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The Critical Care Work Environment and Nurse-Reported Health Care–Associated Infections

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Abstract

Background—Critically ill patients are susceptible to health care–associated infections because of their illnesses and the need for intravenous access and invasive monitoring. The critical care work environment may influence the likelihood of infection in these patients.

Objective—To determine whether or not the critical care nurse work environment is predictive of nurse-reported health care–associated infections.

Methods—A retrospective, cross-sectional design was used with linked nurse and hospital survey data. Nurses assessed the critical care work environment and provided the frequencies of ventilator-associated pneumonias, urinary tract infections, and infections associated with central catheters. Logistic regression models were used to determine if critical care work environments were predictive of nurse-reported frequent health care–associated infections, with controls for nurse and hospital characteristics.

Results—The final sample consisted of 3217 critical care nurses in 320 hospitals. Compared with nurses working in poor work environments, nurses working in better work environments were 36% to 41% less likely to report that health care–associated infections occurred frequently.

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Conclusion—Health care–associated infections are less likely in favorable critical care work environments. These findings, based on the largest sample of critical care nurses to date, substantiate efforts to focus on the quality of the work environment as a way to minimize the frequency of health care–associated infections.

Health care–associated infections (HAIs) are one of the most common complications of care.[1] HAIs are of particular concern in critically ill patients; according to estimates, almost half a million incidents of HAI occur each year in intensive care units (ICUs) alone.[2] Increased susceptibility to HAIs in ICU patients is attributable in part to precarious clinical conditions,[3] depressed immune function,[4] and the need for invasive monitoring to ensure appropriate provision of care. The Centers for Disease Control and Prevention has made specific recommendations to aid in the prevention of central catheter–associated bloodstream infections (catheter-associated BSIs), urinary tract infections (UTIs), and ventilator-associated pneumonias (VAPs).[5] The recommendations focus on specific actions to be implemented by staff members, including hand hygiene, aseptic insertion of catheters, and placing patients in a semirecumbent position during intubation.[5] As the largest group of ICU clinicians who provide direct patient care, critical care nurses are well positioned to implement the recommendations and monitor patients for HAIs.

Development of HAIs in acute care areas has been linked to organizational factors, such as nurse staffing.[6,7] In addition to staffing, a quality work environment—another organizational component of hospital nursing care—presumably provides critical care nurses the time and resources necessary to provide HAI preventive care. Evidence on the relationship between nurse organization, particularly the work environment, and HAIs in critical care units is limited.

The work environment is defined as the organizational characteristics of the workplace that facilitate or constrain professional nursing practice.[8] Researchers have suggested that providing nurses with better resources and more time for patient care within a flat organizational management structure might improve the patient-nurse interaction and quality of care. Indeed, the American Association of Critical-Care Nurses[9] has endorsed the importance of a healthy work environment and the potential link between the environment and patient safety. In 2 descriptive studies,[10,11] members of the association were surveyed on their perceptions of the workplace and the quality and safety of patient care. Approximately 86% of respondents reported that their unit provided excellent or good-quality care, but one quarter of these nurses indicated that the quality of care in their units during the past year had become worse.[10]

Almost half a million health care–associated infections occur each year in intensive care units.

Inconsistencies noted in critical care nurses' reports of quality and safety are also reflected in the ICU literature. Better communication between ICU nurses and physicians has been linked to fewer nurse-reported medication errors and greater job satisfaction.[12,13] Greater variation in effective communication among providers in ICUs was associated with greater rates of VAP.[14] Additionally, scores on the composite Practice Environment Scale of the

Nursing Work Index (PES-NWI), a commonly used measure of nurses' work environment, was not predictive of nurse-assessed VAP and catheter-associated sepsis.[12] However, a more positive organizational climate, a concept similar to the work environment, was significantly associated with higher odds of catheter-associated BSIs and lower odds of UTIs.[15] The mixed evidence, limited in part by small sample sizes, restricted generalizability,[12,15] and inconsistent reports of nurses[10] indicate that more investigation is needed to understand how the critical care work environment may affect the frequency of HAIs.

The purpose of our study was to describe critical care work environments and to determine whether or not the environments were associated with nurse-reported HAIs in a sample of critical care nurses in more than 300 hospitals in 4 states. We hypothesized that nurses in better work environments would be less likely to report frequent HAIs than would nurses in less favorable environments. We posited that a better critical care work environment would offer nurses more time, resources, and support, thereby increasing the number, duration, and quality of nurse-patient interactions. These potentially more frequent, longer, and better quality interactions might enable nurses to use adequate aseptic technique, enhance monitoring of intravenous insertion sites, identify clinical changes early, and prevent the development of a HAI.

Methods

Individual exempt approval was received from the appropriate institutional review board before the study began.

Sample and Setting

A retrospective cross-sectional design was used to conduct a secondary analysis of linked nurse and hospital survey data on the association between the critical care work environment and nurse-reported patient outcomes in 4 states. The sample included adult, nonfederal, acute care hospitals in New Jersey, Pennsylvania, California, and Florida that responded to the American Hospital Association Annual Survey in 2007 and had at least 5 critical care nurse respondents from the University of Pennsylvania Multi-State Nursing Care and Patient Safety Study.

> The sample included critical care nurses in more than 300 hospitals in 4 states.

The Multi-State Nursing Care and Patient Safety Study was conducted from 2005 to 2008. Nurses provided demographic data, including education and specialty certification, unit type, and assessments of their working environments, workload, and quality and safety.[16] Survey data were collected from a random sample of 25% to 50% of all actively licensed registered nurses who resided in California (40%), Pennsylvania (40%), Florida (25%), and New Jersey (50%). The overall response rate using the Dillman method[17] of repeated surveys and postcards was 39%. A follow-up survey was sent to nonresponders to determine if response bias was of concern. A 91% response rate was achieved from this follow-up survey, and no significant differences were noted between responders and nonresponders in

their assessments of nurse staffing or the work environment.[16,18] Further details of the survey approach have been described elsewhere.[16]

In order to restrict the sample to bedside critical care nurses, respondents were excluded if they did not identify themselves as adult critical care nurses and if they reported caring for 7 or more patients on their last shift. Respondents that met these exclusion criteria accounted for only 1% of the sample. According to the intraclass correlation coefficients, a minimum of 5 nurse respondents per hospital was sufficient to produce reliable estimates of the environment.[19,20] A mean of 10 adult critical care nurses responded per hospital.

Measures

Work Environment—The PES-NWI was used to measure critical care work environments.[8,21] The PES-NWI is a 31-item, well-validated tool. It is scored on a 4-point Likert scale and consists of 5 different subscales: Staffing and Resource Adequacy (eg, enough staff to get the work done), Nurse Participation in Hospital Affairs (eg, opportunity for staff nurses to participate in policy decisions), Nursing Foundations for Quality of Care (eg, active staff development or continuing education programs for nurses), Collegial Nurse-Physician Relations (eg, physicians and nurses have good working relationships), and Nurse Manager Ability, Leadership and Support of Nurses (eg, a supervisory staff that is supportive of nurses). Higher scores indicate agreement that the organizational features are present in the current job. Intraclass correlation coefficients (ICC [1, k]) in this sample ranged from 0.50 (Collegial Nurse-Physician Relations) to 0.73 (Nurse Participation in Hospital Affairs). ICCs greater than 0.60 signify that individual measures can be reliably aggregated to the hospital level.[19,20] All ICCs were greater than 0.60 except the ICC for Collegial Nurse-Physician Relations (0.50).

The PES-NWI composite score was calculated by aggregating the individual nurse subscale scores to the hospital level and then calculating the mean of the subscale means. The Staffing and Resource Adequacy subscale was excluded from the composite score because it was significantly correlated with the separate staffing measure. The ICC of the composite PES-NWI score was 0.67 without the Staffing and Resource Adequacy subscale and 0.69 with the Staffing and Resource Adequacy subscale. Hospitals were classified as having better (>75th percentile), mixed (25th-75th percentile), or worse (<25th percentile) critical care work environments on the basis of the PES-NWI composite score.

Nursing Characteristics—Mean staffing levels of critical care nurses were derived from nurses' reports of the number of patients cared for on the nurses' last shift and were aggregated to the hospital level. This variable represented the average patient to nurse ratio in the critical care units of a hospital and was used as a statistical control. Additional control variables supplied by the nurse survey included age, years of experience, sex, attainment of specialty certification (not including Advanced Cardiac Life Support, Basic Life Support, or other required certifications for practice), and acquisition of a bachelor's degree or higher.

Hospital Characteristics—The 2007 American Hospital Association Annual Survey[22] provided data on hospital structural characteristics such as bed size, teaching, and technology status. The number of hospital beds was grouped into 3 categories: small (<250

beds), medium (250-500 beds) and large (≥501 beds). Teaching hospitals were classified into 3 categories according to the ratio of medical trainees to beds: major (1 to 4 or greater), minor (less than 1 to 4), and nonteaching. Hospitals with the capability for open heart surgery and/or organ transplants were denoted as high-technology hospitals to be distinguished from hospitals without such capabilities. Indicator variables for the state the hospital was located in were used to account for variations in staffing and other statewide hospital policies. Case mix index, a measure that reflects clinical complexity of a hospital's patients, was also used and was provided by the Centers for Medicare and Medicaid Inpatient Provider Specific File. The case mix index is centered at 1, so numbers greater than 1 indicate a higher degree of clinical complexity than usual.

Nurse-Reported Patient Outcomes—Outcome variables were derived from the nurse survey. Nurses were asked to rate the frequency of VAPs, catheter-associated BSIs, and UTIs on a 7-point Likert scale, from never to every day. Outcomes were categorized as frequent if nurses reported that the event occurred more than once a month. Previous research[23-25] has indicated that nurses are reliable reporters of patient safety and patient safety outcomes.

Analysis

Descriptive statistics were calculated first. Unadjusted and adjusted logistic regression models that accounted for the clustering of nurses within hospitals were used to predict the association between the critical care work environment and nurses' reports of frequent HAIs. Because the data were clustered, multilevel regression modeling was also used. The results of the multilevel models were equivalent to those of logistic regression with clustering, and only the simpler logistic regression models are included here. The adjusted models had controls for nurse characteristics and hospital characteristics. All analyses were done by using Stata statistical software (StataCorp LP) version 11.0.[26]

Results

Sample characteristics are displayed in Table 1. The final sample included 3217 nurses in 320 hospitals. Most of the nurses had a bachelor's degree or higher, half held a specialty certification, and 11% were men. The average nurse in the sample had more than 12 years of experience, and 58% of the critical care nurses were more than 40 years old. Nearly half (45%) of the nurses reported that VAP was a frequent occurrence on their units, and 39% of the nurses indicated that UTIs and catheter-associated BSIs occurred frequently.

Among the 320 hospitals, 66% had 250 patient beds or more, and 65% were classified as high-technology hospitals. More than half (54%) were either major or minor teaching hospitals. The mean ICU nurse staffing ratio was approximately 2 patients per nurse. By definition, one-quarter of hospitals were classified as having either a better or a worse critical care work environment; the remainder of the sample was classified as having a mixed work environment.

Descriptive statistics of the PES-NWI are displayed in Table 2. The composite score, with a mean of 2.68, is the mean of the 5 subscales across all hospitals in the sample, and 2.73 is

the mean composite score when scores for the Staffing and Resource Adequacy subscale are excluded. The subscales with the highest mean scores were Nurse Foundations for Quality of Care (2.93) and Collegial Nurse-Physician Relations (2.89). The subscale with the lowest mean score was the Nurse Participation in Hospital Affairs (2.52). The subscales and the composite measure had Cronbach α values of 0.89 or higher, indicating scale reliability in this sample of critical care nurses.

The results of the logistic regression analysis are displayed in Table 3. Adjusted models indicate that the odds of nurses' reporting frequent HAIs were significantly lower for nurses who worked in hospitals with better critical care work environments than for nurses who worked in mixed environments for all 3 outcomes by factors ranging from 0.77 for catheter-associated BSIs to 0.80 for VAPs and UTIs. These results indicate that the odds of nurses' who worked in hospitals with a better critical care work environment reporting frequent HAIs would be 36% (ie, $[1\text{-}0.80^2] \times 100$) to 41% lower than the odds for nurses who worked in worse nurse work environments.

Discussion

The purpose of this study was to describe critical care work environments and to determine whether or not critical care work environments were associated with nurse-reported HAIs in a large sample of nurses in more than 300 hospitals in 4 US states. Our principal finding was that frequent nurse-reported HAIs were less likely to occur in critical care settings with better work environments. These results are consistent with our clinical reasoning that HAIs are sensitive to variation in nurses' work environments because critical care nurses maintain patients' central and urinary catheters, perform oral hygiene, and encourage early mobility.[27]

Almost half of all critical care nurses reported that VAPs, catheter-associated BSIs, and UTIs occurred more than once a month in their unit. If each HAI occurred once a month for a year, the actual number of HAIs would range from 12 to 36 per year at a minimum. This estimate is relatively conservative; earlier research[15] indicated that 61 to 105 HAIs occurred during a 1-year period in patients at risk. The frequency of the nurse-reported HAIs in our study is also consistent with evidence that HAIs, specifically those caused by multidrug-resistant bacterial organisms, are steadily increasing.[28]

Our results also shed light on specific critical care work environment areas via description of the PES-NWI subscales. Mean subscale scores were highest for Nurse Foundations for Quality of Care (2.93) and Collegial Nurse-Physician Relations (2.89). Nurses working in critical care units in our sample agreed that the work environments offered opportunity for continuity of care, provided quality assurance programs, and supported good working relationships. Subscales with the lowest mean scores were Staffing and Resource Adequacy (2.54) and Nurse Participation in Hospital Affairs (2.52), suggesting that more work may be needed to improve ICU resources and involvement of ICU nurses in hospital activities. The Nurse Manager Ability, Leadership and Support subscale had one of the lowest scores (2.56) but also had the widest range in scores (1.20-3.57). This wide range suggests wide variation in ICU leadership and nurse support systems, consistent with reports from a national survey[9]

in which 40% of critical care nurses rated the leadership by their nurse managers as fair or poor.

Critical care nurses are the largest group of health care providers in ICUs who provide direct patient care. The ability of these nurses to provide high-quality care, to monitor patients, and to address changes in a patient's status may prevent the development of HAIs. We found that odds of frequent nurse-reported HAIs were lower in better work environments than in less favorable environments. Our results suggest that administrators and nurses can focus their efforts on addressing weaknesses in their critical care work environments by using scores on the 5 domains of the PES-NWI as a guide. Implementing a primary care staffing model, ensuring that appropriate support staff and resources are available, and providing support for nurse managers are examples of interventions that might lower risk for development of HAIs, result in greater staff satisfaction,[29] and translate into improvements in multiple patient outcomes.[30,31]

Limitations

Our results indicate a significant association between ICU work environments and the occurrence of HAI among ICU patients. However, the cross-sectional design of the study makes it impossible to establish that the 2 variables are causally related. Although nurses in previous studies were reliable reporters of patients' outcomes[23,25] and quality of patient care,[24] nurses' reports are not infallible. Unfortunately, administrative data on actual incidences of HAIs were not available for the hospitals in our study to corroborate or use in place of the nurse reports. Reports of national HAI estimates[2] suggest that the HAI occurrences reported by nurses may actually be conservative estimates. Because conservative estimates of the incidence of HAIs would likely bias our results in the direction of the null, our significant findings attest to the strength of the association and substantiate the use of nurse-reported outcomes in analyzing that association. We were unable to control for patients' characteristics because those data were not available, and in an attempt to address this limitation, we controlled for hospital case mix index. However, even without the control for case mix, the ICU patients cared for by the nurses in our study were decidedly less heterogeneous than other populations of patients because all of the patients would have been in ICUs where the nurses practiced and would be at risk for infection by virtue of having similar experiences (ie, with urinary catheters, ventilators, or central catheters). Infectious disease policies at the level of individual hospitals that may influence HAI prevalence were unavailable in the data we used. We were unable to link the direct care provided by nurses to patients. The survey data contain type of nursing unit but not a specific nursing unit. Thus, the aggregate measures of nursing in our study reflect the critical care work environment across units in a hospital. Our analyses are limited to 4 US states, although these states are geographically diverse and account for a large fraction of hospitalizations nationally. Our sample of nurses also appears to be representative of critical care nurses; the nurse demographics are comparable to those of a nationally representative sample of critical care nurses.[11]

More work may be needed to improve involvement of intensive care unit nurses in hospital activities.

Conclusions

HAIs occur frequently in critical care units, and the nurse work environment may be a key organizational strategy for preventing these infections. Focusing interventions on the critical care work environment may reduce the odds for the occurrence of HAIs. Effort is needed to improve particular aspects of the critical care work environment. Each hospital's critical care nursing staff, led by administrators and nurse managers, should examine how best to improve their work environment to mitigate the effects of HAIs in already vulnerable patients. Critical care nurses, as the largest group of ICU clinicians who provide direct care, are well positioned to influence the prevalence and prevention of HAIs in critically ill patients.

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Table 1

Sample characteristics

Characteristic	Value[a]
Nurses (N = 3217)	
Age, y	
21-30	450 (14)
31-40	885 (28)
41-50	1050 (33)
51-60	682 (21)
≥61	113 (4)
Male	338 (11)
Bachelor's degree or higher	1712 (53)
Certification	1747 (54)
Nursing experience, mean (SD), y	12.7 (11.1)
Nurses reporting frequent health care–associated infections	
Ventilator-associated pneumonia	1454 (45)
Urinary tract infections	1265 (39)
Central catheter infections	1257 (39)
Hospitals (N = 320)	
Adult intensive care unit staffing, mean (SD)	2.20 (0.40)
Hospital case mix index, mean (SD)	1.21 (0.43)
No. of beds	
<250	110 (34)
250-500	159 (50)
>500	51 (16)
Teaching status	
None	148 (46)
Minor	134 (42)
Major	38 (12)
High-tech hospital	209 (65)
State	
California	
New Jersey	
Pennsylvania	
Florida	77 (24)

[a] Values are number (%) unless otherwise indicated.

Table 2

Subscale scores for critical care nurses on the Practice Environment Scale of the Nursing Work Index[a]

Subscale	No. of items	Cronbach α	Mean (SD)	Range
Nurse Foundations for Quality of Care	9	0.89	2.93 (0.29)	2.09-3.68
Nurse Participation in Hospital Affairs	9	0.91	2.52 (0.38)	1.50-3.56
Nurse Manager Ability, Leadership, and Support	4	0.92	2.56 (0.43)	1.20-3.57
Collegial Nurse-Physician Relations	3	0.94	2.89 (0.32)	1.83-3.69
Staffing Resource and Adequacy	4	0.91	2.54 (0.40)	1.45-3.69
Composite score, without Staffing and Resource Adequacy subscale	4	0.92	2.73 (0.30)	1.98-3.58
Composite score, with Staffing and Resource Adequacy subscale	5	0.92	2.68 (0.31)	1.92-3.60

[a] A higher score represents a more positive work environment.

Table 3

Odds ratios estimating the effect of the critical care work environment on nurse-reported frequent[a] health care–associated infections

	Odds ratio (95% CI)					
	Central catheter–associated bloodstream infection		Ventilator-associated pneumonia		Urinary tract infection	
Factor	Unadjusted	Adjusted[b]	Unadjusted	Adjusted[b]	Unadjusted	Adjusted[b]
Work environment[c]	0.88	0.77	0.95	0.80	0.86	0.80
	(0.76-1.03)	(0.65-0.91)	(0.81-1.11)	(0.68-0.95)	(0.74-0.99)	(0.69-0.94)
	P = .14	*P* = .003	*P* = .52	*P* = .01	*P* = .04	*P* = .004

[a] Frequent defined as once a month or more.

[b] Models control for hospital teaching and technology status, bed size, case mix index, intensive care unit nurse staffing, nurse education, years of experience, age, sex, and certification. Models cluster for nurses within hospitals and use robust standard error estimation.

[c] Estimates for the work environment represent the change in odds ratios for the effect of “better vs mixed” or “mixed vs worse.”