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Impact of Critical Care Nursing on 30-Day Mortality of Mechanically Ventilated Older Adults

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Abstract

Objectives—The mortality rate for mechanically ventilated older adults in ICUs is high. A robust research literature shows a significant association between nurse staffing, nurses' education, and the quality of nurse work environments and mortality following common surgical procedures. A distinguishing feature of ICUs is greater investment in nursing care. The objective of this study is to determine the extent to which variation in ICU nursing characteristics—staffing, work environment, education, and experience—is associated with mortality, thus potentially illuminating strategies for improving patient outcomes.

Design—Multistate, cross-sectional study of hospitals linking nurse survey data from 2006 to 2008 with hospital administrative data and Medicare claims data from the same period. Logistic regression models with robust estimation procedures to account for clustering were used to assess the effect of critical care nursing on 30-day mortality before and after adjusting for patient, hospital, and physician characteristics.

Setting—Three hundred and three adult acute care hospitals in California, Florida, New Jersey, and Pennsylvania.

Patients—The patient sample included 55,159 older adults on mechanical ventilation admitted to a study hospital.

Interventions—None.

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Measurements and Main Results—Patients in critical care units with better nurse work environments experienced 11% lower odds of 30-day mortality than those in worse nurse work environments. Additionally, each 10% point increase in the proportion of ICU nurses with a bachelor's degree in nursing was associated with a 2% reduction in the odds of 30-day mortality, which implies that the odds on patient deaths in hospitals with 75% nurses with a bachelor's degree in nursing would be 10% lower than in hospitals with 25% nurses with a bachelor's degree in nursing. Critical care nurse staffing did not vary substantially across hospitals. Staffing and nurse experience were not associated with mortality after accounting for these other nurse characteristics.

Conclusions—Patients in hospitals with better critical care nurse work environments and higher proportions of critical care nurses with a bachelor's degree in nursing experienced significantly lower odds of death.

Keywords

health services; intensive care; nursing care; nursing research; outcomes research

Mechanically ventilated older adults in ICUs are a vulnerable and complex patient population. Multiple comorbidities (1), physiologic age-related changes (2), multiple organ failure, and complicated clinical trajectories place them at high risk for adverse outcomes (3). Older adults on mechanical ventilation represent a large portion of ICU patients (4, 5) and as a group are growing in number (6). They are highly dependent on nursing care due to the nature of their illnesses, need for continuous invasive monitoring, and multiple organ system support. Consequently, nursing is the major service provided in ICUs, which were designed and created to meet the need for more intense specialized nursing care (7).

One key role that critical care nurses perform is surveillance (8, 9). ICU nurses are at the patient's bedside around the clock and thus function as an early alarm system for the identification of problems that, if detected early enough, could potentially save a patient's life. In studies of less severely ill patients, the quality of nurse surveillance has been found to be influenced by patient to nurse workloads, nurses' education, nurses' experience, and the quality of the nurse work environment (9, 10). Given the heightened importance of nurse surveillance and early intervention for critically ill patients, it seems logical that these same nursing resources—staffing, work environment, and education—found to be associated with lower mortality in patients undergoing common surgical procedures and would be as or more important for older critically ill patients on mechanical ventilation. However, surprisingly, little research has been conducted to study these relationships in ICUs.

The existing literature exploring the relationship between the organization of critical care nursing and outcomes of ICU patients is limited, with most of the studies evaluating nurse staffing and outcomes (11, 12). Better ICU unit staffing (fewer patients per nurse) was associated with lower patient mortality in some studies (13–16) but not all (17–19). Work has inconsistently demonstrated relationships between aspects of the critical care work environment such as unit culture (20), communication and collaboration (20, 21), and mortality but has been performed in small samples with limited statistical power and generalizability. There is no research on the association between ICU nurses' education and

patient outcomes and, similarly, virtually no evidence supports ICU nurse experience and lower odds of death for adult patients despite theoretical and historical support of the importance of ICU nursing knowledge (7). Given the inconclusive research on the relationship between aspects of critical care nursing and patient mortality, our theoretical understanding of nurse surveillance, and the historical development of ICUs, we chose to focus on these four nursing characteristics—staffing, work environment, education, and experience—and their associations with 30-day mortality for older adults on mechanical ventilation. Our study offers one of the most comprehensive studies of critical care nursing and patient outcomes and examines contributions of critical care nursing in patient survival.

MATERIALS AND METHODS

Study Design and Sample

This study is a cross-sectional analysis of three datasets: 1) University of Pennsylvania Multi-State Nursing Care and Patient Safety Study (2006–2008), 2) American Hospital Association (AHA) Annual Survey (2007–2008), and 3) Medicare claims data (2006–2008). The Multi-State Nursing Care and Patient Safety Study provided information from registered nurses working in hospitals in four states (California, Florida, New Jersey, and Pennsylvania) about their personal demographics (including age, experience, and education), their workplace (including the unit they worked on, their workloads, and the work environment), and about the quality of care in their hospital and unit (10). The study is state-based because of the need to draw large random samples of nurses from state licensure lists in order to have sufficient numbers of nurses reporting on care in large numbers of hospitals. California, Pennsylvania, Florida, and New Jersey were selected as the study states because 1) they are among the largest in the country; 2) they account for more than a fifth of the nation's hospitalizations; 3) they roughly approximate national hospital characteristics (21); and 4) private sources of research funding were available to supplement funding from the National Institute of Nursing Research. Details of the survey methodology have been described elsewhere (10). Our analyses use data from staff nurses working in adult ICUs in nonfederal, acute care hospitals in the four states. The AHA Annual Survey data provided information on hospital structural characteristics. The Medicare Provider Analysis and Review (MedPAR) files provided demographic and claims data for patients admitted to the study hospitals, including whether they had been mechanically ventilated during their hospital stay and whether and when they died.

Hospitals were included if they met three criteria: 1) at least 100 Medicare ICU admissions over the years 2006–2008; 2) at least five critical care nurse respondents to the nurse survey; and 3) participated in the AHA Survey. Patients were included if they were Part A or Part A and Part B Medicare beneficiaries 65 years and older, had been admitted to any study hospital ICU or coronary care unit (CCU), and were mechanically ventilated (in the MedPAR claims data, using *International Classification of Diseases, 9th Edition* [ICD-9] procedure codes 96.70, 96.71, or 96.72). We focused on patients undergoing mechanical ventilation only since they are at high risk of death, and we hypothesized their survival could well be affected by nursing. Additionally, creating a homogenous cohort has been used as a way to a priori adjust for severity of illness for the critically ill (22). Only the first

ICU admission for each patient was studied and patients transferred from another acute care facility were excluded. The critical care nursing measures derived from the 3,193 critical care nurse reports were aggregated to the hospital level. Hospitals with fewer than five nurses were excluded from the study after preliminary analyses (assessment of intraclass correlation coefficients [ICCs]) revealed that five or more critical care nurses were sufficient to provide reliable summary measures of ICU nursing.

Variables

Critical Care Nurse Staffing—Critical care nurse staffing was derived from the critical care nurses' reports of the number of patients they cared for on their last shift. The predictive validity of this measure has been previously established (23, 24) and has been identified as a superior approach than measures of staffing from administrative databases (24, 25). A mean critical care staffing measure for each hospital was generated from nurses who reported caring for at least one but less than seven patients on their last shift. Reports from nurses who cared for seven patients or more (represented < 1% of the respondents) were excluded from the calculation of the mean staffing measure since we suspected that such nurses were not likely to represent bedside critical care nurses. The ICC for the critical care staffing measure using a minimum of five nurse respondents per hospital in this study was 0.65, which is above the generally accepted level of 0.60 for aggregated data (26, 27).

Nurse Work Environment—The Practice Environment Scale-Nursing Work Index (PES-NWI) is a validated tool, endorsed by the National Quality Forum, to measure the nurse work environment (28). It comprised 31 questions that ask nurses whether certain features of nurse work environments are present in their workplaces, scored on a 4-point Likert scale ranging from 1 ("strongly disagree") to 4 ("strongly agree") (29). These questions are used to create five validated subscales: Staffing and Resource Adequacy (i.e., "enough staff to get the work done"), Nurse Participation in Hospital Affairs (i.e., "opportunity for staff nurses to participate in policy decisions"), Nursing Foundations for Quality of Care (i.e., "active staff development or continuing education programs for nurses"), Collegial Nurse-Physician relations (i.e., "physicians and nurses have good working relationships"), and Nurse Manager Ability, Leadership, and Support of Nurses (i.e., "a supervisory staff that is supportive of nurses") (29). The Staffing and Resource Adequacy subscale was highly correlated with the direct staffing measure used in our analyses ($\rho = -0.42$; $p < 0.001$) and was thus excluded from calculation of the composite PES-NWI score. We aggregated the remaining four PES subscale means for critical care nurses to the hospital level to generate a composite nurse work environment score, as previously done (23, 24, 29, 30). The composite score was used to classify the critical care nurse work environments of the hospitals into three distinct categories: better (> 75th percentile), mixed (25th–75th percentile), and worse (< 25th percentile). Cronbach's alphas for the subscales in this specific sample of critical care nurses ranged from 0.89 (Nurse Foundations for Quality Care) to 0.94 (Collegial Nurse-Physician Relations). ICCs (1, k) were calculated for the composite measure, with and without the Staffing and Resource Adequacy subscale, and the resultant values (0.71 and 0.69, respectively) were, in both cases, above the generally accepted level of 0.60 (26, 27).

Education—Nurses were asked to identify the highest degree in nursing they held. A dichotomous variable was created that reflected whether a critical care nurse had a bachelor's degree in nursing (BSN) or higher. Individual responses were aggregated to the hospital level to represent the proportion of critical care nurses within a hospital who had a BSN or higher.

Experience—We also included a variable for nurse experience, using data provided by the Multi-State Nursing Care and Patient Safety Study survey data. We modeled a continuous hospital-level measure of nurse experience defined as the mean number of years critical care nurse respondents reported working in direct patient care as a registered nurse.

Mortality—Thirty-day mortality was obtained from the MedPAR claims and was measured at the patient level as death within 30 days of hospital admission.

Risk Adjustment

Patient characteristics used for risk adjustment were derived from MedPAR claims and included age, sex, race, primary diagnosis, type of admission, and comorbid conditions. In the models we estimated, age was coded as a continuous variable whereas sex (male/female) and emergent admission (yes/no) were dichotomous. Race (white/black/other) was represented by dummy variables. Primary diagnoses were classified using the Health Care Utilization Project Clinical Classification Groups (CCGs), which categorizes ICD-9 codes found in the patient's primary diagnosis field into over 200 distinct groups (31). These groups were then classified into 23 distinct, clinically meaningful categories and used as individual indicator variables in the regressions to allow for parsimonious models (32, 33). Patients not categorized into any of the CCG groups (< 0.02% of the sample) were excluded from analysis. Comorbidities were defined by examining the nine secondary diagnosis fields in MedPAR claims using 28 comorbid conditions as adapted from the Elixhauser model (34). A 180-day look back of ICU and non-ICU hospital admissions was used to identify any other conditions that were not coded on the index admission record (29), allowing for more robust risk adjustment.

Eight hospital structural characteristics obtained from the AHA Survey and MedPAR claims were also included as controls in the models we estimated: 1) number of beds (250, 251–500, and >501 beds); 2) teaching status (major: 1 to 4 resident to bed ratio or greater; minor: less than 1 to 4 ratio, nonteaching); 3) technology status (high/low); 4) state (New Jersey, Florida, Pennsylvania, and California); 5) core-based statistical area (CBSA); 6) intensivist presence; 7) specialty ICU indicator; and 8) volume of mechanical ventilation. High-technology hospitals were hospitals with open-heart surgery and/or organ transplant capabilities. CBSA is a measure of population density and categorized into division, micropolitan, and metropolitan areas. Intensivist presence was a dichotomous variable derived from the 2007 to 2009 AHA Annual Hospital Survey that denoted whether hospitals employed a board-certified critical care physician to work, full or part time, in any of the adult ICUs. Multiple imputation techniques were used to assign values for this specific variable due to approximately 30% missing values (35). We know of no other source of physician data for the large number of hospitals in our study. We derived an indicator

variable for whether the admission was in a specialty ICU or not from MedPAR claims. Hospital stays that were in a general ICU or general CCU were considered nonspecialty, whereas an admission to a trauma ICU, burn ICU, medical ICU, or surgical ICU were classified as specialty admissions. We also added control variables representing a continuous measure of annual volume of mechanical ventilation for 2006 and 2007 (derived from MedPAR), given the evidence of a volume-outcome relationship for mechanical ventilation (36). We do not control for hospitals with Magnet status as Magnet designation has been shown to be a rough proxy variable for the practice environment (37) and using the PES-NWI allows us to quantify and measure practice environments in other hospitals that are not Magnet but may have Magnet-like qualities.

Analysis

Unadjusted and adjusted multilevel logistic regression models were used to assess the relationship of each feature of critical care nursing on 30-day mortality. The adjusted model controlled for patient and hospital characteristics and estimated the effects of the different hospital-level critical care nursing factors on individual patient mortality simultaneously. All models employed robust SE estimation to account for the clustering of patients within hospitals. The MI ESTIMATE command in Stata was used to incorporate the variable estimates for the imputed values of the intensivist variable. All analyses were done using Stata version 11.0 (38). The study was deemed exempt by the University of Pennsylvania Institutional Review Board.

RESULTS

The characteristics of patients in the sample are displayed in Table 1. The analytic sample included 55,159 mechanically ventilated patients cared for in 303 hospitals in four states. The average patient was 78 years old and roughly half of the sample had primary diagnoses of respiratory failure (23%), sepsis (14%), or neurologic disorders (13%). Most patients were white (82%). Roughly three fourths of the patients (76%) were emergency admissions, and nearly half (48%) died within 30 days of hospital admission. Close to two thirds (60%) were mechanically ventilated for 96 hours or less during the hospital admission, and one third (35%) of the sample was admitted to a specialty ICU (trauma ICU, burn ICU, medical ICU, or surgical ICU).

Hospital structural characteristics are displayed in Table 2. Two thirds (66%) of the hospitals had over 250 total hospital beds, and the average number of ICU beds per hospital was approximately 40. The majority of hospitals were high-technology hospitals (67%) and more than half of the hospitals were either minor or major teaching hospitals (53%). One third (33%) reported having one full-time or part-time intensivist on staff in their adult ICUs. Hospitals were distributed fairly evenly across states, with the majority of hospitals being in California (33%). The average annual volume of mechanically ventilated patients across hospitals was 145 patients in 2006 and 122 patients in 2007. Nearly all hospitals (99%) were in densely populated areas (metropolitan or division CBSA).

Table 3 displays the hospital-level critical care nursing measures. Approximately 11 critical care nurses per hospital responded to the nurse survey. The mean number of patients cared

for by each critical care nurse on their last shift was slightly greater than two, though the average number of patients per critical care nurse ranged across hospitals from 1.3 to 3.8. On average, ICU nurses had 12 years of direct patient care experience as a registered nurse. As classified, approximately one quarter of the hospitals had better nurse work environments (24%), about half were classified as mixed environments (49%) and approximately 28% were classified as worse. On average, half of the critical nurses working in a hospital held a BSN or higher, and the percentage of critical care nurses with BSN or higher ranged across hospitals from 0% to 100%.

Table 4 displays the regression results. Unadjusted bivariate logistic regression coefficients (odds ratios [ORs]) and CIs indicating the size and significance of the critical care nursing measures on 30-day mortality are displayed in the second column. The adjusted regression coefficients and CIs indicating the size and significance of the nursing measures when they are estimated jointly while also adjusting for hospital, physician, and patient characteristics are displayed in the third column.

In the bivariate models, nurse education and nurse experience appear to have a significant effect on mortality. In the adjusted model, both nurse education ($OR = 0.98$; $p < 0.05$) and the nurse work environment (OR for better vs worse environments = 0.89 ; $p < 0.05$) were significant predictors of 30-day mortality. Each 10-point increase in a hospital's percentage of BSN-prepared ICU nurses lowers the odds of death by a factor of 0.98, or by 2%. Being cared for in a hospital with a better work environment rather than a worse environment lowers the odds on death by a factor of 0.89, or by 11%. Although it may appear that the latter effect is decidedly larger than the former, it should be recognized that the effect of having more BSN is measured as a multiplicative effect of each 10% point increase in BSN nurses. As such, the difference between hospitals with 75% BSN nurses and 25% BSN nurses would involve a difference by a factor of 0.98 to the fifth power, which implies lower odds by a factor of roughly 0.90, or by 10%. Thus, across the full range of hospitals, the two effects are quite similar. Critical care nurse staffing and years of nurse experience did not reach statistical significance in the adjusted model.

DISCUSSION

The principal findings suggest that when mechanically ventilated older adults were cared for in hospitals with better critical care nurse work environments and in hospitals with a greater proportion of BSN critical care nurses, they experienced lower odds of death. These results persisted even after accounting for critical care nurse staffing, nurse experience, and other hospital characteristics, including the presence of intensivist physicians, and after risk adjusting for patient characteristics. Our findings suggest that fostering environments that allow knowledgeable and educated nurses to care effectively for the critically ill may improve outcomes among mechanically ventilated older adults. Our results confirm similar findings in the general acute setting (9, 10, 24, 39) and suggest that nurses play a similar crucial role in the critical care setting with more complex patient needs and greater nursing care intensity.

There was substantial variation in the proportion of BSN-prepared ICU nurses across hospitals. Some hospitals had no critical care nurse respondents with a BSN or higher, whereas others had all of their ICU nurse respondents with a BSN or higher. When there is such variation in a healthcare resource, as we see in education qualifications of ICU nurses, there are potential consequences for quality of care and patient outcomes. Thus, hospitals may have had as much as a 50% difference in the percentage of BSN-prepared ICU nurses which could be translated into a difference in mortality of roughly 10%. In the mechanically ventilated older adult population, where almost half die within 30 days of hospital admission, the potential for a reduction in odds of death by 10% is substantial and clinically meaningful. Increasing the proportion of nurses with a BSN is feasible and is not costly to the hospital. By contrast, years of nursing experience was not significantly associated with lower odds of death, supporting prior evidence that experience may not be a substitute for education (39). Generally, hospitals do not pay a substantial premium to nurses with BSNs. Furthermore, except for tuition benefits provided to currently employed nurses, hospitals do not bear the costs of BSN education (10, 40). About half of all hospital staff nurses nationally have BSN or higher qualifications suggesting that active recruitment and preferential hiring of BSN-prepared ICU nurses plus investment in BSNs for current staff should make it possible for all ICUs to employ predominantly BSN-qualified nurses.

Critical care nurse staffing was not significantly associated with lower odds of death. Most ICUs in the United States adhere to an unofficial staffing guideline of two patients per nurse with some states mandating this ratio (41, 42). Our findings confirm the adherence by most hospitals to this staffing guideline. The absence of a significant association between critical care nurse staffing and mortality was likely due to the limited variation in staffing across hospitals. Most previous studies of ICU nurse staffing and mortality examined only staffing, not nurse education and the work environment, and thus associations between staffing and mortality when found may have been due to staffing serving as a proxy for unmeasured nursing factors (13, 15–17). The nonsignificant association between ICU staffing and 30-day mortality found in this study, however, does not negate the contribution of ICU nurse staffing to outcomes. Indeed, the first ICUs were created because of a need for more concentrated nurse staffing (7) and this has largely been accomplished (14). Investment in other areas of critical care nursing such as the work environment and nurses' education, while maintaining current staffing levels, may hold greatest promise for improving patient outcomes.

Some limitations of our study should be noted. The cross-sectional design of the study limits the ability to establish that observed relationships are causal. Our analysis was limited to four large U.S. states and during a specific time period (2006–2008). Although the hospitals and the nurses who practice in them resemble national statistics and the hospitals in these states comprise more than a fifth of all hospital admissions nationally, it is possible that our findings may not be generalizable to all parts of the country. The dates of the survey are a noted limitation; however, we know of no other large-scale nurse survey that has been collected more recently that provides empirical measures of nurses' education at the hospital level or assessments of the work environment. We also could not link individual ICU nurses to individual patients or to a specific ICU, and our measure of nurse experience reflected years of experience as a registered nurse in direct patient care and not critical care

experience specifically. Although Medicare claims data are one of the few data sources that identify the number of days spent in an ICU during a patient's hospitalization, the location of a patient's pre- or post-ICU stay is not captured. Because of this limitation, patients were excluded if they were transferred from another acute care hospital. Although we believe we had adequate risk adjustment measures for the purpose of the study, detailed clinical physiologic data were unavailable in the claims data. Risk adjustment was strengthened by selecting a priori, mechanically ventilated patients as well as using previous claims (ICU and non-ICU) from 180 days prior to the index ICU hospitalization to identify all possible comorbid conditions using the Elixhauser comorbidities (43). We controlled for the presence of an intensivist which has been significantly associated with lower odds of death in ICU patients (44). To our knowledge, the AHA Annual Hospital Survey is the only source of information on intensivists in large numbers of hospitals in our sample, and data were missing for this variable on about a third of the hospitals studied. However, multiple imputation methods, a well-validated approach to estimating missing data in large surveys, were employed to estimate the intensivist effect as accurately as possible. The dichotomous measurement of intensivist presence, however, cannot describe how variations in utilization may affect outcomes. Nonetheless, to our knowledge, this is the first study to incorporate a measure of intensivist presence and still demonstrate a significant association between critical care nursing and 30-day mortality in the ICU patient population.

CONCLUSIONS

Critically ill mechanically ventilated adults experience high mortality with close to half dying within 30 days of hospital admission. The results of our study suggest that two relatively low-cost interventions hold promise for improving the survival of these very vulnerable—improving the work environment in ICUs to enable nurses to provide the best possible care and moving toward a predominantly BSN-qualified workforce.

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Table 1 Clinical and Demographic Characteristics of the Patients ($n = 55,159$)

Age, mean (SD)	77.9 (7.0)
Race, n (%)	
White	45,356 (82.2)
Black	5,554 (10.1)
Other	4,249 (7.7)
Female, n (%)	28,074 (50.9)
Specialty ICU admission	19,770 (35.8)
Emergent admission, n (%)	41,504 (76.3)
Top three primary diagnoses	
Clinical classification groups, n (%)	
Respiratory failure	12,669 (23.0)
Sepsis	7,681 (13.9)
Neurologic disorder	7,033 (12.8)
Continuous mechanical ventilation, n (%)	
Unspecified duration	99 (0.2)
For less than 96 consecutive hours	33,182 (60.3)
For 96 consecutive hours or more	21,877 (39.7)
Thirty-day mortality	26,737 (48)

Table 2**Characteristics of the Hospitals (*n* = 303)**

Mean ICU beds, mean (SD)	39.1 (30.3)
Total number of hospital beds, <i>n</i> (%)	
250 beds or less	100 (33)
251–500	152 (50.2)
> 501	51 (16.8)
Teaching status, <i>n</i> (%)	
None	143 (47.2)
Minor (resident to bed ratio less than 1:4)	123 (40.6)
Major (resident to bed ratio 1:4 or greater)	37 (12.2)
High-tech hospital, <i>n</i> (%)	204 (67.3)
Intensivist ^a (one full-time or part-time intensivist on staff in adult ICUs), <i>n</i> (%)	
Present	99 (32.7)
Absent	111 (36.6)
State, <i>n</i> (%)	
California	99 (32.7)
New Jersey	61 (20.1)
Pennsylvania	67 (22)
Florida	76 (25.1)
Annual volume of mechanical ventilation, mean (SD)	
2006	145.2 (87.8)
2007	122.1 (70.9)
Core-based statistical area ^b , <i>n</i> (%)	
Division	131 (45.9)
Micropolitan	4 (1.4)
Metropolitan	150 (52.6)

^aThe intensivist variable had 93 (30%) missing.

^bThe core-based statistical area variable had approximately 18 (5%) missing and those missing values are not reported.

Table 3 Hospital-Level Critical Care Nursing Characteristics ($n = 303$)

Nursing Characteristic	Mean (sd)	Range
Average number of ICU nurses per hospital	10.6 (7.3)	5–69
ICU nurse staffing (patients per nurse)	2.15 (0.37)	1.29–3.8
ICU nurse education (proportion of ICU nurses with a bachelor's degree in nursing or higher)	0.50 (0.20)	0–1.0
Average years of nurse experience in direct patient care	11.6 (8.1)	1–26
ICU nurse work environment, composite score, n (%) ^a	2.73 (0.30)	1.92–3.6
Better	72 (23.8)	
Mixed	147 (48.5)	
Worse	84 (27.7)	

^aThe composite score excludes the Staffing and Resource Adequacy subscale due to its high correlation with the staffing measure.

Table 4 Odds Ratios Estimating the Effect of Critical Care Nursing on 30-Day Mortality ($n = 55,159$)

	Unadjusted ^a OR (95% CI)	Adjusted ^b OR (95% CI)
Nurse staffing ^c	1.08 (0.99–1.17)	1.03 (0.93–1.15)
Nurse education ^d	0.98 (0.97–0.99)	0.98 (0.97–0.99)
Nurse experience ^e	0.99 (0.99–0.99)	1.00 (0.99–1.00)
Nurse work environment (worse is reference category)		
Better	0.92 (0.83–1.00)	0.89 (0.81–0.98)
Mixed	1.00 (0.93–1.07)	0.97 (0.89–1.04)

OR = odds ratio.

^a Unadjusted models estimate the nursing characteristic on mortality separately.^b Adjusted model jointly estimate the critical care nursing characteristics and control for patient's age, sex, race, comorbidities, emergent admission type, specialty ICU admission, primary diagnosis Clinical Classification Groups, average number of years of nursing experience and hospital structural characteristics (teaching status, technology status, bed size, presence of intensivists, core-based statistical area, volume of mechanical ventilation, and hospital state).^c Nurse staffing represents the number of patients per nurse and thus the odds ratio reflects the odds of death with an increase of one patient per nurse.^d Nurse education was multiplied by 10 to represent a change in the odds of death with a 10-point change in proportion of bachelor's prepared ICU nurses at the hospital level.^e Nurse experience represents the mean number of years nurses worked in direct patient care as a registered nurse, at the hospital level.