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Nurse Work Environment and Hospital-Onset *Clostridioides difficile* Infection

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Background: *Clostridioides difficile* is the leading cause of hospital-onset diarrhea and is associated with increased lengths of stay and mortality. While some hospitals have successfully reduced the burden of *C. difficile* infection (CDI), many still struggle to reduce hospital-onset CDI. Nurses—because of their close proximity to patients—are an important resource in the prevention of hospital-onset CDI.

Objective: Determine whether there is an association between the nurse work environment and hospital-onset CDI.

Methods: Survey data of 2016 were available from 15,982 nurses employed in 353 acute care hospitals. These data, aggregated to the hospital level, provided measures of the nurse work environments. They were merged with 2016 hospital-onset CDI data from Hospital Compare, which provided our outcome measure—whether a hospital had a standardized infection ratio (SIR) above or below the national average SIR. Hospitals above the average SIR had more infections than predicted when compared to the national average.

Results: In all, 188 hospitals (53%) had SIRs higher than the national average. The odds of hospitals having higher than average SIRs were significantly lower, with odds ratios ranging from 0.35 to 0.45, in hospitals in the highest quartile for all four nurse work environment subscales (managerial support, nurse participation in hospital governance, physician-nurse relations, and adequate staffing) than in hospitals in the lowest quartile.

Conclusions: Findings show an association between the work environment of nurses and hospital-onset CDI. A promising strategy to lower hospital-onset CDI and other infections is a serious and sustained commitment by hospital leaders to significantly improve nurse work environments.

Key Words: *Clostridioides difficile* infection, infection control, infection prevention, work environment, nursing care

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Clostridioides difficile is the leading cause of hospital-onset diarrhea, with reports of 235,700 cases annually and attributed medical costs of nearly $22,000 within 5 years of diagnosis.[1,2] Since 2015, when the Centers for Medicare and Medicaid Services (CMS) added *C. difficile* infection (CDI) metrics into the Hospital Inpatient Quality Reporting Program, most hospitals have demonstrated a reduction in CDI rates.[1,3,4] However, exposure to antibiotics and colonization of infected patients continue to contribute to the development and spread of CDI, posing a considerable burden to the US health care system.[2,5]

Nurses are integral in implementing CDI prevention and control practices in the acute care setting. Nurses represent the largest number of health care professionals working in hospitals where they work in close proximity to patients, and regularly interact with physicians and other professionals at the bedside in the delivery and monitoring of patient care. It is nurses who implement the bundle of practices to prevent and control the spread of hospital-onset CDI, which includes prompt and appropriate diagnostic testing of unformed stool, prompt initiations of contact precautions among patients with CDI, exceptional hand hygiene, and the potential to influence best environmental disinfection or antibiotic stewardship.[6–8] However, these practices are complex, challenging, and time-consuming for nurses as they often face challenges in communication regarding isolation orders and diagnostic tests, discordant perceptions with physicians regarding CDI risk factors that prompt testing, as well as a pressured workflow to don and doff personal protective equipment appropr iately.[6,8–10] It is hypothesized that a supportive clinical work environment would reduce these barriers and facilitate consistent adherence to best practices in infection prevention.

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In this study, we explore how aspects of the nurse work environment are related to hospital-onset CDI. The work environment of nurses has been identified as an important, modifiable set of organizational features that impact patient outcomes.[11–15] The work environment comprises multiple dimensions, including the extent to which the managers and supervisory staff support nurses and their practice, nurses participate in hospital and nursing committees and contribute to hospital policy decisions, nurses and physicians collaborate and have good working relationships with each other, and hospitals have enough nursing staff to provide quality patient care. These organizational features have been shown to be associated with various positive patient outcomes, including lowered mortality,[12,16–19] failure to rescue,[18,19] readmission,[14] adverse patient events and complications,[13,18] and nurse-rated quality of care.[20] However, to our knowledge, prior research has not yet examined how nurses and the work environment impact hospital-onset CDI.

We focus on the work environment of nursing care because it is where nursing work interplays with the social and political contexts of the organization. The nurse work environment is characterized as a set of organizational features that facilitate or constrain nursing behavior and practice.[21] Studying the work environment aids in our understanding of how organizations can promote frontline staff behavior change and how staff behavior can give rise to organizational change and uptake of new practices,[22,23] such as those relating to CDI prevention and control. When management supports and responds to issues identified by bedside nurses and when nurses are involved in hospital affairs, nurses are more likely to think critically about their work and make suggestions about improving practices.[24,25] In addition, when frontline staff can work effectively in an interdisciplinary team of professionals and mobilize resource resources quickly, they are able to contribute to a better quality of care.[26,27]

In this study, we examine reports from frontline nurses to determine whether there is an association between aspects of the nurse work environment and hospital-onset CDI. Based on a Donabedian framework—which states that structures affect processes, which in turn affect outcomes[28]—we posit that aspects of the nurse work environments, such as human and material resources and structures for frontline nurse participation in hospital affairs, affect processes for CDI prevention and control that are carried out by frontline clinicians such as nurses, which in turn affect hospital-onset CDI.

METHODS

Data Sources and Study Sample

Data for this study were from a 2016 survey of registered nurses actively licensed in four states—California, Florida, New Jersey, and Pennsylvania—the most current dataset with detailed measures of nurses' work environment aggregated to the hospital level. The nurse survey was extensive and included questions about nurse demographic characteristics as well as questions which, when aggregated to the hospital level, allowed us to measure aspects of the nurse work environment. Additional details on the sampling strategy, response rate, survey protocol, and derivation of measures in the parent study have been reported in detail elsewhere.[29–31] We used a double-sampling approach, which involved multiple rounds of mailing, including an intensive resurvey of nonrespondents. This approach yielded data from over 95% of hospitals in the sampling frame, and a 26% response rate from the main survey and 87% from the survey of nonrespondents, with no statistically significant differences at the nurse-level between the 2 groups.[31]

Data from direct care nurses were merged with 2016 data on hospital-onset CDI available from the CMS Hospital Compare and data on hospital characteristics from the American Hospital Association (AHA) Annual Survey. The final sample included 15,982 nurses from 353 general acute care hospitals that had data available from all 3 sources. This study was approved by the Institutional Review Board at Emory University.

Measures

Patient Outcome

Data on hospital-onset CDI were submitted by hospitals to the National Healthcare Safety Network (NHSN) at the Centers for Disease Control and Prevention (CDC) using standardized definitions and methodology. The 2016 CDC identification of hospital-onset CDI involved a positive laboratory test on or after the fourth day of hospitalization. Based on these reports, NHSN calculated a standardized infection ratio (SIR), which compared the actual number of infections to the number predicted for a given population. The SIR was risk-adjusted based on the prevalence of community-onset CDI, CDI laboratory test type, number of intensive care unit beds, total facility bed size, teaching status, availability of oncology services, and others.[32]

To facilitate interpreting and understanding results, a dichotomous variable was created for each study hospital based on the SIR. The dependent variable was coded as 1 if the hospital SIR was above the average SIR nationally (0.92), and 0 if the hospital SIR was below the average SIR. Being above the national SIR implied that more infections were observed than predicted when compared to the national average, and below the national SIR implied that fewer infections were observed than predicted.

Nurse Work Environment

Our measure of the nurse work environment was the extensively validated Practice Environment Scale of the Nursing Work Index (PES-NWI).[33–36] The PES-NWI subscales include: (1) nurse managers' ability, leadership, and support of nurses; (2) nurse participation in hospital affairs; (3) collegial physician-nurse relationship; and (4) staffing and resource adequacy. The PES-NWI is a 4-point Likert-type scale, where 1 = strongly disagree and 4 = strongly agree. The hospital-level subscales used in our analyses included Manager Ability, Leadership, Support (4 items), Nurse Participation in Hospital Affairs (8 items), Collegial Physician-Nurse Relationships (3 items), and Staffing and Resource Adequacy (4 items). All items included in our analysis are

TABLE 1. Characteristics of Study Hospitals (n = 353) and Nurses (15,982)

	n (%)
Hospital characteristics	
Bed size	
50–199	104 (29.5)
200–399	161 (45.6)
400	88 (24.9)
Teaching hospital	47 (13.3)
Ownership status	
For-profit	51 (14.5)
Nonprofit	271 (76.8)
Public	31 (8.78)
Rural referral center	14 (3.97)
Provides oncology services	326 (92.3)
State	
California	122 (34.6)
Florida	97 (27.5)
New Jersey	55 (15.6)
Pennsylvania	79 (22.4)
Hospital SIR higher than national SIR*	188 (53.2)
Nurse characteristics†	
BSN or higher degree	9837 (60.9)
Years as nurse, mean (SD)	18.5 (12.4)
Age, mean (SD)	46.0 (2.18)
Satisfaction with career,‡ mean (SD)	1.49 (0.71)

*In 2016, the national standard infection ratio was 0.92.
†A small number of nurses with missing values were excluded from these calculations.
‡This item was measured using a 1–4 scale, where 1 = very satisfied and 4 = very dissatisfied.
BSN indicates Bachelor of Science in Nursing; SIR, standardized infection ratio.

shown in Table A1 of the Online Appendix, Supplemental Digital Content 1, http://links.lww.com/MLR/C643.

Based on previous work, we excluded hospitals with fewer than 15 nurse respondents.[33] We calculated a hospital-level average value of all the items and aggregated them to produce a single composite measure for each PES-NWI subscale, with scores ranging from 1 to 4. We assessed the internal consistency of the subscales by computing the Cronbach α (published Cronbach α for these scales range from 0.71 to 0.84) and the discriminant validity by comparing the strength of each scale's internal consistency to correlations with other scales. The reliability of scales exceeded conventional standards ($\alpha > 0.90$). Correlation among scales (ranging from 0.65 to 0.81) was lower than intrascale correlations (Table A2, Online Appendix, Supplemental Digital Content 1, http://links.lww.com/MLR/C643).

For ease of interpretation and based on previous work, we collapsed the hospital-level subscale scores into quartiles (Q1–Q4), where Q1 represented the quartile of hospitals with the lowest subscale scores and Q4 represented the quartile of hospitals with the highest subscale scores. This strategy of measuring organizational features of hospitals by aggregating nurse-specific reports has been widely used in nursing outcomes research.[37]

Additional controls included the hospitals' location (or state) and ownership status (public, nonprofit, for-profit). We included these variables, as they have been shown to be associated with hospital-onset CDI.[38,39] We also controlled for the average years as a nurse for all nurses in each hospital and the percentage of nurses with a Bachelor of Science in Nursing (BSN) degree or higher. Lastly, we controlled for the average satisfaction with one's nursing career for all nurses in each hospital (measured using a 1–4 scale, where 1 = very satisfied and 4 = very dissatisfied), as it has been shown to be associated with health care-associated infections.[40,41]

Analysis

Descriptive statistics were used to summarize the study hospitals and nurse survey respondents, using means and SDs to describe continuous variables, and numbers and percentages for categorical variables. Logistic regression models were used, with hospital-level data, to estimate the association between the nurse work environment and hospital-onset CDI, before and after taking account of other hospital characteristics. In our analyses, an odds ratio <1 indicated that hospitals in higher quartiles, with respect to their PES-NWI subscale scores, had lower likelihoods of having above average hospital-onset CDI SIRs, a desirable outcome. We estimated the unadjusted and adjusted odds for the 4 PES-NWI subscales and a composite measure. Data were computed using Stata 17 (StataCorp LLC, College Station, TX) and significance was set at <0.05.

RESULTS

Table 1 shows the hospital and nurse characteristics. Seventy percent of the hospitals in our sample had 200+ beds, 77% were nonprofit, and 92% provided oncology services. Only 4% of hospitals were rural referral centers. On average, nurses reported high satisfaction with their career in nursing (mean = 1.49, on a 1–4 scale where 1 = very satisfied) and having worked nearly 20 years as a nurse. More than 60% of the nurses reported having a BSN or higher degree. We found that 53% of the study hospitals had an SIR for hospital-onset CDI greater than the national average SIR (more infections observed than predicted); the remaining 47% were below the benchmark (fewer than average infections observed).

TABLE 2. Practice Environment Scale of the Nursing Work Index Subscale Scores

	N	Mean	SD
Manager ability, leadership, support	353	2.76	0.27
Q1	89	2.42	0.16
Q2	88	2.68	0.05
Q3	88	2.87	0.05
Q4	88	3.09	0.10
Nurse participation in hospital affairs	353	2.71	0.34
Q1	89	2.26	0.17
Q2	88	2.62	0.07
Q3	88	2.84	0.06
Q4	88	3.12	0.11
Collegial physician-nurse relationship	353	3.05	0.21
Q1	89	2.77	0.09
Q2	88	2.99	0.04
Q3	88	3.12	0.04
Q4	88	3.30	0.09
Staffing and resource adequacy	353	2.54	0.31
Q1	89	2.13	0.16
Q2	88	2.45	0.06
Q3	88	2.65	0.06
Q4	88	2.93	0.13

TABLE 3. Likelihood of Hospital-Onset *Clostridioides difficile* Standard Infection Ratios (SIR) Being Above the National Average SIR (n = 353)

	Unadjusted models odds ratio (95% CI)	Adjusted models† odds ratio (95% CI)
Model 1: manager ability, leadership, support (compared with unfavorable)		
Q2	1.29 (0.71–2.35)	1.09 (0.57–2.08)
Q3	0.85 (0.47–1.54)	0.52^ (0.26–1.05)
Q4	0.82 (0.45–1.47)	0.39* (0.19–0.82)
Model 2. nurse participation in hospital affairs (compared with unfavorable)		
Q2	1.12 (0.62–2.03)	0.83 (0.43–1.61)
Q3	1.18 (0.65–2.13)	0.74 (0.37–1.48)
Q4	0.68 (0.38–1.23)	0.35** (0.17–0.74)
Model 3: collegial physician-nurse relationship (compared with unfavorable)		
Q2	0.68 (0.37–1.23)	0.45* (0.23–0.88)
Q3	0.65 (0.36–1.18)	0.44* (0.22–0.87)
Q4	0.82 (0.45–1.48)	0.43* (0.21–0.89)
Model 4: staffing and resource adequacy (compared with unfavorable)		
Q2	1.02 (0.57–1.85)	0.75 (0.38–1.46)
Q3	1.35 (0.75–2.45)	0.82 (0.40–1.67)
Q4	0.93 (0.52–1.69)	0.45* (0.21–0.99)
Model 5: all factors (compared with unfavorable)		
Q2	1.23 (0.68–2.24)	0.99 (0.52–1.88)
Q3	0.98 (0.54–1.77)	0.68 (0.35–1.30)
Q4	0.75 (0.41–1.35)	0.42* (0.21–0.83)

An odds ratio <1 indicates that an increase in the level of a predictor (ie, manager ability, leadership, support) is associated with a lower likelihood of hospital-onset *C. diff* infection or being below the national SIR for a given hospital, which the a desirable outcome.

†Adjusted models control for state, ownership, as well as respondent characteristics such as satisfaction with career, years as a nurse, and nurses with a Bachelor of Science in Nursing or a higher degree, aggregated to the hospital level.

^$P < 0.10$.

*$P < 0.05$.

**$P < 0.01$.

As shown in Table 2, the average nurse-reported scores were somewhat variable across subscales. The average score for Managerial Ability, Leadership, and Support was 2.76; Nurse Participation in Hospital Affairs was 2.71; Collegial Physician-Nurse Relationships was 3.05; and Staffing and Resource Adequacy was 2.54. The mean subscale scores of the PES-NWI were fairly similar for hospitals in adjacent quartiles, such as between Q4 and Q3, or Q3 and Q2 (ie, <1 SD for each subscale overall), though the difference between hospitals in the highest versus lowest quartiles (Q4 vs. Q1) was quite dramatic (roughly 2.5 SDs in all cases).

Table 3 shows the results from our regression analyses. The odds of hospitals having higher than average SIRs were significantly lower and less than half as great (odds ratios ranged from 0.35 to 0.45) in hospitals in the highest quartile than in hospitals in the lowest quartile for all 4 nurse work environment subscales we considered (managerial support, nurse participation in hospital affairs, physician-nurse relations, and staffing and resource adequacy). The composite scale comprised of all 4 subscales was also significantly associated with hospital-onset CDI.

As a sensitivity analysis, we used Hospital Compare's categorization as an additional outcome variable.[32] Hospital Compare standardizes SIR and computes a 95% CI, wherein if a given hospital's upper bound of the CI is <1, then the hospital's performance is better than the national benchmark. Thus, this additional outcome variable was coded as 1 if a hospital's upper CI was ≤1 (an undesirable outcome) and coded as 0 if the hospital's upper CI was <1 (a desirable outcome). Table A3 in the Online Appendix (Supplemental Digital Content 1, http://links.lww.com/MLR/C643) shows the results. These results are similar to those shown in Table 3 in terms of the direction of the coefficients, but they are not statistically significant, except for collegial physician-nurse relations.

DISCUSSION

To our knowledge, this study is the first to explore the association between the nurse work environment and hospital-onset CDI. Our findings show that all four aspects of the nursing work environment that we examined—managerial support, nurse participation in hospital affairs, collegial physician-nurse relationship, and staffing and resource adequacy—were each, and as a composite measure, associated with a decrease in the odds of having an SIR higher than the national SIR, which implied having a fewer number of infections than predicted, or a desirable outcome.[34]

Prior research has found that nurses face barriers such as nurse understaffing,[36] frequent operational errors,[35] lack of accurate and timely communication, and frequently changing policies related to CDI prevention and control.[6,8–10] Our findings suggest that supportive nurse managers and supervisors and nurses' involvement in organizational governance may serve to mitigate those barriers and contribute to lowering hospital-onset CDI in acute care hospitals. Our findings also indicate that collegial relationships between physicians and nurses as well as nurse staffing and resource adequacy, which are aspects that have been established as being important to patient safety and quality,[26,27] play an important role in preventing and controlling CDI. It is possible that when physicians and nurses have good working relationships, they are able to resolve discordant perceptions regarding CDI risk factors that prompt testing. Future work should also examine the role of effective working relationships among pharmacists, microbiologists, environmental service workers, and other support staff. Compliance with certain CDI prevention and control practices, such as environmental disinfection and antibiotic stewardship, require communication and coordination between multiple professional groups.

Prior studies on CDI prevention and control practices have mostly focused on identifying and describing practices that aim to reduce CDI,[6–8,42] but not as much on the role of nurses. The relationship between the nurse work environment and hospital-onset CDI detected in this study highlights the critical role that bedside nurses may play in preventing and controlling hospital-onset CDI. It is likely that nurses, who work closely with patients and other support staff, facilitate the implementation of CDI prevention and control practices, which are continually evolving, multifactorial, and complex.[6–8] An environment that supports collegial relationships among staff will most likely result in improved daily sporicidal cleaning, a cost-effective infection control measure to prevent CDI.[42] Investing in the nurse work environment may help hospitals to prioritize these interventions and disseminate related information, as supportive work

environments enable nurses to identify opportunities for improvement in daily cleaning or encourage colleagues to be diligent about hand hygiene. Thus, when developing infection prevention and control practices, policymakers and hospital administrators should consider the roles that nurses can play in scaling and disseminating those practices.

Our findings have practical implications. Our results highlight the importance of nurse managers' leadership and support. We find that the odds of being below the national benchmark (ie, fewer infections) is substantially lower when manager ability, leadership, and support are perceived favorably by bedside nurses. With respect to prioritizing quality and motivating adherence to protocols, prior literature on leadership suggests that leader behaviors are crucial, as staff attends to their actions.[11,43] Proven leadership behaviors for promoting the importance of infection prevention and control practices include creating strategic goals with milestones, fostering coordination, and communicating periodically about the implemented protocols.[43,44] Moreover, we found that differences in the extent to which managers listen and respond to issues raised by bedside nurses and nurse participation in organizational affairs were associated with variation in hospital-onset CDI. This study provides a basis for further research to examine additional aspects of the work environment that may contribute to lowering hospital-onset CDI and other infections and to explore interventions focusing on improving aspects of the work environment for frontline staff.

Improving the work environment is not as costly as hiring additional staff, but still comes with its own challenges, as it entails developing managerial effectiveness and distributing authority for governance and decision-making to those closest to patients. Establishing a favorable, positive nurse work environment is an important basis for the American Nurses Credentialing Center's Magnet Recognition Program, which has been demonstrated to result in improved work environments and better patient outcomes.[45] Hospitals may find the guide to achieving Magnet designation helpful when trying to enhance the work environment and address the challenges of culture change.[46]

Our study had a few limitations. First, our data were cross-sectional from only four states and as such, our findings might not be generalizable to nurses and hospitals in other states. However, the 4 states included are exceptionally large and represent a large percentage of the nurses nationwide. Second, CDI data are subject to variations in diagnostic testing practices. Still, the CDC risk-adjustment methods do adjust somewhat for different laboratory testing protocols that have different sensitivity and specificity for detecting infections. Third, our data were limited to 2016 when the nurse survey was administered. That year was the second year in which hospitals were incentivized to reduce CDI risks through participation in Hospital Inpatient Quality Reporting Program. The associations uncovered in this study may or may not be present today. In particular, further investigations are warranted to determine the impact of the COVID-19 pandemic on CDI. Early reports suggest that during the pandemic interdisciplinary teamwork and extensive efforts in infection control have resulted in a decrease in CDI.[47–49] However, if these efforts to control CDI are sustainable has yet to be seen.

A supportive nurse work environment including adequate nurse staffing and resources is a key condition for reducing hospital-onset infections. Because a significant share of hospitals has deficient work environments that continue to hamper infection prevention, a promising strategy to lower hospital-onset CDI and other infections is a serious and sustained commitment by the hospital industry and its leaders to significantly improve hospital nurse work environments.

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