related to missed nursing care in acute care hospitals.
7. Missed nursing care is positively related to occurrence of adverse patient events in acute care hospitals.
8. Missed nursing care is inversely related to patient satisfaction in acute care hospitals.

9. Missed nursing care will mediate the relationship between the nursing practice environment and occurrence of adverse events.
10. Missed nursing care will mediate the relationship between EHR adoption and occurrence of adverse patient events.
11. Missed nursing care will mediate the relationship between EHR adoption and patient satisfaction.

CHAPTER III

Methods

This study used a cross-sectional design to test the relationships among: (1) EHR adoption; (2) the nursing practice environment; (3) missed nursing care; and (4) the patient outcomes of adverse events and satisfaction with inpatient care in a large sample of patients from acute care hospitals in New Jersey. This chapter presents the research design, setting, sample, instruments, procedure for data collection, and management.

Research Design

This is a secondary analysis of cross-sectional data of nurses, patients and hospitals in New Jersey. This study examined the determinants of adverse health care outcomes of hospitalized adults, specifically EHR adoption, nursing practice environment and workforce factors such as staffing and skill mix, and missed nursing care. The nurse measures were derived from a 2006 survey of registered nurses in New Jersey. Data were available from more than 7,000 RN's working in 72 New Jersey hospitals that include detailed information on nurse demographics, workplace characteristics, and the quality of care. Patient outcomes data on approximately one million patients discharged from New Jersey acute care hospitals in 2006 were available for analysis. The outcomes of interest were extensive and included nursing-sensitive Patient Safety Indicators, length of stay, readmission, and patient satisfaction. The analytic approach used ordinary least squares and multivariate regression models that were appropriately matched to the outcomes of interest.

The primary outcomes were patient outcomes (nurse-sensitive PSI's, LOS, readmission, and patient satisfaction). A secondary outcome was missed nursing care.

The primary predictor in both models was adoption of the electronic health record (EHR). Secondary predictors included nurse staffing, nurse educational attainment, the nursing practice environment; missed nursing care was a secondary predictor in the patient outcome models. Additional covariates included hospital characteristics (bed size, teaching status, and hospital technology level). In the models that examined patient outcomes additional covariates included those used in risk adjustment (i.e. patient demographics, comorbid illness).

Research Setting

This secondary analysis of existing data was conducted at Rutgers University, College of Nursing (CON) and The Center for State Health Policy (CSHP). The setting included the infrastructure and resources of the CON and the CSHP. Additionally, expert consultation was provided by an experienced statistician, who has an earned PhD in statistics, following completion of data use agreements and obtaining IRB approval.

Samples

The study design was aimed at a patient population that included adult patients in New Jersey hospitals, and a nurse population that included adult nurses in New Jersey. Individuals under the age of 21 were excluded from this study as the research topic studied examines adult patients as well as nurses who are typically older than 21 years of age. No gender, racial or ethnic groups were excluded. The study used existing data as such there was no recruitment for additional subjects.

Nurse Sample.

In this study, "nurses" refers exclusively to registered nurses (RNs) in acute hospitals providing inpatient care at the bedside. Detailed information about staffing

levels for all types of nursing personnel including licensed practical/vocational nurses and unlicensed assistive personnel from nurse survey data were available. The sample was drawn from a list of all RNs that was obtained from the New Jersey Board of Nursing. The sampling frame included all licensed nurses who held an active RN license and had a mailing address in New Jersey. A 50% sample of New Jersey nurses was surveyed, and 50% of the randomly selected nurses completed and returned the survey. In total 7,805 hospital staff nurses responded to the survey. A random sample of registered nurses actively licensed and residing in the state of New Jersey constitute the nurses in this study. This sample is representative of the nurse population in New Jersey. Over 97% of the nurses in our sample are women, 34% are non-white and 7% are Hispanic or Latino.

Hospital Sample.

Data were obtained from the 72 general acute care hospitals for the year 2006 in New Jersey. Admissions to psychiatric and non-acute care hospitals were excluded from this analysis. As in previous work, (Aiken, Clarke, Sloane, Sochalski, & Silber, 2002) hospitals with less than 50 admissions and 10 nurse survey respondents were excluded from the sample. The sample of hospitals used in the study includes large and small hospitals, teaching and non-teaching hospitals, and hospitals that differ in terms of the level of technology, as well as in terms of the nursing characteristics of interest (i.e., staffing, nurse education and nursing practice environment).

Patient Sample.

Outcomes were examined for medical patients admitted with the following primary acute diagnoses: myocardial infarction, stroke, gastrointestinal bleeding,

congestive heart failure, and general surgery patients, which include general, orthopedic, vascular surgical procedures. Patients with these diagnoses were selected because they are common and well represented in most hospitals, and they comprise a significant proportion of hospital discharges. The selected medical conditions have a higher mortality rate then general surgery patients. Women and minorities are represented similarly to their population distribution. Approximately 32% of hospitalized adults in the database are non-white and 12% Hispanic or Latino. Patient outcomes data covers the 13-month period that encompasses the 2006 nurse survey.

To explore patient outcomes using regression techniques and the probability of a Type 1 error set at 0.05, it was estimated that 80% power to find a 10 percent difference in an outcome required a sample of approximately 8,200 cases; the power calculation indicated sufficient power and sample to detect differences. All of the above estimates were derived from tables described by Hsieh (Hsieh, 1989).

Data Sources and Procedures

Data from the patient discharge summary and hospital nurses were aggregated to the hospital level. All data were from 2006 and compiled from four sources: (1) patient mortality and non-mortality adverse events was derived from the State Inpatient Database (SID) available from the Agency for Healthcare Research and Quality, (2) Healthcare Information and Management Systems Society (HIMSS) Dorenfest Institute database provided metrics on EHR adoption, (3) Centers for Medicare and Medicaid Services data from the Hospital Consumer Assessment of Healthcare Providers and Systems Survey (HCAHPS) provided metrics on patient satisfaction, and (4) New Jersey nurse surveys

provided data on staffing, nursing practice environment, and details on the delivery of nursing care.

Primary data on nursing care.

The New Jersey nurse survey data were collected in a previous study conducted by Dr. Linda Flynn as Principal Investigator. Nurses were surveyed using a modified Dillman method (Dillman, Smyth, & Christian, 2009) to create empirical measures of the delivery of nursing care, particularly care that was left undone due to lack of time to complete it. Additional measures include features of hospitals' care environments and the percent of a hospital's nurses qualified at the baccalaureate level. Nurses were asked a series of questions on demographics, current hospital practice, and the name of their employing hospital. All responses were aggregated across nurses to produce hospital-level measures on missed nursing care and associated information on every adult acute care hospital in New Jersey. Measures of patient-to-nurse ratios and nursing skill mix were also derived from the nurse survey,

Secondary data on staffing and other hospital characteristics.

Data on hospital characteristics were obtained from the NJ nurse survey and the State Inpatient Database (SID). Data on staffing were available from NJ nurse survey and measured as hours of registered professional nurse, licensed practical nurse, unlicensed assistive, and unit clerical services personnel by unit type for each hospital in New Jersey. Data on medical residents were reported as the number of trainees in each postgraduate year (1-6), and the hours of medical resident care provided by specialty.

Data on EHR adoption were obtained from the 2006 HIMSS Analytic Database. HIMSS annually surveys a sample of U.S. nonfederal acute care hospitals including

independent hospitals and those that are part of a health care delivery system. HIMSS it the most comprehensive collection of information technology currently available providing data on more than 5,100 hospitals and has been used in previous research on health information technology (Kazley & Ozcan, 2008; McCullough, Casey, Moscovice, & Prasad, 2010).

Data on patient satisfaction were obtained from HCAHPS. The Centers for Medicare and Medicaid Services (CMS) and AHRQ partnered to develop and sponsor HCAHPS. This is the first national standard for collecting and publically reporting patient perceptions of care and has been endorsed by the National Quality Forum. A survey for measuring patient satisfaction, HCAHPS categories focus on communication with doctors and nurses, responsiveness of hospital staff, pain management, cleanliness and quietness of the hospital environment, and instructions about medications and discharge.

The State Inpatient Database (SID) from the Healthcare Cost Adoption Project (HCUP) contains inpatient discharge abstracts from New Jersey hospitals. The SID contains more than 100 clinical and nonclinical data elements such as: facility identification number, patient demographics, admission and discharge information, payment source, total charges, and length of stay. In addition, *International Classification of Diseases, 9th edition, Clinical Modification* (ICD-9-CM) codes are recorded for both the principal diagnosis and principal surgical procedures. An expanded number of diagnosis and procedure codes and clear demarcation of presenting and secondary (comorbid) diagnoses are unique and important features of the discharge data that permit enhanced risk adjustment.

Instruments and Measures

Electronic health record (EHR).

EHR data has been grouped into five categories based on stage of adoption (Appari, Johnson & Anthony, 2013; Garets & Davis 2008; Jha et al., 2009), (Table 1). Hospitals at EHR Stage 0 may have some clinical systems in place but are considered rudimentary and do not have all three basic ancillary systems installed. Hospitals at EHR Stage 1 have adopted all three core ancillary department information systems (laboratory, radiology, pharmacy). Hospitals at EHR Stage 2 have adopted all of EHR Stage 1 applications and additionally have clinical data and decision support systems. Hospitals at EHR Stage 3 have adopted all of EHR Stage 1 and EHR Stage 2 applications as well as nursing and clinical documentation and order entry management. Hospitals at EHR Stage 4 have achieved all the preceding stages and have Computerized Physician Order Entry (CPOE) and advanced clinical decision support (clinical protocols). This classification is based on the HIMSS Electronic Medical Record Adoption Model (EMRAM) described by Garets and Davis (2008), and the taxonomy developed by an expert consensus panel (Jha et al., 2009). The internal consistency of the HIMSS EMR Adoption model has been reported at .99 (Kazley, Diana, & Menachemi, 2011).

Table 1

Stages of Electronic Health Record Adoption Used in This Study

Level	**Cumulative Capabilities**
Stage 0	All three ancillaries not installed: laboratory, radiology, pharmacy
Stage 1	All 3 ancillaries installed: laboratory, radiology, pharmacy
Stage 2	Clinical data repository (CDR), controlled medical vocabulary, clinical decision support system (CDSS), health information exchange (HIE) capable, may have document imaging and Stage1 applications
Stage 3	Nursing and clinical documentation (flow sheets), CDSS (error checking), picture archiving and communication systems (PACS) available outside of radiology and Stage 1 and 2 applications
Stage 4	Computerized Physician Order Entry (CPOE), Clinical decision support (clinical protocols) and Stage 1, 2, and 3 applications

Nursing practice environment.

Nursing practice environment was measured using the Practice Environment Scale of the Nursing Work Index (PES-NWI) a 5 domain, 31-item 4-point Likert-type (ranging from strongly disagree to strongly agree) instrument that asks nurses to characterize the presence of features in their work environment. Scores were aggregated to the hospital level as subscales and total score. Subscales from the PES-NWI (31 items) used in this study to characterize nurse practice environment include: nurse participation in hospital affairs (9 items), nursing foundations for quality care (10 items), nurse manager ability, leadership, and support of nurses (5 items), staffing and resource adequacy (4 items), and collegial nurse-physician relations (3 items) (Lake, 2002). Published internal consistency coefficients (Cronbach's alphas) for these subscales range from .71 to .84. Intraclass correlation coefficients, reflecting the reliability of each nurse respondent's scoring of the PES-NWI within his or her institution (or the reliability of nurses' assessments of judgments of their hospitals) for the last 2 subscales were from .86 to .96, well within the range of generally-accepted values. Similar values are found with a composite measure. Composite and subscale scores were aggregated to the hospital level. Values above 2.5 indicate general agreement that the characteristics measured are present in the practice environment, whereas values below 2.5 indicate they are absent (Lake & Freise, 2006).

Missed nursing care.

Nurses were asked to identify care activities on their last shift that were necessary, but left undone due to lack of time. These 12 nursing care needs were: (1) adequate surveillance (direct observation/monitoring) of patients, (2) teach patients or family, (3)

prepare patients and families for discharge, (4) comfort/talk with patients, (5) adequately document nursing care, (6) administer medications on time, (7) skin care, (8) oral hygiene, (9) pain management, (10) treatment and procedures, (11) adequately document care, and (12) develop or update nursing care plans.

In addition to the individual measures a nursing care needs composite measure was constructed as an indicator of nursing care quality, as the care needs left undone cannot be directly matched to individual patient outcomes (Lucero et al., 2010; Sochalski 2004). The composite measure was calculated as the average count of the 12 nursing care activities left undone by each nurse respondent. These individual composite measures were then aggregated for each hospital, resulting in a percentage of unmet nursing care needs per hospital. Construct validity of this unmet nursing care needs measure has been demonstrated in that scores have been found to be associated in the theoretically expected direction with RN staffing, quality of care, and frequency of adverse events in hospitals (Sochalski, 2001, 2004). The Unmet Nursing Care Needs composite has an internal reliability coefficient of 0.73 and has been used as a metric in other high-impact studies.

Length of stay (LOS).

Average length of stay for patients has been constructed as a continuous variable. However, the measure of "prolonged" length of stay was also calculated, which could have advantages as a measure of hospital performance, and it could have advantages for measuring the impact of nursing care delivery. The interpretation of a continuous variable measuring length of stay is not always clear. The slower hospital may be less efficient but provide care of equal quality, or the slower hospital may be providing better

quality of care that simply requires more time. It is also feasible that the slower hospital may have longer length of stay because of complications resulting from poor quality of care. Therefore, as in previous work (Silber et al., 2008) "prolonged length of stay" (PLOS) was computed as well as the more conventionally measured length of stay.

PLOS was operationalized as the number of hospitalization days by which a patient's stay is considered prolonged by identifying the prolongation point. The prolongation point for hospital discharges was computed as described by Silber et al., (1999, 2003, 2009) and defined as the day after the day of discharge deceleration, as identified by Kernel-Density plots. This method determines the hospitalization day at which the hazard rate for discharge begins to decline (Silber, 2003, p. 870). The patient's hospital stay was therefore considered prolonged if it exceeded the prolongation point.

Patient adverse events.

There is evidence that discharge-based PSI's are a useful screen for organizations and policy makers to identify hospital level safety problems (McDonald et al., 2002). PSI's were operationally defined as the presence of select nursing sensitive adverse events as defined by AHRQ (Table 2). The outcome data of select Patient Safety Indicators (PSIs) was derived from 2006 New Jersey SIDS data. Nursing-sensitive PSI's included in analyses were: (1) death in low-mortality diagnosis related groups (DRG); (2) death among surgical inpatients; (3) postoperative sepsis; (4) central venous catheter-related blood stream infection; and (5) postoperative hip fracture. Each indicator was defined by selected diagnosis or procedure codes that suggest the occurrence of an adverse event. Many PSI indicators have specific exclusions to reduce the likelihood of false positive cases. The measures included were calculated based on guidelines from the

AHRQ Guide to Patient Safety Indicators that specifies the method by which each measure is calculated, the DRGs, ICD-9-CM codes included in each measure, and appropriate risk-adjustment methodologies (see risk adjustment below).

Table 2

Patient Outcomes Examined in this Study

PSI 02	Death in low-mortality diagnosis related groups (DRGs)
PSI 04	Death among surgical inpatients
PSI 13	Post-operative sepsis rate
PSI 07	Central venous catheter-related blood stream infection
PSI 08	Post-operative hip fracture rate
	Length of Stay
NQF 0330	Hospital 30-day, all cause, heart failure readmission*
NQF 0166	Patient perspective of care-HCAHPS

Note. PSI = Patient Safety Indicator; NQF = National Quality Forum, *= 7 day readmission as provided by HCUP (see analysis)

Patient satisfaction.

Patients' satisfaction with care was measured using publically available HCAHPS survey results. HCAHPS is a national, standardized database of patients' hospital experiences in short-term, acute care hospitals. The 27-item survey is reported as a set of ten measures (6 summary measures, 2 single items and 2 global ratings) related to: (a) communication with nurses and doctors, (b) responsiveness of hospital staff, (c) pain management, (d) communication about medicines, (e) discharge information, (f) cleanliness and quietness of the hospital environment, (g) overall rating of the hospital and (h) willingness to recommend the hospital to friends and family. Individual patient responses are aggregated and risk-adjusted for patient mix and mode of administration. HCAHPS has seven hospital-level subscales with established reliability ranging from 0.62 to .89 and correlation coefficients ranging from 0.53 to 0.76.

Readmissions.

Hospital readmissions often represent an adverse event and additional hospital expenses, and are an additional event that payers will not reimburse. The readmission measure is a modified version of the Centers for Medicare and Medicare Services (CMS) Risk-Standardized Heart Failure Readmission Measure, and was used to examine readmission to any hospital, from all causes, within seven days from discharge.

Nurse demographic and employment characteristics.

Specific demographic characteristics of the nurse respondents include sex, age, race/ethnicity, highest level of nursing education, country where nurses received their basic nursing education, specialty certification, and time since first licensure as a nurse. Information was available on work patterns including full-time or part-time employment,

primary or secondary employment with a hospital float-pool or agency per diem or traveler position. Nurses were asked to identify their race from eight categories: (1) white, (2) black, (3) Filipino, (4) American Indian, (5) Asian, (6) native Hawaiian/ Guamanian/ Samoan/other Pacific Islander, (7) mixed, and (8) other, and if they are of Hispanic/Latino origin.

Nurse education.

Data on the educational attainment of individual nurses are not available through secondary data sources. Therefore, detailed information on the educational attainment of each nurse was obtained through the survey. Nurses were asked to identify the type of program that led to their initial RN licensure, and the highest degree they hold in nursing. Response categories include: (1) diploma, (2) associate degree, (3) baccalaureate degree, (4) master's degree, and (5) doctoral degree. In the analyses, due to the small number of nurses with advanced degrees, the categories baccalaureate, master's and doctoral degree were collapsed to create a variable baccalaureate and higher.

Nurse workload.

Each nurse was asked to report the number of patients she/he cared for during the last shift. For this study, an aggregate of these reports across all medical and surgical nurses in a given hospital was calculated to estimate the average hospital nurse workload. Direct survey measure of the number of patients cared for may be superior to other data sources in predicting patient outcomes, possibly because it includes only nurses in inpatient direct care roles. The predictive validity of this method of measuring hospital nurses' workloads has been described elsewhere (Aiken et al., 2008; Aiken et al., 2002).

Hospital structural characteristics.

The analytic models included a number of hospital structural characteristics derived from NJ nurse survey including: (1) hospitals without any post graduate medical residents or fellows (non-teaching) distinguished from 1:4 or smaller trainee-to-bed ratio (minor teaching) and those with higher than 1:4 (major teaching), (2) bed size stratified as <100 beds, 101-250 beds, and >251 beds, and (3) high technology hospitals identified as are those facilities that provide services for open-heart surgery, organ transplantation, or both.

Additionally, each hospital included in this study was categorized into one of five geographic categories based on United States rural-urban continuity codes (Rural-Urban Continuum Codes) of the county where the hospital is located. Hospitals located in the central county of a Metropolitan Statistical Area (MSA) of more than 1,000,000 people were classified as "metropolitan" hospitals. Those hospitals located in suburban, or ring counties, of an MSA greater than 1,000,000 people were classified as "suburban." "Moderate urban" hospitals were located in an MSA between 250,000 and 1,000,000 people. "Small urban" hospitals were located in an MSA less than 250,000 people. "Rural" hospitals were those hospitals located in counties outside of a MSA.

Procedure for Data Collection and Management

The rights of human subjects were protected by obtaining approval from the Institutional Review Board (IRB) of Rutgers, The State University of New Jersey prior to data analysis. This study poses no risk to patients or nurses. The following data were publically available: (1) State Inpatient Database (SID) available from the Agency for Healthcare Research and Quality (AHRQ); (2) Healthcare Information and Management Systems Society (HIMSS) Dorenfest Institute database of EHR adoption; and (3) Centers

for Medicare and Medicaid Services (CMS) data from the Hospital Consumer Assessment of Healthcare Providers and Systems Survey (HCAHPS). In the publically available datasets all personal identifiers were removed prior to release to the public.

The nurse survey data used in this study were granted by Dr. Linda Flynn, Principal Investigator of the original study. There were no contractual obligations. All nurse-survey data were de-identified. Additionally, no links to hospital names were processed, all data were scrubbed prior to processing, and no links were available. Thus, there were no identifiers that link data origination to the hospital name from which it was originated.

All data were obtained by the investigator from the sources described above and stored electronically on a pass-word protected desktop computer behind a secure firewall. Computer files were backed up onto a portable encrypted external drive and kept in a locked cabinet. These data were then transferred and stored on secured servers in the College of Nursing at Rutgers University, Newark, NJ and the Rutgers Center for State Health Policy, New Brunswick, NJ. All patient and nurse survey data were secured and accessible only to the researcher, a data analyst and statistician. HCUP has clear guidelines for the use of their de-identified patient data that were scrupulously followed. Every precaution was taken to ensure that data regarding specific hospitals could not be linked to the institutions' names, including omitting hospital names from all working analytic files.

Data integration methods included a cross-walk based on hospital identifiers; the common identifier was then used to link all datasets. Datasets were constructed using information from the sources previously mentioned to address the aims of this study.

Initially, separate patient level data sets for each medical condition and surgical procedure of interest were assembled. The datasets included all patients discharged from hospitals in New Jersey with the conditions or procedures, plus all additional patient characteristics, as well as characteristics of the hospitals to which the different patients were admitted, including the measures of EHR adoption, the delivery of nursing care, staffing and nursing practice environment derived from the nurse surveys.

Hospital level data from HIMSS Analytics and the nurse survey were linked with the patient data, to provide information such as level of EHR adoption, hospital size, location (urban, rural), teaching status, and nurse staffing and skill mix. The nurse survey data provided, after individual nurses responses were aggregated to the hospital level and adjusted for differences in nurse characteristics that might vary across hospitals and affect responses, additional information on the delivery of nursing care. Additional staffing and skill mix variables from these surveys were derived, since nurses were queried about these characteristics of the unit on which they work. For all the different condition-specific groups of patients, identified based on ICD-9-CM codes in the discharge abstracts in the SID, information on in-hospital mortality and non-mortality adverse events was employed in the analysis below. A descriptive analysis of demographic characteristics was conducted to describe the sample characteristics.

Control variables.

Theoretical and empirical literatures indicate that several other factors are associated with adverse patient events and patient satisfaction with inpatient care. Therefore, the relationships between these factors and the dependent variables of interest were explored in this study, and their effects were controlled if indicated. Additionally,

relationships between these factors, or control variables, and the study's predictor variables were assessed for multicollinearity prior to model testing. These control variables included: (1) nurse staffing levels, operationally defined as the ratio of patients to nurses in each hospital; (2) hospital size, operationalized as less than or equal to 100 beds, 101 to 250 beds, or greater than or equal to 250 beds; (3) teaching status, operationalized as the trainee-to-bed ratio, (number of medical residents and fellows) and categorized as minor teaching (less than 1:4 residents to trainee ratio) or major teaching (greater than 1:4 ratio); (4) high technology status, operationally defined as facilities with open-heart surgery, major organ transplant, or both; (5) hospital geographic categories, operationally defined based on United States rural-urban continuity codes (Rural-Urban Continuum Codes) of the county where the hospital is located; and (7) nurse education, operationally defined as less than or a baccalaureate degree or higher. Additionally, patient risk adjustment covariates used in this study included ICD9-CM primary and secondary diagnosis codes, age, sex, race, and insurance type, operationalized using the AHRQ risk adjustment method, based on the Elixhauser method, including a comprehensive set of 30 comorbidities (Elixhauser, Steiner, Harris & Coffey (1998). Finally, clustering of patients within hospitals was controlled.

Risk adjustment.

The risk adjustment covariates used in this study include ICD9-CM primary and secondary diagnosis codes, age, sex, race, and, insurance type. This AHRQ risk adjustment method was based on the model developed by Elixhauser, Steiner, Harris and Coffey (1998). The Elixhauser method includes a comprehensive set of 30 comorbidities and has been shown to outperform other approaches (Stukenborg, Wagner, & Connors,

2001). This is achieved through the use of medical diagnostic category (MDC), DRGs and comorbidities included in the SID and are applied to each rate by the PSI software (version 3.1). For patients with AMI, additional adjustments were made based on the anatomic location of the AMI. For patients with stroke, adjustments for hemorrhagic and ischemic events were made.

Hospital clustering.

Clustering is problematic in that it may result in inaccurate standard errors (underestimated) and inflated test statistics, as such the clustering of patients within hospitals is important to control for in statistical analyses. Because of similarities in practice patterns within hospitals and differences in organization across hospitals, patients treated at the same hospital are more likely to receive similar care than patients treated at different hospitals. Without adjusting for these similarities, standard errors may be inaccurate depending on the correlation between patient outcomes in each hospital cluster. Therefore, appropriate measures were taken in analysis to account for clustering of patients (Wears, 2002).

CHAPTER IV

Analysis of the Data

The purpose of this study was to address important gaps in the empirical literature by determining the relationships among the nursing practice environment, EHR adoption stage, missed nursing care, patient satisfaction, and adverse patient outcomes. Adverse patient outcomes were operationalized as select AHRQ Patient Safety Indicators (PSI), length of stay, prolonged length of stay, and hospital readmissions. Study data were compiled from four sources including: (1) the Healthcare Cost and Utilization Project (HCUP) State Inpatient Database (SID) available from the Agency for Healthcare Research and Quality (AHRQ), (2) Healthcare Information and Management Systems Society (HIMSS) Dorenfest Institute database of EHR adoption, (3) Centers for Medicare and Medicaid Services (CMS) data from the Hospital Consumer Assessment of Healthcare Providers and Systems Survey (HCAHPS), and (4) New Jersey nurse survey data. The final analytic sample consisted of 854,258 patients and 7,679 nurses in 70 New Jersey hospitals. The following metrics were used: (1) adverse PSI events were measured using the SIDS PSI algorithm (version 3.1); (2) patient satisfaction was measured using HCAHPS survey scores (3) the nurse practice environment was measured using the Practice Environment Scale- Nursing Work Index (PES-NWI), (Lake, 2002) from the nurse survey data; (4) missed nursing care was measured using reliable and tested items from the nurse survey (Lucero et al., 2010; Sochalski, 2001, 2004); (5) EHR adoption stage was measured using the EMR Adoption Model (EMRAM) scale (Garets & Davis, 2008; HIMSS, 2008). Analysis of the data from this study is presented in this chapter.

Statistical Description of the Study Variables

Descriptive statistics of the independent and dependent patient, nurse and hospital study variables are presented in Tables 3-6.

Table 3

Characteristics of Patients included in Analyses of Adverse Events (N = 854,258)

Characteristic	*No. (%)*
Age, mean (SD)	59.01 (20.35)
Gender	
Female	507,634 (59.4)
Male	346, 616 (40.5)
Race	
White	560,401 (65.6)
Black	137,151 (16.0)
Hispanic	97,815 (11.5)
Other	45,732 (5.4)
Insurance Status	
Insured	705,618 (82.6)
Not insured	97,385 (11.4)
Medicaid	51,255 (5.9)
Medical History (comorbidity*)	
Alcohol abuse	29,822 (3.1)
Blood loss anemia	20,584 (2.2)
Deficiency anemia	89,020 (9.4)
Congestive heart failure	68,073 (7.2)
Chronic pulmonary disease	145,744 (15.5)
Coagulation deficiency	22,533 (2.4)
Depression	48,817 (5.2)
Diabetes, uncomplicated	145,035 (15.4)
Diabetes, complicated	31,272 (3.3)
Drug abuse	31,435 (3.3)
Hypertension	392,171 (4.2)
Hypothyroidism	61,446 (6.5)
Fluid and electrolyte disorders	143238 (15.2)
Neurological disorders	53,963 (5.7)
Obesity	40,451 (4.3)
Peripheral vascular disease	31,462 (3.3)
Psychoses	24,717 (2.6)
Renal failure	78,833 (8.3)
Valvular disease	38,368 (4.1)

*Other comorbidities used to risk adjust included weight loss, peptic ulcer disease, solid tumor without metastasis, pulmonary circulation disorders, paralysis, metastatic cancer, lymphoma, liver disease, rheumatoid arthritis/collagen vascular diseases and AIDS/HIV. All of these were exhibited by fewer than 2% of all patients. Percentages may not equal 100 due to missing data.

Table 4

Characteristics of Nurses and Hospitals: Descriptive Statistics

Characteristics	No. (%)
Nurses (N=7,679)	
Nurse Education (%BSN)	3400 (44.3)
Nurse staffing (Patients/Nurse, mean SD)	6.69 (1.14)
Nursing certification	4010 (52.2)
Hospitals (N= 70)	
Bed Size	
<100	2 (2.8)
101-250	31 (44.3)
>250	37 (52.9)
Technology Status	
Not high tech	52 (75.3)
High tech	17 (24.3)
Teaching Status	
None	32 (46.4)
Minor	30 (43.5)
Major	7 (10)

Note. Percentages may not equal 100 due to missing data.

Table 5

Descriptive Statistics of Patient Outcomes by Hospital

Outcome Variable	*M*	*SD*	*Range*
Adverse Events (*N* =70)			
Death in low-mortality DRG's (PSI 2)	0.80	0.88	0 to 4.92
Failure to rescue (PSI 4)	119.67	25.72	54.1 to 173.91
Central venous catheter-related blood stream infection (PSI 7)	2.48	1.36	0 to 6.44
Postoperative hip fracture (PSI 8)	0.21	0.37	0 to 1.59
Postoperative sepsis (PSI 13)	16.99	15.91	0 to 75.94
Readmission within 7 days of discharge*	0.13	0.20	0 to 0.90
Length of Stay (LOS)	5.27	0.77	3.88 to 8.39
Prolonged Length of Stay (PLOS)	0.49	0.05	0.39 to 0.72
Patient Satisfaction (*N* =41)			
MD communicates well	77.1	3.1	68 to 83
RN communicates well	72.0	5.0	60 to 80
Receive help quickly	56.2	6.7	40 to 69
Pain well controlled	66.1	4.5	56 to 74
Medications explained	53.9	5.3	42 to 63
Environment clean	65.5	7.2	45 to 82
Environment quiet	47.5	5.1	33 to 60
Given discharge information	74.6	4.5	61 to 83
High rating for hospital (9-10)	59.1	8.3	36 to 76
Definitely recommend hospital	64.3	9.8	36 to 84

*Readmissions N = 49.

Note. PSIs expressed in rates per 1,000 discharges, length of stay (LOS) measured in average days per hospital. Other outcomes expressed as an average of the mean number of events per hospital patient population. Patient satisfaction responses are "top box;" highest rating or response of "always."

Table 6

Descriptive Statistics of Predictors by Hospital (N = 70)

Variable	*M*	*SD*	*Range*
Composite Nursing Practice Environment	2.69	0.19	2.23 to 3.08
Subscales			
Staffing and resource	2.43	0.23	1.86 to 2.88
Foundations for quality	2.96	0.18	2.47 to 3.32
Nurse-physician relations	2.84	0.19	2.25 to 3.15
Hospital affairs	2.6	0.26	1.9 to 3.17
Nurse manager leadership	2.58	0.19	2.04 to 3.00
Missed Nursing Care	0.17	0.04	0.10 to 0.27
EHR Adoption Stage	2.05	1.39	0 to 4

Note. Nursing practice environment measured on 1-4 scale with >2.5 indicating better work environment. Missed nursing care is average of 12 possible tasks left undone such that higher number indicates more necessary care left undone (each item missed = 0.083). EHR adoption scale 0-4 with higher number indicating more advanced implementation.

Data Management

Prior to analysis, all datasets were aggregated to the hospital level. Assumptions associated with the estimation of linear regression models include linearity, independence, normality and equality of variance and were met as outlined below (Kutner, Nachtsheim, Neter, & Li, 2005). The distributions of study variables were assessed for normality using both graphical and numerical theory and descriptive methods. These include histograms, normal probability plots (NPP), and Skewness–Kurtosis tests by Shapiro-Wilk. Adverse patient outcomes were positively skewed and demonstrated a non-normal distribution, with the exception of failure to rescue. Therefore, nonparametric tests of correlation using Spearman rank order statistics were used to test the relationship of these adverse outcomes with potential confounding variables. Examination of the patient satisfaction (HCAHPS) outcomes using the Shapiro–Wilk test of normality indicated that these outcomes were normally distributed, and therefore Pearson correlations were performed to explore relationships with the independent variables. Scatterplot matrix graphs were generated and relationships were examined between each independent variable (nursing practice environment, missed nursing care, and EHR adoption stage) and each dependent variable. Visual inspection of the data did not show evidence of bimodal distribution.

Data were assessed for outliers and missing data and addressed as follows. In this study, consistent with the literature, the nurse staffing measure was calculated as the mean patient load of medical-surgical unit nurses who reported caring for no more than 20 patients on the last shift worked (Aiken, Clarke, Sloane et al., 2002; Friese, Lake, Aiken, Silber & Sochalski, 2008). That is, the staffing measure excluded the outliers of

reports of greater than 20 patients cared for on the last shift. Two hospitals from the sample were excluded from the readmission analysis due to incomplete data, resulting in a sample of 49 hospitals in the analysis of this variable.

Dependent variables were represented by continuous-level data; therefore, linear regression models were constructed to test the hypotheses. For these regression models, the sample sizes were sufficient to ensure that the models were robust to concerns of non-normality and non-linearity by means of the central-limit theorem. Rules on number of predictor variables were followed such that for a linear regression model, the number of variables in a multivariable model did not exceed the number of observations divided by 10. Finally, the distribution of the residuals were examined to ensure linear model assumptions were met (i.e. errors follow a normal distribution and are independent).

Because nurse, patient, and EHR data were clustered in hospitals, this study employed appropriate statistical methods for analyzing clustered data (Wears, 2002). This advanced method entailed reducing the remaining individual observations within hospital clusters to a summary measure, expressed as a cluster mean or proportion. Standardizing the cluster level summary statistics improves the ability to adjust for individual-level covariates (Wears, 2002). The three key independent variables, (1) nursing practice environment and (2) missed nursing care, and (3) EHR adoption stage are hospital-level measures. Nurses' reports of the work environment and missed nursing care, although collected at the individual nurse level, are customarily aggregated to produce a hospital-level metric (Aiken, Cimiotti, Sloane, Smith, Flynn & Neff, 2011). Although hospital-level aggregation can dramatically reduce sample size, it is theoretically and statistically appropriate for clustered data.

With respect to the measure of Prolonged Hospital Stay (PLOS), the concept of PLOS is theoretically defined as the beginning of the deceleration in the rate of patient discharge from a hospital (Silber et al., 1999; Silber, et al., 2009). Measures of PLOS are deduced from empirical observations that after daily discharge rates peak there is a certain distribution point at which the discharge rate declines (Silber, et al., 2009). The daily patient discharge rate was calculated as 1/LOS (length of stay) consistent with the literature (Silber et al., 1999; Silber, et al., 2009). The distribution of patients by the 26 Major Diagnostic Categories (MDC) classifications was then examined. The prolongation point for hospital discharges, or day of deceleration, was identified by Kernel-Density plots constructed for the discharge rates by each MDC and defined as the day after the prolongation point. Kernel-Density plots were selected to examine and identify the deceleration point of discharge as a refinement of the histogram to best estimate the probability density function based on the sample data.

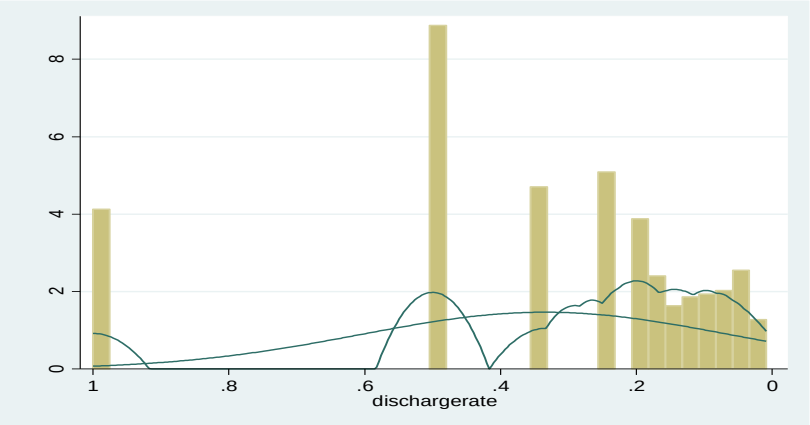
In these data, therefore, the patient's hospital stay is considered prolonged if it exceeds the prolongation point (day of hospitalization), identified for each MDC, by the Kernel–Density plots. By example, examining the MDC 18 (Infectious and Parasitic Diseases, Systemic or Unspecified Sites) the mean discharge rate was 0.34. In the Kernel–Density Plot (Figure 3) the rate begins to decelerate approaching the value 0.3 (which equates to 3 days, or 1/LOS = 0.33).

Demographic Data

The relationship between potentially confounding variables (control variables) and their respective dependent variables were examined using bivariate Pearson or Spearman correlations, as determined by the Shapiro-Wilk test of normality. Those showing

significant relationships ($p < .05$) were retained for inclusion in the multivariable models as control variables. Multicollinearity was examined by tolerance and variance inflation factor (VIF) diagnostics. The presence of multicollinearity was identified by a VIF >10. In such cases, only one variable was included from the set of correlated variables.

Figure 3



Note. In this Kernel-Density plot the discharge rate from left to right declines (e.g. 0.5 = 2 day LOS, 0.4 = 2.5 day LOS, 0.2 = 5 day LOS).

The potential confounding variables hypothesized to affect patient outcomes included (Aiken, Clarke & Sloane, 2002; Aiken, Clarke, Sloane, Sochalski & Silber, 2002; Appari, Johnson & Anthony, 2013; Elnahal, Joynt, Bristol & Jha, 2011; Himmelstein, Wright and Woolhandler, 2010): (1) nurse staffing levels, operationally defined as the ratio of patients to nurses in each hospital; (2) hospital size, operationalized as less than or equal to 100 beds, 101 to 250 beds, or greater than or equal to 250 beds; (3) teaching status, operationalized as the trainee-to-bed ratio, (number of medical residents and fellows) and categorized as minor teaching (less than 1:4 residents to trainee ratio) or major teaching (greater than 1:4 ratio); (4) high technology

status, operationally defined as facilities with open-heart surgery, major organ transplant, or both; (5) hospital geographic categories, operationally defined based on United States rural-urban continuity codes (Rural-Urban Continuum Codes) of the county where the hospital is located; and (6) nurse education, operationally defined as: (a) less than or a baccalaureate degree or (b) a baccalaureate degree or higher

Additionally, patient risk adjusted covariates used in this study include ICD9-CM primary and secondary diagnosis codes, age, sex, race, and insurance type, operationalized using the AHRQ risk adjustment method, based on the Elixhauser method, which included a comprehensive set of 30 comorbidities (Elixhauser, Steiner, Harris & Coffey, 1998).

Following these steps, the number of variables retained in all multivariable models was based on rules for regression modeling (Harrison, 2001). For linear models this rule is to divide the number of observations by 10 and round down. This result then becomes the limiting number of variables allowed in the linear model (Harrison, 2001). Thus, adverse outcome models were limited to seven independent predictor variables; patient satisfaction models were limited to four independent predictor variables. Simple unadjusted OLS regression models testing the hypotheses were then conducted followed by adjusted models using the retained control variables identified by the steps previously described. These models were then assessed for heteroskedasticity, run with robust standard errors (Huber-White) if indicated, and residuals were examined. In the presentation of analyses to follow standardized coefficients (β) are reported.

Hypotheses

Hypothesis 1.

The first hypothesis was developed based on the theoretical proposition that EHR adoption stage is inversely related to the occurrence of adverse patient events in acute care hospitals. Hypothesis1 stated: "The use of EHR is inversely related to the occurrence of adverse patient events in acute care hospitals." Separate OLS regression models were run for each adverse outcome. The unadjusted effects of EHR adoption on outcomes are reported, as well as the effects adjusted for control variables. The findings are presented in Table 7 and indicate this hypothesis was minimally supported.

The unadjusted effect of testing the relationship between EHR and the patient outcome of prolonged length of stay (PLOS) was not significant (R^2 = .003, F (1, 68) = 0.21, p = .65). However, when adjusting for control correlates of PLOS (patient comorbidity, patient age, nurse staffing, and hospital technology status) the adjusted effect was significant (R^2 = .462, F (4, 63) = 6.54, p < .01), with EHR adoption stage significantly contributing to the outcome of PLOS (β = -.21, p = .03). This means that for every standard deviation unit (*SD* = 1.39) increase in EHR adoption stage, PLOS decreases by .21 standard deviation units (*SD* = 0.05). Succinctly, with every increase in EHR adoption stage, where one *SD* (1.39) approximates one stage of adoption, there is a 1% (0.21 x .05 x 100) decrease in percentage of patients with a prolonged length of stay.

The unadjusted effect of testing the relationship between EHR adoption stage and the patient outcome of readmission within seven days was significant (R^2 = .09, F (1, 47) = 4.70, p = .03). Bivariate correlations did not significantly identify any potential confounders that required additional testing using adjusted models. However, the Breusch-Pagan test demonstrated evidence of heteroskedasticity (p < .01), thus the model

was estimated with robust standard errors and was not significant (p = .06). EHR adoption stage was a non- significant predictor of all other adverse outcomes.

In summary, higher levels of EHR adoption stage was a statistically significant predictor of one adverse outcome, prolonged length of stay. Thus, hypothesis 1 was minimally supported.

Table 7

Effects of EHR Adoption Stage on Adverse Outcomes (N = 70)

	Unadjusted			Adjusted		
Outcome Variable	β	R^2	F	β	R^2	F
Death in low-mortality DRG's (PSI 2)	-0.06	0.00	0.26	-0.21	0.28	6.29
Failure to rescue (PSI 4)	-0.16	0.03	1.83	-0.20	0.19	3.87
Central venous catheter-related blood stream infection (PSI 7)	0.00	0.00	0.00	-0.02	0.07	2.64
Postoperative hip fracture (PSI 8)	0.02	0.00	0.06	0.00	0.15	3.11
Postoperative sepsis (PSI 13)	-0.16	0.02	1.71	-0.17	0.11	2.13
Readmission within 7 days of discharge	-0.30*	0.09	4.70	-0.30	0.09	3.60
Length of Stay (LOS)	-0.10	0.01	0.70	-0.08	0.38	9.92
Prolonged Length of Stay (PLOS)	-0.05	0.00	0.21	-0.21*	0.46	6.54

*$p < .05$

Note. PSI expressed in rates per 1,000 discharges, length of stay (LOS) measured in average days per hospital. Other outcomes expressed as an average of the mean number of events per hospital patient population. Adjusted models included control variables following regression modeling rules from the set of variables: nurse staffing levels, certification, education; patient comorbidities, age, race, gender and insurance status; and hospital geographic location, size (beds), high technology status and teaching status. Robust standard errors were applied as indicated by heteroskedasticity testing and clustered means were created to account for clustering of patients in hospitals.

Hypothesis 2.

Hypothesis 2 was derived from the theoretical proposition that the stage of EHR adoption in acute care hospitals is positively related to patient satisfaction. Hypothesis 2 stated: "The use of EHR is positively related to patient satisfaction in acute care hospitals." This hypothesis tested the relationship between EHR adoption stage with each patient satisfaction (HCAHPS) outcome in unadjusted and adjusted OLS models. In adjusted models, EHR adoption stage was a significant predictor for one of the ten patient satisfaction outcomes. Thus, this hypothesis was minimally supported as evident in Table 8.

The adjusted model testing the relationship between EHR adoption stage and the patient outcome of "yes, given discharge information" was estimated. The Breusch-Pagan test did not demonstrate significant evidence of heteroskedasticity ($p = .46$), thus the model was not run with robust standard errors. The model included the control variables of patient race, being insured and nurse staffing. Findings indicate that the overall model was significant ($R^2 = .04$, $F(4, 36) = 7.56$, $p < .01$), with EHR adoption stage significantly contributing to this outcome ($\beta = -.31$, $p = .02$). This was the only significant finding, and indicates that higher EHR adoption stages were predictive of lower percentages of patients who respond "yes, given discharge information." Therefore, in summary, the hypothesis that EHR adoption stages will be positively related to patient satisfaction was not supported.

Table 8
Effects of EHR Adoption Stage on Patient Satisfaction (N = 41)

	Unadjusted			Adjusted		
Outcome Variable	β	R^2	F	β	R^2	F
MD communicates well	0.00	0.00	0.00	-0.04	0.12	2.64
RN communicates well	0.10	0.01	0.46	-0.03	0.45	9.97
Receive help quickly	0.02	0.00	0.03	-0.08	0.29	4.95
Pain well controlled	0.07	0.00	0.22	0.00	0.15	3.11
Medications explained	-0.03	0.00	0.05	-0.08	0.10	2.23
Environment clean	-0.18	0.03	1.38			
Environment quiet	0.14	0.02	0.80	0.12	0.15	3.32
Given discharge information	-0.26	0.06	2.74	-0.31*	0.46	7.56
High rating for hospital (9-10)	0.00	0.00	0.00	-0.08	0.39	5.77
Definitely recommend hospital	-0.02	0.00	0.02	-0.10	0.47	8.15

*$p < .05$

Note. All responses are "top box" or response of "always" or highest possible rating. Adjusted models included control variables following regression modeling rules from the set of variables: nurse staffing levels, certification, education; patient comorbidities, age, race, gender and insurance status; and hospital geographic location, size (beds), high technology status and teaching status

Hypothesis 3.

Hypothesis 3 was derived from the theoretical proposition that a supportive nursing practice environment will be inversely related to occurrence of adverse patient events in acute care hospitals. Hypothesis 3 stated: "A supportive nursing practice environment will be inversely related to occurrence of adverse patient events in acute care hospitals." This was first tested using the composite PES-NWI nursing environment score as the key predictor of adverse outcomes, then by using each of the five the subscales (foundations for quality care, staffing and resource adequacy, participation in hospital affairs, collegial nurse-physician relationships, and nurse manager leadership and abilities) of the PES-NWI as key predictors of adverse outcomes. The primary variable from the unadjusted regression models did not remain significant after adjusting for control variables and estimated with robust standard errors as evident in Table 9. In summary, there were no significant relationships between the nursing work environment and adverse patient events when controlling for theoretically and empirically important covariates. Thus, hypothesis 3 was not supported.

Table 9

Effects of Nursing Practice Environment on Adverse Outcomes (N = 70)

	Unadjusted			Adjusted		
Outcome Variable	β	R^2	F	β	R^2	F
Death in low-mortality DRG's (PSI 2)	0.03	0.00	0.09	0.03	0.23	8.70
Failure to rescue (PSI 4)	-0.02	0.00	0.02	0.02	0.18	2.86
Central venous catheter-related blood stream infection (PSI 7)	0.04	0.00	0.10	-0.07	0.08	3.48
Postoperative hip fracture (PSI 8)	-0.21	0.04	3.24	-0.21	0.19	3.41
Postoperative sepsis (PSI 13)	-0.05	0.00	0.16	-0.18	0.08	1.56
Readmission within 7 days of discharge	0.06	0.00	0.21			
Length of Stay (LOS)	-0.23*	0.05	3.99	-0.17	0.40	9.00
Prolonged Length of Stay (PLOS)	-0.32*	0.10	7.59	-0.12	0.43	6.40

*$p < .05$

Note. Adjusted models included control variables following regression modeling rules from the set of variables: nurse staffing levels, certification, education; patient comorbidities, age, race, gender and insurance status; and hospital geographic location, size (beds), high technology status and teaching status. Robust standard errors were applied as indicated by heteroskedasticity testing and clustered means were created to account for clustering of patients in hospitals.

Hypothesis 4.

Hypothesis 4 was derived from the theoretical proposition that a supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals. Hypothesis 4 stated: "A supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals." Separate OLS regression models were first run for each of the 10 patient satisfaction outcomes in unadjusted models, then these models were adjusted to include control variables as indicated by bivariate correlations. Following the rule of regression modeling, estimated models included no more than four predictors per model (Harrell, 2001). None of the tests indicated evidence of heteroskedasticity by the Breusch-Pagan tests.

The findings of the effects of the composite PES-NWI nursing practice environment measure on patient satisfaction are presented in Table 10. As evident in the data presented in Table 10, the composite PES-NWI nursing practice environment measure predicted five of the 10 patient satisfaction measures in unadjusted models (β estimates range 0.32-0.54, $p < .05$) and two of the 10 in adjusted models (β estimates range 0.30-0.37, $p < .05$). There is additional support for this hypothesis in both the unadjusted and adjusted models that estimated the effects of the staffing and resource adequacy dimension of the PES-NWI on patient satisfaction outcomes. As evident in the data presented in Table 11, the nursing work environment dimension of staffing and resource adequacy predicted eight of the 10 patient satisfaction outcomes in unadjusted models (β estimates range 0.41-0.58, $p < .05$) and six of the 10 patient satisfaction outcomes in adjusted models (β estimates range 0.32-0.43, $p < .05$).

Table 10

Effects of Composite Nursing Practice Environment on Patient Satisfaction (N = 41)

	Unadjusted			Adjusted		
Outcome Variable	β	R^2	F	β	R^2	F
MD communicates well	0.32*	0.10	4.32	0.24	0.17	4.03
RN communicates well	0.41*	0.17	7.90	0.23	0.49	11.85
Receive help quickly	0.26	0.07	2.89	0.11	0.29	5.06
Pain well controlled	0.20	0.04	1.71	0.09	0.55	10.98
Medications explained	0.21	0.04	1.76	0.24	0.15	3.45
Environment clean	-0.18	0.03	1.38			
Environment quiet	0.17	0.03	1.15	0.23	0.18	4.26
Given discharge information	0.38*	0.12	6.75	0.26	0.43	6.82
High rating for hospital (9-10)	0.48*	0.23	11.85	0.30*	0.45	7.39
Definitely recommend hospital	0.54*	0.27	16.20	0.37*	0.57	11.72

*$p < .05$

Note. All responses are "top box" or response of "always" or highest possible rating. Adjusted models included control variables following regression modeling rules from the set of variables: nurse staffing levels, certification, education; patient comorbidities, age, race, gender and insurance status; and hospital geographic location, size (beds), high technology status and teaching status. Clustered means were created to account for clustering of patients in hospitals.

Table 11

Effects of Staffing and Resources on Patient Satisfaction (N = 41)

	Unadjusted			Adjusted		
Outcome Variable	β	R^2	F	β	R^2	F
MD communicates well	0.41*	0.16	7.83	0.33*	0.22	5.31
RN communicates well	0.52*	0.27	14.43	0.32*	0.53	13.79
Receive help quickly	0.43*	0.18	8.81	0.28	0.34	6.49
Pain well controlled	0.29	0.08	3.61	0.19	0.57	11.74
Medications explained	0.41*	0.16	7.68	0.34*	0.20	4.81
Environment clean	0.46*	0.22	10.74			
Environment quiet	0.21	0.05	1.90	0.28	0.21	5.11
Given discharge information	0.46*	0.21	10.34	0.33*	0.46	7.54
High rating for hospital (9-10)	0.55*	0.30	16.68	0.39*	0.49	8.75
Definitely recommend hospital	0.58*	0.34	20.42	0.43*	0.55	13.47

*$p < .05$

Note. All responses are "top box" or response of "always" or highest possible rating. Adjusted models included control variables following regression modeling rules from the set of variables: nurse staffing levels, certification, education; patient comorbidities, age, race, gender and insurance status; and hospital geographic location, size (beds), high technology status and teaching status. Clustered means were created to account for clustering of patients in hospitals.

The following are the effects of the staffing and resource adequacy dimension of the nursing work environment on patient satisfaction outcomes; these computations were based on the standard deviations presented in Tables 5 and 6. A one *SD* (0.23) increase in the hospital score of staffing and resource adequacy predicted the following increases in the percentage of hospitalized patient responses: (a) 1.5% (.33 x 4.5) "yes, given discharge information" ($\beta = .33$ $p < .05$) ; (b) 1% (.33 x 3.1) MD's always communicate well ($\beta = .33$, $p = .03$); (c) 1.6 % (.32 x 5.0) RN's always communicate well ($\beta = .32$, $p = .01$); (d) 1.8% (.34 x 5.3) medications were always explained well ($\beta = .34$, $p = .03$); (e) 3.3% (.46 x 7.2) hospital cleanliness ($\beta = .46$, $p < .01$); (f) 3.3% (.39 x 8.3) giving the hospital a high rating ($\beta = .39$, $p < .01$); and (g) 3.6% (.43 x 9.8) definitely recommending the hospital ($\beta = .43$, $p < .01$).

That is, increasing the hospital staffing and resource adequacy score by one point on the four point Likert scale (where a 1 point increase equals a factor of 4.34 given a *SD* of 0.23) will predict the following increases in the percentage of hospitalized patient responses: (a) 6.5% (4.34 x 1.5%) "yes, given discharge information;" (b) 4.3% (4.34 x 1%) MD's always communicate well; (c) 7% (4.34 x 1.6%) RN's always communicate well; (d) 7.8% (4.34 x 1.8%) medications were always explained well; (e) 14.3% (4.34 x 3.3%) hospital cleanliness; (f) 14.3% (4.34 x 3.3%) giving the hospital a high rating and (g) 15. 6% (4.34 x 3.6%) definitely recommending the hospital.

The significant adjusted effect of the composite PES-NWI score predicting patient reports of giving the hospital a high rating ($\beta = .30$, $p = .04$) indicates that increasing the hospital composite PES-NWI score by one *SD* (0.19) predicts a (.30 x 8.3), or 2.5% increase in this satisfaction measure. That is, increasing the hospital composite PES-

NWI score by one point on the four point Likert scale will result in a 13% increase in the percentage of patients giving the hospital a high rating. Similarly, the significant adjusted effect of the composite PES-NWI score predicting patient response they would definitely recommend the hospital ($\beta = .37$, $p < .01$) indicates that increasing the hospital composite PES-NWI score by one *SD* (0.19) predicts a (.37 x 9.8), or 3.6% increase in this satisfaction measure. That is, increasing the hospital composite PES-NWI score by one point on the four point Likert scale (where a 1 point increase equals a factor of 5.27 given a *SD* of 0.19) will result in a 19% (5.27 x 3.6%) increase in the percentage of patients who definitely recommend the hospital.

In summary, hypothesis 4, stating that a supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals, was strongly supported. As evident in the data presented in Tables 10 and 11, the PES-NWI composite score and the dimension of staffing and resource adequacy were found to be significant predictors of patient satisfaction outcomes when controlling for theoretically and empirically important covariates. Therefore, hypothesis 4 was supported.

Hypothesis 5.

Hypothesis 5 was derived from theoretical propositions that the use of EHR is inversely related to missed nursing care in acute care hospitals. Hypothesis 5 stated: "The use of EHR is inversely related to missed nursing care in acute care hospitals." The regression model indicated no significant relationship ($\beta = -0.29$, $p = .80$), thus hypothesis 5 was not supported.

Hypothesis 6.

Hypothesis 6 stated: "A supportive nursing practice environment is inversely related to missed nursing care in acute care hospitals." This hypothesis was strongly supported by the data presented in Table 12, the PES-NWI composite score and each of the five dimensions of the practice environment were found to be significant, inverse predictors of missed care (β estimates range -0.47 to -0.77, $p < .01$). Thus, hypothesis 6, stating that the practice environment is inversely associated with missed nursing care was supported.

Table 12

Effects of Nursing Practice Environment on Missed Nursing Care (N = 70)

Variable	β	R^2	F
Composite Nursing Practice Environment	-0.67*	0.44	41.47
Subscales			
Staffing and resource	-0.77*	0.59	60.59
Foundations for quality	-0.58*	0.33	27.61
Nurse-physician relations	-0.56*	0.32	39.72
Hospital affairs	-0.47*	0.22	20.33
Nurse manager leadership	-0.61*	0.37	34.37

*$p < .01$

Note. Robust standard errors were applied as indicated by heteroskedasticity testing.

Hypothesis 7.

Hypothesis 7 was derived from the proposition that missed nursing care is positively related to occurrence of adverse patient events in acute care hospitals. Hypothesis 7 stated: "Missed nursing care is positively related to occurrence of adverse patient events in acute care hospitals." Separate OLS regression models, testing the unadjusted and adjusted effects of the predictor, were estimated for each adverse outcome. These findings are presented in Table 13. In summary, the data presented in Table 13 indicate there were no significant relationships between missed nursing care and adverse patient events when controlling for theoretically and empirically important covariates. Thus, hypothesis 7 was not supported.

Table 13

*Effects of Missed Nursing Care on Adverse Outcomes (N = 70**)*

	Unadjusted			Adjusted		
Outcome Variable	β	R^2	F	β	R^2	F
Death in low-mortality DRG's (PSI 2)	0.08	0.00	0.44	0.03	0.23	7.15
Failure to rescue (PSI 4)	0.06	0.00	0.27	0.07	0.16	3.05
Central venous catheter-related blood stream infection (PSI 7)	0.01	0.00	0.01	0.05	0.07	2.71
Postoperative hip fracture (PSI 8)	0.17	0.03	2.21	0.17	0.18	4.81
Postoperative sepsis (PSI 13)	-0.03	0.00	0.07	-0.03	0.08	1.57
Readmission within 7 days of discharge	-0.08	0.00	0.30			
Length of Stay (LOS)	0.19	0.04	2.60	0.17	0.40	8.49
Prolonged Length of Stay (PLOS)	0.31*	0.10	7.22	0.06	0.43	6.94

*$p < .05$, **Readmission $N = 49$

Note. Adjusted models included control variables following regression modeling rules from the set of variables: nurse staffing levels, certification, education; patient comorbidities, age, race, gender and insurance status; and hospital geographic location, size (beds), high technology status and teaching status. Robust standard errors were applied as indicated by heteroskedasticity testing and clustered means were created to account for clustering of patients in hospitals.

Hypothesis 8.

Hypothesis 8 was derived from the proposition that missed nursing care is inversely related to patient satisfaction in acute care hospitals. Hypothesis 8 stated: "Missed nursing care is inversely related to patient satisfaction in acute care hospitals." Separate OLS regression models were estimated for each of the 10 patient satisfaction outcomes. The data presented in Table 14 indicate the only significant relationship identified was that between missed nursing care and the satisfaction outcome of definitely recommending the hospital. The adjusted model included patient race, insurance status and bed size as control variables. In summary, there was one significant relationship between missed nursing care and patient satisfaction outcomes. Thus, hypothesis 8 was partially supported.

Hypothesis 9.

Hypothesis 9 stated: "Missed nursing care will mediate the relationship between the nursing practice environment and occurrence of adverse events." Models to test mediation were constructed to test the hypotheses that missed nursing care will mediate the relationship between the nursing practice environment and occurrence of adverse events using methods described by Baron and Kenny (1986), adapted using the Sobel-Goodman tests as provided in the statistical software STATA/MP 12.1 package. Prior to testing a mediation model the simple linear regression model must be statistically significant. In the preceding hypotheses testing there were statistically significant relationships between the nursing practice environment and two adverse outcomes; prolonged length of stay (PLOS) and length of stay (LOS) in the unadjusted models (Table 9). However, these were not significant in the adjusted models therefore no

further mediation testing was indicated. In summary, there was no evidence that missed nursing care mediates the relationship between the nursing work environment and adverse patient outcomes. Thus, hypothesis 9 was not supported.

Table 14

Effects of Missed Nursing Care on Patient Satisfaction (N = 41)

	Unadjusted			Adjusted		
Outcome Variable	β	R^2	F	β	R^2	F
MD communicates well	-0.19	0.03	1.47	-0.14	0.14	3.09
RN communicates well	-0.15	0.02	0.95	-0.37	0.45	9.98
Receive help quickly	-0.11	0.01	0.46	-0.01	0.28	4.80
Pain well controlled	-0.11	0.01	0.52	-0.13	0.55	11.31
Medications explained	-0.16	0.02	0.99	-0.11	0.11	2.38
Environment clean	-0.21	0.04	1.85			
Environment quiet	-0.11	0.01	0.48	-0.17	0.16	3.66
Given discharge information	-0.17	0.03	1.27	-0.08	0.37	5.50
High rating for hospital (9-10)	-0.30	0.09	3.88	-0.21	0.42	6.66
Definitely recommend hospital	-0.32*	0.10	4.59	-0.23*	0.51	8.10

*$p < .05$

Note. All responses are "top box" or response of "always" or highest possible rating. Adjusted models included control variables following regression modeling rules from the set of variables: nurse staffing levels, certification, education; patient comorbidities, age, race, gender and insurance status; and hospital geographic location, size (beds), high technology status and teaching status. Robust standard errors were applied to account for heteroskedasticity as indicated.

Hypothesis 10.

Hypothesis 10 stated: "Missed nursing care will mediate the relationship between EHR adoption and occurrence of adverse patient events." Models to test mediation were constructed to test the hypotheses that missed nursing care will mediate the relationship between EHR adoption stage and occurrence of adverse patient events. In the preceding hypothesis testing there were statistically significant relationships between EHR adoption stage and two adverse outcomes, that of readmissions and prolonged length of stay (PLOS), (Table 7). These models were tested and no significant associations were found. Further, Sobel tests indicated that missed nursing does not mediate the relationship between EHR adoption stage and patient readmissions (z = -.3255, p = .74) or PLOS (z = -.377, p = .70). Thus, no further testing of this mediation model was indicated. In summary, hypothesis 10 was not supported.

Hypothesis 11.

Hypothesis 11 stated: "Missed nursing care will mediate the relationship between EHR adoption and patient satisfaction." Only one model was constructed to test hypothesis 11 because the effect of EHR adoption was significantly related only to the response "yes, given discharge information." This model was tested and no significant association was found. Further, the Sobel test indicated that missed nursing care does not mediate the relationship between EHR adoption stage and the response "yes, given discharge information" (z = -.08, p = .93). In summary, there was no evidence that missed nursing care explains the relationship between EHR adoption stage and patient satisfaction outcomes. Thus, hypothesis 11 was not supported.

Additional analysis

Additional analyses were conducted to explore the important relationships identified in the above testing of hypotheses. Multiple linear regression analyses were conducted to test the joint effects of the significant relationships among the three main independent variables (EHR adoption stage, nursing practice environment and missed nursing care) and patient satisfaction outcomes. That is, analyses were conducted to examine with greater precision the theoretical proposition that advanced EHR technology is positively related to patient satisfaction outcomes by controlling for the statistically significant effects of the nursing practice environment and missed nursing care. The nursing practice environment dimension of staffing and resource adequacy was specifically tested secondary to the evident relationship between this measure and patient satisfaction. The results of these analyses are presented in Table 15.

There was a significant unadjusted effect of EHR adoption stage, missed nursing care and the dimension of staffing and resource adequacy on the patient response the RN always communicates well (R^2 = .45, F (3, 37) = 10.08, p < .01), indicating 45% of the variance in this response can be explained by this model. Missed nursing care (β = .62, p < .01) and staffing and resource adequacy (β = 1.0, p < .01) were the only significant predictors in this model, and remained after adjusting for patient race, missed nursing care (β = .50, p < .01) and staffing and resource adequacy (β = .76, p < .01), explaining 62% of the variance in response that the RN always communicates well.

This effect was similar for satisfaction with other caregiver communication in that the linear combination of these measures demonstrated a significant unadjusted effect on the response the MD always communicates well (R^2 = .20, F (3, 37) = 3.20, p = .03), indicating 20% of the variance in this response was explained by this model. Staffing

and resource adequacy was the only significant predictor in this unadjusted model (β = .64, $p < .01$), and remained the only significant predictor after adjusting for patient race (β = .53, $p = .04$), explaining 24% of the variance in response that the MD always communicates well.

There was a significant unadjusted effect of EHR adoption stage, missed nursing care and the dimension of staffing and resource adequacy on the response of always receiving help quickly ($R^2 = .31$, F (3, 37) = 5.55, $p < .01$), indicating 31% of the variance in this patient response was explained by this model. Missed nursing care (β = .55, $p = .01$) and staffing and resource adequacy (β = .85, $p < .01$) were the only significant predictors in this model, and remained after adjusting for patient race, missed nursing care (β = .44, $p = .03$) and staffing and resource adequacy (β = .65, $p < .01$), explaining 42% of the variance in response of always receiving help quickly.

There was a significant unadjusted effect of EHR adoption stage, missed nursing care and the dimension of staffing and resource adequacy on the patient response that medications are always explained ($R^2 = .22$, F (3, 37) = 3.5, $p = .02$), indicating 22% of the variance in this patient response was explained by this model. Staffing and resource adequacy (β = .69, $p < .01$) was the only significant predictor in this model, and remained after adjusting for patient race, (β = .60, $p < .01$), explaining 25% of the variance in response of always receiving help quickly.

There was a significant unadjusted effect of EHR adoption stage, missed nursing care and the dimension of staffing and resource adequacy on the patient response that the environment was always clean ($R^2 = .28$, F (3, 37) = 4.8, $p < .01$), indicating 28% of the variance in this patient response can be explained by this model. Staffing and resource

adequacy (β = .70, $p < .01$) was the only significant predictor. Bivariate analysis did not identify the need to include any of the control variables.

There was a significant unadjusted effect of EHR adoption stage, missed nursing care and the dimension of staffing and resource adequacy on the patient response that they were given discharge information ($R^2 = .26$, F (3, 37) = 5.75, $p < .01$), indicating 26% of the variance in this patient response was explained by this model. Staffing and resource adequacy (β = .73, $p < .01$) was the only significant predictor in this model. The adjusted model included patient race and was statistically significant ($R^2 = .47$, F (4, 36) = 8.01, $p = .00$), explaining 47% of the variance in the response "yes, given discharge information". Within this adjusted model significant key predictors were staffing and resource adequacy (β = .49, $p = .02$) and EHR adoption stage in a negative direction (β = -.27, $p = .04$).

There was a significant unadjusted effect of EHR adoption stage, missed nursing care and the dimension of staffing and resource adequacy on the patient response of giving the hospital a high rating ($R^2 = .33$, F (3, 37) = 6.25, $p < .01$), indicating 33.6% of the variance in this patient response can be explained by this model. Staffing and resource adequacy (β = .77, $p < .01$) was the only significant predictor in this model, and remained after adjusting for patient race, (β = .59, $p < .01$), explaining 43% of the variance in response of giving the hospital a high rating.

There was a significant unadjusted effect of EHR adoption stage, missed nursing care and the dimension of staffing and resource adequacy on the patient response of definitely recommending the hospital ($R^2 = .38$, F (3, 37) = 7.63, $p < .01$), indicating 38% of the variance in this patient response was explained by this model. Staffing and

resource adequacy ($\beta = .82$, $p < .01$) was the only significant predictor in this model, and remained after adjusting for patient race, ($\beta = .61$, $p < .01$), explaining 51% of the variance in response of definitely recommending the hospital.

In summary, additional analyses were conducted to examine the combined linear effect of EHR adoption stage, the staffing and resource adequacy dimension of the nursing work environment and missed nursing care on patient satisfaction outcomes. Results of these analyses indicate strong, significant relationships among staffing and resource adequacy, missed nursing care and patient satisfaction, and that these strong relationships are not confounding the effects of EHR adoption stage on patient satisfaction.

Table 15

Effects of Staffing and Resources, Missed Nursing Care and EHR Stage on Patient Satisfaction (N = 41)

	Unadjusted			Adjusted		
Outcome Variable	*β*	*t*	*p*	*β*	*t*	*p*
MD communicates well						
EHR stage	0.06	0.40	0.70	-0.10	-0.77	0.45
Missed care	0.30	1.33	0.19	0.25	1.06	0.29
Staffing and resources	0.64*	2.81	0.00	0.53*	2.18	0.03
RN communicates well						
EHR stage	0.19	1.61	0.11	0.11	1.07	0.29
Missed care	0.62*	3.27	0.00	0.50*	3.04	0.00
Staffing and resources	1.00*	5.29	0.00	0.76*	4.42	0.00
Receive help quickly						
EHR stage	0.10	0.74	0.46	0.03	0.25	0.80
Missed care	0.55*	2.57	0.01	0.44*	2.21	0.03
Staffing and resources	0.85*	4.00	0.00	0.65*	3.07	0.00
Medications explained						
EHR stage	0.02	0.17	0.86	-0.00	-0.04	0.96
Missed care	0.37	1.64	0.11	0.32	1.41	0.17
Staffing and resources	0.69*	3.04	0.00	0.60*	2.46	0.01
Environment clean						
EHR stage	-0.12	-0.90	0.37			
Missed care	0.31	1.44	0.16			
Staffing and resources	0.70*	3.19	0.00			
Given information						
EHR stage	-0.19	-1.41	0.16	-0.27*	-2.19	0.03
Missed care	0.37	1.76	0.08	0.25	1.31	0.19
Staffing and resources	0.73*	3.43	0.00	0.49*	2.43	0.02
High rating						
EHR stage	0.06	0.46	0.64	-0.00	-0.01	0.99
Missed care	0.29	1.41	0.17	0.20	1.00	0.32
Staffing and resources	0.77*	3.70	0.00	0.59*	2.46	0.01
Definitely recommend						
EHR stage	0.04	0.35	0.73	-0.02	-0.23	0.82
Missed care	0.30	1.51	0.14	0.20	1.05	0.29
Staffing and resources	0.82*	4.06	0.00	0.61*	3.10	0.00

*$p < .05$

Note. All responses are "top box" or response of "always" or highest possible rating. Adjusted models included potential confounders following regression modeling rules from the set of variables: nurse staffing levels, certification, education; patient comorbidities, age, race, gender and insurance status; and hospital geographic location, size (beds), high technology status and teaching status.

CHAPTER V

Discussion of the Findings

Knowledge of the relationships among system factors, nursing care delivery and patient outcomes is sparse in the empiric literature, yet such knowledge is essential to improving the health outcomes of hospitalized patients. Therefore, the purpose of this study was to examine the relationships among nursing practice environment, EHR utilization and functionality, and missed nursing care on adverse patient outcomes (PSIs, readmissions, length of stay and prolonged length of stay) and patient satisfaction. This study bridges the disciplines of nursing, biomedical informatics, and healthcare systems and quality; it is interdisciplinary in nature and as such the research should be based upon theoretical models that link and integrate these disciplines (Aboelela, Larson, Bakken…et al., 2007). The findings are discussed in this chapter and presented in context of the overarching model, the Quality Health Outcomes Model (QHOM), and the propositions from the theories and models that integrate these disciplines.

Specifically, the theoretical relationships tested include the proposed positive relationships among the practice environment, technology, quality nursing care practices, and positive patient outcomes. The proposed positive relationship between advanced information technology, such as an EHR and quality nursing care processes was also tested (Huber, 1990; Powell-Cope et al., 2008). Thirdly, the theoretical explanation that EHR, through the enhancement of communication and more timely decision processes, reduces missed nursing care, thus supporting a negative relationship between EHR and missed nursing care was tested (Kalisch, 2006; Kalisch, Landstrom & Hinshaw, 2009; Kalisch, Landstrom & Williams, 2009). Finally, the significant gap in the literature,

testing missed nursing care as a mediating factor between EHR adoption, nursing practice environment and patient outcomes was conducted. This discussion will present the empiric study findings in light of the theoretical underpinnings that guided this study.

EHR and Adverse Patient Events

Hypothesis 1 stated that EHR adoption stage will be inversely related to the occurrence of adverse patient events in acute care hospitals. This hypothesis and the theoretical proposition from which it was derived were minimally supported by the data. The hypothesis was derived from the theoretical literature that posits an inverse relationship between advanced technology, such as EHR adoption stage, and adverse patient outcomes (Huber, 1990; Powell-Cope et al., 2008). Evidence from previous research is mixed (Himmelstein, Wright and Woolhandler, 2010; Nowinski et al., 2007; Poissant, Pereira, Tamblyn and Kawasumi 2005); however this study finding is consistent with recent findings by Furukawa, Raghu & Shao (2011) that found no evidence that EHR adoption is associated with decreased adverse outcomes.

EHR adoption stage was measured using the Electronic Medical Record Adoption Model scale (EMRAM), (HIMSS, 2008) and adverse outcomes were measured using the PSI algorithm and patient outcomes data from the HCUP SIDS data. Although the relationships were in the inverse direction as theorized, findings were not statistically significant for any outcome in adjusted models with the exception of prolonged length of stay (PLOS), ($\beta = -.21$, $p = .03$). This minimally supports the theoretical explanation of the effect of technology on adverse outcomes, such as PLOS, in that the use of technology assisted communication and decision support will lead to more rapid and higher quality provider decisions, thus promoting positive outcomes (Huber, 1990).

The following may explain the lack of an effect on all other adverse outcomes in this study. Although theory and conceptual models propose that advanced EHR adoption can negatively influence the occurrence of adverse events, a re-examination of the conceptual model indicated that additional workplace factors such as: (a) organizational arrangements, (b) social factors, (c) physical environment, and (d) technology affect the initial and continued use of technology by nurses (Powell-Cope et al., 2008). In this study, attempts to capture these organizational factors using existing data were made, yet data on social factors and unit level physical environment were not available to be evaluated. Further, EHR is in one of seven categories of technology that are theorized to affect patient outcomes (Powell-Cope et al., 2008), other categories such as patient and nurse protective devices or patient assessment technologies were not tested in this study.

In closer examination of theory and conceptual models early adoption may incur unintended consequences of temporary fixes to problems with technology (Huber, 1990; Powell-Cope et al., 2008). In order to optimize the positive effect of EHR on patient outcomes, organizational strategies and resources must be committed to ease and guide the transition to this technology (Huber, 1990; Walker et al., 2008). Although this study accounted for organizational factors that may serve as indicators of available resources (teaching status, hospital size, geographic location and technology status), the comprehensive nature and extent of the organizational strategy to implement EHR technology was unknown. In summary, hypothesis 1, which stated that EHR adoption stage will be inversely related to the occurrence of adverse patient events in acute care hospitals, was not supported in this study, as explained by theoretical and methodological rationale.

EHR and Patient Satisfaction

Hypothesis 2 stated that the use of EHR is positively related to patient satisfaction in acute care hospitals. The hypothesis and theoretical proposition from which it was derived were not supported by the data. The hypothesis was derived from the theoretical literature that postulates a positive relationship between advanced EHR levels and patient reported satisfaction outcomes (Huber, 1990; Powell-Cope et al., 2008). Although prior research findings in the hospital setting is scant and mixed, the results of this study are consistent with most recent reports that the level of EHR adoption does not significantly relate to patient satisfaction (Jarvis et al., 2013).

Notably, in the final adjusted models the relationships between EHR adoption stage and patient satisfaction, only one satisfaction outcome, the patient response of being given discharge information, reached the level of statistical significance. This relationship, however, was in the opposite direction of that which is theorized. There is little to no extant theoretical or empirical support for this unexpected finding. One possible theoretical explanation, however, is that the relationship between EHR and satisfaction may be moderated by insufficient resources, which in the presence of new technology has the effect of changing and reducing workflow and time efficiencies (Huber, 1990; Poissant, Pereira, Tamblyn & Kawasumi, 2005).

Methodologically, patient responses cannot be linked temporally to specific hospital EHR adoption timelines. This study was designed to mitigate this possible limitation by including data from HCAHPS release date of March 2008, which captures data from July 2006 through June 2007. However, it remains unknown if this negative finding may in part reflect early adoption of EHR and the attendant human factors and

operational challenges present, that are theorized to effect the use of this technology and subsequent proposed benefit, by nurses and patients alike (Powell-Cope et al., 2008). In summary, hypothesis 2, which stated that use of EHR is positively related to patient satisfaction in acute care hospitals, was not supported in this study, as explained by theoretical and methodological rationale.

Nursing Practice Environment and Adverse Patient Events

Hypothesis 3 stated that a supportive nursing practice environment will be inversely related to occurrence of adverse patient events in acute care hospitals. The hypothesis was derived from the theoretical literatures that postulate and inverse relationship between supportive nursing practice environments and the occurrence of adverse patient events (Aiken, 2002; Aiken, Sochalski, Lake, 1997; Laschinger & Leiter, 2006; Leiter & Laschinger, 2006). The hypothesis and theoretical proposition from which it was derived were not supported by the data. This finding is not consistent with the previous research (Aiken, Clarke, Sloane, 2002; Djukic, Kovner, Brewer, Fatehi & Cline, 2011; Sochalski, 2009).

In this study, the nursing practice environment was measured using the PES-NWI and adverse patient outcomes were measured using the SIDS PSI algorithm. The nursing practice environment significantly predicted two outcomes, length of stay (LOS) and prolonged length of stay (PLOS) in unadjusted models; however this relationship was not statistically significant in the adjusted models. These results indicate that more variance in these outcomes is explained by patient, nurse and organizational factors than the composite nursing practice environment score.

Theorists describe the effect of a supportive nursing work environment as positively relating to improved work effectiveness and higher quality nursing care which, in turn, affects patient outcomes (Aiken et al., 1997; Leiter & Laschinger, 2006; Laschinger & Leiter, 2006; Purdy et al., 2010). This hypothesis did not test the effect of the work environment on work effectiveness and nursing care processes, thus it may be possible that the effect of better work environments on patient outcomes was obscured by the mediating effect nursing care delivery factors. Additionally, theorists propose that environmental factors interact and influence nursing engagement processes that in turn affect patient outcomes (Laschinger & Leiter, 2006; Manojlovich & Laschinger, 2007). Methodologically, nursing engagement was not tested in this hypothesis.

Methodologically, in contradistinction to most prior research which has used nurse-reported outcomes, this study employed the AHRQ PSI algorithm to quantify adverse patient events (Aiken, Clarke & Sloane, 2002; Lucero et al., 2010; Sochalski, 2004). Additionally, despite extensive risk adjustment using all possible administrative data to control for extraneous factors, there is the possibility that other organizational features that may influence the work life of the nurse, and thus nursing care processes and patient outcomes, were omitted. In summary, hypothesis 3, which stated that a supportive nursing practice environment will be inversely related to occurrence of adverse patient events in acute care hospitals, was not supported in this study, as explained by theoretical and methodological rationale.

Nursing Practice Environment and Patient Satisfaction

Hypothesis 4 stated that a supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals. The hypothesis and

theoretical proposition from which it was derived were supported by the data. The hypothesis was derived from the theoretical literature that postulates a positive, direct relationship between a better nursing practice environment and patient satisfaction outcomes (Purdy et al., 2010). This finding is consistent with previous research (Aiken et al., 2012; Brooks-Carthon, Kutney-Lee, Sloane, Cimiotti & Aiken, 2011; Kutney-Lee, McHugh, Sloane, Cimiotti, Flynn, Neff & Aiken, 2009).

These study findings indicated that increasing the composite PES-NWI hospital score by one *SD* (0.19) increased the satisfaction response of giving the hospital a high rating by 2.5% and "definitely" recommending the hospital by 3.6%. Succinctly, increasing the hospital level composite PES-NWI score by one point is associated with hospital level patient satisfaction increases of 13% in high rating and 19% in definitely recommending the hospital scores. The subscales were significant predictors of satisfaction outcomes as well, particularly staffing and resource adequacy.

The staffing and resource adequacy dimension of the nursing work environment asks respondents to rate on a one to four scale if they have: (a) enough staff to get the work done, (b) enough registered nurses to provide quality patient care, (c) adequate support services allow me to spend time with my patients and (d) enough time and opportunity to discuss patient care problems with other nurses. Findings indicated that improvements in this modifiable nursing work environment dimension have a significant and strong effect on patient satisfaction. Data previously presented indicated that a one *SD* (0.23) increase in hospital staffing and resource adequacy scores improved satisfaction scores 1- 3.6%. That is, improving the hospital level score of this dimension by one point was associated with increased patient satisfaction scores between 4.3-15.6%.

These findings support the theoretical and empiric literature that better work environments positively relate to patient satisfaction. In summary, hypothesis 4, which states that a supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals, was supported.

EHR and Missed Care

Hypothesis 5 stated that the use of EHR is inversely related to missed nursing care in acute care hospitals. The hypothesis and theoretical proposition from which it was derived were not supported by the data ($\beta = -0.29$, $p = .80$). The hypothesis was derived from the theoretical literatures that postulate the adoption of communication technology, such as EHR, will directly and positively affect quality nursing care processes by providing cues for nurses to provide direct and indirect care that is needed, as well as enhance priority decision making by nurses (Huber, 1990; Kalisch, Landstrom & Hinshaw, 2009; Powell-Cope et al., 2008). Although there is some evidence that EHR is associated with improved guideline adherence and decreased documentation time; there are no studies that have evaluated the impact of EHR on specific nursing care processes (DesRoches, Miralles, Buerhaus, Hess & Donelan, 2011; Jamal, McKenzie & Clark, 2009).

The possible theoretical and methodological reasons this hypothesis is not supported mirror those that may explain the lack of a relationship between EHR and adverse outcomes and satisfaction. Although it is known that all applications to meet the EHR stage were categorized as live and operational, the theory and conceptual models do not explicate time as a factor, which some literature suggests may be important (Appari, Johnson, & Anthony, 2013). Methodologically, the data does not allow for an evaluation

of the duration of time technology such as EHR has been in place. In summary, hypothesis 5, which posited advanced EHR stage would be inversely related to missed nursing care, was not supported in this study, as explained by theoretical and methodological rationale.

Nursing Practice Environment and Missed Care

Hypothesis 6 stated that a supportive nursing practice environment is inversely related to missed nursing care in acute care hospitals. The hypothesis and the theoretical proposition from which it was derived were supported by the data. The hypothesis was derived from the theoretical literature that postulates a negative relationship between a supportive practice environment and missed nursing care (Aiken, Sochalski & Lake, 1997; Kalisch & Kalisch, Landstrom & Hinshaw, 2009; Kalisch & Williams, 2009). This finding is consistent with previous research (Al-Kandari & Thomas, 2009; Lucero et al., 2010; Sochalski, 2004; Schubert et al., 2008).

The nursing practice environment was measured using the PES-NWI and a significant inverse relationship was found. This hypothesis was strongly supported, as measured by the composite PES-NWI and each of the five subscales. Separate ordinary least squares regression (OLS) models, demonstrated a moderate to strong effect on missed nursing care as follows: (a) composite PES-NWI score explained 44% of the variance ($\beta = -.666$, $p < .01$); (b) nursing foundations for quality of care explained 33% of the variance ($\beta = -.576$, $p < .01$); (c) staffing and resource adequacy explained 60% of the variance ($\beta = -.773$, $p < .01$); (d) nurse participation in hospital affairs explained 22% of the variance ($\beta = -.466$, $p < .01$); (e) collegial nurse physician relationships explained 31% of the variance ($\beta = -.559$, $p < .01$); and (f) nurse manager leadership, ability, and

support of nurses explained 37% of the variance ($\beta = -.608$, $p < .01$). These findings support the theoretical proposition of an inverse relationship between nursing practice environment and missed nursing care.

Additionally, these findings indicated that increasing the hospital score of the composite PES-NWI by one *SD* (0.19) predicted a (-.666 x .04) 2.6% decrease in the hospital level percentage of missed care. That is, for every full point increase in the hospital score on the composite PES-NWI, indicating a better work environment, there is a 13.7% decrease in the percentage of necessary care that is left undone by nurses in hospitals.

Moreover, relatively small increases (less than one quarter of one point) in any one of the five modifiable nursing work environment subscale scores significantly decreased the percentage of missed nursing care in hospitals: (a) increasing staffing and resource adequacy by one *SD* (.23) predicted a 3.1% decrease; (b) increasing nurse manager leadership, ability, and support of nurses by one *SD* (.19) predicted a 2.4% decrease; (c) increasing foundations for quality measure by one *SD* (.18) predicted a 2.3% decrease; (d) increasing collegial nurse physician relationships by one *SD* (.26) predicted a 2.2% decrease; and (e) increasing nurse participation in hospital affairs by one *SD* (.26) predicted a 1.9% decrease in the percentage of missed nursing care.

In summary, in this study nurses missed a significant amount of necessary care ranging between 10-27%. The nursing work environment, as measured by the composite PES-NWI and subscales, explained 22-60% of the variance in missed nursing care. Importantly, these findings indicate the amount of missed nursing care in hospitals can be decreased by 7.3% to 13.5% by increasing any one of the nursing practice environment

subscale scores by one point on the four point Likert scale, with the greatest effect attributed to the staffing and resource adequacy measure. These findings suggest that targeted interventions to improve any one of the dimensions of the nursing work environment will have a positive effect, thereby reducing the amount of missed nursing care. In summary, hypothesis 6 was strongly supported.

Missed Care and Adverse Patient Events

Hypothesis 7 stated that missed nursing care is positively related to occurrence of adverse patient events in acute care hospitals. The hypothesis and theoretical proposition from which it was derived were not supported by the data. The hypothesis was derived from the theoretical literature that postulates a positive relationship between higher levels of missed nursing care and adverse patient events (Kalisch, 2006; Kalisch, Landstrom & Hinshaw, 2009; Kalisch, Landstrom & Williams, 2009). This finding is not consistent with previous research (Lucero et al., 2010; Schubert et al., 2008; Sochalski 2004; Thomas-Hawkins, Flynn & Clarke, 2008).

Methodologically, in contradistinction to most prior research that uses a variable of nurse reports of adverse and quality outcomes, this study employed the AHRQ PSI algorithm to determine the adverse patient event data. The precision of these data are dependent on the documentation in the record and coding applied by trained medical coders, thus discrepancies in data and accuracy may exist at the hospital level (AHRQ, 2004, 2010; Zhan & Miller, 2003). Additionally, although administrative data have been used extensively in a number of large studies despite well-documented problems with the completeness and consistency of coding, they may not be as sensitive to nursing care processes (Iezzoni, 2003). In sum, hypothesis 7 which posited a positive relationship

between missed nursing care and adverse patient outcomes was not supported in this study, as explained by theoretical and methodological rationale.

Missed Care and Patient Satisfaction

Hypothesis 8 stated that missed nursing care is inversely related to patient satisfaction in acute care hospitals. The hypothesis and theoretical proposition from which it was derived were minimally supported by the data. The hypothesis was derived from the theoretical literature that postulates an inverse relationship between higher levels of missed nursing care and patient satisfaction (Donabedian, 1966; Kalisch Landstrom, & Hinshaw, 2009; Mitchell Ferketich, & Jennings, 1998). The significant findings are consistent with prior research (Schubert, Clarke, Glass, Schaffert-Witvliet & DeGeest, 2008; Schubert, Glass, Clarke, Aiken, Schaffert-Witvliet, Sloane & DeGeest, 2008).

All relationships between missed nursing care and patient satisfaction responses were in the inverse direction as theorized, though tested relationships reached the level of statistical significance for one response, definitely recommending the hospital. This effect remained significant in the adjusted model ($\beta = -.23$, $p = .04$), indicating that a one *SD* (0.04) increase in the amount of missed nursing care predicted a one *SD* (9.8), or 2.2% decrease in the patient response of definitely recommending the hospital. This can be interpreted as for every one less task (or 0.08%) that nurses miss, the hospital level indicator of definitely recommending the hospital will increase by 4.4%. This finding is consistent with the theoretical literature and prior studies. In summary, hypothesis 8 was minimally supported.

Nursing Practice Environment, Missed Care and Adverse Patient Events

Hypothesis 9 stated that missed nursing care will mediate the relationship between the nursing practice environment and occurrence of adverse events. The hypothesis and theoretical propositions from which it was derived were not supported by the data in prior hypothesis testing thus, precluding testing of this mediation model (Kalisch, Landstrom, & Williams, 2009; Leiter & Laschinger, 2006, Laschinger & Leiter, 2006). There are no prior studies that have tested these relationships. In summary, hypothesis 9 was not supported.

EHR, Missed Care and Adverse Patient Events

Hypothesis 10 stated that missed nursing care will mediate the relationship between EHR adoption and occurrence of adverse patient events. The hypothesis and theoretical propositions from which it was derived were not supported by the data (Powell-Cope et al., 2008). Two models were run with the previously significant adverse outcomes of readmission and prolonged length of stay (PLOS). Results of mediation testing were not statistically significant and thus, this hypothesis and theoretical propositions from which it was derived were not supported by the data. There are no prior studies that have tested these relationships. Thus, hypothesis 10 was not supported.

EHR, Missed Care and Patient Satisfaction

Hypothesis 11 stated that missed nursing care will mediate the relationship between EHR adoption and patient satisfaction. The hypothesis and theoretical propositions from which it was derived were not supported by the data. In the preceding testing of the effect of EHR adoptions stage on patient satisfaction outcomes one significant effect was demonstrated, that is the relationship with patient reports staff always give information about recovery at home, thus a mediation model for this

outcome was tested. The findings were not statistically significant, thus this hypothesis was not supported. In summary, as theoretically posited, EHR stage was a significant predictor of this outcome; however, the data did not support the proposed operant mechanism of missed nursing care. There are no prior studies in which this mediation model was tested. Thus, hypothesis 11 was not supported.

Additional Findings

Additional analyses were conducted to examine with greater precision the theoretical proposition that advanced EHR technology is positively related to patient satisfaction outcomes by controlling for the statistically significant effects of the nursing practice environment and missed nursing care. That is, models were constructed to examine if the effects of advanced EHR stages were being confounded by the practice environment and missed nursing care. The nursing practice environment dimension of staffing and resource adequacy was specifically tested secondary to the evident relationship between this dimension of the nursing work environment and patient satisfaction. The results of these analyses were presented in Table 15.

Important findings strongly indicate staffing and resource adequacy, and to a lesser extent missed nursing care, explain patient satisfaction responses. In these models, staffing and resource adequacy was the only significant predictor in all eight models, missed nursing care in an inverse direction in two models, and EHR adoption stage in an inverse direction in one model.

These relationships have not been tested in prior studies, as such these novel findings may indicate that at these stages of EHR adoption (EMRAM stages 0-4), the patient satisfaction benefit is tempered by staffing and resource adequacy, and to a lesser

extent this is also explained by how much nursing care is left undone. The staffing and resource adequacy subscale of the PES-NWI asks respondents to rate if they have: (a) enough staff to get the work done, (b) enough registered nurses to provide quality patient care, (c) adequate support services allow me to spend time with my patients and (d) enough time and opportunity to discuss patient care problems with other nurses. In theoretical context, this finding might be explained by insufficient resources in the presence of new technology which has the effect of changing workflow and time efficiencies (Huber, 1990; Poissant, Pereira, Tamblyn and Kawasumi, 2005).

Methodologically, it is unknown if achievement of these EHR adoption stages is new in these settings, and consequently it is unknown if changes in attendant processes of care and workflow have been embedded. However, these finding do indicate minimally that sufficient staffing and resources, as rated by the nurses, is essential for advanced EHR adoption and patient reported outcomes of satisfaction; these findings are consistent with extant literature (Furukawa, Raghu & Shao, 2011; Jha et al., 2009; Kazley & Ozcan, 2007; Walker et al., 2008). These findings may also signify that the patient benefits of advanced technology will only be realized in context of sufficient human resources.

Limitations

This study was cross-sectional and as such correlations, relationships, and associations between variables of interest were examined, but not causality. The precision of the PSI data were dependent on the documentation in the record and coding applied by trained medical coders, thus discrepancies in data and accuracy could have existed at the hospital level (AHRQ, 2004, 2010; Zhan & Miller, 2003). However,

administrative data have been used extensively in a number of large studies despite well-documented problems with the completeness and consistency of coding (Iezzoni, 2003). It was impossible to link nurses to specific patients; however, this was not considered a major limitation since multiple nurses can care for a patient during a hospitalization.

Administrative inpatient data were used to compute the PSIs; however, the PSIs can be subject to selection bias due to the elective nature of some admissions and surgical procedures. PSIs can also be subject to information bias and case mix bias. Risk adjustment and multivariate smoothing were performed to mitigate the impact of these limitations. Data on hospital characteristics are typically derived from American Hospital Association Annual Survey (AHA); however, AHA has several limitations such as imputation of large amounts of missing data. To eliminate these limitations, data on hospital characteristics were obtained from the NJ nurse survey.

EHR data were obtained from HIMSS and patient satisfaction from HCAHPS; both are voluntary reporting systems, and as such these data were subject to self-selection bias. HIMSS is a self-report survey of EHR adoption used primarily for market research and as such it may over estimate scores for EHR adoption. Finally, analysis at the hospital level limits sample size, and though the power analysis indicated the sample size was sufficient to detect differences, and significant effects were identified, the sample size of hospitals in the patient satisfaction models may have been a limitation.

CHAPTER VI

Summary, Conclusions, Implications, and Recommendations

Summary

The purpose of this study was to examine the relationships among the nursing practice environment, EHR utilization and functionality, and missed nursing care on adverse patient outcomes (PSIs, readmissions, length of stay and prolonged length of stay) and patient satisfaction in hospitalized patients. Theoretical propositions derived from theories and conceptual models of outcomes (Mitchell Ferketich, & Jennings, 1998; Mitchell & Lang, 2004), information technology (Huber, 1990; Powell-Cope et al., 2008); nursing practice environment (Aiken et al., 2002, Laschinger & Leiter, 2006); and missed nursing care (Kalisch, Landstrom, & Williams, 2009) were tested in this study.

In this study, an adverse patient event was theoretically defined as unintended harm to an inpatient that is most likely caused by clinical management or the health care delivery system rather than an underlying disease or condition (Brennan et al., 1991; DHHS, 2012; Hunt et al., 2005). Early hospital readmission was defined as the readmission of a patient who was recently discharged following a hospitalization (CMS, 2012). The concept of prolonged length of stay (PLOS) was defined as the beginning of the deceleration in the rate of patient discharge from a hospital (Silber et al., 1999; Silber, et al., 2009). Patient satisfaction with health care was defined as the patient's perception of care and rating of their satisfaction with their hospital experience (CMS, 2012; Donabedian, 1966, 1988). Electronic health record (EHR) was defined as the level of EHR capabilities that has been implemented within the hospital environment (HIMSS, 2008; IOM, 2012). Nursing practice environment was defined as "the organizational

characteristics of a work setting that facilitate or constrain professional nursing practice," (Lake, 2002, p.178). Finally, missed nursing care was theoretically defined as necessary nursing care that is omitted, either in part or whole, or delayed (Kalisch, Landstrom, & Hinshaw, 2009).

Outcomes models propose that system-level factors, such as the structural characteristics in which care is provided, affect both the processes of care and the outcomes of care (Donabedian, 1966; 1988). Moreover, theory and conceptual models specifically propose that the adoption of technology, such as EHR, is a system-level characteristic that has a positive, direct effect on the quality of nursing care, and a positive, direct effect on patient outcomes (Huber, 1990; Mitchell, Ferketich, & Jennings, 1998; Powell-Cope et al., 2008). Theory and conceptual models also explain that EHR, through the enhancement of communication and more timely decision processes, reduces missed nursing care, thus supporting a negative relationship between EHR and missed nursing care (Kalisch, 2006; Kalisch, Landstrom & Hinshaw, 2009; Kalisch, Landstrom & Williams, 2009). Finally, theory and conceptual models propose positive relationships among the practice environment, technology, quality nursing care practices, and positive patient outcomes (Mitchell, Ferketich & Jennings, 1998).

There is previous empirical support for the theorized relationships in that technology enhances communication and decision making and positively impacts provider performance and a variety of patient outcomes, including patient satisfaction (DesRoches et al., 2011; Elnahal et al., 2011; Himmelstein et al., 2010; Kazley et al., 2012; Kutney-Lee & Kelly, 2011). There is also previous empirical support for the theorized relationship between the nursing practice environment and patient outcomes,

including satisfaction, in diverse samples of nurses and patients a variety of settings (Aiken et al., 2002, 2012; Brooks-Carthon, Kutney-Lee, Sloane, Cimiotti & Aiken, 2011; Flynn et al., 2012; Kutney-Lee et al., 2009; Purdy et al., 2010). Finally, there is extant empiric support that increased missed nursing care, as an indicator of inferior nursing care practices is associated with increased adverse patient events and decreased patient satisfaction (Lucero et al., 2010; Schubert et al., 2008; Sochalski 2004; Thomas-Hawkins, Flynn & Clarke, 2008).

Therefore, based on the theoretical and empirical literature the following hypotheses were derived:

1. The use of EHR is inversely related to the occurrence of adverse patient events in acute care hospitals.
2. The use of EHR is positively related to patient satisfaction in acute care hospitals.
3. A supportive nursing practice environment will be inversely related to occurrence of adverse patient events in acute care hospitals.
4. A supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals.
5. The use of EHR is inversely related to missed nursing care in acute care hospitals.
6. A supportive nursing practice environment is inversely related to missed nursing care in acute care hospitals.
7. Missed nursing care is positively related to occurrence of adverse patient events in acute care hospitals.
8. Missed nursing care is inversely related to patient satisfaction in acute care hospitals.

9. Missed nursing care will mediate the relationship between the nursing practice environment and occurrence of adverse events.
10. Missed nursing care will mediate the relationship between EHR adoption and occurrence of adverse patient events.
11. Missed nursing care will mediate the relationship between EHR adoption and patient satisfaction.

This study is a secondary analysis of cross sectional data. Study data were compiled from four sources including: (1) the Healthcare Cost and Utilization Project (HCUP) State Inpatient Database (SID) available from the Agency for Healthcare Research and Quality (AHRQ), (2) Healthcare Information and Management Systems Society (HIMSS) Dorenfest Institute database of EHR adoption, (3) Centers for Medicare and Medicaid Services (CMS) data from the Hospital Consumer Assessment of Healthcare Providers and Systems Survey (HCAHPS), and (4) New Jersey nurse survey data. The final analytic sample consisted of 854,258 adult patients and 7,679 nurses in 70 New Jersey acute care hospitals.

The following metrics were used: (1) adverse PSI events were measured using the SIDS PSI algorithm (version 3.1); (2) patient satisfaction was measured using Centers for Medicare and Medicaid Services data from the Hospital Consumer Assessment of Healthcare Providers and Systems Survey (HCAHPS) survey; (3) the nurse practice environment was measured using the Practice Environment Scale-Nursing Work Index (PES-NWI), (Lake, 2002) from the nurse survey data; (4) missed nursing care was measured using reliable and tested items from the nurse survey data (Lucero et al., 2010;

Sochalski, 2001, 2004); and (5) EHR adoption stage was measured using the EMR Adoption Model (EMRAM) scale (Garets & Davis, 2008; HIMSS, 2008).

Data were analyzed using STATA/MP 12.1 software. Descriptive statistics were conducted to analyze the characteristics of the sample by Pearson and Spearman correlations following Shapiro-Wilk tests of normality. Ordinary least squares (OLS) and multiple regression techniques were used to test the hypotheses. Robust procedures with Huber-White sandwich variance estimators and clustered means were used to account for the clustering of patients within hospitals and heteroskedasticity. The level of significance at which the research hypotheses were tested was at .05.

The first hypothesis which stated that the use of EHR is inversely related to the occurrence of adverse patient events in acute care hospitals was minimally supported by a significant relationship between EHR and prolonged length of stay (PLOS). This is the first study to have examined this relationship between EHR adoption stage and PLOS, thus extending this knowledge. The second hypothesis which stated the use of EHR is positively related to patient satisfaction in acute care hospitals was not supported. The third hypothesis which stated a supportive nursing practice environment will be inversely related to occurrence of adverse patient events in acute care hospitals was not supported. The fourth hypothesis which stated that a supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals was supported. This study also estimated the work environment dimension of staffing and resource adequacy in separate models, which was not conducted in prior studies, thus extending this knowledge.

The fifth hypothesis which stated the use of EHR is inversely related to missed nursing care in acute care hospitals was not supported. This is the first study that has tested this relationship. The sixth hypothesis which stated that a supportive nursing practice environment is inversely related to missed nursing care in acute care hospitals was supported, thus extending the limited knowledge of this relationship. The seventh hypothesis which stated that missed nursing care is positively related to occurrence of adverse patient events in acute care hospitals was not supported.

The eighth hypothesis which stated that missed nursing care is inversely related to patient satisfaction in acute care hospitals was minimally supported by a significant relationship between missed nursing care and the response of "definitely recommending" the hospital. This is the first study to examine this relationship using the National Quality Forum endorsed HCAHPS measures, thus extending this knowledge. The ninth, tenth and eleventh hypotheses which stated that missed nursing care will mediate: (a) the relationship between the nursing practice environment and occurrence of adverse events; (b) the relationship between EHR adoption and occurrence of adverse patient events and (c) the relationship between EHR adoption and patient satisfaction were not supported. A summary of these results is presented in Table 16.

In summary, theoretical propositions were tested to explain the relationships among the nursing practice environment, EHR utilization and functionality, and missed nursing care on adverse patient outcomes (PSIs, readmissions, length of stay and prolonged length of stay) and patient satisfaction in hospitalized patients. The theoretical propositions tested explained the relationships between: (a) EHR adoption stage and PLOS, (b) the nursing practice environment and patient satisfaction, (c) the nursing

practice environment and missed nursing care, and (d) missed nursing care and patient satisfaction.

Table 16

Summary of Results of Hypotheses Testing

Hypothesis	Supported
1. The use of EHR is inversely related to the occurrence of adverse patient events in acute care hospitals.	Partial
2. The use of EHR is positively related to patient satisfaction in acute care hospitals.	No
3. A supportive nursing practice environment will be inversely related to occurrence of adverse patient events in acute care hospitals.	No
4. A supportive nursing practice environment will be positively related to patient satisfaction in acute care hospitals.	Yes
5. The use of EHR is inversely related to missed nursing care in acute care hospitals.	No
6. A supportive nursing practice environment is inversely related to missed nursing care in acute care hospitals.	Yes
7. Missed nursing care is positively related to occurrence of adverse patient events in acute care hospitals.	No
8. Missed nursing care is inversely related to patient satisfaction in acute care hospitals.	Partial
9. Missed nursing care will mediate the relationship between the nursing practice environment and occurrence of adverse events.	No
10. Missed nursing care will mediate the relationship between EHR adoption and occurrence of adverse patient events.	No
11. Missed nursing care will mediate the relationship between EHR adoption and patient satisfaction.	No

Conclusions

As hypothesized, findings from this study support that an inverse relationship exists between EHR adoption stage and the adverse patient outcome of PLOS. Moreover, findings support the theoretical positive relationship between the nursing practice environment and patient satisfaction; the theoretical inverse relationship between the nursing practice environment and missed nursing care; and the theoretical, inverse relationship between missed nursing care and patient satisfaction. Among the subscales, or dimensions, of the nursing practice environment that were tested, staffing and resource adequacy was the strongest predictor of missed nursing care and patient satisfaction.

Contrary to the hypotheses, the findings of this study did not support the theoretical propositions that increased EHR adoption stages are related to the adverse outcomes of PSIs and readmissions, patient satisfaction or missed nursing care. Thus, the hypotheses that missed nursing care mediates these relationships was not supported either. As guided by the theoretical literature further analysis was conducted to examine if the relationships among the nursing work environment, missed nursing care and patient satisfaction were confounding the effect of EHR on patient satisfaction outcomes. Findings indicate that there is no direct effect of EHR on patient satisfaction outcomes when controlling for the nursing practice environment and missed nursing care. In summary, findings in this study do not support the theoretical propositions between advanced EHR adoption stage and patient outcomes, other than PLOS, but do support the relationships among a better work environment, less missed care and higher patient satisfaction.

Implications

The implications of the knowledge generated by this study are significant for nurses, administrators and policy makers, particularly in context of the shifting healthcare delivery landscape. In 2011, the consequential IOM report *The Future of Nursing: Leading Change, Advancing Health* asserted that the U.S. healthcare system has a unique opportunity to transform itself, and that nurses have a crucial role "with respect to the quality, accessibility, and value of care," (p. 28). Presently, this paradigm shift in U.S. healthcare is underway, aimed at transforming healthcare to make it more efficient, economical, and equitable resulting in the delivery of higher quality care for more people. A key facet of this shift is the permeation of technology in the healthcare environment, which is radically changing how care, including nursing care, is delivered (IOM, 2012). This shift is strongly guided by two key legislative acts that are changing the context of healthcare delivery and nursing practice in the U.S.

In 2009, the federal government passed the American Recovery and Reinvestment Act (ARRA); this included a provision for the Health Information Technology for Economic and Clinical Health (HITECH) Act (CMS, 2012b; DHHS, 2010b). One year later, the Affordable Care Act (ACA) of 2010 established the Hospital Value Based Purchasing (VBP) program, a CMS initiative that rewards acute-care hospitals with incentive payments for the quality of care provided (CMS, 2013). This affects payment for inpatient stays in 2, 985 U.S. hospitals (CMS, 2013). Succinctly, the ARRA offered significant financial incentives to hospitals for implementing EHRs and will begin penalizing those that do not; the ACA followed and rewards only the high performing hospitals with payment through the Medicare program and penalizes lower performing organizations. Undoubtedly, this has challenged hospital administrators as they balance

increasingly scarce resources and formulate how to direct valuable human and material resources in efforts to meet both the provisions of both the ARRA and the ACA.

In context of HITECH, the belief that health information technology will foster healthcare reform is supported by a $35 billion federal investment for HITECH programs (DHSS, 2010a; ONC, 2010). Organizations that accept Medicare and Medicaid dollars are eligible to participate in the EHR incentive programs and receive EHR incentive payments from fiscal years 2011 to 2015 (Medicare), or 2011 to 2016 (Medicaid), beginning with a $2 million base payment (CMS, 2012). These payment summaries have totaled over $5 billion dollars to date (CMS, 2012). However, eligible hospitals that do not demonstrate Meaningful Use will be subject to payment adjustments in 2015 (CMS, 2012; DHHS, 2010a; HIMSS, 2012a).

Specifically, it is the Meaningful Use of technology enabled healthcare that matters under HITECH. Meaningful Use is conceptualized as encompassing adoption, data security and confidentiality, sharing of information, engaging patients in electronic health information and improving care by incorporation of certified EHR technology into healthcare practice (ONC, 2010). Across the U.S., hospitals and nurses have made significant efforts to achieve higher Meaningful Use stages. Nearly 44% of U.S. hospitals that submitted data to HIMSS in 2012 achieved the EMRAM middle stage (3) of adoption, this would equate to meeting Meaningful Use Stage 1 objectives (Appari, Johnson & Anthony, 2012; HIMSS 2012b). In this study of NJ hospitals in 2006, 37% had achieved EMRAM stage 3; one-third of those achieved the next cumulative level of EMRAM stage 4. The EMRAM stages measured in this study would correspond to

Meaningful Use Stages 1 and 2, thus there are significant implications of these study findings for both current and future nursing practice and hospital payment.

Despite the evident momentum, data indicate the majority of hospitals in both this NJ 2006 baseline data and more recent 2012 national data were below EMRAM stage 3, thus a possible critical point in realizing the potential impact of EHR may not yet be reached. Importantly, achieving EMRAM stage 3, which includes nursing documentation, the primary mechanism of electronic communication, is essential for safe transitions of care (Table 1). As such, outcomes that are more sensitive to good communication and care transitions, such as readmissions, PLOS and patient reports of "yes, given discharge information," may conceivably be early indicators of the impact of advanced EHR adoption, such as EMRAM stage 3.

This study demonstrated that EHR does have a positive, adjusted effect on a patients' prolonged length of stay; and it is theoretically plausible that as features of advanced technology becomes embedded in healthcare organizations that the positive benefits may extend to additional patient outcomes (Huber, 1990; Powell-Cope et al., 2008). Indications of this relationship are also suggested by the adjusted model for readmissions that was near the level of significance set for this study ($\beta = -.30$, $p = .06$), and the significant effect of higher EHR adoption stages, though in the opposite direction theorized, of patients who responded "yes, given discharge information" ($\beta = -.31$, $p = .02$). Conceivably, it may be that once a tipping point of both longer duration of EHR adoption and advanced stages (EMRAM 3 or higher) is reached, the benefits of EHR will become fully evident. Until such time, as the HITECH act drives the integration of technology into the work flow of nurses, it will be important to reexamine what nurses do

at the point of care and how they interact with the patient. That is, technology cannot be viewed in isolation, but as part of the fabric of hospital healthcare, as the integration of EHR in health systems is not the end, but a possible means to the end of improved patient safety, outcomes, and satisfaction, as supported by findings from this study.

The second important context in which to consider the findings of this study is the impact of the Affordable Care Act (ACA). The ACA introduced the concept of Value Based Purchasing (VBP), which is dramatically shaping healthcare delivery in the U.S. VBP places 2% of hospital Medicare reimbursement at risk by metrics of quality, outcomes and experiences of care (CMS, 2013). Specifically, the domains of VBP and relative weights for fiscal year 2013 include: (a) core measures 70% and (b) patient satisfaction as measured by HCAHPS at 30%. These domain weights broaden to include: (a) efficiency 20%, (b) outcomes 30%, (c) clinical process of care 20%, and (d) HCAHPS at 30% by FY 2015 (CMS, 2013). Thus, hospital administrators have a strong financial incentive to implement strategies that will enhance patient satisfaction.

Important to this financial incentive, this study found a strong and positive impact of features of the nursing work environment on patient satisfaction outcomes. That is, findings indicate that features of a better nursing practice environment will contribute to the reimbursement associated with patient satisfaction, or 30% of the 1% at risk base DRG operating payment in fiscal year (FY) 2013, which rises to 2% by FY 2017 (CMS, 2013). Moreover, as evident above, the domain weighing for score calculations and future payment of the domains of VBP consistently value patient satisfaction at 30% through 2015 (CMS, 2013). Importantly, findings from this study indicate that a one

point improvement in a hospital's nursing practice environment is associated with a mean 16% increase in patient satisfaction scores.

Also of note, study findings indicate that the amount of missed nursing care in hospitals can be decreased by 7.3% to 13.5% by increasing any one of the nursing practice environment subscale scores by one point on the four point Likert scale, with the greatest effect attributed to the staffing and resource adequacy measure. Moreover, this study found that for every one less care task that nurses miss, the hospital level indicator of definitely recommending the hospital will increase by 4.4%.

Beyond the significant and direct financial impact of these study findings in context of the ARRA and the ACA, there is potential for indirect impact. The funds hospitals risk and receive reimbursement for are tied to performance, that is care that has been provided to patients. It is important to consider that business growth, or the financial viability of an organization, is also impacted by admission volume (Messina, Scotti, Ganey & Zipp, 2009). Admission volume is due in part to a patient's willingness to return and willingness to recommend a hospital (Al-Mailam, 2005; Otani, Waterman, Faulkner, Boslaugh, Burroughs, & Dugan, 2009). This in turn is influenced by better nursing care and patient satisfaction (Otani, Waterman, Faulkner, Boslaugh, & Dugan, 2010). As such, quality nursing care and patient satisfaction influence patients willingness to return and to recommend a hospital, this in turn impacts hospital volume and subsequent revenue generated.

Finally, the significant financial impact of these findings is in context of the ARRA and ACA, the public funding of health care; the impact of private payer revenue streams is unknown, yet indications suggest this source of revenue will be impacted by

reformed payment models as well (Ginsberg, 2013; White, 2013). Thus, in a consumer-centric market, an aim of transforming healthcare in the U.S., patient satisfaction as an indicator of high quality care is of vital importance to an organizations' success (Berwick, Nolan & Whittington, 2008). In sum, these study findings have significant implications in context of both the direct financial impact on hospitals for the quality of care already provided, and the indirect financial impact on hospitals ability to provide care for future patients.

In summary, the vision to transform healthcare in the U.S., still urgently needed following a clarion call from the IOM over decade ago, is presently being actualized through legislation of the ACA and ARRA (IOM, 2001; IOM, 2012). The dual demands, however, of the legislative provisions to implement health information technology and improve quality outcomes may exacerbate the difficult decisions hospital administrators need to make regarding allocation of valuable resources. There is a strong financial incentive to integrate technology into the healthcare work environment, and sound theoretical rationale to believe that through enhanced communication, improved data management and better transitions of care that EHR will benefit patients and providers alike. These benefits, however, are not broadly evident from the findings of this study. Strongly evident in the findings, however, is the importance of not overlooking the fundamentals of quality nursing care as technology is integrated into practice. Significantly, this study identifies that the fundamentals of quality nursing care and enhanced patient satisfaction are dependent, at least in part, on a supportive nursing practice environments, adequate nurse staffing, and sufficient access to resources that are needed by nurses in the conduction of their important work.

Broader implications of these study findings suggest that organizations that have these fundamentals of quality nursing care in place may realize improved patient satisfaction outcomes that translate into real dollars through the VBP program. Viewed through the lens of the dynamic Quality Health Outcomes Model, the implications of this study suggest that meeting the demands of the ARRA and ACA may not be mutually exclusive. Rather, in an iterative manner, a supportive nursing work environment that is adequately staffed and resourced will improve patient satisfaction, leading to better organizational financial health. These fiscal resources, can in turn, be used by organizations to continue advancing EHR adoption and the transformation of health care in the U.S.

This innovative study addressed significant empirical gaps in the patient safety literature and advances the important nursing research goal to improve patient safety outcomes. The key finding is that good nursing practice environments, adequate staffing, and sufficient resources for the provision of nursing care are crucial in that they demonstrate a strong impact on the delivery of quality care and patient satisfaction. Findings may be used to inform key healthcare executives and policymakers to render better decisions regarding the allocation of valuable resources. By example, informed policies that support important provisions of a good nursing practice environment can be enacted at organizational and legislative levels.

Moreover, findings from this study will be relevant to hospital administrators as they attempt to construct and deploy efficient mixes of material and human resources that will support the provision of safe, error free care. In context of the financial constraints it will be necessary for organizations to redefine the delivery of healthcare in terms of value

and non-value added nursing work, work-design and skill mix. Additionally, findings from this study inform a technologically based, multi-faceted approach to reduce the adverse event of prolonged length of stay and enhance patient satisfaction in acute care hospitals. Lastly, findings from this study add to a growing body of knowledge in nursing health services research that identifies modifiable system factors and hospital-level determinants that may be modified through broader alternative strategies to improve patient outcomes and satisfaction.

Recommendations

Based on the findings of this study, recommendations for future research include:

1. Replicate this study with most recent data from these four sources and re-examine these relationships in hospitals that have achieved advanced stages on the HIMSS EMRAM scale in a larger, multi-site, multi-state study.
2. Conduct a comparative research effectiveness study and cost analysis to examine the impact of various modalities to improve the items of the staffing and resource adequacy scale (enough staff, enough registered nurses, adequate support services, and enough time and opportunity to discuss patient care problems) and the impact on patient satisfaction outcomes.
3. Conduct studies in other settings that test the relationship among EHR stages, nursing practice environment, missed nursing care and setting specific patient safety indicators, as well as the AHRQ PSI 90 composite measure.
4. Conduct studies to test if missed nursing has a moderated–mediation effect on the relationship between the nursing practice environment and patient satisfaction

5. Conduct research to identify specific components of EHR that improve patient outcomes.

REFERENCES

Aboelela, S.W., Larson, E.L., Bakken S, Carrasquillo, O., Formicola, A, Glied, S.A. (2007). Defining interdisciplinary research: Conclusions from a critical review of the literature. *Health Services Research, 42,* 329-46.

Agency for Healthcare Research and Quality (AHRQ), (2004). *AHRQ Quality Indicators – Guide to Patient Safety Indicators.* Rockville, MD: Agency for Healthcare Research and Quality, 2003. Version 2.1, Revision 2, AHRQ Pub.03-R203

Agency for Healthcare Research and Quality (AHRQ), (2010a). *AHRQ quality indicators: Composite measures user guide for the patient safety indicators (PSI).* Version 4.2 (September, 2010). Department of Health and Human Services Agency for Healthcare Research and Quality. Retrieved: http://www.qualityindicators.ahrq.gov

Agency of Healthcare Research and Quality (AHRQ), (2010b). AHRQ Quality Indicator: Comparative Data for the PSI based on the 2008 Nationwide Inpatient Sample (NIS), Version 4.1b. Department of Health and Human Services Agency for Healthcare Research and Quality. Retrieved: http://www.qualityindicators.ahrq.gov

Agency of Healthcare Research and Quality (AHRQ), (2012). AHRQ PSNet Patient Safety Network: Glossary. Retrieved: http://psnet.ahrq.gov/glossary.aspx.

Aiken, L.H. (2002). Superior outcomes for Magnet hospitals: The evidence base. In: M.L. McClure & A.S. Hinshaw (Eds.), *Magnet Hospitals Revisited: Attraction and Retention of Professional Nurses* (pp. 61-81). Washington, DC: American Nurses Publishing.

Aiken, L. H., Cimiotti, J. P., Sloane D. M., Flynn, L. & Neff, D. F. (2011). Effects of nurse staffing and nurse education on patient deaths in hospitals with different nurse work environments. *Medical Care, 49* (12): 1047-53.

Aiken, L.H., Clarke, S.P., & Sloane, D.M. (2002). Hospital staffing, organizational, and quality of care: Cross-national findings. *Nursing Outlook, 50,* 187-194. doi: 10.1067/mno.2002.126696.

Aiken, L. H., Clarke, S. P., Sloane, D. M., Sochalski, J., & Silber, J. H. (2002). Hospital nurse staffing and patient mortality, nurse burnout and job dissatisfaction. *Journal of the American Medical Association, 288*(16), 1987-1993.

Aiken, L. H., Clarke, S. P., Sloane, D. M., Lake, E. T., & Cheney, T. (2008). Effects of hospital care environment on patient mortality and nurse outcomes. *Journal of Nursing Administration, 38*(5), 223-229.

Aiken L.H., Sermeus, W., Van den Heeds, K., Sloane, D.M., Busse, R., McKee, M…Kutney-Lee, A. (2012). Patient safety, satisfaction, and quality of hospital care: cross sectional surveys of nurses and patients in 12 countries in Europe and the United States. *British Medical Journal.* Retrieved: *BMJ* 2012; 344:e1717 doi: 10.1136/bmj.e1717 (Published 20 March 2012).

Aiken, L.H., Sloane, D.M., Cimiotti, J.P., Clarke, S.P., Flynn, L., Seago, J.A., Spetz, J., & Smith, H.L. (2010). Implications of the California nurse staffing mandate for other states. *Health Services Research, 45(*4), 904-921.

Aiken, L.H., Sloane, D.M., Lake, E.T., Sochalski, J., & Weber, A.L. (1999). Organization and outcomes of inpatient AIDS care. *Medical Care, 37,* 760-772.

Aiken, L.H., Sochalski, J., & Lake, E.T. (1997). Studying outcomes of organizational change in health services. [Supplemental material]. *Medical Care, 35*(11), NS6-NS18.

Al-Kandari, F. & Thomas, D. (2009). Factors contributing to nurse task incompletion as perceived by nurses working in Kuwait general hospitals. *Journal of Clinical Nursing, 18,* 3430-3440. doi: 10.1111/j.1365-2702.2009.02795.x

Al-Mailman, F.F. (2005). The effect of nursing care on overall patient satisfaction and its predictive value on return-to provider behavior: a survey study. *Quality Management in Health Care, 14*(2), 116-120.

Appari, A., Johnson, E. & Anthony, D.L. (2013). Meaningful use of electronic health record systems and process quality of care: Evidence from a panel analysis of U.S. acute-care hospitals. *Health Services Research, 48*(2), 354-375.

Ashton, C.M., Kuykendall, D.H., Johnson, M.L., Wray, N.P., & Wu, L. (1995). The association between quality of inpatient care and early readmissions. *Annals of Internal Medicine, 122*(6), 415-421.

Ashton, C.M., & Wray N.P. (1996). A conceptual framework for the study of early readmission as an indicator of quality of care. *Social Science & Medicine, 43*(11), 1533-1541.

Bakken S. (2006). Informatics for patient safety: A nursing research perspective. *Annual Review of Nursing* Research, *24*, 219-254.

Bakken, S., Stone, P.W. & Larson, E.L. (2008). A nursing informatics research agenda for 2008-18: Contextual influences and key components. *Nursing Outlook, 56*(5), 206-214. doi: 10.1016/j.outlook.2008.06.007

Bates, D, & Gawande, A. (2003). Improving patient safety with information technology. *New England Journal of Medicine, 348*(25), 2526-2534.

Berwick, D.M., Nolan, T.W. & Whittington, J. (2008). The Triple Aim: Care, health and cost. *Health Affairs, 27*(3), 759-769.

Bittner, N.P. & Gravlin, G. (2009). Critical thinking, delegation, and missed care in nursing practice. *Journal of Nursing Administration, 39*(3), 142-146.

Boyle, A.M. (2004). Nursing unit charactersitics and patient outcomes. *Nursing Economics,* 22(3), 111-123.

Brooks-Carthon, J.M., Kutney-Lee, A., Sloane, D.M., Cimiotti, J., & Aiken, L.H. (2011). Quality of care and patient satisfaction in hospitals with high concentrations of black patients. *Journal of Nursign Scholarship, 43*(3), 301-310. doi: 10.1111/j.1547-5069.2011.01403.x

Brennan, T.A., Leape, L.L., Laird, N.M., Herbert, L., Localio, R., Lawthers, A.G., Newhouse, J.P., Weiler, P.C., & Hiatt, H.H. (1991). Incidence of adverse events and neglience in hopsitalized patients: Results of the Harvard Medical Practice Study I. *New England Journal of Medicine, 324*(6), 370-376.

Buntin, M. B., Burke, M. F., Hoaglin, M. C., & Blumenthal, D. (2011). The benefits of health information technology: A review of the recent literature shows predominantly positive results. *Health Affairs, 30*(3), 464-471.

Buerhaus, P. I., Donelan, K., Ulrich, B. T., Norman, L., DesRoches, C., & Dittus, R. (2007). Impact of the nurse shortage on hospital patient care: Comparative perspectives. *Health Affairs, 26*(3), 853-862.

Bureau of Labor Statistics (2012). Occupational Employment Statistics, May 2011.

Retrieved: http://www.bls.gov/oes/current/oes292061.htm

Centers for Medicare & Medicaid Services, (CMS). (2012a). Hospital care quality information from the consumer perspective. Retrieved: http://www.hcahpsonline.org.

Centers for Medicare & Medicaid Services, (CMS). (2012b). EHR Incentive program: Active Registrations. Retrieved: https://www.cms.gov/Regulations-and-Guidance/Legislation/EHRIncentivePrograms/Downloads/July2012_MonthlyReports.pdf

Centers for Medicare & Medicaid Services, (CMS). (2013). Hospital value-based purchasing program. Retrieved: http://www.cms.gov/Medicare/Quality-Initiatives-Patient-Assessment-Instruments/Hospital-Value-Based-Purchasing/

DesRoches, C.M., Miralles, P., Buerhaus, P., Hess, R., & Donelan, K. (2011). Health information technology in the workplace. *The Journal of Nursing Administration, 41(*9), 357-364.

Dillman, D.A., Smyth, J. D., & Christian, L. M. (2009). Internet, *Mail, and Mixed-Mode Surveys: The Tailored Design Method.* ASIN: B00387FOGM.

Donabedian, A. (1980). *Explorations in Quality Assessment and Monitoring: Vol. 1 The Definition of Quality and the Approaches to its Assessment.* Health Administration Press: MI.

Donabedian, A. (1988). *The quality of care: how can it be assessed? Journal of the American Medical Association, 260* (12), 1743-1748.

Donabedian, A. (1966). Evaluating the quality of medical care. *The Millbank Memorial Fund Quarterly, 44*(3), Part 2: Health Services Research I., 166-206.

Djukic, M., Kovner, C.T., Brewer, C.S., Fatehi, F.K. & Cline, D.D. (2011). Work environment factors other than staffing associated with nurses' ratings of patient care quality. *Health Care Management Review*, [electronic edition], doi:10.1097/HMR.0b013e3182388cc3.

Elixhauser, A., Steiner, C., Harris, D. R., & Coffey, R. M. (1998). Comorbidity measures for use with administrative data. *Medical Care, 36*, (1), 8-27.

Elnahal, S.M., Joynt, K.E., Bristol, S.J., & Jha, A.K., (2011). Electronic health record functions differ between the best and worst hospitals. *American Journal of Managed Care, 17*(4), e121-e147.

Flood, A.B., & Fennell, M.L. (1995). Through the lenses of organizational sociology: the role of organizational theory and research in conceptualizing and examining our health care system [Extra issue]. *Journal of Health and Social Behavior*, 154-169.

Flynn, L., Liang, Y., Dickson, G., & Aiken, L. (2010). Effects of nursing practice environments on quality outcomes in nursing homes. *Journal of the American Geriatric Society, 58(*12), 2401-2406.

Flynn, L., Liang, Y., Dickson, G.L., Xie, M., & Suh, D. (2012). Nurses' practice environments, error interception practices, and inpatient medication errors. *Journal of Nursing Scholarship, 44*(2), 180-186.
.

Friese, C.R., Lake, E.T., Aiken, L.A., Silber, J.H., & Sochalski, J. (2008). Hospital nurse practice environments and outcomes for surgical oncology patients. *Health Services Research, 43*(4), 1145-1162. doi: 10.1111/j.1475-6773.2007.00825.x

Furukawa, M.F., Raghu, T.S. & Shao, B.M. (2011). Electronic medical records, nurse staffing, and nurse-sensitive patient outcomes: evidence from the national database of Nursing Quality Indicators. *Medical Care Research and Review, 68*(3), 311-331. doi: 10.1177/1077558710384877

Gardner, J.K., Thomas-Hawkins, C., Fogg, L., & Latham, C.E. (2007). The relationships between nurses' perceptions of the hemodialysis unit work environment and nurse turnover, patient satisfaction, and hospitalizations. *Nephrology Nursing Journal, 34*(3), 271-281.

Garets, D., & Davis, M. (2006). *Electronic medical records vs. electronic health records: Yes, there is a difference.* Chicago, IL. HIMSS Analytics. Retrieved: http://www.himssanalytics.org/docs/WP_EMR_EHR.pdf

Ginsberg, P.B. (2013). Achieving health care cost containment through provider payment reform that engages patients and providers. *Health Affairs, 32*(5), 929-934.

Harrell, F.E. (2001). *Regression modeling strategies: With applications to linear models, logistic regression, and survival analysis.* New York, N.Y.: Springer

HCUP State Inpatient Databases (SID), (2012a). Healthcare Cost and Utilization Project (HCUP). New Jersey, 2006- 2007. Agency for Healthcare Research and Quality, Rockville, MD. Retrieved May 27, 2012: www.hcup-us.ahrq.gov/sidoverview.jsp

HCUP (2012b). SID Description of Data Elements All States, Healthcare Cost and Utilization Project (HCUP). Agency for Healthcare Research and Quality, Rockville, MD. Retrieved May 27, 2012: http://www.hcup-us.ahrq.gov/db/state/siddist/sid_multivar.jsp.

Himmelstein, D.U., Wright, A., & Woolhandler, S. (2010). Hospital computing and the costs and quality of care: A national study. *American Journal of Medicine, 123*, 40-46. doi: 10.1016/j.amjmed.2009.09.004

Healthcare Information and Management Systems (HIMMS). (2008). EMR Adoption Model. Retrieved: http://www.himssanalytics.org/docs/EMRAM.pdf?src=winews20081112

Healthcare Information and Management Systems Society (HIMSS), (2012a). HIMSS executive summary: Medicare and Medicaid Programs; Electronic Health Record Incentive program- Stage 2. Retrieved: www.himss.org/policy/d/20120829_HIMSS_Stage2_MU_Final...

Healthcare Information and Management Systems Society (HIMSS), (2012b). United States EMRAM. Retrieved from http://www.himssanalytics.org/home/index.aspx

Huber, G. P. (1990). A theory of the effects of advanced information technologies on organizational design, intelligence, and decision making. *Academy of Management Review, 15*(1), 47-71.

Hughes R.G., (Ed.). (2008). *Patient Safety and Quality: An Evidence-Based Handbook for Nurses*. Rockville (MD): Agency for Healthcare Research and Quality (US).

Hunt, D. R., Verzier, N., Abend, S.L. Lyder, C. Jaser, L.J., Safer, N. & Davern, P. (2005). Fundamental of Medicare patient safety surveillance: Intent, relevance, and transparency. *Advances in Patient Safety: From Research to Implementation*. Volumes 1-4, AHRQ Publication Nos. 050021 (1-4). February 2005. Agency for Healthcare Research and Quality, Rockville, MD. Retrieved: http://www.ahrq.gov/qual/advances/

Hsieh, F.Y. (1989). Sample size tables for logistic regression. *Statistics in Medicine, 8,*

795-802.
Iezzoni, L. I. (Ed.). (2003). *Risk adjustment for measuring health care outcomes* (3rd Ed.). Chicago: Health Administration Press.
Institute of Medicine (IOM). (2001). *To Err is Human: Building a Safer Health System.* Washington, DC: National Academies Press.
Institute of Medicine (IOM). (2004). *Patient Safety: Achieving a New Standard for Care*. Washington, DC: The National Academies Press.
Institute of Medicine (IOM). (2009). *Comparative Effectiveness Research*. Washington, DC: National Academies Press.
Institute of Medicine (IOM). (2011). *The Future of Nursing: Leading Change, Advancing Health.* Washington, DC: National Academies Press.
Institute of Medicine (IOM). (2012). *Health IT and Patient Safety: Building Safer Systems for Better Care.* Washington, DC: National Academies Press.
Irvine, D.M., Sidani, S. & McGillis Hall, L. (1998). Linking outcomes to nurses; roles in health care. *Nursing Economics, 16,* 58-64.
Jamal, A., McKenzie, K., & Clark, M. (2009). The impact of health information technology on the quality of medical and health care: a systematic review. *Health Information Management Journal, 38*(3), 26-37.
Jarvis, B., Johnson, T., Butler, P., O'Shaughnessy, K., Fullam, F., Tran, L., & Gupta, R. (2013). Assessing the impact of electronic health records as an enabler of hospital quality and patient satisfaction. *Academic Medicine, 88*(10), 1471-1477.
Jha, A. K., DesRoches, C. M., Campbell, E. G., Donelan, K., Rao, S. R., Ferris, T. G.,…Blumenthal, D. (2009). Use of electronic health records in U.S. hospitals. *New England Journal of Medicine, 350*(16), 1628-1638.
Jha, A.K., Orav, J., Zheng, J. & Epstein, A.M. (2008). Patient's perceptions of hospital care in the United States. *New England Journal of Medicine, 359*(18), 1921-1931.
Kalisch, B. J. (2006). Missed nursing care a qualitative study. *Journal of Nursing Care Quality, 21*(4), 306-313.
Kalisch, B. J., Landstrom, G. L., & Hinshaw, A. S. (2009). Missed nursing care: a concept analysis. *Journal of Advanced Nursing, 65*(7), 1509-1517.
Kalisch, B., Landstrom G, & Williams, R. (2009). Missed nursing care: Errors of omission. *Nursing Outlook, 57*(1), 3-9.
Kalisch, B., McLaughlin, M., & Dabney, B.W. (2012). Patient perceptions of missed care. *The Joint Commission Journal on Quality and Patient Safety, 38*(4), 161-167.
Kalisch, B., Tschanen, D., & Lee, K.H. (2011). Missed nursing care, staffing and patient falls. *Journal of Nursing Care Quality, 27*(1), 6-12.
Kalisch, B. & Williams, (2009). Development and psychometric testing of a tool to measure missed nursing care. *Journal of Nursing Administration, 39*(5), 211-219.
Kazley, A.S., Diana, M.L., Ford, E.W., & Menachemi, N. (2012). Is electronic health record use associated with patient satisfaction in hospitals? *Health Care Management Review, 37*(1), 23-30. doi: 10.1097/HMR.0b0113e3182307bd3
Kazley, A. S., Diana, M. L., & Menachemi, N. (2011). The agreement and internal consistency of national hospital EMR measures. *Health Care Management Science, 14*(4), 307-313.

Kazley, A. S. & Ozcan, Y. A. (2008). Does hospital electronic medical record use increase health care quality? An examination of three clinical conditions. *Medical Care Research Review, 65*(4), 496-513.

Kazley, A. S. & Ozcan, Y. A. (2007). Organizational and environmental determinants of hospital EMR adoption: A National Study. *Journal of Medical Systems, 31,* 375-384. doi: 10.1007/s10916-007-9079-7

Kelley, T. F., Brandon, D. H. and Docherty, S. L. (2011). Electronic nursing documentation as a strategy to improve quality of patient care. *Journal of Nursing Scholarship, 43(2),* 154–162.

Kutney-Lee, A. & Kelly, D. (2011). The effect of hospital electronic health record adoption on nurse-assessed quality of care and patient safety. *Journal of Nursing Administration, 41*(11), 466-472.

Kutney-Lee, A., McHugh, M.D., Sloane, D.M., Cimiotti, J.P., Flynn, L., Neff, D.F. & Aiken, A.H. (2009). Nursing: A key to patient satisfaction. *Health Affairs, 28*(4), w669-w677. doi:10.1377/hltaff.28.4w669

Lake, E.T. (2002). Development of the Practice Environment Scale of the Nursing Work Index. *Research in Nursing & Health, 25(3),* 176-186.

Lake, E.T. (2007). The nursing practice environment: Measurement and evidence. *Medical Care Research and Review, 64*(2), 104S-122S. doi: 10.1171/107755870799253

Landrigan, C.P., Parry, G.J., Bones, C.B., Hackbarth, A.D., Goldmann, D.A., & Sharek, P.J. (2010). Temporal trends in rates of patient harm resulting from medical care. *New England Journal of Medicine, 363*(26), 2124-2134.

Laschinger H.K.S. & Leiter, M.P. (2006). The impact of the work environments on patient safety outcomes. *Journal of Nursing Administration, 36*(5), 259-267.

Leape, L., Berwick, D., Clancy, C., Conway, J., Gluc, J., Guest, J., Lawrence, D., Morath, J., O'Leary, D. O'Neil, P., Pinakiewicz, D. & Isaac, T. (2009). Transforming health care: a safety imperative. *Quality and Safety in Health Care, 18*(6), 424-428.

Leiter, M.P. & Laschinger, H.K.S. (2006). Relationships of work and practice environment to professional burnout testing a causal model. *Nursing Research, 55*(2), 137-146.

Lohr K.N. (1988). Outcome measurements: concepts and questions. *Inquiry, 25*(1):37–50

Lucero, R. J., Lake, E. T. & Aiken, L. H. (2010). Nursing care quality and adverse events in US hospitals. *Journal of Clinical Nursing, 19*(15-16), 2185-2195.

Manojlovich, M. & Laschinger, H. (2007). The nursing worklife model: Extending and refining new theory. *Journal of Nursing Management, 15,* 256-263.

McCullough, J. S., Casey, M., Moscovice, I., & Prasad, S. (2010). The effect of health information technology on quality in U.S. hospitals. *Health Affairs,* 29(4), 647-654.

McDonald K, Romano P, Geppert J, et al. (2002). Measures of Patient Safety Based on Hospital Administrative Data: The Patient Safety Indicators (Technical Report No. 5). *AHRQ Publication No. 02-0038*. Rockville, MD: Agency for Healthcare Research and Quality.

Messina, D.J., Scotti, D.J. Ganey, R. & Zipp, P. (2009). The relationship between patient satisfaction and inpatient admissions across teaching and nonteaching hospitals. *Journal of Healthcare Management, 54*(3), 177-190.

Meurier, C.E. (2000). Understanding the nature of errors in nursing: Using a model to analyze critical incident reports of errors which had resulted in an adverse or potentially adverse event. *Journal of Advanced Nursing, 32*, 202-207.

Mitchell, P., Ferketich, S., & Jennings, B. M. (1998). Quality Health Outcomes Model. *Journal of Nursing Scholarship, 30*(1), 43-46.

Mitchell, P.H., & Lang, N.M. (2004). Framing the problem of measuring and improving healthcare quality: has the Quality Health Outcomes Model been useful? *Medical Care, 42(*2), SII-4-II-11.

Mitchell, P. H. & Shortell, S. M. (1997) Adverse outcomes and variations in organization and delivery of care. *Medical Care, 35*(11, Suppl.), NS19-N32.

National Institute of Nursing Research (NINR), (2012). Bringing science to life: NINR strategic plan. Retrieved: http://www.ninr.nih.gov/NR/rdonlyres/8BE21801-0C52-44C2-9EEA-142483657FB1/0/NINR_StratPlan_F2_508.pdf

National Quality Forum (NQF), (2013). Quality Positioning System; Measure Title HCAHPS. Retrieved: http://www.qualityforum.org/Qps/MeasureDetails.aspx?standardID=1192

Nightingale, F. (1863). *Notes on Hospitals,* (3rd Edition). Retrieved: http://archive.org/stream/notesonhospital01nighgoog#page/n6/mode/2up

Nowinski, C.J., Becker, S.M., Reynolds, K.S., Beaumont, J.L., Caprini, C., Hahn, e., Peres, A., & Arnold, B.J. (2007). The impact of converting to an electronic health record on organizational culture and quality improvement. *International Journal of Medical Informatics, 76*[Supplement], S174-S183. doi: 10.1016/j.ijmedinf.2006.05.016

Otani, K., Waterman, B., Faulkner, K.M., Boslaugh, S., Burroughs, T.E., & Dunagan, W.C. (2009). Patient satisfaction: Focusing on "excellent". *Journal of Healthcare Management, 54*(2), 93-103.

Otani, K., Waterman, B., Faulkner, K.M., Boslaugh, S., & Dunagan, W.C. (2010). How patient reactions to hospital care attributes affect the evaluation of overall quality of care, willingness to recommend, and willingness to return. *Journal of Healthcare Management, 55*(1), 25-37.

Office of the National Coordinator for Health Information Technology (ONC), (2010). Federal Health Information Technology Strategic Plan 2011-2015. Retrieved from http://healthit.hhs.gov/portal/server.pt/gateway/PTARGS_0_0_4318_1211_15583_43/http%3B/wci-pubcontent/publish/onc/public_communities/f_j/onc_website___home/fed_health_strategic_plan/fed_health_it_strategic_plan_home_portlet/files/final_federal_health_it_strategic_plan_0911.pdf

Page, A. (Ed.). (2004). *Keeping Patients Safe: Transforming the Work Environment of Nurses.* Retrieved: http://www.nap.edu/catalog.php?record_id=10851#toc

Poissant, L., Pereira, J., Tamblyn, R., and Kawasumi, Y. (2005). The impact of electronic

health records on time efficiency of physicians and nurses: A systematic review. *Journal of the American Medical Informatics Association, 12*(5), 505-516. doi: 10.1197/jamia.M1700

Powell-Cope, Nelson, A.L., & Patterson, E.S. (2008). Patient care technology and safety. In *Patient Safety and* Quality*: An Evidence-Based Handbook for Nurses* (AHRQ Publication No. 08-0043), (Chapter 50), Agency for Healthcare Research and Quality: Rockville, MD. Retrieved: http://www.ahrq.gov/qual/nurseshdbk/

Purdy, N., Laschinger, H.K.S., Finegan, J., Kerr, M., & Olivera, A.F. (2010). Effects of work environments on nurse and patient outcomes. *Journal of Nursing Management* 18, 901–913. doi: 10.1111/j.1365-2834.2010.01172.x

Reed, P.G. & Shearer, N.C. (Ed.). (2009). Perspectives on nursing theory (5th Ed.). Philadelphia: J. B. Lippincott.

Savitz, L.A., Jones, C.B. & Bernard, S. (2005). Quality indicators sensitive to nurse staffing in acute care settings, p. 375- 385. In: *Advances in Patient Safety: From Research to Implementation.* Agency for Healthcare Research and Quality, Rockville, MD.

Schubert, M., Clarke, S.P., Glass, T.R., Schaffert-Witvliet, B., S & DeGeest, S. (2009). Identifying thresholds for relationships between impacts of rationing of nursing care and nurse- and patient-reported outcomes in Swiss hospitals: A correlational study. *International Journal for Nursing Studies, 46,* 884-893. doi: 10.1016/j.ijnurstu.2008.10.008

Schubert, M., Glass, T.R., Clarke, S.P., Aiken, L.H., Schaffert-Witvliet, B., Sloane, D.M. & DeGeest, S. (2008). Rationing of nursing care and its relationship to patient outcomes: the Swiss extension of the International Hospital Outcomes Study. *International Journal for Quality in Health Care, 20*(4), 227-237.

Schoen, C., How, S.K.H., Weinbaum, I., Craig, J.E. & Davis, K. (2006). Public views on shaping the future of the U.S. health system. *The Commonwealth Fund,* NY, NY. Retrieved: http://www.cmwf.org/

Schoen, C., Osborn, R., Squires, D., Doty, M., Pierson, R. & Applebaum, S. (2011). New 2011 survey of patients with complex care needs in eleven countries finds that care is often poorly coordinated. *Health Affairs, 30*(12), 2437-2448. doi: 10.1377/hltaff.2011.0923

Shekelle PG, Morton SC, Keeler EB. Costs and Benefits of Health Information Technology. Evidence Report/Technology Assessment No. 132. (Prepared by the Southern California Evidence-based Practice Center under Contract No. 290-02-0003.) AHRQ Publication No.06-E006. Rockville, MD: Agency for Healthcare Research and Quality. April 2006.

Silber, J.H., Rosenbaum, P.R., Evan-Shoshan, O., Shabbout, M., Zhang, X., Bradlow, E.T., & Marsh, R.R. (2003). Length of stay, conditional length of stay, and prolonged length of stay in pediatric asthma. *Health services Research, 38*(3), 867-886.

Silber, J.H., Rosenbaum, P.R., Rosen, A.K., Romano, P.S., Itani, K.M.F., Cen, L., Mi, L., Halenar, M.J., Even-Shoshan, O., & Volpp, K.G. (2009). Prolonged hospital stay and the resident duty hour rules of 2003. *Medical Care,* 47(12), 1191-1200. doi:10.1097/MLR.0b013e3181adcbff.

Silber, J.H., Rosenbaum, P.R., Koziol, L.F., Sutaria, N., Marsh, R.R. & Even-Shoshan, O. (1999). Conditional length of stay. *Health services Research, 34*(1), 349-363.

Sochalski, J. (2001). Quality of care, nurse staffing, and patient outcomes. *Policy, Politics, & Nursing Practice, 2*(1), 9-18.

Sochalski, J. (2004). Is more better? The relationship between nurse staffing and the quality of nursing care in hospitals. *Medical Care, 42*(Suppl. 2), 67-73.

Sovie, M.D. & Jaward, A.F. (2001). Hospital restructuring and its impact on outcomes. *Journal of Nursing Administration, 31*, 588-600.

Stukenborg G. J., Wagner D. P., & Connors, A.F. (2001). Comparison of the Performance of two comorbidity measures, with and without information from prior hospitalizations. *Medical Care, 39*(7), 727–739.

Thomas-Hawkins, C., Flynn, L. & Clarke, S. (2008). Relationships between registered nurse staffing, processes of nursing care, and nurse-reported patient outcomes in chronic hemodialysis units. *Nephrology Nursing Journal*, 35(2), 123-131.

U.S. Department of Health and Human Services (DHHS), (2010a). Office of Inspector General. *Adverse events in hospitals: National incidence among Medicare beneficiaries* (OEI Publication No, 06-09-00090). Retrieved: http://oig.hhs.gov/oei/reports/oei-06-09-00090.pdf

U.S. Department of Health and Human Services (DHHS), (2010b). Department of Health and Human Services Agency- wide plan. Retrieved: http://www.hhs.gov/recovery/reports/plans/index.html

U.S. Department of Health and Human Services (DHHS), Office of Inspector General. (2012). *Hospital incident reporting systems do not capture most patient harm.* (OEI Publication No, OEI-06-09-00091). Retrieved: http://oig.hhs.gov/oei/reports/oei-06-09-00091.asp

Wachter, R. M. (2010a). Patient safety at ten: Unmistakable progress, troubling gaps. *Health Affairs, 29*(1), 1-9.

Wachter, R. M. (2010b). Why diagnostic errors don't get any respect – and what can be done about them. *Health Affairs, 29*(9), 1605-1610.

Walker, J.M., Carayon, P., Leveson, N., Paulus, R.A., Tooker, J., Chin, H., Boothe, A., & Stewart, W.F. (2008). EHR safety: The way forward to safe and effective systems. *Journal of the Medical Informatics Association, 15*, 272-277. doi: 10.1197/jamaia.M2618

Waneka, R. & Spetz, J. (2010). Hospital information technology systems' impact on nurses and nursing care. *Journal of Nursing Administration, 40*(12), 509-514.

Wears, R.L. (2002). Advanced Statistics: Statistical methods for analyzing cluster and cluster-randomized data. *Academic Emergency Medicine, 9*, 330-341.

White, C. (2013). Contrary to Cost-Shift Theory, lower medicare hospital payment rates for inpatient care lead to lower provate payment rates. *Health Affairs, 32*(5), 935-943.

Zhan, C., & Miller, M. R. (2003). Administrative data based patient safety research: a critical review. *Quality and Safety in Health Care, 12* [Supplement 2], ii58-63.

VITA

Amanda Jane Hessels

1971	Born September 2 in Middletown, New York
1989-1995	Attended University of Rochester, School of Nursing, Rochester, New York; majored in Nursing
1995	Bachelor of Science in Nursing (BSN), Magna cum Laude
1995-1998	Critical Care Senior Staff RN, New York University Hospital, New York, New York
1998-2000	Critical Care Staff RN, Lenox Hill Hospital, New York, New York
1999-2001	Attended City University of New York, Hunter College, New York, New York; majored in Community Health Nursing and Public Health
2000-2003	Nurse Epidemiologist, New York City Department of Health, New York, New York
2001	Master of Science in Community Health Nursing (MSN) and Master of Public Health (MPH)
2003-2005	Coordinator, Communicable Disease Bureau, Rockland County Department of Health, Pomona, New York
2006-2011	Infection Preventionist, Jersey Shore University Medical Center, Neptune, New Jersey
2007-2012	Adjunct Professor, Nursing Brookdale Community College Lincroft, New Jersey
2009-2014	Attended Rutgers University, College of Nursing, Newark, New Jersey; majored in Nursing, PhD
2010-2011	F.M. Kirby Fellow, Rutgers University, College of Nursing, Newark, New Jersey
2011-2013	Quality Excellence Coordinator, Jersey Shore University Medical Center, Neptune, New Jersey
2012	Dr. Dorothy J. DeMaio Research Fellow, Rutgers University, College of Nursing, Newark, New Jersey
2012-2013	Research Fellow, Grant number 434982, Rutgers University, College of Nursing, Newark, New Jersey for Dissertation Award from the Agency for Healthcare Research and Quality (R36HS021988)
2013-	Nurse Scientist, Meridian Health System, Ann May Center for Nursing Neptune, New Jersey
2014	February 28, defended PhD Dissertation “Impact of Health Information Technology on the Delivery and Quality of Patient Care”