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Nurses' Practice Environments, Error Interception Practices, and Inpatient Medication Errors

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Abstract

Purpose: Medication errors remain a threat to patient safety. Therefore, the purpose of this study was to determine the relationships among characteristics of the nursing practice environment, nurse staffing levels, nurses' error interception practices, and rates of nonintercepted medication errors in acute care hospitals.

Design: This study, using a nonexperimental design, was conducted in a sample of 82 medical-surgical units recruited from 14 U.S. acute care hospitals. Registered nurses (RNs) on the 82 units were surveyed, producing a sample of 686 staff nurses.

Methods: Data collected for the 8-month study period included the number of medication errors per 1,000 patient days and the number of RN hours per patient day. Nurse survey data included the Practice Environment Scale of the Nursing Work Index as a measure of environmental characteristics; a metric of nurses' interception practices was developed for the study. All survey measures were aggregated to the unit level prior to analysis with hierarchical linear modeling.

Findings: A supportive practice environment was positively associated with error interception practices among nurses in the sample of medical-surgical units. Importantly, nurses' interception practices were inversely associated with medication error rates.

Conclusions: A supportive practice environment enhances nurses' error interception practices. These interception practices play a role in reducing medication errors.

Clinical Relevance: When supported by their practice environments, nurses employ practices that can assist in interrupting medication errors before they reach the patients.

Medication errors remain one of the leading threats to patient safety, contributing to more than 7,000 inpatient deaths per year in the United States (US). On average, a U.S. hospital patient is subjected to at least one medication error per day; making medication errors the most common cause of preventable adverse patient events (Institute of Medicine [IOM], 2006). There is, however, considerable variation in medication error rates across hospitals, indicating that organizational factors may contribute to this lapse in patient safety (IOM, 2006).

Although medication errors can originate at the prescribing, transcribing, dispensing, or administration stage, research has demonstrated that it is registered nurses (RNs) who are most likely to identify and intercept inpatient medication errors, regardless of source, before the errors reach the patient (Cullen, Bates, & Leape, 2001; Rothschild et al., 2005). Yet, despite studies illuminating the critical role of nurses in the interception of inpatient medication errors, little is known regarding organizational factors that facilitate nurses' efforts in performing this vital safety function. Although a substantial body of research indicates that characteristics of the nursing practice environment are an important organizational determinant of quality nursing care and patient outcomes (Aiken, Clarke, & Sloane, 2002; Flynn, 2007; Kutney-Lee et al., 2009), there has been little research investigating the impact of the practice environment on nurses' error interception practices. The focus of this study was to disentangle the effects of the practice environment, nurses' error interception practices, and RN staffing levels on rates of nonintercepted medication errors in acute care hospitals.

Background

According to the National Coordinating Council for Medication Error Reporting and Prevention (NCCMERP; 2005), a medication error is any preventable event that may lead to inappropriate medication use or patient harm. Included in the Council's definition of medication error are those errors that occur but are intercepted before the error reaches the patient. Reason (1990), a pioneer of error theory, focused on a systems approach to intercepting errors, explaining the need for organizations to develop layers of defenses aimed at identifying and interrupting errors before they cause injury. Reason further proposed that the presence of supportive organizational factors such as good interdisciplinary communication and collaboration, adequate staffing levels, employee input into decision making, competent supervision, staff education and training, and access to information will not only reduce both individual and systemic causes of error but will also aid in error interception.

Consistent with an organizational approach to explaining error, the Nursing Organization and Outcomes Model (Aiken et al., 2002) is a set of propositions that posit a link between the presence of characteristics in the environment that support professional nursing practice and positive patient outcomes. A supportive nursing practice environment is described as a core set of organizational traits that include (a) opportunities for nurses to participate in organizational decisions; (b) competent and supportive front-line nurse managers; (c) collaborative nurse-physician relationships; (d) strong foundations for quality care, including staff development and continuous quality improvement activities; and (e) adequate resources. According to the model's propositions, the presence of these supportive traits within the nursing practice environment facilitates nurses' important work, resulting in higher quality nursing care processes or practices. Subsequently, these higher quality nursing practices promote positive patient outcomes and reduce adverse patient events, thereby serving as an operant mechanism through which a supportive practice environment affects patients. Additionally, the model indicates that higher RN staffing levels facilitate nurse surveillance and early detection of complications or error, thereby also improving the processes and outcomes of care.

The development of the Nursing Work Index-Revised (Aiken & Patrician, 2000) and the Practice Environment Scale of the Nursing Work Index (PES-NWI; Lake, 2002) as measures of the nursing practice environment facilitated a large body of research supporting these proposed relationships. Conducted in a variety of settings and nations, findings indicate that supportive nursing practice environments are significantly associated with superior patient outcomes and fewer adverse events, including lower rates of inpatient mortality and failure to rescue, fewer complications during outpatient hemodialysis, and a lower prevalence of pressure ulcers in skilled nursing facilities (Aiken, Buchan, Ball, & Rafferty, 2008; Aiken, Clarke, Sloane, Lake, & Cheney, 2008; Aiken et al., 2010; Flynn, Liang, Dickson, & Aiken, 2010; Thomas-Hawkins, Flynn, & Clarke, 2008). Yet, despite a body of research related to the nursing practice environment, few if any studies have investigated the influence of the environment as conceptualized by the Nursing Organization and Outcomes Model on RNs' error interception practices.

The empirical literature remains mixed regarding the proposed association between RN staffing levels and the frequency of nonintercepted medication errors. Some findings have indicated a link between higher RN staffing levels and lower rates of nonintercepted errors (Blegen & Vaughn, 1998; Hall, Doran, & Pink, 2004; Whitman, Kim, Davidson, Wolf, & Wang, 2002), and other studies have found no significant relationship (Cho, Ketefian, Barkauskas, & Smith, 2003; Mark & Belyea, 2009). Unmeasured variations in nurses' practice environments, however, may have contributed to these mixed findings (Aiken et al., 2011).

Nonintercepted medication errors have the potential for harm and cost more than $2 billion per year in the United States (IOM, 2006). RNs are well positioned to serve as a patient safety net, interrupting errors before they make contact with patients. Little is known, however, regarding the factors that facilitate nurses' performance of this important safety function. Therefore, the purpose of this study, informed by the Nursing

Organization and Outcomes Model, was to determine the associations among characteristics of the nursing practice environment, RN staffing levels, nurses' error interception practices, and the rate of nonintercepted medication errors on medical-surgical units in acute care hospitals.

Methods

In this nonexperimental design, individual medical-surgical units within acute care hospitals comprised the unit of analysis. Staff RN survey data, aggregated to the unit level, were linked with unit level RN staffing and error data to investigate relationships among study variables. Prior to data collection, the study was approved by Rutgers University Institutional Review Board (IRB), as well as by the IRBs of participating hospitals.

Hospital Sample

The total hospital sample consisted of 14 U.S. acute care hospitals located in New Jersey. Hospitals in this convenience sample were selected to represent major geographic regions of the state. Hospitals ranged in size from 178 to 600 licensed beds. A total of three of the 14 hospitals were considered to be medium in size (100–250 hospital beds), and the remaining 11 hospitals were considered large (> 250 hospital beds). All 14 hospitals were classified as teaching hospitals, 12 as not-for-profit and 2 as private, for-profit facilities. The hospital sample produced a total of 82 adult medical, surgical, or combination medical-surgical units as designated by licensing categories established by the New Jersey Department of Health and Senior Services. Thus, participating units were delimited to general medical, surgical, or medical-surgical units; there were no critical care or step-down units included in the sample.

Nurse Sample

Nurses employed as staff RNs on each of the 82 medical-surgical units in the total sample were surveyed to determine their ratings of their practice environments and the frequency with which they employed error interception strategies in their professional nursing practice. The nurse sampling frame consisted of all staff RNs working between 7 a.m. and 7 p.m. on the day that survey distribution and collection was scheduled at their hospital. The only inclusion criteria were that the survey participants be registered nurses employed in a position of staff nurse on their unit. Nurses working as temporary float nurses and therefore not regularly assigned to a participating unit were not included in the sample. Each hospital selected an employee to serve as the onsite study liaison to coordinate the data collection schedule with the research team and to notify staff RNs of the opportunity to participate. In most hospitals, the study liaison was either employed in the nursing education department or was a member of the nursing research council. At each site, on the scheduled day of survey collection, nurse surveys were distributed and collected by the principal investigator. Prospective participants were given a written document containing all of the elements of informed consent, including a description of the study, its purpose, and participants' rights as research subjects. As approved by all of the IRBs, survey completion indicated consent to participate; nurse participants did not sign a consent form since their identities and responses were anonymous, and a signed consent would create a record of identity. Nurse response rates, indicated by the percentage of RNs per unit who completed the survey, ranged from 50% (1 unit) to 100% (69 units), with a mean RN response rate per unit of 96%. An average of 8.4 RNs per unit completed the survey, producing a sample of 686 RNs. The demographic characteristics of the RN sample are presented in **Table 1**.

Table 1. Characteristics of Nurse Sample ($n = 686$)

Variable	*M*	*SD*
Age	38.6	10.3
Years of nursing experience	11.6	10.0
	n	%
Gender		
Female	601	87.6
Male	51	7.4
Not reported	34	5.0
Race		
African American/Black	56	8.2
Asian/Pacific Islander	162	23.6
Hispanic	34	5.0
White	336	49.0
Other	38	5.5
Not reported	60	8.7
Highest nursing degree		
Diploma	84	12.2
Associate degree	247	36.0
Baccalaureate degree	286	41.7
Master's degree or higher	23	3.4
Not reported	46	6.7

Measures

Using the definition of medication errors endorsed by the NCCMERP (http://www.nccmerp.org/), nonintercepted medication errors were defined as the number of medication errors reaching the patient per 1,000 patient days. Medication errors include prescribing, transcribing, dispensing, and administration errors that result in a wrong medication, wrong administration method, wrong dose, inappropriate continuation, inadvertent omission, or administration to patients despite known allergies to the medication. Errors related to wrong time or delay in time of administration are not specified in the NC-CMERP definition. Data related to the number of medication errors reaching the patient were routinely collected by all participating hospitals via incident reports for the 8-month study period. The number of patient days per unit during this period was also reported, and the medication error rate per 1,000 patient days was calculated for each unit by the research team. The number of patient days per unit for any specified time period is defined as the sum of the total number of days each patient stayed on the unit (Mosby, 2009). In this sample of 82 units, reported medication errors per 1,000 patient days ranged from 0 to 5.32 per 1,000 days ($M = 1.42$; $SD = 0.91$), which is lower than the national average of 5.66 per 1,000 patient days estimated in a nationwide study of adult inpatient care units (Stratton, Blegen, Pepper, & Vaughn, 2004).

Additional administrative data obtained from participating hospitals included the number of RN hours per patient day for each unit, which was calculated for the 8-month study period. The number of RN hours per patient day is a nurse staffing metric endorsed by the National Quality Forum (NQF; 2009) and is defined as the number of productive hours worked by RN nursing staff, including employee and contract RNs with direct patient care responsibilities, divided by the total number of inpatient days. In the sample of 82 units, RN hours per patient day ranged from 2.69 to 7.18 hours ($M = 4.73$, $SD = 1.01$).

The nursing practice environment was measured by a composite score on the PES-NWI (Lake, 2002), which was aggregated to the unit level. The PES-NWI is an NQF-endorsed measure of the practice environment consisting of 31 items from the original Nursing Work Index-Revised (Aiken & Patrician, 2000). Items on the PES-NWI comprise five subscales consistent with the five domains of the practice environment as characterized by the Nursing Organization and Outcomes Model, including (a) Nurse Participation in Hospital Affairs; (b) Nursing Foundations for Quality of Care; (c) Collegial Nurse-Physician Relations; (d) Supportive and Competent Nurse Manager; and (e) Staffing and Resource Adequacy. Respondents indicate, on a 4-point rating scale, the extent to which they agree that the organizational attribute depicted in each item is present in their current job. The instrument is scored by calculating mean subscale scores and a total composite score for each respondent. Composite and subscale scores can range from 1 to 4, with higher scores indicating more supportive practice environment. Validity was established in previous research via the "known groups" technique in that nurses practicing in magnet hospitals had significantly higher scores than nurses in nonmagnet hospitals. Moreover, confirmatory factor analysis supported the five-subscale structure in a sample of 41,860 nurses practicing in 210 Pennsylvania hospitals (Lake 2002; Laschinger & Leiter, 2006). An internal consistency alpha of 0.95 was calculated in the current nurse sample. Composite and subscale scores were aggregated to the unit level prior to data analysis. Total aggregated composite scores ranged from a low of 1.99 to a high of 3.62 ($M = 2.94$, $SD = 0.34$) in this sample of 82 medical-surgical units.

Four survey items measuring nurses' medication error interception practices were developed for this study. Items for this measure were derived from qualitative interviews with staff RNs practicing on medical-surgical units (Dickson & Flynn, 2011). Items reflected the four nursing practices nurses described as specifically focused on identifying and intercepting existing errors, regardless of source, in contradistinction to the primary prevention of error. These practices consisted of (a) independent comparisons between the medication administration record and patient record at the beginning of the nurse's shift, (b) determining the rationale for each ordered medication, (c) requesting that physicians rewrite orders when improper abbreviations were used, and (d) ensuring that patients and families were knowledgeable regarding the medication regimen so that they could question unexplained variances. Nurse respondents were asked to identify, on a summated rating scale, the frequency with which they normally engaged in these interception practices in the course of their daily work. Responses ranged from 1 = *never* to 5 = *all of the time*; higher scores indicated superior error interception practices. Total scores could range from 4 to 20. Reliability analysis indicated that item-to-total correlations were acceptable in that all were greater than 0.30 and ranged from 0.37 to 0.46. An internal consistency coefficient of 0.61 for the four-item scale indicated acceptable reliability for a short scale (Nunnally, 1994). Scores were aggregated to the unit level to create a unit level error interception practices score. Aggregated unit scores ranged from 14.00 to 18.67, with a mean of 16.33 ($SD = 1.10$).

Although the empirical literature is mixed regarding the impact of medication safety technology on rates of medication errors, some studies have found an association between the use of safety technology and reductions in errors (Durieux et al., 2010; Shamliyan, Duval, Du, & Kane, 2008). Therefore, the implementation status of electronic medication administration records, bar coding, and computerized physician order entry (CPOE) were collected for each unit from hospital pharmacists. Hospital pharmacists were asked to rate the existing

Table 2. Effects of the Practice Environment on Nurses' Error Interception Practices

Variable	β	*SE*	*df*	*t*	*p*
Nursing practice environment composite score	1.25	0.37	64.00	3.41	.001
Nursing practice environment subscales					
Foundations for Quality	1.56	0.41	74.01	3.82	.000
Collaborative RN-Physician Relationships	1.33	0.31	78.47	4.41	.000
Nurse Participation	1.03	0.33	53.22	3.10	.003
Supportive Nurse Manager	0.64	0.29	66.60	2.20	.032
Adequate Staffing & Resources	0.58	0.32	77.10	1.82	.073

implementation of each of these technologies as (a) not implemented, (b) partially implemented, or (c) fully implemented.

Analysis

Correlation coefficients were computed between study variables. Associations among study variables were then estimated using hierarchical linear modeling (HLM) to account for clustering of units within hospitals (Raudenbush & Bryk, 2002).

Findings

Demographic characteristics of the nurse sample are presented in Table 1. Descriptive analysis of technology utilization indicated that a total of 81.7% of the units utilized a fully implemented computerized medication record, 22.0% utilized a fully implemented bar coding system, and 15.9% utilized a fully implemented CPOE system.

There were no associations between RN staffing levels, measured by the number of RN hours per patient day, and any study variable including nurses' error interception practices or medication error rates. As presented in **Table 2**, HLM indicated that the nursing practice environment, measured by the PES-NWI composite score, was positively and significantly associated with nurses' error interception practices. Due to high intercorrelations between the five PES-NWI subscale scores, error interception practices scores were modeled separately on each of the individual PES-NWI subscales. All subscales of the PES-NWI with the exception of Staffing and Resource Adequacy were positively associated with nurses' error interception practices. The subscales of Collegial Nurse-Physician Relationships and Foundations for Quality Care had the strongest association with nurses' interception practices.

Table 3. Effects of Study Variables on Medication Errors per 1,000 Patient Days

Variable	β	*SE*	*df*	*t*	*p*
Nurses' interception practices	−0.19	0.08	73.98	−2.48	.015
Nursing practice environment composite score	−0.26	0.30	79.95	−0.87	.388

There was no significant association between the use of computerized medication records, bar coding, or CPOE and medication error rates. As presented in Table 3, a significant association was found between nurses' error interception practices and medication error rates. There was no association, however, between the composite score of the PES-NWI and medication error rates.

Discussion

Findings from this study indicate that the practices used by nurses to identify and intercept medication errors have a modest but significant effect on the rate of medication errors on medical-surgical units in acute care hospitals. More frequent engagement by nurses in these important interception practices was associated with fewer documented medication errors per 1,000 patient days. These findings support that nursing practices have an important role in enhancing patient safety.

In addition to patient safety, the fiscal implications of nurses' error interception practices should be considered. Medication errors are costly, frequently resulting in longer lengths of stay and an estimated $4 million per hospital in additional annual patient care costs (Paradis, Stewart, Bayley, Brown, & Bennett, 2009). Therefore, nursing practices that identify and intercept medication errors, such as those investigated in this study, not only contribute to error reduction but can consequently contribute to reductions in associated costs.

Moreover, findings from this study support two major tenants of the Nursing Organization and Outcomes Model (Aiken et al., 2002). As proposed by the model, results indicate that supportive practice environments are associated with higher quality nursing practices. A supportive nursing practice environment, overall, and four of the five environment domains were significantly associated with nurses' more frequent engagement in error interception practices. Furthermore, as proposed by the model, this higher quality nursing care, represented by error interception practices, was associated with fewer adverse patient events.

Fortunately, the characteristics of the practice environment are modifiable through managerial and administrative initiatives. Strategies that create and maintain a supportive environment have been shown to include activities such as encouraging teamwork between physicians and nurses, increasing nurses' opportunities to participate in hospital and unit level decisions, fostering the continuity of patient care assignments, offering continuing education opportunities, and retaining nurse administrators that are visible and accessible, who listen to nurses' concerns, and who expect high standards of care from the nursing staff.

No significant relationship between RN staffing levels and medication errors were found. One possible explanation is that RN hours per patient day, as a measure of staffing, is captured and reported by hospital informatics systems. Therefore, the measure may reflect total paid hours in contradistinction to productive hours and therefore be an inaccurate metric of staffing (Spetz, Donaldson, Aydin, & Brown, 2008).

There are limitations to this study that must be considered. The most obvious is the use of incident reports to measure the frequency of medication errors. The underreporting of inpatient medication errors is well documented (Costello, Torowicz & Yeh, 2007; IOM, 2006) and most likely occurred in this study as indicated by a mean error rate that is lower than the national average. Additionally, nurses may not perceive the delayed administration of a medication to be an error and may not report these incidences. Therefore, incident reports, as used in this study, are considered less reliable than chart review or direct observation for capturing and measuring medication errors. Yet, despite this limitation, incident reports can be considered a marker or proxy for medication errors, if not a precise metric (Paradis et al., 2009). Another limitation of this study involves the items used to measure error interception practices, which were developed for use in this study. Although the items were derived from extensive qualitative interviews, additional research is needed to further evaluate their reliability and utility as a measure.

Conclusions

These findings support that nurses' error interception practices are associated with lower rates of nonintercepted medication errors, further quantifying the important role of nurses in enhancing patient safety. Moreover, findings add to a growing body of evidence indicating that a supportive practice environment is associated with a higher quality of nursing care. Therefore, healthcare administrators should carefully consider available strategies that create such work environments. Medication errors are costly to patients and hospitals, yet when supported, nurses' employ practices that can assist in interrupting those errors before they reach the patient. Therefore, practice environments must be created and sustained that support nurses in their important work of keeping patients safe.

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Clinical Resource

- National Coordinating Council for Medication Error Reporting and Prevention: http://www.nccmerp.org/

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