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Major article

Nurse staffing, burnout, and health care–associated infection

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Background: Each year, nearly 7 million hospitalized patients acquire infections while being treated for other conditions. Nurse staffing has been implicated in the spread of infection within hospitals, yet little evidence is available to explain this association.
Methods: We linked nurse survey data to the Pennsylvania Health Care Cost Containment Council report on hospital infections and the American Hospital Association Annual Survey. We examined urinary tract and surgical site infection, the most prevalent infections reported and those likely to be acquired on any unit within a hospital. Linear regression was used to estimate the effect of nurse and hospital characteristics on health care–associated infections.
Results: There was a significant association between patient-to-nurse ratio and urinary tract infection (0.86; $P = .02$) and surgical site infection (0.93; $P = .04$). In a multivariate model controlling for patient severity and nurse and hospital characteristics, only nurse burnout remained significantly associated with urinary tract infection (0.82; $P = .03$) and surgical site infection (1.56; $P < .01$) infection. Hospitals in which burnout was reduced by 30% had a total of 6,239 fewer infections, for an annual cost saving of up to $68 million.
Conclusions: We provide a plausible explanation for the association between nurse staffing and health care–associated infections. Reducing burnout in registered nurses is a promising strategy to help control infections in acute care facilities.

The Centers for Disease Control and Prevention estimate that approximately 1.7 million hospitalized patients annually acquire infections while being treated for other conditions, and more than 98,000 of these patients (or 1 in 17) will die as a result of the acquired infection.[1] Over the years, a substantial body of research has provided evidence linking invasive devices[2-10] and clinical practice[11-14] to these infections, and although improvement has been noted,[15-18] more work is needed to eliminate health care–associated infections. Recent evidence, including an extensive review of 42 articles,[19] suggests that elements of nursing care are also associated with the prevalence of health care–associated infections. Nurse staffing in the form of nurse-patient ratios[20-23] and hours of nursing care per patient-day[22,24-27] have been implicated in the spread of infection; however, to date there has been no rigorous study of the possible mechanism underlying the staffing–infection relationship.

Job-related burnout has been linked to suboptimal medical care[28] and patient satisfaction.[29,30] Maslach's theory posits that a key component of burnout in health care professionals is emotional exhaustion, which is associated with emotional and cognitive detachment from work as a way to cope with work demands.[31] Some evidence suggests that hospital nurses experience high levels of job-related burnout,[32-36] but whether and to what extent higher burnout rates affect clinical outcomes has gone largely unexplored to date. No published study has examined the association between nurse burnout and health care–associated infection. In this study, we examined job-related burnout in registered nurses to determine whether it accounts, in full or in part, for the relationship between nurse staffing and patient infections acquired during hospital stays.

METHODS

In this study, we analyzed secondary data from a 2006 survey of 7,076 registered nurses working in 161 hospitals in Pennsylvania.

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We merged 3 data sources: the nurse survey data, the 2006 Pennsylvania Health Care Cost Containment Council (PHC4) report on hospital infections, and the American Hospital Association (AHA) Annual Survey on hospital characteristics. The PHC4 data on health care–associated infections are not identified by administrative patient discharge data codes, but rather infections are identified based on definitions from the Centers for Disease Control and Prevention.[37] The PHC4 methodology for collection and reporting of health care–associated infections has been described in detail elsewhere.[38-41]

Our sample of hospitals included all hospitals that reported data on health care–associated infections to the PHC4 in 2006, and our sample of registered nurses represented all nurses employed in those same hospitals who responded to our questionnaire. We chose to examine 2 types of infection, catheter-associated urinary tract infections and surgical site infections. These were the 2 most prevalent infections reported by the PHC4, and patients are at risk of acquiring them on any hospital unit. This study was approved by the University of Pennsylvania's Institutional Review Board.

Hospital characteristics used as controls were obtained from the AHA's Annual Survey and included bed size, teaching status, and technology. Bed size was defined as the total number of licensed beds per hospital. Teaching status was defined by the number of medical residents and fellows and contrasted nonteaching hospitals (no residents/fellows), minor teaching hospitals (with a ≤1:4 trainee-to-bed ratio) and major teaching hospitals (with a >1:4 trainee-to-bed ratio). Hospitals were designated as high technology if they had facilities for open-heart surgery, major organ transplants, or both. Because patients who acquire health care–associated infections are often severely ill, we computed a severity of illness measure from the PHC4 data, in which a mean MediQual score was computed for each hospital.

Data on nurse demographics and burnout were obtained from the nurse survey. Using a list provided by the state board of nursing, we mailed the survey to the homes of a large random sample of registered nurses licensed and residing in Pennsylvania. The mail survey, described in detail elsewhere,[33] was conducted following a modified Dillman method.[42] The overall survey response rate was 41%. To estimate sample bias, we conducted an intensive second survey of a random sample of 650 nurses who did not respond to the first survey, and were able to achieve a 92% response rate with extensive follow-up and compensation, which was not feasible in the large original sample. Comparing responses to the 2 surveys revealed no substantive differences in responses between those that originally responded and those that responded after increased efforts,[43] indicating no systematic bias in the broader sample of survey respondents.

Job-related burnout was assessed with the Maslach Burnout Inventory–Human Services Survey (MBI-HSS). The MBI-HSS is a highly reliable and valid instrument that contains 22 Likert-type items on job related attitudes that assess the 3 distinct subscales of burnout: emotional exhaustion, depersonalization, and personal accomplishment. We used the emotional exhaustion subscale of the MBI-HSS, because emotional exhaustion has been identified as the key component of burnout syndrome.[44] As in previous research,[44] we defined high burnout as a score ≥27, the norm for all health care workers. We created a hospital-level measure for proportion of nurses with high burnout, and multiplied this proportion by 10 to interpret regression coefficients as changes in infection rate associated with 10% changes in burnout.

DATA ANALYSIS

Descriptive information is provided for the hospitals and nurses in our sample. We used ordinary least squares regression models to estimate the effect of nurse staffing on infection rates, before and after controlling for nurse and hospital characteristics. We estimated 3 linear regression models for both types of hospital infections to assess the individual effect of nurse staffing on infection rate, and the extent to which nurse burnout could explain that effect. In our first model, we regressed the hospital infection rate on nurse staffing. With nurse burnout excluded, the staffing coefficient in this simple model can be interpreted as the sum of the direct effect of staffing on the infection rate and the indirect effect of staffing on the infection rate as a result of its effect on nurse burnout. In our second model, we estimated the effect of nurse burnout on the rates of the 2 types of health care–associated infection rates, with staffing excluded. Our third model included both nurse staffing and burnout as covariates. We used this model to examine whether nurse burnout could account for the effect of staffing on infection rates, that is, whether or not the infection rate differences between hospitals of differing staffing levels could be attributed to nurse burnout, controlling for nurse age and years of experience and hospital teaching status, technology status, bed size, and patient acuity. Finally, using the estimates from these models, we estimated the effects of 10%, 20%, and 30% decreases in nurse burnout on the number of infections that could be avoided and the total cost savings in US dollars. Using data from a Centers for Disease Control and Prevention report on the direct medical costs of health care–associated infections,[45] we were able to estimate a range for the total cost of urinary tract and surgical site infections. All analyses were conducted using SAS version 9.2 (SAS Institute, Cary, NC), and statistical significance was set at $P < .05$.

RESULTS

Characteristics of the study hospitals and nurses used as controls are summarized in Table 1. Our sample included 161 acute care Pennsylvania hospitals that provided infection data to the PHC4 and nurses who were surveyed and employed in those same hospitals. The average number of beds per hospital was 227, almost half of the hospitals were identified as teaching hospitals, and 40% were high-technology hospitals. On average, nurses cared for 5.7 patients, the average number of patients per hospital was 9,758, and the average number of nurse respondents per hospital was 48. The average age of the nurses across all hospitals was 44 years, and the overwhelming majority (95%) were female. Roughly 38% of the nurses were educated at the baccalaureate level or higher, and the nurses had an average of 17 years of nursing experience. More than one-third of all nurses reported high levels of job-related burnout.

Overall, 16 patients per 1,000 acquired some type of infection while hospitalized. The most common infections were urinary tract infections (8.6 per 1,000) and surgical site infections (4.2 per 1,000), followed by gastrointestinal infections (2.5 per 1,000) and pneumonia (2.1 per 1,000) (Table 2).

Table 3 presents regression coefficients from our models of the relationships among nurse staffing, nurse burnout, and infection rates. Using urinary tract infection rate as our outcome measure and staffing as our covariate of interest, we found a significant staffing coefficient of 0.86 ($P = .02$); that is, an additional patient assigned to each nurse in a hospital was associated with a 0.86-unit increase (or an increase of nearly 1 per 1,000) in the rate of urinary tract infection. In our study population, this would translate to 1,351 additional infections for each patient added to a nurse's workload. Using the same model for surgical site infection, we obtained a significant staffing coefficient of 0.93 ($P = .04$).

In our second model examining the association between nurse burnout and infection rate, nurse burnout was highly associated with both urinary tract infections ($\beta = 0.85$; $P = .02$) and surgical

Table 1
Hospital and nurse characteristics used as controls in this study

Hospital characteristics (n = 161)	
Bed size, mean (SD)	227 (186)
Teaching status, n (%)	
Major	19 (12)
Minor	58 (36)
High technology, n (%)	63 (40)
Nurse staffing, mean (SD)	5.7 (1.1)
Nurse characteristics (n = 7076)	
Age, years, mean (SD)	43.9 (10.6)
Female sex, n (%)	6,679 (94.5)
BSN degree or higher, n (%)	2,672 (37.8)
Years of experience, mean (SD)	17.2 (11.0)
High burnout, n (%)	2,544 (36.5)

Table 2
Summary of health care–associated infections (n = 161 hospitals)

Infection type	Number of cases	Infection rate (per 1,000 cases)
Cases with infection	30,213	19.2
Urinary tract	13,567	8.6
Surgical site	1,668	4.2
Gastrointestinal	3,959	2.5
Pneumonia	3,321	2.1
Bloodstream	2,945	1.9
Other	962	0.6
Multiple	3,730	2.4
Cases without infection	1,540,855	NA

NA, not applicable.

Table 3
Models estimating the effects of nurse staffing and burnout on health care–associated urinary track and surgical site infection

	Model 1			Model 2			Model 3		
	Estimate	SE	*P* value	Estimate	SE	*P* value	Estimate	SE	*P* value
Urinary tract infections									
Nurse staffing	0.86	0.35	.02				0.21	0.35	.54
Burnout				0.85	0.36	.02	0.82	0.36	.03
Surgical site infections									
Nurse staffing	0.93	0.46	.04				0.78	0.46	.09
Burnout				1.58	0.41	<.01	1.56	0.43	<.01

NOTE. Regression estimates are adjusted for nurse age, years of experience, patient severity, bed size, teaching status, and technology status.

site infections ($\beta = 1.58$; $P < .01$). In other words, a 10% increase in a hospital's composition of high-burnout nurses is associated with an increase of nearly 1 urinary tract infection and 2 surgical site infections per 1,000 patients. In our third model combining burnout and staffing, for both urinary tract and surgical site infections, the staffing effect was no longer significant after adjusting for nurse burnout. For urinary tract infection, the staffing coefficient was 0.21 ($P = .54$), and the effect of nurse burnout on urinary tract infection was 0.82 ($P = .03$). Similarly, for surgical site infection, the staffing effect was reduced to 0.78 ($P = .09$), whereas the coefficient for burnout remained highly significant ($\beta = 1.56$; $P < .01$). These findings are graphically represented in Figure 1.

Table 4 show the effect of decreasing high nurse burnout on the annual number of urinary tract and surgical site infections, along with the total cost savings associated with the decreased number of infections. Lowering burnout reduces the number of infections and the associated costs of infection across the range of burnout levels, but is most pronounced when burnout is reduced by 30%. In hospitals where burnout is reduced by 30%, urinary tract and surgical site infections can be reduced by 4,006 and 2,233 infections, respectively. The average attributable per-patient costs of infection ranged from $749 to $832 for urinary tract infections and from $11,087 to $29,443 for surgical site infections. This translates into an annual cost savings from nearly $28 million to more than $69 million from prevented urinary tract and surgical site infections due to a 30% reduction in nurse burnout.

In summary, the result to be taken away from the comparison of these nested models is that differences in nurse workloads across hospitals are associated with the rate of patient infections. To the extent that these models reflect causation, which is uncertain because of the cross-sectional character of the data, high nurse burnout appears to be a possible explanation for this association.

DISCUSSION

In this study, we examined the effect of nurse staffing and burnout on health care–associated urinary tract and surgical site infections. Our findings confirm an association between nurse staffing and health care–associated infection rates, with fewer infections seen in hospitals in which nurses care for fewer patients. The higher rate of infections in hospitals in which nurses care for more patients seems to be related, at least in part, to the high nurse burnout associated with heavier patient caseloads. Nurse burnout has been linked to job dissatisfaction and overall quality of patient care,[32] but not to "nursing-sensitive" clinical outcomes. Burnout has been associated with self-reported medical errors among surgeons[46] and internal medicine residents.[47] Holden et al[48] reported that external mental demands, such as interruptions, divided attention, and feeling rushed, are associated with burnout and the increased likelihood of perceived medication-dispensing errors in pharmacists. We hypothesize that the cognitive detachment associated with high levels of burnout may result in inadequate hand hygiene practices and lapses in other infection control procedures among registered nurses.

We found that increasing a nurse's workload by 1 patient was associated with increases in both urinary tract and surgical site infections. The average rate of urinary tract infections across hospitals was 7 per 1,000 patients, and the average rate of surgical site infections was slightly below 5 per 1,000 patients. We found that increases in both urinary tract and surgical site infections were largely attributed to differences in nurse burnout; every 10% increase in burned-out nurses in a hospital increased the rate of urinary tract infections by nearly 1 per 1,000 patients and the rate of surgical site infections by more than 2 per 1,000 patients. These findings are both statistically and clinically significant. If the proportion of nurses with high burnout could be reduced to 10% from an average of 30%, some 4,160 infections would be prevented in Pennsylvania hospitals, leading to a estimated cost savings of $41 million. Urinary tract infections are the most common health care–associated infection, and some previous studies have linked these infections to nursing care.[49-52] Our finding that nursing care is associated with surgical site infections and that nurse burnout is associated with both urinary tract and surgical site infections has not been reported previously.

This study has some limitations. Although nurse characteristics and rates of patient health care–associated infections could be

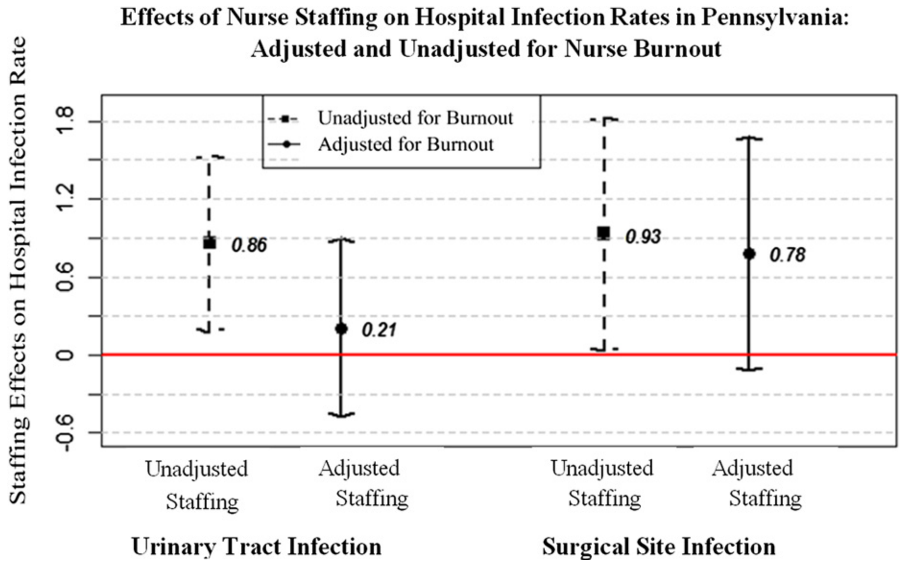

Fig 1. Adjusted and unadjusted effects of burnout on nurse staffing and health care–associated urinary tract and surgical site infections.

Table 4
Reduction in nurse burnout and the associated decrease in the number of urinary tract and surgical site infections and total cost savings

	Urinary tract infections			Surgical site infections		
Reduction in burnout	Infections prevented	Cost savings, low	Cost savings, high	Infections prevented	Cost savings, low	Cost savings, high
−10%	1,335	$1,000,220	$1,111,059	744	$8,251,897	$21,914,009
−20%	2,671	$2,000,441	$2,222,119	1,489	$16,503,795	$43,828,017
−30%	4,006	$3,000,661	$3,333,178	2,233	$24,755,692	$65,742,026

NOTE. Cost savings are reported in 2007 US $.

linked to specific hospitals in this study, nurses could not be linked to specific patients. Thus, it is difficult to establish that the relationships between them are causal. We acknowledge that health care–associated infections often occur in high-risk patients; however, the two infection types examined in this study are typically found in low-risk populations. Furthermore, the PHC4 excludes high-risk patients (ie, those with burns and organ transplants) from their infection report, and we controlled for patient severity by computing the mean MediQual score for each hospital in the PHC4 infection report.

In this study, we provide a plausible explanation for the association between nurse staffing and health care–associated infections. Based on our finding that the staffing–infection relationship is mediated by job-related burnout, practitioners should work to implement organizational changes known to build job engagement, such as educational interventions, performance feedback, and social support, as strategies to reduce nurse burnout and thereby help control infections in acute care facilities.

Health care–associated infections are associated with morbidity, mortality, and enormous costs to health care facilities, and insurance providers nationwide are denying payment for costs associated with these infections. Health care facilities can improve nurse staffing and other elements of the care environment and alleviate job-related burnout in nurses at a much lower cost than those associated with health care–associated infections. By reducing nurse burnout, we can improve the well being of nurses while improving the quality of patient care.

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