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Effects of Nurse Staffing and Nurse Education on Patient Deaths in Hospitals With Different Nurse Work Environments

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Abstract

Context: Better hospital nurse staffing, more educated nurses, and improved nurse work environments have been shown to be associated with lower hospital mortality. Little is known about whether and under what conditions each type of investment works better to improve outcomes.

Objective: To determine the conditions under which the impact of hospital nurse staffing, nurse education, and work environment are associated with patient outcomes.

Design, Setting, and Participants: Outcomes of 665 hospitals in 4 large states were studied through linked data from hospital discharge abstracts for 1,262,120 general, orthopedic, and vascular surgery patients, a random sample of 39,038 hospital staff nurses, and American Hospital Association data.

Main Outcome Measures: A 30-day inpatient mortality and failure-to-rescue.

Results: The effect of decreasing workloads by 1 patient/nurse on deaths and failure-to-rescue is virtually nil in hospitals with poor work environments, but decreases the odds on both deaths and failures in hospitals with average environments by 4%, and in hospitals with the best environments by 9% and 10%, respectively. The effect of 10% more Bachelors of Science in Nursing Degree nurses decreases the odds on both outcomes in all hospitals, regardless of their work environment, by roughly 4%.

Conclusions: Although the positive effect of increasing percentages of Bachelors of Science in Nursing Degree nurses is consistent across all hospitals, lowering the patient-to-nurse ratios markedly improves patient outcomes in hospitals with good work environments, slightly improves

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them in hospitals with average environments, and has no effect in hospitals with poor environments.

Keywords

hospital nurse staffing; nurse education; hospital work environment; comparative effectiveness

Nursing is one of the largest categories in hospitals' budgets estimated to account for 25% or more of annual operating expenses and as much as 40% of direct care costs.[1,2] There is good scientific evidence of an association between lower nurse workloads and better patient outcomes, including lower hospital mortality.[3–7] A case for the cost effectiveness of investments in registered nurse staffing to improve patient outcomes has been made[8–10] but doubts persist. Earlier research has documented the importance of nursing on patient outcomes generally, but provides little insight into the core question of comparative effectiveness research; which investments in hospital nursing care delivery work best, for whom, and under what circumstances.[11] With the national registered nurse workforce numbering over 3 million,[12] assumptions that significantly more nurses may be needed to improve patient safety and outcomes have serious implications for hospital care costs and for how many nurses the nation will need in the future and whether they can be produced or recruited without exhausting other countries' supply of nurses.[13]

The effects of nursing characteristics on patient outcomes have typically been studied 1 by 1 and additively rather than in combination. Evidence suggests that lower patient-to-nurse ratios,[3,6,14] higher proportion of nurses with a baccalaureate level education,[5,15–18] and better nurse work environments[4,19] are associated individually and additively with lower mortality and failure-to-rescue. Better nurse work environments are those in which doctors and nurses have good working relationships, nurses are involved in hospital affairs, management listens and responds to patient care problems identified by bedside nurses, and institutions invest in the continued learning of nurses and quality improvement for patient care.

This study reveals, for the first time, the conditional circumstances under which particular nursing investments yield the best outcomes. Results suggest that nursing characteristics sometimes need to be considered in combination, and point to promising strategies for improving the quality and safety of hospital care while preserving scarce nurse resources by making informed investments.

METHODS

We estimate the relationship between measures of levels of nurse-to-patient staffing, organizational aspects of the nurse work environment, and nurse education—3 hospital-level measures derived from the nurse surveys— and risk-adjusted 30-day inpatient mortality and failure-to-rescue across 665 adult acute care general hospitals in California (n = 271), Pennsylvania (n = 153), Florida (n = 168), and New Jersey (n = 73). These are 4 of the nation's largest states, and account for more than 20% of annual hospitalizations. The nurse survey data were collected in California, Pennsylvania, and New Jersey between September 2005 and August 2006 and in Florida between November 2007 and April 2008. Patient discharge data from 2005 to 2006 and American Hospital Association (AHA) Annual Survey data from 2005 were linked to the nurse survey data for California, New Jersey, and Pennsylvania and patient discharge data from 2006 to 2007 and AHA data from 2007 were linked to the nurse survey data for Florida, using common hospital identifiers. Patient discharge data were obtained from the Office of State-wide Healthcare Planning and Development in California, The Agency for Health Care Administration in Florida, the Department of Health and Senior Services in New Jersey, and the Pennsylvania Health Care Cost Containment Council in Pennsylvania.

The units of analysis in the study are 665 hospitals, but the units of observation are variously hospitals, patients, and nurses, and the statistical modeling is with reference to a hierarchical model in which patients are nested within hospitals. The hospitals included in our sample represent 86% of all general acute hospitals in the 4 states and account for more than 90% of all adult general, vascular, and orthopedic surgical patient discharges in those states. Hospitals not analyzed are primarily small hospitals with fewer than 10 nurse respondents, which we regard as too few to provide reliable estimates of the hospital-level nursing characteristics of interest.

Adjustments in our models for differences in patient outcomes due to hospital characteristics not related to nursing are made using measures of hospital size, teaching status, and technology from the 2006 AHA Annual Survey. Three size categories (≤ 100 beds, 101 to 250 beds, ≥ 251 beds) were used. Teaching status was defined by number of medical residents and fellows (non-teaching without any residents/fellows; minor teaching with 1:4 or smaller trainee to bed ratios; major teaching with ratios higher than 1:4). Hospitals were designated as high technology if they had facilities for open-heart surgery, major organ transplants, or both.

The 3 key predictor variables—nurse staffing, nurse education, and the nurse work environment—are hospital-level measures. They are averages of reports from large random samples of registered nurses from state licensure lists who identified themselves as working in 1 of our study hospitals. The strategy of measuring organizational features of hospitals by aggregating nurse-specific reports is derived from the sociology of organizations research literature[20–29] and has been widely used in research reports on nursing outcomes.[14,15,19,30,31] This method of measuring organizational features of hospitals is at least as accurate, and probably considerably more accurate, than reports by a single “key informant” within a hospital,[32,33] and avoids the problem of hospital-level nonresponse bias where hospital officials may choose not to participate on the basis of the nursing features being studied.[34] We obtained mail responses from over 100,000 nurses in the 4 states, including 39,038 staff nurses working in our study hospitals, for an average of approximately 60 nurse reports per hospital (the other nurse respondents were not working in hospitals).

The large mail survey undertaken in the study—surveys were mailed to 272,783 nurses in the 4 states: 106,532 in California, 49,385 in Florida, 52,545 in New Jersey, and 64,321 in Pennsylvania—had a response rate of 39% at the nurse level, owing to the impossibility of targeting the mailings to hospital staff nurses, providing monetary incentives, or undertaking extensive follow-ups with such a large sample. However, a high response rate from nurses is of secondary importance to having a high response at the hospital level and reliable reports from a representative sample of nurses in a large and unbiased sample of hospitals, covering a broad range of important issues. The survey included items that assessed, in addition to nurse workloads, nurse education, the nurse work environment, nurse demographics, burnout, job dissatisfaction, intent to leave, the quality of care, patient safety indicators, and frequency of adverse events on their unit. We have information from 9 of every 10 hospitals in all 4 states. We also have evidence, from an intense resurvey of 1300 original nonrespondents with a 91% response rate and a rigorous evaluation of possible bias, that there were no significant differences in responders and nonresponders in reports of hospital-level organizational features of nursing.[31,34]

Hospital nurse staffing was calculated from nurse survey data by dividing the average number of patients reported by nurses on their units on their last shift by the average number of nurses on the unit. Nurses' educational composition was the percentage of staff nurses in each hospital holding baccalaureate degrees in nursing or higher. The nurse practice environment was derived from the Practice Environment Scale of the Nursing Work Index-Revised (PES-NWI), an extensively validated survey measure.[4,30,35–37] The 31 item Likert-type scale indicates the degree (1 = strongly disagree to 4 = strongly agree) to which various organizational features are present in the practice setting. In earlier analyses, we used 5 subscales that were validated and shown to be strong predictors of patient and nurse outcomes: nurse participation in hospital affairs (9 items), nursing foundations for quality care (10 items), nurse manager ability, leadership, and support of nurses (5 items), staffing/resource adequacy (4 items), and nurse-physician relations (3 items). Published internal consistency coefficients (Cronbach α) for the 5 subscales range from 0.71 to 0.84. In the analyses reported here 4 of 5 PES-NWI subscales were used. The staffing/resource adequacy subscale was excluded because it empirically overlaps our direct measure of nurse staffing. Subscale measures were calculated for each hospital by averaging the values of all items on each of the subscales for all nurses in the hospital. These 4 aggregated subscales were then averaged to produce a single composite measure of the practice environment. PES-NWI subscales and the composite scale range in value from 1 to 4 and in the regression models were standardized to have a mean of 0 and standard deviation of 1.

Patients aged 19 to 89 years with a diagnosis-related group classification of general, orthopedic, or vascular surgery were included for a total of 1,262,120 patients. Measures included 30-day inpatient mortality and failure-to-rescue (defined as deaths for the subset of patients who experienced complications). International Classification of Diseases, Ninth Revision, Clinical Modification codes in the secondary diagnosis and procedure fields of discharge abstracts were scanned for evidence of 39 clinical events suggestive of complications.[38] Elixhauser et al's[39] risk adjustment approach was used consisting of 27 comorbidities (excluding fluid and electrolyte disorders and coagulopathy).[40,41] Additional adjustments included sex, age, transfer status, and a series of 61 dummy variables indicating the type of surgery. Risk adjustment was enhanced by a 180-day look back to previous hospitalizations to distinguish between complications and comorbidities. C statistics (area under the receiver operating characteristics curve)[42] for the risk adjusted mortality and failure-to-rescue models were 0.89 and 0.82, respectively.

Data Analysis

Descriptive statistics are provided to show characteristics of the study hospitals and characteristics of surgical patients discharged from and the nurses who were surveyed in different hospitals. Logistic regression models were used to estimate the effects of nurse staffing, nurse work environment, and nurse education on patient mortality and failure-to-rescue, before and after controlling for other patient and hospital characteristics. Our final model is one which includes an interaction effect involving nurse staffing and the nurse work environment. We use the estimated odds ratios from this final model to show the differing effect of staffing in hospitals with different environments and, alternatively, the different effects of work environments at different staffing levels. To account for the clustering of patients and nurses within study hospitals, all model estimates were computed using Huber-White (robust) procedures to adjust the standard errors of the estimated parameters. All analyses were conducted using STATA version 10.1 (STATA Corp, College Station, TX).

RESULTS

Table 1 provides information on characteristics of the 665 study hospitals, and the numbers and percentages of patients discharged from and nurses surveyed in each of the types of hospitals defined by these characteristics. Forty-one percent of the hospitals are in California, roughly 23% are in Pennsylvania, another 25% are in Florida, and 11% are in New Jersey. The hospitals range broadly on nursing characteristics. Slightly more than 1 in 4 hospitals have patient-to-nurse ratios of 4 or less, whereas 1 in 5 have ratios of 7 or more. Thirty percent have poor nurse work environments, more than half have mixed environments, and 20% have good environments. Thirty percent of the hospitals have fewer than 30% of their nurses that are Bachelors of Science in Nursing Degree (BSN)-prepared, whereas 20% of the hospitals have more than 50% BSN-prepared nurses. The hospitals also show considerable variability in bed size (15% have fewer than 100 beds, and 40% have more than 250 beds), technology (40% are high technology hospitals), and teaching status (just over half are nonteaching, 41% are minor teaching, and 7% are major teaching). Although the numbers of patients in hospitals in each state and in each type of hospital defined by the nursing factors are roughly proportional to the number of hospitals in each state and of each type, there are proportionately more patients and nurses in larger, high technology, and major teaching hospitals.

Table 2 describes the characteristics of the surgical patients in our sample that were used in the analyses. Of the 1,262,120 patients studied, 438,990 (35%) experienced a major complication and 14,687 (1.2% of all patients and 3.4% of those with complications) died. Just over half of the surgical patients (and 44% of those with complications) underwent orthopedic operations, and roughly one third of the surgical patients (and 37% of those with complications) underwent digestive tract and hepatobiliary operations. Hypertension was the most common comorbidity, and virtually all comorbidities were more common among patients with complications than among surgical patients generally, obesity being the lone exception.

Table 3 shows the results of modeling the effects of the different nursing factors on mortality and failure-to-rescue. The upper panel of that table provides odds ratios that indicate the effects of nurse staffing, the nurse work environment, and nurse education on mortality from unadjusted models, which estimate the effects of each of those factors one at a time, and from adjusted models that estimate their effects simultaneously, with controls for the other hospital and patient characteristics. The second adjusted model includes the significant interaction between the nurse work environment and nurse staffing. Interactions between nurse staffing and nurse education and between the nurse work environment and nurse education were tested and found, at least in some models, to be insignificant, and as such were dropped from the model. The lower panel shows the estimated effects from similar models for failure-to-rescue. In both the unadjusted bivariate models and the adjusted models in which their effects are estimated simultaneously, all of the nurse factors have significant effects. Higher patient-to-nurse ratios increase the odds on patient deaths and failures to rescue, whereas better work environments and higher percentages of BSN nurses decrease those odds.

The fully adjusted main effects model, which excludes the interaction term, indicates that increased workloads (measured by a unit change in the number of patients per nurse) increase the odds on patient deaths and failures-to-rescue, by a factor of roughly 1.03 (or 3%). Independent of this, better work environments (measured continuously and in standard deviation units) and better educated nurses (measured to reflect the effect of a 10% increase in BSN nurses) decrease the odds on patients dying, by factors of 0.93 and 0.96 (or by 7% and 4%, respectively). Although differences in metrics and how these variables are measured make it difficult to assess which has the largest effect, it should be emphasized that these are not clinically insignificant differences. Although the effect of education for example may seem small when we observe that 10% more BSN nurses yields a reduction in the odds of dying by a factor of “only” 0.96, or by 4%, when we recognize that some hospitals have 40% more BSN nurses than others, and realize the attendant difference in mortality for groups of hospitals as different as that involves a reduction by 0.96 × 0.96 × 0.96 × 0.96, or by 0.85 or 15%, we can see that it is not a small effect at all. The presence of the significant interaction in the model indicates that it would be inappropriate to describe the effects of the other 2 factors using simple main effects estimates. The significant interaction between nurse staffing and the work environment implies that the effect of nurse staffing is conditional upon the work environment and, alternatively, that the effect of the work environment is conditional on nurse staffing.

This interaction is described in Table 4. The top panel of the table shows that the effect of higher patient-to-nurse ratios on deaths and failure is virtually nil (ie, odds ratios are nearly 1.0) in hospitals with worse than average work environments, but increases the odds on both outcomes in hospitals with average work environments by roughly 4%, and in hospitals with the best environments (2 SDs above the mean) by 9% or 10%. To the extent that this relationship is truly causal, this implies that lowering the patient-to-nurse ratio would markedly improve these patient outcomes in hospitals with good work environments, slightly improve them in hospitals with mixed environments, and have virtually no effect in hospitals with poor ones. The second panel of the table indicates that better nurse work environments lower the odds on deaths and failures in hospitals across the entire range of nurse staffing, but the effect is most pronounced in the best staffed hospitals (where the patient-to-nurse ratio is below average). In the poorest staffed hospitals, better environments decrease the odds on mortality and failure-to-rescue by approximately 2% or 3%; in the best staffed hospitals better environments decrease the odds on mortality and failure-to-rescue by roughly 12 and 14%, respectively.

DISCUSSION

Higher patient-to-nurse ratios increase the odds on patient deaths and failure-to-rescue, whereas better work environments and higher percentages of BSN nurses decrease those odds. The most important new finding in this study is that the impact of nurse staffing is contingent upon the quality of the nurse work environment, and vice versa. Absent a good work environment, reducing nurse workloads by adding additional nurses, a costly proposition, may have little consequence. At the same time, the effect of improving staffing will be more pronounced in hospitals where work environments are good than in hospitals with mixed environments.

Independent of staffing and the environment, we confirm our previous finding using 1999 data[15] that a 10% increase in BSN educated nurses decreases the odds on patients dying by approximately 4%. The documented effect of BSNs on lower mortality in this study is at least the fifth major study to confirm this association.[5,15–18] Although the results reported above suggest that the effect of nurse education is similar across different hospitals, additional models revealed that nurse education may, like nurse staffing, have a more pronounced effect in hospitals with good work environments. That effect was only marginally significant when we used hierarchical linear models, rather than robust regression models, to estimate it. Given the equivocal nature of that interaction, we refrained from reporting it with the same degree of certainty that we attach to the staffing-work environment interaction.

Improving work environments is not expensive but requires changing interprofessional culture and devolving more authority for care management decisions to those closest to patients. Many hospitals have found the blueprint for improving nurse work environments imbedded in the Magnet Recognition Program a useful guide for proceeding with the challenges of culture change.[43] Close to 400 hospitals have achieved Magnet Recognition, most within the past 7 years. Research shows that Magnet hospitals tend to be in the “good” category of work environments as empirically measured in this study by the Practice Environment Scale of the Nursing Work Index.[29]

Such as improving the work environment, recruiting a more educated nurse workforce is not necessarily more expensive for hospitals, as there is no significant difference in compensation for BSN nurses practicing in hospitals; plus any differences in compensation should be offset by the avoidance of expensive patient complications. Hospitals and patients would be well served by policies that enable new nurses to enter the workforce with a baccalaureate degree.[44] Indeed, the Institute of Medicine’s[45] recent recommendation to increase the proportion of nurses with BSNs from 50% to 80% by 2020 reflects the growing evidence linking BSN nurse education and better patient outcomes.

A primary limitation of the study includes its reliance on cross-sectional data and the attendant problem with establishing causality. In addition, we cannot rule out the possibility that omitted variables may be responsible for the associations found, even though our patient risk adjustment is extensive and we use all of the hospital characteristics that can be found in available administrative data to control for potential confounds. Additional models we estimated (not shown) that included a measure of hospital volume did not change our estimates of the effects of the nursing factors. Further, while we can link patients and nurses to the same hospitals to investigate how nursing characteristics affect patient outcomes across hospitals, we cannot link individual patients and nurses. Our measures of patients per nurse were derived from surveys of direct care bedside nurses only and thus are better indicators of clinical care workloads than administrative data sources that generally include nurses with no patient assignments and often nurses in outpatient settings. Our measures are hospital-level averages across all shifts and should not be interpreted as unit-specific patient-to-nurse ratios. A recent study by Needleman et al[6] shows that actual staffing for specific patients varies across days and shifts even when a hospital uses a unit-specific nurse staffing target. Thus, our measure should be considered a rough approximation of patient-to-nurse workloads ratios at any given point in time. That having been said, it is all the more impressive that we find strong association between staffing and mortality and demonstrating the conditions under which that relationship pertains.

CONCLUSIONS

We have shown that better staffing, better work environments, and better educated nurses all “work” to improve outcomes, at least for general surgical patients, and that the question of whether one works better than the other is, at least in one sense, less central than under what conditions they work at all. Better staffing, the most expensive option to improve care, has little effect on surgical mortality and failure-to-rescue in hospitals with poor work environments, but in hospitals with better work environments staffing has a sizable effect. Getting better value for investments in hospital nursing requires better staffing in the context of a good nurse work environment, and a more educated nurse workforce.

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TABLE 1.

Numbers and Percentages of Study Hospitals With Different Characteristics, and Numbers and Percentages of Patients and Nurses in Them

	Hospitals (n = 665)	Patients (n = 1,262,120)	Nurses (n = 39,038)
Hospital Characteristic	**No. (%)**	**No. (%)**	**No. (%)**
Location			
California	271 (40.8)	535,603 (42.5)	12,917 (33.09)
Pennsylvania	153 (23.0)	288,193 (22.8)	9,591 (24.57)
Florida	168 (25.3)	304,537 (24.1)	7,820 (20.03)
New Jersey	73 (11.0)	133,122 (10.6)	8,710 (22.31)
Nurse Staffing (Patients/Nurse)			
4 or fewer	174 (26.2)	348,598 (27.6)	9,820 (25.2)
5	209 (31.4)	470,144 (37.3)	15,232 (39.0)
6	146 (22.0)	262,923 (20.8)	8,974 (23.0)
7	77 (11.6)	114,074 (9.0)	3,181 (8.2)
8 or more	59 (8.9)	66,381 (5.3)	1,831 (4.7)
Nurse Work Environment			
Poor (>2.65)	198 (29.8)	291,116 (23.1)	8,838 (22.6)
Mixed (2.65–2.95)	337 (50.7)	666,644 (52.8)	20,820 (53.3)
Good (>2.95)	130 (19.6)	304,360 (24.1)	9,380 (24.0)
Nurse Education (% BSN)			
0–19	67 (10.1)	57,419 (4.6)	1,638 (4.2)
20–29	133 (20.0)	220,349 (17.5)	6,534 (16.7)
30–39	188 (28.3)	349,297 (27.7)	11,126 (28.5)
40–49	146 (22.0)	308,784 (24.5)	9,811 (25.1)
≥ 50	131 (19.7)	326,271 (25.9)	9,929 (25.4)
Bed Size			
<100	100 (15.1)	62,796 (5.0)	1,998 (5.2)
101–250	300 (45.3)	401,244 (32.0)	11,804 (30.6)
>250	262 (39.6)	788,295 (63.0)	24,817 (64.3)
Technology			
Not high tech	402 (60.5)	502,475 (39.8)	16,228 (41.6)

	Hospitals (n = 665)	Patients (n = 1,262,120)	Nurses (n = 39,038)
Hospital Characteristic	**No. (%)**	**No. (%)**	**No. (%)**
High tech	262 (39.5)	759,372 (60.2)	22,787 (58.4)
Teaching Status			
None	341 (52.4)	562,854 (44.6)	16,487 (42.3)
Minor	264 (40.6)	519,216 (41.2)	16,496 (42.3)
Major	46 (7.1)	179,777 (14.3)	6,032 (15.4)

TABLE 2.

Characteristics of Surgical Patients Included in Analyses of Mortality and Failure to Rescue

	All Patients (n = 1,262,120)	Patients With Complications (n = 438,990)
Characteristic	**No. (%)**	**No. (%)**
Men	543,312 (43.1)	204,104 (46.5)
Age (y), mean (SD)	60.6 (17.5)	64.6 (16.7)
Transfer status (transferred vs. not transferred)	14,687 (1.2)	9,231 (2.0)
Deaths within 30 days of admission	14,687 (1.2)	14,687 (3.4)
MDCs		
General surgery		
Digestive system diseases and disorders (MDC 6)	284,758 (22.6)	114,756 (26.1)
Hepatobiliary system diseases and disorders (MDC 7)	139,852 (11.1)	47,538 (10.8)
Diseases and disorders of the skin, subcutaneous tissue, and the breast (MDC 9)	44,946 (3.6)	17,289 (3.9)
Endocrine, nutritional, metabolic diseases, and disorders (MDC 10)	70,148 (5.6)	19,877 (4.5)
Orthopedic surgery		
Musculoskeletal system diseases and disorders (MDC 8)	653,447 (51.8)	193,266 (44.0)
Vascular surgery		
Circulatory system diseases and disorders (MDC 5)	68,969 (5.5)	46,264 (10.5)
Medical history (comorbidity)*		
Congestive heart failure	68,451 (5.4)	44,735 (10.2)
Valvular disease	58,734 (4.7)	27,047 (6.2)
Peripheral vascular disorders	54,215 (4.3)	30,995 (7.1)
Hypertension	2,453 (47.7)	25,998 (51.5)
Other neurological disorders	52,083 (4.1)	34,635 (7.9)
Chronic pulmonary disease	83,541 (14.5)	80,458 (18.3)
Diabetes, uncomplicated	85,611 (14.7)	68,847 (15.7)
Diabetes, complicated	41,533 (3.3)	25,817 (5.9)
Hypothyroidism	16,713 (9.2)	41,391 (9.4)
Renal failure	58,336 (4.6)	38,147 (8.7)
Liver disease	28,734 (2.3)	13,537 (3.1)
Metastatic cancer	42,413 (3.4)	22,032 (5.0)
Rheumatoid arthritis/collagen vascular diseases	29,096 (2.3)	10,868 (2.5)
Obesity	3,690 (8.2)	34,654 (7.9)
Weight loss	22,563 (1.8)	17,829 (4.1)
Deficiency anemias	66,440 (13.2)	77,118 (17.6)
Alcohol abuse	29,431 (2.3)	15,032 (3.4)
Depression	87,434 (6.9)	31,863 (7.3)

*Other comorbidities used to risk adjust in our models included pulmonary circulation disorders, paralysis, solid tumor without metastasis, blood loss anemias, drug abuse, psychoses, peptic ulcer disease, HIV and AIDS, and lymphoma. All of these were exhibited by fewer than 2% of all patients and fewer than 3% of patients with complications.

MDC indicates major diagnostic categories.

TABLE 3.

Odds Ratios Indicating the Unadjusted and Adjusted Effects of Nurse Staffing, the Nurse Work Environment, and Nurse Education on Patient Mortality and Failure-to-Rescue

	Odds Ratios from Models for Patient Mortality							
	Nurse Staffing		**Nurse Work Environment**		**Nurse Education**		**Staffing × Work Environment**	
Model	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI) P**	***P***
Unadjusted	1.033 (1.011–1.056)	0.0030	0.913 (0.884–0.942)	<0.0001	0.960 (0.936–0.984)	0.0012		
Fully Adjusted	1.033 (1.009–1.057)	0.0052	0.926 (0.897–0.956)	<0.0001	0.957 (0.936–0.978)	<0.0001		
Fully Adjusted with Interactions	1.039 (1.016–1.063)	0.001	0.926 (0.898–0.955)	<0.0001	0.958 (0.937–0.980)	<0.0001	1.029 (1.010–1.048)	0.003
	Odds Ratios from Models for Failure-to-Rescue							
	Nurse Staffing		**Nurse Work Environment**		**Nurse Education**		**Staffing × Work Environment**	
Model	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***	**OR (95% CI)**	***P***
Unadjusted	1.027 (1.005–1.051)	0.0175	0.918 (0.888–0.949)	<0.0001	0.957 (0.934–0.982)	0.0007		
Fully Adjusted	1.031 (1.007–1.056)	0.0111	0.925 (0.896–0.954)	<0.0001	0.955 (0.934–0.976)	<0.0001		
Fully Adjusted with Interactions	1.039 (1.016–1.063)	0.001	0.925 (0.897–0.954)	<0.0001	0.956 (0.935–0.978)	<0.0001	1.036 (1.016–1.055)	<0.001

Unadjusted models are bivariate models, which estimate the effect of each nursing characteristic separately, without any controls. Fully adjusted models estimate all 3 nursing characteristics simultaneously, whereas controlling for the full set of patient characteristics used in risk adjustment, and hospital characteristics.

CI indicates confidence interval; OR, odds ratio.

TABLE 4.

Odds Ratios Indicating (a) the Effect of Staffing in Various Nurse Work Environments, and (b) the Effect of the Nurse Work Environment at Various Staffing Levels

(a) When the Hospitals Nurse Work Environment is:	**The Odds Ratio Indicating the Effect of Staffing is:**	
	On Mortality	**On Failure-to-Rescue**
Two standard deviations below the mean	0.982	0.969
One standard deviation below the mean	1.010	1.004
At the mean	1.039 *	1.039 *
One standard deviations above the mean	1.070 *	1.076 *
Two standard deviations above the mean	1.101 *	1.115 *
(b) When the Hospitals Patient-to-Nurse Ratio is:	**The Odds Ratio Indicating the Effect of the Nurse Work Environment is:**	
	On Mortality	**On Failure-to-Rescue**
Two patients per nurse above mean	0.981	0.975
One patient per nurse above mean	0.952 *	0.958 *
At the mean	0.926 *	0.925 *
One patient per nurse below mean	0.900 *	0.893 *
Two patients per nurse below mean	0.875 *	0.863 *

Asterisks denote odds ratios which are significant at the 0.05 level.