

Grant Final Report

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**Impact of Health Information Technology on Delivery
and Quality of Patient Care**

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Abstract

Purpose: 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.

Scope: The analytic sample consisted of data on 854,258 adult patients discharged from 70 New Jersey hospitals in 2006 and 7,679 nurses working in those same hospitals.

Methods: This secondary analysis of cross sectional data was compiled from four sources: (1) State Inpatient Database (SID) from the Healthcare Cost Utilization Project (HCUP); (2) Healthcare Information and Management Systems Society (HIMSS) Dorenfest Institute; (3) Hospital Consumer Assessment of Healthcare Providers and Systems Survey (HCAHPS) and (4) New Jersey nurse survey data. The analytic approach used ordinary least squares and multiple regression models to estimate the effects of EHR adoption stage 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.

Results: 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. 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.

Key Words: electronic health records; EHR; missed nursing care; nursing practice environment; adverse patient events; patient satisfaction; patient safety indicators

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Final Report

Purpose

The specific aims of the project are to:

- Quantify the unique and cumulative effects of differing: 1) EHR adoption stages; 2) organizational climate; and 3) nurse staffing levels on the delivery of nursing care.
- Quantify the unique and cumulative effects of differing: 1) EHR adoption stages; 2) organizational climate; 3) nursing staff levels; and 4) the delivery of nursing care on patient mortality and non-mortality adverse outcomes such as catheter-related blood stream infections and hospital readmission.
- Quantify the unique and cumulative effects of differing: 1) EHR adoption stages; 2) organizational climate; 3) nursing staff levels; and 4) the delivery of nursing care on patient satisfaction.

Scope

Background

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.

Theoretical 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).

However, 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, 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.

Derived from the theoretical and empirical literatures this study tested 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.

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 this 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 than 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.

Methods

Study Design

This is a secondary analysis of cross sectional data. All of the study data were from 2006 and 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. Data from the patient discharge summary and hospital nurses were aggregated to the hospital level.

Data Sources and Procedures

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 is 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). EHR adoption stages 0-4 will be tested as defined by the EMR Adoption Model (EMRAM) scale.

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.

Measures

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, Lake & Aiken, 2010; Sochalski, 2001, 2004); and (5) EHR adoption stage was measured using the EMR Adoption Model (EMRAM) scale (Garets & Davis, 2008; HIMSS, 2008).

Independent Variables. EHR adoption was operationally defined as a hospital's total cumulative score on the Electronic Medical Record Adoption Model scale (EMRAM) ranging between 0-4 (HIMSS, 2008). 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). 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 was derived from the nurse survey data. 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. The composite measure was calculated as the average count of the 12 nursing care activities left undone by each nurse respondent.

Dependent Variables. Specifically, nurse-sensitive PSIs that were examined in this study included: (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). Early hospital readmissions was 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).

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.

Patient satisfaction was 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.

Control Variables. 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).

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.

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.

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). Without adjusting for these similarities, standard errors may be inaccurate depending on the correlation between patient outcomes in each hospital cluster. 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.

The analytic approach used ordinary least squares and multiple regression models to estimate the effects of EHR adoption stage on the delivery of nursing care and patient outcomes, controlling for characteristics of patients, nurses, and hospitals. Simple unadjusted OLS regression models testing the hypotheses were 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.

Data were analyzed using STATA/MP 12.1 software. The level of significance at which the research hypotheses were tested was at .05 and in the presentation of results to follow standardized coefficients (β) are reported. Descriptive statistics of the key independent and dependent variables are presented in Tables 1 and 2, respectively.

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.

Table 1. 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.

Table 2. 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.”

Results

Principal Findings

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 partially 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.

In summary, the principle 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. That is hypothesis 1, 4, 6 and 8 were supported as detailed below.

Hypothesis 1. 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 ($\beta = -.21$, $p = .03$). 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% ($0.21 \times .05 \times 100$) 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 ($p < .01$), and conservatively 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 partially supported.

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 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. Specifically, 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, $p < .05$).

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. 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.

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 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.

Discussion

EHR and Adverse Patient Events. 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 minimally supported in this study, as explained by theoretical and methodological rationale.

Nursing Practice Environment and Patient Satisfaction

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). Consistent with previous research this hypothesis was supported by the data (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.

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 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.

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 are presented in Table 3.

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 findings 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.

Table 3. Effects of Staffing and Resources, Missed Nursing Care and EHR Stage on Patient Satisfaction (N = 41)

Outcome Variable	Unadjusted β	Unadjusted t	Unadjusted p	Adjusted β	Adjusted t	Adjusted 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.

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.

Significance

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, 2000), there has been minimal improvement in patient safety (Leape et al., 2009; Wachter, 2010a, 2010b). Perhaps most disturbing are findings from a recent large, landmark study indicating that despite national attention and substantial resource allocation, there has been no reduction in the rate of preventable adverse inpatient events over the last several years. In fact, the rate of preventable harm to patients remained 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).

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, 2010). Yet, the use of EHR is one promising system-level initiative that may improve provider performance, interdisciplinary communication, reduce adverse patient events, and ultimately improve patient satisfaction with care (Elnahal, Joynt, Bristol & Jha, 2011; Jamal, McKenzie & Clark, 2009; Kazley & Ozcan, 2008; Staggers, Weir, & Phansalkar, 2008; Waneka & Spetz, 2010).

Although there is a growing body of evidence quantifying the benefits of EHR implementation on patient outcomes, some major gaps in the evidence remain. An evidence report published by AHRQ (Shekelle et al., 2006) concluded that there are too few studies linking organizational structures and care processes with outcomes when examining the positive effects of EHR. Moreover, the AHRQ evidence report further specified that the effects of EHR across differing organizational climates remain unknown. Lastly, much of existing evidence regarding EHR has been generated with relatively small samples of hospitals. Although it has been several years since AHRQ released the evidence report, these major gaps in the evidence persist. Moreover, there have been no multi-site studies that have disentangled the complex relationships among EHR, the delivery of nursing care, and patient outcomes.

This innovative study addressed these significant empirical gaps in the patient safety literature and advances the important nursing research goal to improve patient safety outcomes. This study was 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. By leveraging existing databases, this study addressed these 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 in a sample of 854,258 patients and 7,679 nurses in 70 New Jersey hospitals.

This 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, 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.

Specifically, as an indication of the need and significance of this study, this study was strongly endorsed by the HIMSS Dorenfest Institute, the New Jersey Hospital Association (NJHA), and NJHA's Chief Information Officer, who is a member of the Governor's Health Information Technology Commission. It is planned that evidence-based recommendations resulting from study findings will be presented to the Constituency Group of the NJHA Chief Information Officers, the HIMSS members, and disseminated to the Governor's Health Information Technology Commission, and NJ Organizations of Nurse Executives, thus having the potential to directly influence organizational, state and national policy decisions.

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). 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.

List of Publications and Products

Hessels AJ. Impact of health information technology on delivery and quality of patient care [dissertation]. Newark (NJ): Rutgers University; 2014.

Hessels AJ. Impact of health information technology on delivery and quality of patient care [oral presentation]. *Thirty-first Annual Rutgers Interprofessional International Technology Conference*, 2013 April 4-7; Atlantic City (NJ).

Hessels AJ. Impact of health information technology on delivery and quality of patient care [poster presentation]. *Rising Stars of Scholarship and Research Awardee and Poster Presentation, Sigma Theta Tau 42nd Bi-Annual Convention*, 2013 November 16-20; Indianapolis (IN).