Using an Electronic Health Record to Examine Nurse Continuity and Pressure Ulcers

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Abstract

Purpose: To examine the influence of nurse continuity on the prevention of hospital-acquired pressure ulcers (HAPUs).

Scope: There is little research demonstrating the influence of nurse continuity in preventing adverse patient outcomes, despite an intuitive belief that care continuity makes a difference. The literature revealed multiple continuity definitions and measures, but few nursing studies that measured the influence of nurse continuity on patient outcomes. Also, nurse staffing conceptual models either did not include a nurse continuity variable or did not adequately describe either the direct influence of nurse continuity or the combined influence of nursing continuity and other relevant nurse-staffing variables on patient outcomes.

Method: A secondary use of data from the Hands-on Automated Nursing Data System (HANDS) was performed for this comparative study. The HANDS is a nursing plan-of-care database containing 42,403 episodes documented by 787 nurses, on nine units, in four hospitals, and includes nurse staffing and patient characteristics. Via data mining, we created an analytic dataset of 840 care episodes, 210 with and 630 without HAPUs, matched by nursing unit, patient age, and patient characteristics. Logistic regression analysis determined the influence of nurse continuity and additional nurse staffing variables on the presence of HAPUs.

Results: Poor nurse continuity (continuity index=.21-.42 [1.0=optimal continuity]) was noted on all nine units. Nutrition, mobility, perfusion, hydration, and skin problems on admission and patient age were associated with HAPUs ($p<.001$). Controlling for patient characteristics, nurse continuity and interactions between nurse continuity and other nurse staffing variables were not significantly associated with HAPUs.

Key words: Health information technology, data mining, nurse continuity, pressure ulcers

Purpose

The study purpose was to examine the influence of nurse continuity (the number of consecutive care days by the same/consistent RN[s]) on the prevention of hospital-acquired pressure ulcers (HAPU). Study aims include:

Aim 1: To determine which patient characteristics in the HANDS database (*Age, Nutrition, Skin, Cognition, Perfusion, Mobility, Hydration, Continence*) influence the presence of hospital-acquired pressure ulcers for the purpose of creating an analytic dataset.

Aim 2: Using the analytic dataset and controlling for the characteristics, determine the influence of nurse continuity (*number of consecutive days cared for by the same/single RN*) and nurse staffing variables (*worked hours per patient day, patient-to-nurse ratio, RN experience, RN education, shift length [8 versus 12 hours], number of shifts cared for by very-part-time [.3 FTE or less] versus part-/full-time staff [.5-1.0 FTE]*) on the presence of hospital-acquired pressure ulcers.

Scope

Background

Healthcare is costly, with expenditures of 2.6 trillion dollars in 2010, a 10-fold increase since 1980.[1] Despite escalating expenditures, patient outcomes do not reflect a positive return on investment. Never events (adverse events affecting patients during hospitalization that are serious and largely preventable)[2] alone generate $21 billion dollars of nonreimbursed hospital costs[3] and are an important target for nursing care quality improvement efforts. As the largest hospital operating expense,[4] nurses are viewed as valued but costly resources for safeguarding patients from harm and improving outcomes.[5] Nurses comprise over one third of hospital employees and more than 50% of the expense.[4] It is not surprising, therefore, that nursing services are targeted for reorganization efforts to reduce hospital expenses.[6] Efforts to contain costs by reorganizing nursing services were first introduced in the 1980s[6] and have continued through the nursing shortage of the 1990s,[7] with workforce transformation an ongoing focus of healthcare administrators, including Chief Nurse Executives (CNEs).[8]

Reorganization strategies included replacing RNs with less-educated assistive personnel, using lower nurse-to-patient ratios, and decreasing RN care hours.[6] Recent healthcare reorganization has been associated with the development of a care delivery system increasingly fragmented by varied shift lengths, nurse schedules, and diverse care providers,[6] leading to a loss of care continuity and compromising one of healthcare's most important functions, protecting patients from harm when receiving hospital care.[9]

Researchers have examined nursing services re-organization, with mounting evidence that nurse staffing variables have a strong influence on patient outcomes. Researchers have conducted six multihospital studies[10-15] and several systematic reviews and meta-analyses[16-19] that include patient outcomes related to the nurse-to-patient ratio, education, or experience of RN care providers. Study results indicate significant associations between additional nursing care hours/higher proportion of RN care and patient outcomes, including reductions in pressure ulcers.[11,21] A richer RN skill mix increases satisfaction,[22] and more educated and experienced RN providers have improved mortality outcomes.[14,23-24] Results are suggestive that investment in additional RNs with more education and hours of care at the bedside would result in reduced incidence of negative patient outcomes. However, this connection is inconsistently demonstrated. Institution of mandatory RN staffing ratios generated no significant improvement in pressure ulcer prevalence.[25] Additional researchers found no connection between RN staffing and incidence of pressure ulcers[26] and no differences in patient mortality with either increased RN experience[15] or education levels.[11,15,27] One possible interpretation of this inconsistency may be that not all critical staffing variables have been examined. Nurse continuity, once a hallmark of the primary nurse staffing model,[28-30] has been infrequently studied, especially in relation to its influence on patient outcomes.

This gap in the health services literature may be attributable to both the inconsistent definition of continuity and the absence of reliable and valid evaluation measures that link continuity and patient outcomes. Common continuity descriptions include informational,[9,31-32] interpersonal,[31-34] and management.[31,33,35]

Continuity measurements include instruments to measure assignment patterns,[36-37] chronological calculations,[29,38] self-report surveys and questionnaires,[39-42] and indices[43-44] that are seldom used in nursing research.[45] Despite the value the primary nursing model invested in continuity, there are few patient outcome studies underscoring the value of nurse continuity. Three studies were found that include nurse continuity and patient outcomes, but only one addressed never events. Bostrom et al.[38] reported improved patient satisfaction; Russell et al.[46] found reduced use of hospitals and emergent care; and Siow[47] noted a safer environment with experienced nurses when increased nurse continuity was present. Notably, in the early 2000s, eight federally funded studies commissioned to direct public policy around nurse staffing and patient outcomes did not include nurse continuity as a critical staffing variable.[48]

Context

The inconsistent definition of continuity and the absence of reliable and valid evaluation measures have led to a lack of substantive data that healthcare administrators such CNEs can use to develop a convincing argument linking the influence of nursing services reorganization and subsequent RN staffing changes with patient outcomes.[48] The diversity of definitions and measurements makes it difficult for CNEs to compare studies to their actual practice setting and to reach conclusions linking continuity in nurse staffing with patient outcomes. The challenge for health services researchers is to define and use a consistent continuity measure across care settings to demonstrate the value to patients of having continuous nurse providers within the context of nurse staffing variables while controlling for patient variables.

The CNE needs but currently lacks efficient, effective, and readily available[49] data to connect nurse staffing variables, such as nurse continuity, with patient outcomes. To create an effective argument, CNEs must have meaningful, real-time evidence from a source that is specific to their own patient and nursing populations.[50] The ideal source should not add cost and must be easily explained to other hospital administrators.[49] The electronic health record (EHR) is proposed in this study as an untapped resource for helping to demonstrate the connection between nurse staffing and patient outcomes. The EHR can be a valuable data source if it contains nursing plan of care (POC) documentation coded in a way that allows easy access and is in a form amenable to analysis. In this study, HANDS[51] is such a resource and was used as an exemplar data source for examining the nurse staffing variable, nurse continuity, and its connection with the prevention of one never event, hospital-acquired pressure ulcers.

Innovation

This study is innovative in that a novel nursing EHR system was used to demonstrate how a readily accessible, effective data source can be used to examine the relationship between nurse staffing variables, including nurse continuity and patient outcomes. The National Database for Nursing Quality Indicators (NDNQI) is one available standardized database that comparatively displays nursing quality indicators across hospital units.[52] However, variable unit definitions can make the database challenging to interpret and use comparatively. In addition, databases such as NDNQI focus on hospital- and unit-level variables but are unable to connect patient specific outcomes with individual nurse characteristics. The HANDS database prior to use in this study had already been successfully deployed in clinical practice and has been shown to generate standardized nursing care data that could be statistically analyzed and mined for best practices[51] as well as translated into evidence-based decision support for end-of-life pain management.[53-54] The HANDS database uniquely allows delineation of associative patterns that can be drilled down to the shift level, with linked data for the individual nurse providing care and the patient receiving care. This level of inquiry made the study innovative, as we examined the influence of number of consecutive days cared for by the same/single RN on the presence of hospital-acquired pressure ulcers. Possessing data at this level, we believe, will equip CNEs with rationale for the optimal nurse staffing resources needed at the bedside to prevent hospital-acquired pressure ulcers.

This study focus was also innovative in that we used the standardized data collected with HANDS to examine the influence of nurse continuity, controlling for associated patient-level characteristics and including nurse continuity and nurse staffing variables collected at the point of care that have not previously been available in nursing documentations systems. Twelve-hour shifts were initially introduced as a cost-cutting measure for hospitals and to enhance the quality of RN work/life balance through a reduced work week.[40] There is some debate, however, about the impact of these shifts on patient care quality and whether working

fewer shifts per week is balanced out by having staff spending longer periods of time with patients during a single day.[55] Studies including 8- and 12-hour shifts typically document positive <u>nurse perceptions</u> about fatigue levels,[19,56-58] satisfaction,[41,58-60] planning and documenting care,[42,57,59] patient communication,[42,59,61] and continuity of care [40,59-60] with the 12-hour shifts. Research studies including the influence of shift length on actual outcomes are limited, depicting some negative findings, including increased errors,[62-63] needle stick injuries,[64] pneumonia deaths,[65] and performance lags,[66] with less time actually spent in direct patient care as the shift lengthens.[67] Only one research team[58] attempted to correlate shift length with three adverse patient outcomes (medication errors, falls, and pressure ulcers) using incident reports, but the team was unsuccessful in showing a relationship.

This study is unique because HANDS affords a consistently defined and measured set of characteristics and outcome variables that allowed an investigation of whether a measure of nurse continuity has any influence on preventing hospital-acquired pressure ulcers. Pressure ulcer development is a prevalent never event (5%-10%),[68] is very costly to hospitals ($8.5-$11.0 billion dollars/year),[69] and is a major nurse-sensitive outcome.[70] Excellent skin care is a hallmark of nursing care quality.[71] A connection between improved pressure ulcer outcomes and the vigilant care and preventive actions fostered by nurse continuity[72] could provide meaningful evidence for CNEs when deliberating with other hospital administrators about changes to nursing services delivery.

Summary

Current evidence about nurse-to-patient ratio, RN education, or RN experience is inconclusive regarding the connection between nursing staffing and improved patient outcomes. Examination of nurse continuity along with other nurse staffing variables, while controlling for patient characteristics, may provide the supportive evidence to demonstrate that connection. With the ongoing financial pressures faced by hospitals, the erosion of nursing services will continue unless there is evidence of a clear relationship between nurse continuity and improved patient outcomes. Research findings are urgently needed to facilitate understanding of the true consequences and economic implications that nurse resource deployment decisions can have on patient outcomes.[21]

Methods

Study Design

This comparative study was a secondary use of the HANDS database. This same database has been used to examine best practice findings related to pain[53-54] and death anxiety[73] outcomes for patients at the end of life and to document findings from usability studies that examine nurse preferences for the presentation of evidence as part of clinical decision support interfaces.[74] This study was submitted to the Institutional Review Board (IRB) at the University of Illinois at Chicago for review and was determined to not meet the definition of human subject research, because the data were de-identified.

Setting

The HANDS is an electronic documentation tool with standardized nursing terminologies (SNTs) used by RNs to enter data during each shift. The HANDS tracks a patient's diagnoses (North American Nursing Diagnosis Association International [NANDA-I]),[75] interventions (Nursing Interventions Classification [NIC]),[76] and outcomes (Nursing Outcomes Classification [NOC]),[77] as well as patient demographics and nurse characteristics.[78] The HANDS is a valid and reliable database[51,54] implemented as the nursing documentation system on nine units in four hospitals for 12 or 24 months. The hospitals included two large community, one university, and one small community setting with units composed of medical-surgical and critical care patients.

Sample

The HANDS database contains 42,403 episodes of care, defined as a continuous patient stay on a single hospital unit, and consists of all care plans entered at admission, the end of each shift, and discharge by 787 unique registered nurses.[54] From this original HANDS dataset, we extracted the 24,609 episodes that satisfied the following criteria: (1) no pressure ulcers (PUs) present upon admission, (2) each episode associated with a unique patient (one HAPU episode was excluded in this process), (3) patient age 18 years or older, and (4) episode lasted more than one day to allow a meaningful continuity measure. We also measured gaps in documentation, defined as missing care plans within a patient care episode, and found an 11% average gap.

Given the low percentage of missing data, we used mean imputation in our analysis.

Measures

HAPUs. Structured query language (SQL) commands were developed to identify and extract all HAPU episodes in the HANDS dataset. The HAPU episodes were defined as all episodes in which the label NIC: Pressure Ulcer Care was placed on the patient's POC at least 24 hours *after* admission to the unit. Episodes in which this NIC was placed on a patient's POC within 24 hours of admission to the unit were considered admission pressure ulcers (APU). This definition ensured that PUs present on admission to the unit that were identified and documented by the nurse within the first 24 hours of care were not included as HAPUs. A total of 896 pressure ulcers were located in the original database (N=42,403), with 685 classified as APU and 211 as HAPUs.

Patient risk factors. Eighteen NANDA-I, 29 NOC, and 39 NIC labels were selected to identify patient characteristics that might predispose PUs. Two methods were used to elicit these labels. The first method examined common labels for the patient characteristics using the NANDA-I to NOC and NOC to NIC linkages available in the HANDS system and in the NNN literature.[75-77] Next, a list of all NNN labels present on the POCs for the 896 PU episodes were reviewed to narrow down the most consistently used labels for these patient characteristics. The final list of 86 NNN labels was validated by a clinical nurse expert with extensive experience and research in the use of SNTs. These labels fall under seven distinct categories: Nutrition, Mobility, Hydration, Continence, Skin, Perfusion, and Cognition, each representing a factor suggesting PU vulnerability. For each episode, we examined the admission POC and extracted the relevant NOC ratings to indicate the patient condition in each of these categories.

Nurse staffing. Nurse-staffing variables were operationalized using the raw data also available in the HANDS dataset. For the HAPU episodes, nurse staffing variables were examined on the shifts leading up to the ulcer occurrence. The variable *nurse continuity* was calculated using the total number of consecutive days worked by each RN with the patient and operationalized as the percent of consecutive care days by the same/single RNs in a patient episode. For our calculation, we computed the episode continuity index by dividing the total number of consecutive days (from all RNs) by the total number of possible consecutive days excluding the first day. *Nurse experience* was calculated using the number of years the RNs were in the nursing profession and was operationalized as the percent of time a patient was cared for by RNs with at least 2 years of experience. The RN education variable was determined by the highest nursing degree reported and was operationalized as the percent of time a patient was cared for by RNs with a BSN or greater. The *shift length* variable was calculated using the number of consecutive hours worked by each RN with the patient and was operationalized as the percent of 8-hour RN care shifts in a patient episode. The RN *work pattern* variable (full,- part-, or very-part-time status) was calculated using the actual hours worked as a fraction of full-time status (80 hours over 2 weeks) for each RN caring for the patient in an episode. Very-part-time status was defined as any nurse who worked less than or equal to 24 hours (.3) per pay period (pay period=80 hours over 2 weeks), with part-time to full-time status classified as greater than .3-1.0. The RN work pattern variable was operationalized as the percent of very-part-time RNs caring for a patient. To determine the *average patient-to-nurse ratio* across a patient episode, we computed for each 4-hour window the patient-to-nurse ratio on the unit and averaged the ratios of all windows spanned by the patient episode. Finally, *worked hours per patient days* (whppd) were determined by calculating an average whppd over the course of a patient care episode. The whppd definition used in this study was the total number of RN hours on a unit in a 24-hour period divided by the number of patients on that unit at midnight.

Analyses

HANDS database structure. The HANDS POC documentation method was implemented and tested in four hospitals over 12-24 months from 2005-2008.[51] Seven hundred eighty-seven unique RNs documented the care they provided using HANDS for either one (four units) or two (five units) years, creating a dataset of 42,403 episodes of care. The HANDS dataset resides in a relational database consisting of 89 tables and 747 columns of data.[78]

HANDS data entry process. A training program with unit champions oriented all nurse users to the HANDS method, and nurses were competency validated on creating admission care plans and on updating

care plans using NANDA-I, NOC, and NIC (NNN) terminologies.[51] The HANDS documentation begins with the admission POC for an episode submitted at the first nursing handoff.[51] This POC includes nursing diagnoses, outcomes, and interventions (delineated with NNN labels) identified during the initial shift. The subsequent care plans build on the initial plan and include any additions, deletions, or resolutions that occur during the time period since the last POC submission. The current status of all POC NOC outcomes is rated (or re-rated) at each handoff. When a NOC outcome label is first added to a POC, an expected NOC rating (goal at discharge from a unit) is also identified. The entry of a current NOC status rating at each handoff and the expected NOC outcome rating make it possible to gauge progress toward meeting outcome goals during an episode. All NOC outcomes are scored on a rating scale ranging from 1-5, with a 5 representing the best outcome.[51] The reliability and validity of the NOC outcomes ratings were established in prior studies.[79-80]

Data processing to identify a matched sample for the analytic dataset. Cluster mining was used to identify the matched control group for the analytic dataset. Clustering is a machine-learning algorithm that groups observations into multiple clusters, with each cluster different from another but with members within each cluster consisting of observations of similar characteristics.[81] The objective was to identify matched controls for HAPU episodes in the database. Thus, clustering was an ideal tool to group episodes with similar PU risk factors together.

To utilize clustering to accomplish our goal, we defined a similarity measure based on variables predictive of PUs, including NOC ratings for seven patient characteristics (Perfusion, Skin, Nutrition, Mobility, Hydration, Cognition, Continence), patient age, and hospital unit. Variables were weighted using a weight-by-uncertainty operator, which assigns higher weights to variables that are more predictive (and thus reduce more uncertainty) of the HAPU outcome to ensure that the similarity measure closely reflects the similarity in HAPU risks between episodes. A range of cluster solutions was examined to identify a solution with no significant imbalance between the HAPU and control episodes. For each cluster solution, we randomly selected for each HAPU episode three matched control episodes from the same cluster but without PUs. Our goal was to locate a cluster solution with clusters that contained highly similar members based on the NOC ratings for the patient characteristics, patient age, and/or units that either led to HAPUs or did not lead to HAPUs (matched controls). As the number of clusters increased, the episodes within each cluster should become more similar, allowing us to achieve a better balance between the control and HAPU cases.

For example, in a five-cluster solution, the episodes were clustered primarily by unit, and there were significant differences in the mean NOC outcome ratings for five of seven patient characteristics and age comparing HAPUs and controls. By 18 clusters, the differences in the mean NOC outcome ratings for some of the patient characteristics and age had decreased when comparing the HAPU episodes and matched controls (e.g., the p values for the perfusion characteristic t tests went from 0.00 in the five-cluster solution to 0.43 in the 18-cluster solution); however, there remained significant differences in patient age as well as three of the seven characteristics between the HAPU and control episodes. With a 200-cluster solution, we achieved our goal of no statistically significant differences in HAPU versus matched control episodes noted with the seven patient characteristics and patient age as measured by the independent t test. There was also no difference in the distribution of HAPU and non-HAPU episodes across the nine clinical units (Fisher's exact test, p=1.0). The 630 matched control cases selected from this cluster solution and the 210 HAPU cases comprised the analytic dataset for the regression analysis.

Aim analyses. Analyses to address the study aims included descriptive statistics (frequencies, means, and standard deviations) to enhance understanding of the patient characteristics associated with HAPUs in the HANDS database. Frequencies were also calculated for the nurse staffing variables by patient unit. A logistic regression using the STATA 12 statistical software package[82] was performed, regressing HAPU outcomes against nurse continuity and six nurse staffing variables (whppd, patient-to-nurse ratio, RN experience, RN education, shift length, RN work pattern [number of shifts cared for by very-part-time versus part-/full-time staff]). A second logistic regression introduced interaction terms between nurse continuity and each nurse staffing variable to determine whether nurse continuity had a moderating effect, enhancing the influence of other nurse staffing variables on HAPU outcomes.

Results

Principle Findings/Outcomes

Within the reduced dataset, the average age of patients with HAPUs was 68.9 (15.3) years compared with 65.1 (18.2) years for episodes without (Table 1). The mean admission NOC outcome ratings were higher for all seven patient characteristics in the non-HAPU versus HAPU episodes. Results were statistically significant at a p<.001 for all but the cognition and continence patient characteristics (Table 1). Study analyses were then conducted on a subset of HAPU episodes (n=210) with matched controls (n=630) derived from the reduced dataset, as described in the measures and analysis sections. With our sample of 840 episodes (including 210 HAPU episodes) and a two-sided significance level of 0.05, we detected with 80% power the continuity effect size that was 0.22 or larger.

The overall continuity index for the reduced dataset was low (0.32, SD=0.35) (0 to 1.0 possible), with the lowest values (0.21, SD=0.21) on the ICU and neuro units and the highest (0.42, SD=0.24) on the gerontology unit in the large community hospital (Table 2). Comparing the HAPU and the matched control episodes, HAPU episodes had a lower percentage of BSN nurses and a lower patient-to-nurse ratio but a higher percentage of 8-hour shifts, VPT nurses, experienced nurses, whppd, and continuity. None of these differences were statistically significant (Table 3). Over 50% of the RNs in the dataset had a BSN, more than 75% of the RNs had greater than 2 years of experience, and just over 40% of the nurses worked 8-hour shifts.

The regression analysis revealed that continuity was not significantly associated with the HAPU outcome both when it was the only predictor (p=.50) and when we controlled for other nurse staffing variables (p=.37) (Table 4). Similarly, none of the nurse staffing variables entered in the logistic regression reached statistical significance with HAPU outcomes. In a second logistic regression that introduced six interaction terms between nurse continuity and each nurse staffing variable, no statistically significant relationships with HAPU outcomes were noted.

Discussion

Nurse continuity is an understudied nurse staffing variable in part due to difficulties in defining and measuring the concept. Consequently, research examining the influence of continuous nurse care providers on patient outcomes is very limited. In this study, we used the HANDS, an EHR with linked data, to operationalize and measure nurse continuity. Our continuity definition was based on consecutive nurse care days and examined the influence of nurse continuity and several other nurse staffing variables on HAPUs. None of the nine units participating in our study had good continuity in practice, with unitwide average continuity ranging from very poor (0.21) to poor (0.42). We were able to validate that nutrition, mobility, perfusion, hydration, and skin problems on admission as well as patient age were associated with HAPU development (p<.001). However, we were not able to demonstrate statistically significant relationships between continuity and HAPUs or with nurse continuity as a moderator of other nurse staffing variables and HAPU development. Combining these findings with our power analysis, our study results indicate that the effect of nurse continuity and other nurse staffing variables on HAPU outcomes over a patient episode are likely small. Patient characteristics such as nutrition, mobility, and perfusion, on the other hand, were found to be clearly associated with HAPUs. One study implication is that, to reduce the potential for HAPU never events, the preferred strategies may be ones that focus on prevention (good skin care, alternative bed surfaces) and aggressive intervention to address patient characteristics that contribute to skin breakdown (poor nutrition, impaired mobility) rather than adjustments to nurse staffing.

A second important finding was that we found a wide variation between good and poor continuity on each of the nine care units as noted by our standard deviation calculations. This finding might reflect individual nurse efforts to direct their assignments to achieve continuity with particular patients, a strategy which can lead to increased nurse satisfaction, retention, and better patient outcomes.[83] Although this study did not reveal a significant relationship between nurse continuity and development of HAPUs, future studies using the HANDS database might allow us to examine the influence of continuous nurse staffing on outcomes such as nurse turnover and nurse or patient satisfaction. Another future study might consider drilling deeper into hospital-acquired adverse outcomes by looking at the characteristics of an individual nurse and the staffing on the

actual shift in which a HAPU or a fall occurred. The availability of nurse staffing variables, unit environment characteristics, and patient outcomes data in HANDS make these additional queries possible.

A third notable finding is that it took 200 clusters before we were able to identify a cluster solution with no significant imbalance between the HAPU and matched-control episodes. Our goal was to locate a cluster solution with each individual cluster different from the next one but within each cluster members that were highly similar based on the NOC ratings for the patient characteristics, patient age, and/or units that either led or did not lead to HAPUs (matched controls). The fact that there were 200 different clusters in our solution, each made up of a particular combination of patient characteristics, patient age, and/or units, reflects the highly diverse profile of vulnerability that leads to a HAPU. The implication of this finding is that the one-size-fits-all, standardized care bundles now commonly used for many nurse-sensitive outcomes (i.e., ventilator-associated pneumonia, catheter-associated urinary tract infections) may not be the most effective strategy to address the complexity of this patient condition. Rather, a case-by-case analysis of patient vulnerabilities for pressure ulcers with a customized intervention strategy may be the most optimal approach for addressing this unique and persistent hospital-acquired event.

Significance

This study was groundbreaking for its use of an EHR big data set containing nursing POC documentation as a means to inform about a nurse-sensitive patient outcomes. Historically, use of nursing POC documentation in medical records for research inquiries would have been futile, as documentation has been incomplete and of poor quality.[84-85] In one pre- and post-EHR implementation study, only 28% (N=20/71 records) demonstrated full documentation of a nursing problem, interventions, and outcomes using the electronic system.[84] In a second study of 161 records from a healthcare center, nursing POCs were rarely found; if present, none of the plans included complete documentation of a problem, interventions, and outcomes.[85] However, for this study, the HANDS POC documentation system was uniquely available to examine nurse staffing and patient outcomes, with a remarkable 78%-92% compliance rate at shift handoff for a 12- to 24-month use period.[51] This database allowed a specific examination of a HAPU outcome, linking it back to the nurse staffing for patient care over the course of a hospital episode. Though the National Database for Nursing Quality Indicators (NDNQI)[52] is available and frequently used to comparatively display nursing quality indicators across hospital units, at this juncture, that database is unable to connect patient specific outcomes with individual nurse characteristics. The availability of the HANDS POC system and our use of cluster mining uniquely allowed us to identify patients with HAPUs in the dataset as well as to operationalize the characteristics of the nurse caregivers over the course of the episode. We were thus able to drill down into readily available nursing POC EHR data to examine such questions as whether the percentage of experienced nurses or the average patient load influenced PU development. This accomplishment represents an important advance for nursing science in the big data era.

Limitations

There were several study limitations that may have affected the significance of our findings. For example, we recognize that HAPUs physiologically develop over time but manifest on a single shift. Our analysis did not allow us to determine if the care was inadequate on one particular shift or whether insufficient nurse staffing over the course of several shifts contributed to the PU vulnerability. For our next analysis, we will examine the shift in which a HAPU occurred and examine the characteristics of the individual nurse caregiver, including his/her continuity with the patient on prior shifts or in previous days. A second limitation is that hospital never events, though an important nurse-sensitive indicator, occur infrequently, making it more challenging to demonstrate a significant relationship between nurse staffing and patient outcomes. We had sufficient power to detect a small effect (.22) of nurse continuity on HAPU development after controlling for the other factors influential in HAPU development. In this study, however, we lacked power to detect very small effects of nurse continuity, those smaller than .22. A further limitation was that our secondary use of a dataset restricted inquiries to the available data and did not include the entire EHR. For example, the HANDS dataset had only RN POC documentation, omitting the contributions of assistive nursing personnel.

Two final study limitations may have been our continuity and pressure ulcer definitions. As noted in the literature review, nurse continuity was previously studied using consistency indices looking at the number of

repeat days by the same nurses over the hospitalization.[38, 47] It was noted early in our inquiry that this type of continuity measure was confounded by length of stay (LOS) and so we created a new definition that defined continuity as the number of consecutive care days by the same RN. If an RN missed a consecutive care day but was assigned to the patient again at a later point in the episode that day was not weighted in our definition. In retrospect this definition might not have been broad enough and in light of our current short hospital LOS may have increased our difficulty in discerning an influence from continuity.

This study also used a very conservative PU definition (prevalence = 0.7% versus 5-10% in published research)[68] as we selected a single label, NIC: Pressure Ulcer Care, to increase our certainty that included cases reflected only HAPUs. Expanding our definition to include other labels in the HANDS database such as NIC: Pressure Management would have increased our case count by 1,000 (prevalence = 2.1%) but without further study it is unclear that this less specific term applies only to HAPUs. We acknowledge the possibility that PU cases may have existed and gone unrecognized in our matched controls due to our conservative definition.

Conclusions

In this study we demonstrated use of a large EHR database**,** the HANDS, as an innovative data mining source for practice-based research. We set out to measure and determine the influence of nurse continuity, an understudied nursing-staffing variable, on the prevention of a common never event, HAPUs. Our initial findings suggest that nurse continuity and other nurse-staffing variables may not be as influential in HAPU development as previously thought. However, despite the absence of significant findings in this first study, we are encouraged by our study method to continue examining patient outcomes influenced by nurse staffing, made possible by the standardized clinical practice data in the HANDS database. We believe that these studies are urgently needed so that hospital administrators can make informed decisions when reorganizing health care delivery systems, thus securing safe, high quality care for all hospitalized patients.

List of Publications and Outputs from the Study

Dissertation:
Stifter, J**.** Using an Electronic Health Record to Examine Nurse Continuity and Pressure Ulcers [dissertation]. Chicago, IL: University of Illinois at Chicago, College of Nursing; 2014.

Publications:
Stifter, J, Yao, Y, Lodhi, M, et al. Using Electronic Health Record (EHR) "Big Data" to Examine the Influence of Nurse Continuity on a Hospital-Acquired Never Event. *Nursing Research.* (In Review, 2015).

Stifter, J, Yao, Y, Dunn Lopez, K, et al. Defining a new conceptual model and an innovative approach for measuring the influence of nurse continuity on patient outcomes. *Advances in Nursing Science.* (In review, 2014).

Podium Presentations/Posters:
Stifter, J, Yao, Y, Lodhi, M, et al. Using Electronic Health Record (EHR) "Big Data" to Examine the Influence of Nurse Continuity on a Hospital-Acquired Never Event. The National Pediatric Nurse Scientist Collaborative Nursing Research Fly-in 2015; 2015 June 10-11; Chicago, Illinois.

Stifter, J, Yao, Y, Lodhi, M, et al. Using Electronic Health Record (EHR) "Big Data" to Examine the Influence of Nurse Continuity on a Hospital-Acquired Never Event. The University of Illinois at Chicago Annual Research Day; 2015 March 6; Chicago, Illinois.

Stifter, J, Yao, Y, Lodhi, M, et al. An Innovative Study to Link Patient Outcomes and Individual Nurse Continuity Using Practice Based Evidence. Advocate Research and Innovation Forum; 2014 October 15; Park Ridge, Illinois.

Stifter, J, Yao, Y, Lodhi, M, et al. Creating a Comparable Control Group Using Standardized NANDA-I, NOC, and NIC (NNN) Terminologies to Examine the Influence of Nurse Staffing on Patient Outcomes. International Conference on Nursing Knowledge; 2014 September 11-13; Porto, Portugal.

Stifter, J, Yao, Y, Lodhi, M., et al. An Innovative Study to Link Patient Outcomes and Individual Nurse Continuity Using Practice Based Evidence. Midwest Nursing Research Society; 2014 March 27-30; St. Louis, Missouri.

Stifter, J, Yao, Y, Lodhi, M, et al. An Innovative Study to Link Patient Outcomes and Individual Nurse Continuity Using Practice Based Evidence. The National Pediatric Nurse Scientist Collaborative Nursing Research Fly-in 2014; 2014 May 1-2; Milwaukee, Wisconsin.

Stifter, J, Yao,Y, Lodhi, M, et al. An Innovative Study to Link Patient Outcomes and Individual Nurse Continuity Using Practice Based Evidence. 2nd Annual Advocate Nursing Research Symposium; 2014 April 9; Chicago, Illinois.

Tables

Table 1

Patient Characteristics and HAPU^a vs. Non-HAPU Episodes in the Reduced Dataset (N=24,609)

Patient Characteristics	HAPUs Mean of NOC [b]on Admission (SD)[c]	Non-HAPUs Mean of NOC on Admission (SD)	*t* test *P* value
Nutrition	4.35 (1.27)	4.62 (0.94)	0.00
Mobility	4.10 (1.25)	4.49 (0.98)	0.00
Cognition	4.57 (1.02)	4.64 (0.85)	0.26
Perfusion	3.95 (1.29)	4.49 (0.92)	0.00
Continence	4.83 (0.66)	4.88 (0.54)	0.20
Hydration	4.12 (1.17)	4.60 (0.86)	0.00
Skin	4.10 (1.29)	4.47 (1.01)	0.00
Age	68.9 (15.3)	65.1 (18.2)	0.00

[a]HAPU = Hospital-Acquired Pressure Ulcer
[b]NOC = Nursing Outcomes Classification
[c]SD = Standard Deviation

Table 2

Continuity Index by Unit in the Reduced Dataset (N=24,609)

	Continuity	
	Mean (SD)[a]	Median (IQR)[b]
Overall	0.32 (0.25)	0.33 (0.14-0.50)
LCH1[c]: Med	0.32 (0.23)	0.32 (0.17-0.50)
LCH1:ICU	0.31 (0.26)	0.29 (0.08-0.43)
LCH1:Gerontology	0.42 (0.24)	0.43 (0.29-0.54)
SCH[d]: Med	0.37 (0.29)	0.33 (0.13-0.50)
LCH2[e]:Med	0.32 (0.21)	0.33 (0.20-0.44)
LCH2:Gerontology	0.35 (0.21)	0.33 (0.22-0.50)
UH[f]:Neuro	0.21 (0.22)	0.18 (0.00-0.33)
UH:ICU	0.21 (0.21)	0.18 (0.00-0.33)
UH:Cardiac	0.28 (0.22)	0.25 (0.14-0.40)

[a]SD = Standard Deviation
[b]IQR = Interquartile Range
[c]LCH1 = Large Community Hospital 1
[d]SCH = Small Community Hospital
[e]LCH2 = Large Community Hospital 2
[f]UH = University Hospital

Table 3

Nurse Staffing Characteristics: HAPU[a] vs. non-HAPU Episodes in the Analytic (N=840) Dataset

	HAPU	non HAPU	*P* value
BSN[b]	53.3% (23.0%)	54.1% (22.3%)	.66
Experienced	75.3% (21.5%)	75.1% (23.2%)	.93
8-hour Shifts	44.9% (30.3%)	43.5% (32.3%)	.57
Workload	3.63 (1.46)	3.67 (1.33)	.72
Whppd[c]	8.32 (3.19)	8.25 (3.15)	.79
%VPT[d]	3.9% (6.3%)	3.5% (6.5%)	.37
Continuity	0.30 (0.22)	0.29 (0.22)	.51

[a]HAPU = Hospital-Acquired Pressure Ulcer
[b]BSN = Bachelor of Science in Nursing
[c]Whppd = Worked Hours per Patient Day
[d]%VPT = Percent Very Part Time

Table 4

Regressing Nurse Continuity and Nurse-Staffing Variables on Hospital-Acquired Pressure Ulcers (HAPUs) (N=840)[a]

Outcome	Predictor	Coefficient	SE	z	*P* > [z]
HAPUs	Nurse Continuity	.35	.39	0.90	0.37
	Experience	-.09	.40	-0.23	0.82
	BSN[b]	-.14	.37	-0.38	0.70
	Load (patient-to-nurse ratio)	-.06	.12	-0.47	0.64
	8-hour shifts	.22	.30	0.73	0.46
	Very-part-time	1.09	1.24	0.88	0.38
	Whppd[c]	-.00	.05	-0.02	0.98

[a]Analytic dataset contains episodes with and without HAPUs (matched controls) using the patient characteristics, units, and patient age as the similarity measure
[b]BSN = Bachelor of Science in Nursing
[c]Whppd = Worked hours per patient day

Memorandum

March 2, 2015

To: Tamara D. Willis, PhD, MPH
        Office of Extramural Research, Education, and Priority Populations
        Agency for Healthcare Research and Quality

From: Janet Stifter, PhD, RN
        University of Illinois at Chicago
        College of Nursing, Health Systems Sciences

Re: Reference List and Early Completion of the Grant Statement

Dr. Willis, please find enclosed the two attachments to accompany the Final Progress Report for the AHRQ Grant Number 1R36HS023072-01. These include the reference list and a Budget Expenditures and Rationale for Early Completion of the Grant statement. If you have any questions or concerns upon review of this summary document please do not hesitate to contact me. Thank you, Janet

Attachments:

Reference List
Rationale for Early Completion of the Grant Statement

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Budget Expenditures

<u>Total Award:</u> $40,192
<u>Expenditures:</u>
Monthly stipend May 2014 - December 2014: $18,790.40
Travel/lodging/conference fees: $805.60
<u>Total Expenditures:</u> $19,596.00 (as of December 31, 2014, balance remaining is $20,596)

Rationale for Early Completion of this Study

The original research proposal for this study was approved on March 16, 2013, by members of the primary investigator's dissertation committee at the University of Illinois at Chicago, College of Nursing. The proposal underwent revisions in anticipation of its submission to the Agency for Healthcare Research and Quality (AHRQ) on August 1, 2013. Due to the ready availability of the HANDS database for this secondary data analysis, work commenced in August 2013 to include operationalization of the study variables and initial data mining of the reduced prior to the proposal being funded by the AHRQ in May 2014. The primary investigator was motivated to complete and defend the dissertation study in the Fall 2014 due to the planned departure of her dissertation chair. The dissertation study was completed and defended on September 3, 2014. Subsequent efforts to render the dissertation suitable for publication resulted in two manuscripts being prepared with the first submitted to *Advances in Nursing Science* in December 2014 and the second to *Nursing Research* in January 2015. The primary investigator completed all of the requirements of the PhD and graduated from the program in December 2014, with subsequent termination of the grant funding that month.