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Intensive Care Unit Utilization Following Major Surgery and the Nurse Work Environment

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ABSTRACT

Background: Across hospitals, there is wide variation in ICU utilization after surgery. However, it is unknown whether and to what extent the nurse work environment is associated with a patient's odds of admission to an intensive care unit.

Purpose: To estimate the relationship between hospitals' nurse work environment and a patient's likelihood of ICU admission and mortality following surgery.

Methods: A cross-sectional study of 269 764 adult surgical patients in 453 hospitals was conducted. Logistic regression models were used to estimate the effects of the work environment on the odds of patients' admission to the intensive care unit and mortality.

Results: Patients in hospitals with good work environments had 16% lower odds of intensive care unit admission and 15% lower odds of mortality or intensive care unit admission than patients in hospitals with mixed or poor environments.

Conclusions: Patients in hospitals with better nurse work environments were less likely to be admitted to an intensive care unit and less likely to die. Hospitals with better nurse work environments may be better equipped to provide postoperative patient care on lower acuity units.

Key words: intensive care units, nurses, practice patterns, quality of health care

As the demand for intensive care unit (ICU) services continues to increase in the United States, weighing the risks and benefits of admitting a patient to the ICU remains an ongoing challenge.[1] Among surgical patients, postoperative admission to the ICU is not consistently associated with better survival, and the potential misuse of the ICU has important implications for patients.[2] For example, ICU care is more likely to include potentially unnecessary invasive procedures and tests and increases a patient's risk for deconditioning, developing delirium, or acquiring a nosocomial infection.[3-5] Understanding modifiable factors predictive of ICU admission is essential for optimizing patient outcomes.

Guidelines from the Society of Critical Care Medicine recommend considering patient needs (eg, requiring life-supportive therapies

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with higher probability of recovery) and hospital characteristics (eg, available clinical expertise, bed availability) when making ICU admission decisions.[6,7] However, for many patients, it can be difficult to predict the benefit of ICU care; thus, the provider's decision about a patient's required level of care is discretionary. Provider preference for ICU admission may explain, at least in part, the wide variation in ICU use. For example, studies of postoperative patients have found ICU admission rates across hospitals to range from less than 5% to 100% for similar patients undergoing the same surgical procedures.[2,8] In studies on variation in ICU utilization, 17% to 19% of the variation is attributed to hospitals, independent of patient characteristics.[9,10] Little is known about specific causes of variation in ICU use across hospitals; even less is known about how the work environment of hospital nurses is linked to the likelihood of a patient being admitted to an ICU.

We hypothesized that the work environment of hospital nurses is associated with the likelihood of a patient being admitted to the ICU, because nurses provide direct 24-hour care to patients in most settings within a hospital. Studies have shown that when nurses have manageable workloads and work in an environment that fosters collegial nurse-physician relationships, clinical autonomy, and supportive management and nursing leadership, patients experience a variety of better outcomes, including lower rates of mortality and failure to rescue.[11-14] Surgical patients require close nursing surveillance in the postoperative period. Complications, such as clinical deterioration, can become life-threatening if early warning signs are not identified and treated promptly. Because of their training and proximity to patients, nurses are the front-line providers in preventing, identifying, and treating postoperative complications.

The purpose of this study was to analyze the relationships between the nurse work environment, ICU admission, and mortality in a large sample of Medicare beneficiaries undergoing general, orthopedic, or vascular surgical procedures. We hypothesized that surgical patients in hospitals with better nurse work environments would be less likely to be admitted to the ICU and that patients not admitted to the ICU would not have higher odds of mortality.

Materials and Methods

Data Sources and Sample

We conducted a retrospective observational study of Medicare patients admitted for surgical procedures between January 2006 and October 2007. Three data sources were linked by using a unique hospital identifier. The Medicare Provider Analysis and Review file was used to identify fee-for-service Medicare beneficiaries aged 65 years and older who underwent a general, orthopedic, or vascular surgery (Table 1). These surgeries were selected since they are commonly studied and have robust risk adjustment, which is important in analyzing patient outcomes.[15] We excluded patients who were admitted to hospitals without ICU capabilities (defined as having no ICU center revenue codes) or who were transferred from another acute care hospital. In cases in which patients had multiple hospitalizations during the study period, the first surgical hospitalization was selected for analysis.

The RN4CAST (2006) survey of registered nurses provided data on the work environments of hospital nurses.[11] The survey was mailed to a random sample of licensed registered nurses in 4 large states—California, Florida, New Jersey, and Pennsylvania—and achieved a 36% response rate (~34 000 nurses). In the survey, hospital nurses were asked to report on features of their work environment (eg, nurse-physician teamwork, adequate staffing and resources, clinical autonomy). Nurses were also asked to identify their hospital name, which facilitated linkage with administrative datasets and allowed nurse responses to be aggregated by hospital. Nurse responses were aggregated for hospitals with at least 10 survey respondents to ensure reliable hospital-level measures. Previous work has established that the survey design generated an unbiased sample of representative hospitals, that there were no significant differences between responders and nonresponders on ratings of their work environment, and that nurse reports of the work environment in hospitals have changed little over a 10-year period (from 2006 to 2016).[11,16,17] For example, in a longitudinal study of nurses, researchers found that the patient-to-nurse ratio decreased and the proportion of nurses with a bachelor of science in nursing increased between 2006 and 2016, yet measures of the nurse work environment changed little over the same decade.[17] The American

Table 1: Surgical Patient Diagnosis-Related Groups (Version 23 and 24)

DRG	Description
	General Surgical Diagnosis-Related Groups
Digestive System	
146	Rectal resection with complications
147	Rectal resection without complications
148	Major small & large bowel procedures with complications
149	Major small & large bowel procedures without complications
150	Peritoneal adhesiolysis with complications
151	Peritoneal adhesiolysis without complications
152	Minor small & large bowel procedures with complications
153	Minor small & large bowel procedures without complications
154	Stomach, esophageal & duodenal procedures age >17 with complications
155	Stomach, esophageal & duodenal procedures age >17 without complications
157	Anal & stomal procedures with complications
158	Anal & stomal procedures without complications
159	Hernia procedures except inguinal & femoral age >17 with complications
160	Hernia procedures except inguinal & femoral age >17 without complications
161	Inguinal & femoral hernia procedures age >17 with complications
162	Inguinal & femoral hernia procedures age >17 without complications
164	Appendectomy with complicated principal diagnosis with complications
165	Appendectomy with complicated principal diagnosis without complications
166	Appendectomy without complicated principal diagnosis with complications
167	Appendectomy without complicated principal diagnosis without complications
170	Other digestive system OR procedures with complications
171	Other digestive system OR procedures without complications
Hepatobiliary	
191	Pancreas, liver & shunt procedures with complications
192	Pancreas, liver & shunt procedures without complications
193	Biliary tract procedure except only cholecyst. With or without CDE with complications
194	Biliary tract procedure except only cholecyst. With or without CDE without complications
195	Cholecystectomy with CDE with complications
196	Cholecystectomy with CDE without complications
197	Cholecystectomy except by laparoscope without CDE with complications
198	Cholecystectomy except by laparoscope without CDE without complications
199	Hepatobiliary diagnostic procedure for malignancy
200	Hepatobiliary diagnostic procedure for non-malignancy
201	Other hepatobiliary or pancreas OR procedures
493	Laparoscopic Cholecystectomy without CDE complications
494	Laparoscopic Cholecystectomy without CDE without complications
Skin, subcutaneous tissue, breast	
257	Total mastectomy for malignancy with complications
258	Total mastectomy for malignancy without complications
259	Subtotal mastectomy for malignancy with complications
260	Subtotal mastectomy for malignancy without complications
261	Breast procedures for non-malignancy except biopsy & local excision
262	Breast biopsy & local excision for non-malignancy
263	Skin graft &/or debridement for skin ulcer or cellulitis with complications
264	Skin graft &/or debridement for skin ulcer or cellulitis without complications
265	Skin graft &/or debridement except for skin ulcer or cellulitis with complications
266	Skin graft &/or debridement except for skin ulcer or cellulitis without complications
267	Perianal & pilonidal procedures
268	Skin, subcutaneous tissue & breast plastic procedures

Continued

Table 1: *Continued*

DRG	Description
	General Surgical Diagnosis-Related Groups (*cont.*)
Endocrine, nutritional, metabolic	
285	Amputation of lower limb for endocrine, nutritional & metabolic disorders
286	Adrenal & pituitary procedures
287	Skin grafts & wound debridement for endocrine, nutritional & metabolic disorders
288	OR procedures for obesity
289	Parathyroid procedures
290	Thyroid procedures
291	Thyroglossal procedures
292	Other endocrine, nutritional & metabolic OR procedures with complications
293	Other endocrine, nutritional & metabolic OR procedures without complications
493	Laparoscopic cholecystectomy without CDE with complication
494	Laparoscopic cholecystectomy without CDE without complications
	Orthopedic Diagnosis-Related Groups
210	Hip & femur procedures except major joint age >17 with complications
211	Hip & femur procedures except major joint age >17 without complications
213	Amputation for musculoskeletal system & connective tissue disorders
216	Biopsies of musculoskeletal system & connective tissue
217	Wound debridement & skin graft except hand, for musculoskeletal & connective tissue disorder
218	Lower extremities & humerus procedure except hip, foot, femur age >17 with complications
219	Lower extremities & humerus procedure except hip, foot, femur age >17 without complications
223	Major shoulder/elbow procedure, or other upper extremity procedure with complication
224	Major shoulder/elbow procedure, or other upper extremity procedure without complication
225	Foot procedures
226	Soft tissue procedure with complications
227	Soft tissue procedure without complications
228	Major thumb or joint procedure, or other hand or wrist procedure with complications
229	Major thumb or joint procedure, or other hand or wrist procedure without complications
230	Local excision & removal of interior fix devices of hip & femur
232	Arthroscopy
233	Other musculoskeletal system & connective tissue OR procedure with complications
234	Other musculoskeletal system & connective tissue OR procedure without complications
471	Bilateral or multiple major joint procedures of lower extremity
491	Major joint & limb reattachment procedures of upper extremity
496	Combined anterior/posterior spinal fusion
497	Spinal fusion except cervical with complications
498	Spinal fusion except cervical without complications
499	Back & neck procedures except spinal fusion with complications
500	Back & neck procedures except spinal fusion without complications
501	Knee procedures with prior diagnosis of infection with complications
502	Knee procedures with prior diagnosis of infection without complications
503	Knee procedures without prior diagnosis of infection
519	Cervical spinal fusion with complications
520	Cervical spinal fusion without complications
537	Local excision & removal of interior fix device except hip & femur with complications
538	Local excision & removal of interior fix device except hip & femur without complications
544	Major joint replacement or reattachment of lower extremity
545	Revision of hip or knee replacement
546	Spinal fusion except cervical with curvature of the spine or malignancy
	Vascular Diagnosis-Related Groups
110	Major cardiovascular procedures with complications
111	Major cardiovascular procedures without complications
113	Amputation for circulatory system disorders except upper limb & toe
114	Upper limb & toe amputation for circulatory system disorders
119	Vein ligation & stripping
120	Other circulatory system OR procedures

Abbreviations: CDE, common duct exploration; OR, operating room.

Hospital Association Annual Survey provided data on hospital characteristics, including size, teaching status, and technology capabilities. The University of Pennsylvania Institutional Review Board approved this study (#819470).

Outcome Variables

The patient outcomes studied were ICU admission, in-hospital mortality, and 30-day mortality. We identified ICU admission by using revenue center codes. Admissions to intermediate care and psychiatric units were not considered ICU admissions. In-hospital mortality was defined as a death that occurred during the index hospitalization. Thirty-day mortality was defined as a death that occurred within 30 days of admission to the index hospital. Additionally, we examined a joint outcome, ICU admission or death within 30 days of hospital admission, to capture a death that may have been avoided had the patient been admitted to the ICU. Patients were counted only once for either event in the joint outcome.

Nurse Work Environment

The predictor variable in our analysis was the nurse work environment, which was measured by using the Practice Environment Scale of the Nursing Work Index (PES-NWI), a measure endorsed by the National Quality Forum.[17] The PES-NWI is a 31-item scale with 5 subscales that measure professional nursing practice, including quality, staffing, resources, and interprofessional communication.[18] Items were rated on a 4-point Likert scale ranging from strongly disagree to strongly agree, with higher scores indicating more favorable work environments. The PES-NWI subscales are reliable measures at both the nurse and hospital levels, with Cronbach α ranging from 0.71 to 0.84; subscale scores and a composite measure of the nurse work environment have been tested for validity and the ability to detect differences between hospitals.[18] Nurse responses in our analysis were aggregated among nurses working in each hospital setting to obtain hospital-level mean scores; hospitals were then classified as having good (top 25%), mixed (middle 50%), or poor (bottom 25%) work environments.

Covariates

Patient-level adjustment variables included demographic data (ie, age, sex), comorbidities identified by the Elixhauser Comorbidity Index (excluding fluid and electrolye disorders and coagulopathy), and diagnosis-related groups (to represent surgical procedures).[19,20] Hospital-level adjustment variables included size, teaching status, and technology capabilities. Hospital size was determined by the number of beds and categorized into 3 groups: small, 100 or fewer beds; medium, 101 to 250 beds; and large, more than 250 beds. Teaching status was determined by the ratio of medical trainees to hospital beds and categorized into 3 groups: nonteaching, 0 trainees; minor teaching, a ratio less than or equal to 1:4; and major teaching, a ratio greater than 1:4. Hospitals that reported facilities for open-heart surgery, major organ transplantation, or both were defined as high technology.

Analysis

Patient and hospital characteristics were summarized with descriptive statistics. Using the χ^2 test, we assessed these characteristics for differences in ICU admission and mortality across groups of hospitals with different work environments. Multilevel logistic regression models were used to estimate the effects of the nurse work environment on patient outcomes after adjusting for patient and hospital characteristics. Huber-White sandwich estimators accounted for clustering of patients within hospitals.[21] This estimator is appropriate for cluster-correlated data, as the clusters (ie, hospitals) are independent, but the observations within each hospital (ie, patients) may not be independent. Data management and analysis were performed with Stata 15 statistical software.[22]

Results

We identified 269 764 patients admitted for general, orthopedic, or vascular surgeries in 453 hospitals (Table 2). Twelve percent of patients were admitted to an ICU during their index hospitalization. Admission to an ICU varied significantly by surgical group, with vascular surgical patients having the highest use of ICUs (47.4%), followed by general (18.2%) and orthopedic (5.9%) surgical patients. Among all surgical patients, in-hospital mortality was 1.8% and 30-day mortality was 3.1%.

Hospital characteristics are described in Table 3. Hospital size, teaching status, and technology capabilities varied significantly across the categories of the hospital nurse work environment. Hospitals with the best nurse work environments were nonteaching hospitals with more than 250 beds.

Table 2: Patient Characteristics and Outcomes

Outcome	All Patients (N=269 764)	Surgical Procedure Group[a] General (n=76 168)	Orthopedic (n=176 359)	Vascular (n=17 237)	*P* value
ICU admission, %	12.0	18.2	5.9	47.4	< .01
In-hospital mortality, %	1.8	2.8	0.7	7.9	< .01
30-day mortality, %	3.1	4.3	1.9	10.6	< .01
Characteristic					
Age, mean	76.7	76.3	76.9	76.0	< .01
Male sex, %	61.9	60.7	65.2	35.8	< .01
Elixhauser comorbidities, %					
0	11.2	11.0	11.9	4.5	< .01
1	25.8	23.9	27.5	15.8	
2	28.3	27.8	28.8	26.0	
3	20.1	20.8	19.1	26.3	
≥4	14.6	16.5	12.7	27.4	

Abbreviation: ICU, intensive care unit.

[a] χ^2 tests were used to test for differences between surgical procedure groups.

Table 3: Hospital Characteristics

Characteristic, n (%)	All Hospitals (N=453)	Nurse Work Environment[a] Poor (n=114)	Mixed (n=226)	Good (n=113)	*P* value[b]
Hospital size					
≤100 beds	37 (8.2)	10 (8.8)	13 (5.8)	14 (12.4)	.11
101-250 beds	196 (43.3)	65 (57.0)	86 (38.1)	45 (39.8)	.003
>250 beds	220 (48.6)	39 (34.2)	127 (56.2)	54 (47.8)	.001
Teaching status					
No residents	214 (47.2)	67 (58.8)	93 (41.2)	54 (47.8)	.009
Minor teaching program	198 (43.7)	44 (38.6)	107 47.3)	47 (41.6)	.27
Major teaching program	41 (9.1)	3 (2.6)	26 (11.5)	12 (10.6)	.02
Technology status					
Low	252 (55.6)	80 (70.2)	116 (51.3)	56 (49.6)	.001
High	201 (44.4)	34 (29.8)	110 (48.7)	57 (50.4)	.001

[a] Poor work environment is the lowest 25th percentile; mixed work environment is the middle 50th percentile; good work environment is the highest 25th percentile.
[b] *P* value represents comparisons between nurse work environments using χ^2 tests.

In unadjusted analyses, the odds of ICU admission, in-hospital mortality, and 30-day mortality were significantly lower for patients in hospitals with good nurse work environments than for those in hospitals with poor or mixed nurse work environments (Table 4). These differences remained after adjusting for patient and hospital characteristics. In the fully adjusted model, which accounts for patient and hospital factors, we found that surgical patients in hospitals with good versus mixed nurse work environments and mixed versus poor nurse work environments had 16% lower odds of being admitted to an ICU, 12% lower odds of in-hospital mortality, 11% lower odds of 30-day mortality, and 15% lower odds of being admitted to an ICU or 30-day mortality.

The nurse work environment is a categorical variable with 3 levels (0 = poor, 1 = mixed, 2 = good). Since the effects from logistic regression models are multiplicative, the odds ratios represent the difference in the odds for patient outcomes between hospitals with good versus mixed environments and mixed versus poor

Table 4: Effect of Nurse Work Environment on Patient Outcomes Before and After Adjustments[a]

	Nurse Work Environment			
	Unadjusted Model		Fully Adjusted Model	
Patient Outcomes	OR (CI)	OR^2 (CI)	OR (CI)	OR^2 (CI)
ICU admission	0.85 (0.77-0.93)[b]	0.72 (0.59-0.86)[b]	0.84 (0.75-0.94)[c]	0.71 (0.56-0.88)[c]
In-hospital mortality	0.85 (0.79-0.91)[b]	0.72 (0.62-0.83)[b]	0.88 (0.82-0.94)[b]	0.77 (0.67-0.88)[b]
30-day mortality	0.83 (0.79-0.89)[b]	0.69 (0.62-0.79)[b]	0.89 (0.84-0.94)[b]	0.79 (0.71-0.88)[b]
ICU admission or 30-day mortality	0.84 (0.78-0.92)[b]	0.71 (0.61-0.85)[b]	0.85 (0.77-0.93)[b]	0.72 (0.59-0.86)[b]

Abbreviations: ICU, intensive care unit; OR, odds ratio; OR^2, squared odds ratio.

[a] OR, OR^2, and CIs were derived from regression models that accounted for clustering of observations within hospitals. Patient adjustments were age, sex, comorbidities, and diagnosis-related group. Hospital adjustments were size, teaching status, and technology status.
[b] $P \leq .001$.
[c] $P \leq .01$.

environments. To estimate the difference in odds for patient outcomes in hospitals with good versus poor environments we calculated squared odds ratios. Surgical patients in hospitals with good versus poor environments had 29% lower odds of being admitted to an ICU, 23% lower odds of in-hospital mortality, 21% lower odds of 30-day mortality, and, 28% lower odds of being admitted to an ICU or 30-day mortality. Patients in hospitals with poor nurse work environments had the highest occurrence of ICU use or 30-day mortality (16.1%; Figure); patients in the best nurse work environments had the lowest occurrence (12.1%).

Discussion

Main Findings

In this study, we found that surgical patients in hospitals with good nurse work environments were significantly less likely to be admitted to the ICU than patients in hospitals with mixed or poor nurse work environments. Also, patients not admitted to the ICU had significantly lower odds of mortality, indicating that hospitals with good nurse work environments may be better equipped to provide high-quality care in a non-ICU setting, such as a surgical floor.

In prior studies, researchers have found that hospitals have similar patterns of ICU utilization across patient conditions, indicating that institutional factors may influence ICU admission decisions.[3,8,10] Our study brings a new understanding to a potential source of and potential solution to variation in ICU utilization across hospitals: the nurse work environment. Good nurse work environments are those that promote high quality professional practice and clinical care, including professional autonomy, effective leadership and interprofessional relationships, inclusion in institutional decisions, and adequate staffing and patient-care resources.[18]

Within ICUs, nurses routinely work as part of an interprofessional team because of the complex nature of critically ill patients. This team-based structure requires all members understanding the unique contribution of each role and closely collaborating to achieve a common goal.[23,24] As such, nurses in ICUs maintain a high degree of clinical authority and autonomy, and they often report effective teamwork.[25,26] Nurses on medical-surgical units with good environments likely have these same attributes, possibly explaining why patients in good nurse work environments have lower odds of ICU admission. In hospitals where nurses on medical-surgical units have good work environments, surgeons may be more inclined to admit their postoperative patient to a floor instead of to an ICU.

Importantly, the characteristics of the nurse work environment can be modified and improved via hospital leadership. For example, the American Nurses Credentialing Center Magnet Recognition Program is an evidenced-based way to improve the nurse work environment.[27] This voluntary program provides a blueprint for transforming the work environment in an organization. Magnet designation is conferred to those hospitals whose organizational culture supports an excellent nurse work environment, as measured by nurse and patient outcomes.[28] The process of

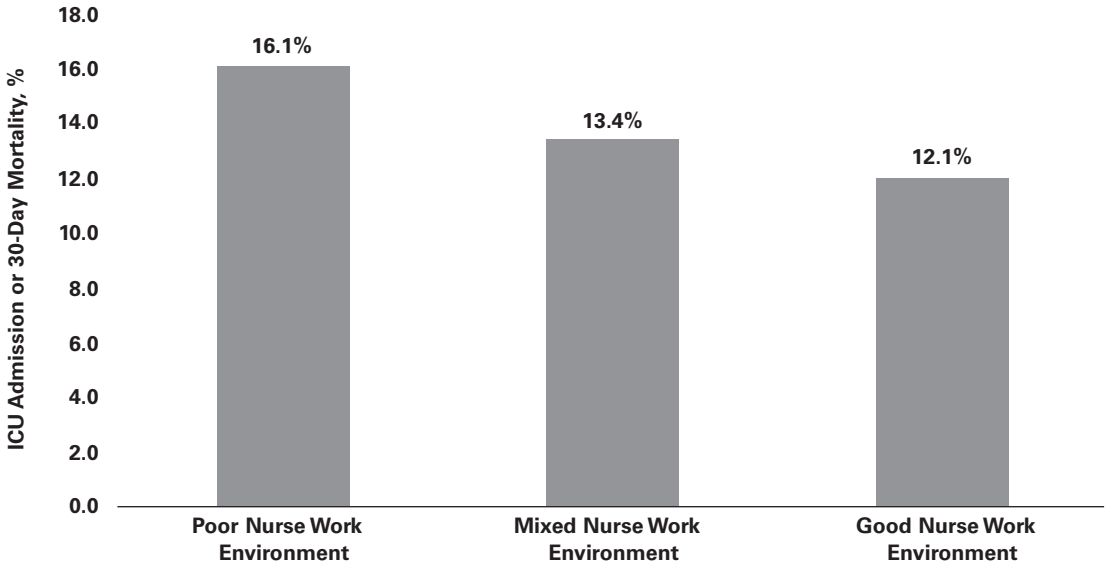

Figure: Percentage of patients who were admitted to the ICU or who died within 30 days of admission by quality of nurse work environment. Values were compared by using analysis of variance; all differences were significant ($P < .001$). Poor work environment is the lowest 25th percentile; mixed work environment is the middle 50th percentile; good work environment is the highest 25th percentile. ICU indicates intensive care unit.

applying for Magnet designation takes, on average, 4.25 years, which demonstrates the time investment needed to develop and maintain an organizational culture that supports professional nursing.[29] This investment is beneficial for hospitals and patients, as Magnet hospitals report better outcomes. Patients receiving care in Magnet hospitals have lower rates of mortality and failure to rescue, indicating that the nurses in these hospitals are better able to detect patient deterioration and to intervene to prevent complications.[30,31]

In a study of surgical patients, Silber et al[32] found lower rates of ICU utilization among patients in hospitals with Magnet recognition. The authors hypothesized that nurses in good nurse work environments were able to provide better care in non-ICU settings for some patients, thus avoiding admitting those patients to an ICU. In our study, we used a nurse-reported measure of the work environment, an advancement of prior work that used Magnet recognition as a proxy measure of a good nurse work environment. Magnet hospitals represent only 9% of hospitals, and hospitals that achieve Magnet status tend to have similar hospital system structures, such as being large, centralized health care systems.[33] Previous analyses of the RN4CAST data used in this study demonstrate that the survey provides data on a large and unbiased sample of hospitals.[11] Our findings build upon the evidence from Silber et al by using the PES-NWI as a more discrete measure of the quality of the nurse work environment among a larger sample of surgical patients.[15]

Beyond the Magnet Recognition Program, hospitals can routinely assess the quality of the nurse work environment. The PES-NWI is the most widely used tool for measuring the quality of a nurse work environment; it can provide focus for interventions to strengthen the nurse work environment and monitor changes over time.[18,34,35] Based on the PES-NWI categories, specific strategies to improve the nurse work environment at the unit and hospital level have been summarized in a study by Twigg and McCullough.[36] Strategies include ensuring that nurses serve on hospital committees, creating a nursing research committee and encouraging its members to present at conferences, providing leadership development for nurse managers, developing adequate nurse staffing models, and establishing nurse-physician coleadership positions.[36] Findings from this study suggest that in future research, investigators should consider the nurse work environment as a modifiable intervention for reducing variation in ICU utilization.

Within hospitals, one of the principal differences between ICU and non-ICU care is the

amount of nursing care provided. Nurse staffing in ICUs is generally less variable than staffing on medical and surgical units, where the workload is about 5 patients per nurse on average but has ranged up to 10 patients per nurse in some hospitals.[16,37] A large body of evidence demonstrates associations between lower nurse workloads and better patient outcomes, including lower rates of postoperative mortality and failure to rescue.[38-40] However, various measures of hospital nurse staffing (eg, full-time equivalent nurses per 1000 patient days, fraction of nurses to hospital beds) have not been associated with variation in ICU use across hospitals.[10,41,42] Thus, to estimate the effect of nursing care on patient utilization of ICUs, we used a nurse work environment measure to assess aspects of nursing care not captured by nurse staffing measures.

The implications of our findings are particularly salient in the context of the COVID-19 pandemic, which maximally stressed health care systems and providers to meet the surging demands for acute and critical care. A survey of academic health centers across the United States found that, to adjust during the pandemic, two-thirds of hospitals added new staff or changed staffing ratios and nearly half of hospitals increased their number of inpatient beds, particularly ICU beds.[43] Our findings suggest that during the pandemic, fewer additional ICU beds may have been needed if, during the pre-pandemic period, hospitals had good nurse work environments and enough nurses to safely care for patients in lower acuity settings.

Limitations

This study should be considered within the context of several limitations. First, although the data sources in our study are from 2006 to 2007, no other data set has the type of information about nurse work environments and patients in as many hospitals as we were able to study. This study is the first study to directly link the nurse work environment to ICU use. Future studies are needed to account for known changes in hospital characteristics, such as the growing utilization of intermediate care units,[44] and changes in diagnoses and acuity of ICU populations.[45,46] To corroborate the relationship we found between the nurse work environment and ICU use in this study, additional research is needed in other patient populations, such as patients admitted for medical conditions. Second, the use of administrative data limited the ability to capture certain relevant information, such as whether ICU admission was planned or unplanned and whether ICU admission occurred directly after surgery or later during the hospital stay. Nevertheless, administrative data allowed the analysis of hundreds of thousands of patients in hundreds of hospitals. Third, the study's cohort consisted of Medicare beneficiaries and may not be generalizable to patients younger than 65 years or to non-US health care systems, although Medicare beneficiaries account for a significant proportion of hospital and ICU admissions in the United States.

Conclusion

Patients in hospitals with better nurse work environments had lower odds of postsurgical ICU use and lower odds of mortality than patients in hospitals with poorer nurse work environments. Hospitals with better nurse work environments may be better equipped to provide patient care in a lower acuity setting without compromising a patient's odds of mortality. Avoiding unnecessary ICU admission has clinical benefits for patients. Our findings suggest that ICU utilization can be reduced through interventions that improve the work environments of hospital nurses.

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