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Nurse Staffing and Post Surgical Outcomes in Black Patients

J. Margo Brooks Carthon, PhD, RN [Assistant Professor], Ann Kutney-Lee, PhD, RN [Assistant Professor], Olga Jarrín, PhD, RN [Post-Doctoral Fellow], Douglas Sloane, PhD [Adjunct Professor], and Linda H. Aiken, PhD RN [Professor]

Center for Health Outcomes and Policy Research, University of Pennsylvania School of Nursing, Philadelphia, PA

Abstract

Objectives—To determine the association between nurse staffing and postsurgical outcomes, including 30-day mortality and failure-to-rescue among older black patients.

Design and Setting—A cross-sectional study of University of Pennsylvania Multi-State Nursing Care & Patient Safety Survey data, linked to 2006–07 administrative patient discharge data from four states (CA, PA, NJ, FL), American Hospital Association Annual Survey data, and a U.S. Census-derived measure of socioeconomic status (SES). Risk-adjusted logistic regression models with correction for clustering were used for the analysis.

Participants—Patients age 65 and over having general, orthopedic and vascular surgeries. Our final sample included 548,397 patients: 94% white and 6% black.

Measurements and Results—In models adjusting for sex and age, 30-day mortality was significantly higher for black than white patients [Odds Ratio (OR)=1.42, 95% confidence interval (CI) 1.32–1.52]. In fully adjusted models that accounted for patient SES, surgery type, and comorbidities, as well as hospital characteristics, including nurse staffing, the odds of 30-day mortality were not significantly different for black than white patients. In the fully adjusted models, one additional patient in the average nurse's workload was associated with higher odds of 30-day mortality for all patients [OR 1.03, 95% CI 1.01–1.05]. We detected a significant interaction between race and nurse staffing for 30-day mortality, such that blacks experienced higher odds of death with each additional patient per nurse (OR=1.10; 95% CI 1.03–1.18) compared to whites (OR=1.03; 95% CI 1.01–1.06). Similar patterns were detected in failure-to-rescue models.

Conclusion—Older surgical patients experience poorer post surgical outcomes, including mortality and failure-to-rescue, when cared for by nurses with higher workloads. The impact of nurse staffing inadequacies is more significant in older black patients.

Keywords

Disparities; Nursing care; Surgical outcomes

Corresponding Author, 418 Curie Blvd., Claire Fagin Hall, University of Pennsylvania School of Nursing, Philadelphia, PA 19104, (215)898-8050 (phone), jmbrooks@nursing.upenn.edu.

Author Contributions:

All authors were involved in the concept and design of the study, data analysis, interpretation of results, and preparation of the manuscript.

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INTRODUCTION

Racial disparities following operative procedures have been widely documented in the health sciences literature.^{1–7} Black Americans are less likely to undergo necessary operative procedures⁸ and, compared to their white counterparts, are at greater risk of experiencing poorer outcomes, including excess mortality^{3,5,6} and complications following surgery.⁹ Older black patients in particular may bear a disproportionate burden of post surgical mortality risk due to a mixture of individual- and institutional-level factors including lower socio-economic status (SES),^{10–11} increased incidence and severity of medical comorbidities, and differences in quality within the institutions where minority patients receive care.¹² While a number of studies have suggested that differences in hospital quality influence healthcare disparities, left unanswered is how the quality of nursing care within these institutions may affect minority patient outcomes.

Over the past two decades, a growing body of research has systematically demonstrated an inverse relationship between nurse staffing and adverse events.^{13–14} Inadequate nurse staffing has been linked to higher mortality rates,^{13,15} pressure ulcers,¹⁶ and hospital acquired infections.¹⁴ By virtue of their direct and frequent contact with patients, nurses constitute around-the clock-surveillance systems in hospitals and are in key positions to detect changes in patient status and prompt intervention when patients' conditions deteriorate.¹⁷ Theoretically, if minority older adults receive sub-optimal nursing care due to poor nurse staffing, then patient assessment may be compromised, leading ultimately to avoidable adverse outcomes.

To assess the influence of nurse staffing on post surgical outcomes for older minority patients, we analyzed four linked data sources: 2006–07 administrative patient discharge data from 4 states (CA, PA, NJ, FL), American Hospital Association (AHA) Annual Survey data, U.S. Census data, and data from the University of Pennsylvania Multi-State Nursing Care & Patient Safety Survey.^{18,19} The primary outcomes were 30-day mortality and failure-to-rescue, or death following a complication, among older black and white patients undergoing general, vascular and orthopedic surgery. Our analyses were conducted to assess for outcome disparities both between and within hospitals.

METHODS

Data Sources

This study included 599 adult nonfederal acute care hospitals in California, Pennsylvania, New Jersey, and Florida that (1) had at least 100 surgical discharges during the study period, (2) responded to the 2006 American Hospital Association (AHA) Annual Survey of Hospitals, and (3) were represented by respondents to the Multi-State Nursing Care & Patient Safety Survey (2005–2007).^{18,19} We merge the cross-sectional nurse survey data with administrative hospital and patient discharge data by a unique hospital identifier. Patient discharge data were obtained from California's Office of Statewide Health Planning and Development (OSHPD), Florida's Agency for Health Care Administration (AHCA), the New Jersey Department of Health and Senior Services (NJDHSS), and the Pennsylvania Health Care Cost Containment Council (PHC4). These four states were selected because they are among the largest in the country and account for more than one-fifth of the nation's hospitalizations. Moreover, the hospitals represented in our nurse survey represent over 86% of all acute care hospitals in these four states, and conduct 90% of all adult general, vascular and orthopedic operations. Over 100,000 nurses responded to our Multi-State Nursing Care & Patient Safety Survey, which was mailed to large random samples of all registered nurses in California, New Jersey, and Pennsylvania in 2005–2006, and in Florida in 2006–2007.¹⁹ For this study, we used responses of the 26,944 hospital staff nurses working in direct

patient care, including information on hospital-specific nurse staffing in our 599 study hospitals (on average, 45 nurses per hospital [range 10–282]). Publicly available U.S. Census data were used to derive a neighborhood socioeconomic index for each ZIP code in the four states.

Measures

Patient characteristics—The patient sample was composed of all patients aged 65–99 with a Diagnosis Related Group (DRG) for general, orthopedic, or vascular surgery with a length of stay of at least one day. Patients admitted between January 1, 2005, and December 31, 2006 in California, New Jersey, and Pennsylvania, and between January 1, 2006 and December 31, 2007 in Florida were included in the analysis. These operations were selected because they are common, are associated with well-known adverse occurrences, and are performed in most general hospitals. Race data was obtained from the patient discharge records, and patients categorized as white or black were included in our analytic sample. In addition to race and sex, other patient characteristics were included in our risk-adjustment models, including age, the primary DRG for the admission, whether the admission was a transfer from another hospital, insurance type (Medicare, Medicaid, or other), and a set of dummy variables indicating the presence of 27 individual comorbidities as defined by Elixhauser, Steiner, Harris, & Coffey.²⁰ Fluid and electrolyte disorders and coagulopathies were excluded from our risk adjustment models as studies have shown that these conditions may be indicators of complications rather than comorbidities, and should not be used when “present on admission” data are missing.^{21–22} Finally, based on their home zip code, each patient was assigned a Neighborhood Socioeconomic Summary Index score.²³ This index includes six aggregate measures of wealth/income, education and occupation/employment that were derived from 2000 U.S. Census data. The socioeconomic summary index was created by summing the z-score for each of the six measures and ranged from –14 to 32, with higher scores corresponding to higher neighborhood socioeconomic status.

Hospital characteristics—The 2006 AHA Annual Survey provided data on several structural characteristics of the hospitals. Teaching status was defined by the number of medical residents and fellows, and was classified as major (>1:4 trainee to bed ratio), minor (<1:4 trainee to bed ratio), or non-teaching (no medical trainees). Hospital size was classified as large (>251 beds), medium (101–250), and small (<100 beds). Technology status was defined as high if the hospital had facilities for open-heart surgery, major organ transplants, or both. Core Based Statistical Area (CBSA) is a census-based measure of population density defined by the Office of Management and Budget and is divided into four categories: division (>2.5 million), metro (50,000–2.5 million), micro (10,000–50,000), and rural (<10,000).

Nurse Staffing

Nurse staffing was calculated as the average number of patients on the unit on the last shift divided by the average number of RNs on the unit as reported by all nurse survey respondents. Throughout the text, references to nurse staffing levels refer to the average patient-to-nurse ratios across a 24-hour period.

Outcomes—Thirty-day mortality was defined as death within 30 days of admission. In addition to using the variable of discharge status to identify deaths, patient records were linked to vital statistics by the various state agencies to determine if patients died outside the hospital.

Failure-to-rescue was defined as death following the development of a complication in the hospital after surgery.²⁴ Using Silber and colleagues’ methodology, patients who developed

one of 39 clinical events were identified, and a variable was created to indicate failure-to-rescue if the patient subsequently died.²⁵ Models that examined failure-to-rescue as an outcome included only patients who had experienced a complication. Failure-to-rescue has well-established psychometric properties and provides a strong theoretical base for studying the impact of organizational characteristics on patient outcomes.^{25–28}

Data Analysis—We first examined descriptive differences between black and white patients on demographic and clinical risk factors, as well as frequency of complications, failure-to-rescue, and 30-day mortality. We then explored the characteristics of hospitals, including nurse staffing, where black and white patients were admitted. Differences in proportions for categorical variables were evaluated using χ^2 tests; while t tests were used to evaluate the significance of mean differences for continuous variables.

Robust logistic regression models were used to examine the effect of race and nurse staffing on 30-day mortality and failure-to-rescue. We used Huber/White sandwich estimators to adjust the standard errors for clustering of patients and nurses within hospitals. Models were constructed in hierarchical fashion so that each subsequent model added a variable, or set of variables to those included in the previous model. Model 1 included race, age, and sex. Model 2 added the Neighborhood SES Index.¹⁰ Model 3 added the set of patient characteristics defined previously, including surgical DRG, comorbidity dummies, insurance type, and transfer status. Model 4 then added the hospital characteristics, including bed size, teaching status, technology status, CBSA and state dummies, as well as nurse staffing. We then fit a series of interaction models between race and nurse staffing to explore how the impact of nursing staffing levels on outcomes may vary depending on race (Model 5). Subsample analyses were undertaken that produced effect sizes for nurse staffing for black and white patients separately.

In a separate analysis, we fit a series of fixed-effects logistic regression models using a set of hospital dummy variables. Similar to our logistic regression approach, we added each set of adjustment variables to the fixed-effects models in sequence to assess the extent to which odds of 30-day mortality and failure-to-rescue differed between black and white older patients, accounting for both measured and unmeasured characteristics of the different hospitals to which patients were admitted.

Sensitivity Analysis—We conducted a number of sensitivity analyses to determine the impact of other commonly studied patient and hospital characteristics. To assess the impact of severity of illness, we examined our outcomes of interest using the Charlson Score.²⁹ There was no significant difference in our outcomes using Elixhauser controls as opposed to the Charlson, thus Elixhauser risk adjustment was used in the final models to account for medical comorbidity. Moreover, a number of studies have shown that the Elixhauser approach has better discrimination as compared to other approaches for risk adjustment using administrative data.^{30,31} To assess the impact of a hospital's payer mix, we created a measure of the proportion of patients in a hospital with Medicaid as a proxy for hospital-level SES. Both in unadjusted bivariate models and in fully adjusted multivariate models for mortality and failure-to-rescue, this measure was statistically insignificant. We also tested a number of other interactions between race and SES, and race and gender. Each of these interactions was also insignificant. All analyses were performed using Stata version 11.0 (STATA Corp, College Station, TX).

RESULTS

Patient and Hospital Characteristics

A comparison of the patient characteristics and clinical preoperative risk factors of our sample shows significant differences between racial groups (Table 1). On average, black patients were slightly younger, lived in neighborhoods with lower socioeconomic status, and had significantly more comorbidities compared to white patients. Half of the black patients in the sample experienced a post-surgical complication compared to 42% of white patients ($P<0.001$). The most common complications across the sample included G.I. bleed, renal dysfunction and respiratory compromise. Despite elevated complication rates among all older surgical patients, there was no significant difference between the groups in terms of their failure-to-rescue rates. About 4% patients in both groups died within 30 days of admission, however the percentage was slightly higher among black patients (4.3% vs. 3.7%, $P<0.001$).

Table 2 describes the distribution of hospital characteristics for our samples of black and white patients. Black patients were more likely to have operations in larger, urban, teaching hospitals as well as hospitals with high technology capability. About 44% of older black patients were cared for in hospitals where nurses cared for 5 patients or fewer on average as compared to 41% of white patients ($P<0.001$).

Table 3 displays the odds ratios for 30-day mortality and failure-to-rescue for black patients across all hospitals in the sample. The 30-day mortality models included all patients ($n=548,397$). In Model 1, which controlled for only age and sex, black patients had higher odds of dying within 30 days than white patients, by a factor of 1.42 (95% confidence interval (CI) 1.32–1.52). After adjusting for SES (Model 2), the difference in mortality between black and white patients was attenuated slightly, with the odds ratios indicating that the odds of dying were 1.29 (95% CI 1.20–1.39) times greater for black than white patients. Once patient characteristics were taken into account in Model 3, the odds of 30-day mortality were reversed and lower for black patients than white patients, by a factor of 0.91 (95% CI 0.84–0.98), or by 9 percent. After the addition of hospital and nursing characteristics (Model 4), the odds of 30-day mortality for black patients were not significantly different from that of white patients. In this model, the odds of death increased for all patients by a factor of 1.03 (95% CI 1.01–1.05) with each additional patient in the average nurse's workload.

We found roughly similar patterns in the failure-to-rescue models that included patients who had experienced a complication ($n=231,390$). In the unadjusted models, black patients had higher odds of failure-to-rescue than white patients, by a factor of 1.14 (95% CI 1.07–1.23), when only sex and age were controlled. After adjustment for SES in Model 2, the magnitude of these differences became insignificant, and once patient characteristics were added in Model 3, the difference in failure-to-rescue between black and white patients was reversed, with black patients having significantly lower odds of failure-to-rescue, by a factor of 0.84 (95% CI 0.78–0.91). Once controls were added for hospital and nursing effects, the odds of failure-to-rescue were 12% lower for black patients (Odds Ratio(OR)=0.88, 95% CI 0.81–0.95). Though none of the other hospital-level characteristics were significant, we found here too that the odds of failure-to-rescue were higher for patients in settings with poorer nursing staffing (Odds Ratio=1.04, 95% CI 1.01–1.06).

Finally, we detected a significant interaction between race and nurse staffing (Model 5) for the outcome of 30-day mortality, such that black patients experienced higher odds of death (OR=1.10; 95% CI 1.03–1.18) than whites (OR=1.03; 95% CI 1.01–1.05). Similar effect sizes were demonstrated for the outcome of failure-to-rescue, where black patients had

higher odds of dying after a complication (OR=1.10; 95% CI, 1.03–1.17) as compared to whites (OR=1.03; 95% CI 1.01–1.06). A subsample analysis conducted on black and white patients separately confirmed these findings. In fully adjusted models without the interaction, the odds of 30-day mortality with each additional patient per nurse among blacks increased by a factor of 1.10 (95% CI 1.02–1.18), while the odds of mortality for whites increased by a factor of 1.03 (95% CI 1.01–1.05). Similarly, for each additional patient in the average nurse's workload, the odds of failure-to-rescue among blacks increased by a factor of 1.10 (95% CI 1.02–1.18), while the odds of failure-to-rescue for whites increased by a factor of 1.04 (95% CI 1.01–1.06).

To make the interpretation of the interaction more accessible, predicted probabilities of 30-day mortality were calculated for black and white patients under various conditions of staffing, given patients' demographics, comorbidities and surgical type. Figure 1 shows that although higher nurse workloads significantly increase the likelihood of death for all patients, there is a pronounced adverse effect on the predicted probability of death for black patients. The figure suggests that the probability of death for black patients is equal to that of white patients when the patient to nurse ratio is low (between 3 and 4 patients per nurse), while in poorly staffed hospitals black patients have much higher mortality than in well-staffed hospitals, and much higher mortality than white patients.

In our assessment using fixed effects models, which allow for all measured and unmeasured differences in mortality that result from patients being in different hospitals, we see the same evidence of the relative importance of patient characteristics. (see Table 4 in Appendix) Controlling only for age and gender (Model 1), black patients had higher odds of death by a factor of 1.25 (95% CI 1.17–1.33). After adjustment for SES (Model 2), the effect of race-associated differences in mortality diminished to 1.19 (95% CI 1.12–1.27). Following the addition of other patient characteristics (Model 3) however, including medical comorbidities and surgical DRG, the higher mortality odds for black patients not only disappeared, but were reversed, and were 12% lower for black relative to white patients (OR=0.88, 95% CI 0.82–0.94). With all patient controls in place, there were no significant differences between black and white patients with respect to failure-to-rescue.

DISCUSSION

Using patient- and hospital-level data, we examined the effects of patient, hospital, and nursing characteristics on patient mortality and whether nurse staffing in particular was related to post-surgical 30-day mortality and failure-to-rescue among older black patients. Our results uncovered significant relationships between patient underlying health status and post surgical outcomes. Most importantly in a diverse set of hospitals, after accounting for patient characteristics, including SES and level of individual health risk, we found an association between nurse staffing and mortality outcomes among black surgical patients. To our knowledge, this is the first study to provide empirical evidence demonstrating an association between nurse workload and minority patient outcomes.

Older black patients had a significantly greater unadjusted risk of 30-day mortality and failure-to-rescue than their white counterparts *across* hospitals in our sample. However, these differences were fully explained after adjustment for socioeconomic status, the types of operative procedures (DRG), and individual health status. We were admittedly surprised to find lower adjusted 30-day mortality among older black patients, specifically in light of persistent documented health disparities throughout the U.S. healthcare system.³² Nevertheless, a number of studies have found that older black patients have better outcomes than white patients^{33, 34, 35} and that this survival advantage becomes more pronounced after controlling for care sites.³⁶ The difference between our findings and those of others³⁷ is

that we detected better surgical outcomes for older black patients only after adjusting for patient characteristics such as medical comorbidities.

Our comparisons of postsurgical outcomes *within* sites of care revealed elevated unadjusted mortality risk among older black patients. Our findings suggest that when older black patients are hospitalized at the same sites as white patients, comorbid medical conditions significantly explain hospital mortality differences over and above the site of care. The consistency of our results taken across mortality and failure-to-rescue measures within and between acute care sites suggests that underlying health status and SES function as critical key determinants of postsurgical outcomes among older black patients.

Our results have important implications for hospital care, specifically as it relates to nursing. While we found little predictive effect of hospital structural characteristics such as teaching status and bed size on our primary outcomes, we found that all older patients, irrespective of race, benefit from optimal nurse staffing. These findings are consistent with other studies that have found strong associations between the availability of nursing resources and patient outcomes, including a seminal IOM report, *Keeping Patients Safe: Transforming the Work Environment of Nurses*,³⁶ which cited nurse staffing as an important factor in improving patient outcomes, and a recent review by Kane et al,³⁹ which demonstrated similar associations across a range of studies.

Although we find that all patients are adversely affected by higher patient-to-nurse ratios, older black patients are more likely than white patients to suffer unfavorable outcomes when cared for by nurses with higher workloads and more patient demands. The presence of increased complex comorbidities among black patients may make them more vulnerable to surveillance failures and missed care when patient-to-nurse ratios are higher. These findings carry important clinical weight for older minority patients. In busy settings such as those found in many postoperative step-down and medical surgical units, nurses' ability to monitor and detect changes in patient status hinges in large part upon their workloads. To the degree that older minority patients are cared for within hospitals with suboptimal nursing resources, they face significant risk post-operatively. From a clinical perspective our results suggest that hospital organizations should develop care environments that integrate the individual patient care needs of older minority adults with system-level improvements in nursing care.

Limitations

We note some limitations to our study. Because this study relied on cross-sectional nurse survey and patient discharge data we were unable to determine causality. We also acknowledge limitations in the reliability of the racial designations of our sample due to our use of administrative data.⁴⁰ In addition, our results may not be attributed to nurse staffing alone but may be influenced by other unmeasured factors such as the environment where nurses work, Magnet status, or other characteristics of the hospital's workforce. Our study of hospitals includes four of the most populous U.S. states. However, they may not be representative of hospitals in the Midwest and Deep South, which were not included in our sample. The omission of the Deep South admittedly represents a large sector of black patients who have suffered historically with poorer health outcomes, segregation and poverty,⁴¹ hence our findings might have varied with their inclusion. Also, we are unable to determine the influence of 'do not resuscitate' (DNR) orders or advanced directives on our findings as these data elements were not available in the patient discharge files. Our findings may not fully account for unmeasured confounding that might persist even after multivariable model risk adjustment, such as differences in baseline characteristics including cognitive and functional status, and social support.⁴² Because this analysis is based on data extracted from administrative data, the risk of selection bias may also exist, since older

adults who are selected for invasive procedures may differ in unmeasurable ways, such as severity of underlying illness, from patients who are not.⁴³ Finally, we relied on ZIP-code-level, as opposed to patient-level data to evaluate the role of SES on our three outcomes of interest. While this method has been validated in a number of previous studies,¹⁰ and is commonly used in research using administrative data,⁵ individual-level data would be invaluable in assessing the role of SES in explaining between-hospital differences in surgical outcomes by race.

Conclusion

Hospitalized surgical patients sometimes experience periods of instability in vital functions, and the quality of nursing care they receive has a significant impact on their recovery and well-being. This is particularly relevant to older black patients due to risk factors such as complex medical comorbidities that may compromise their physiological status postoperatively. Our finding that the odds of death for older black patients increased in hospitals where nurses carried heavier workloads has particular implications for the delivery of care and signals an important focus of future research and intervention. Our results suggest that comprehensively improving the quality of postsurgical outcomes of older black patients may come through maximizing the clinical resources of nurses at the bedside.

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Conflict of Interest:

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Appendix

Table 4

Fixed-Effect Odds Ratios (95% CI) by Race for 30-Day Mortality

	Sex/Age	SES	Additional Patient Characteristics
<i>30-Day Mortality</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>
Black	1.25 *** (1.17–1.33)	1.19 *** (1.12–1.27)	0.88 *** (0.82–0.94)
Male	1.62 *** (1.57–1.66)	1.62 *** (1.58–1.67)	1.19 *** (1.16–1.23)
Age	1.09 *** (1.08–1.09)	1.09 *** (1.08–1.09)	1.08 *** (1.07–1.08)
SES		0.99 *** (0.98–0.99)	0.995 ** (0.99–0.999)

NOTE:

* p 0.05
 ** p 0.01

p 0.001.

Models are presented in step-wise fashion so that each subsequent model includes the variables in the prior model. Coefficients for patient characteristics were suppressed due to space. Model 1 includes adjustment for sex and age. Model 2 adds Neighborhood SES Index. Model 3 adds patient characteristics: surgical DRG, 27 Elixhauser comorbidity dummies, insurance type, and transfer status.

Figure 1.
Effect of Nurse Staffing on 30-Day Mortality for Black and White Patients

Table 1

Characteristics of Older Adult Surgical Patients in the Study Hospitals by Race, 2005–07 (n=548,397)

Characteristic	White n=515,224 (94.0%)	Black n=33,173 (6.1%)	P value
<i>Age, mean ($\pm$SD)</i>	77.1 ($\pm$ 7.6)	74.9 ($\pm$ 7.3)	p<0.001
<i>Age, by category, no. (%)</i>			p<0.001
65–74	204,214 (39.6%)	17,742 (53.5%)	
75–84	217,370 (42.2%)	11,473 (34.6%)	
85+	93,640 (18.2%)	3,958 (11.9%)	
<i>Men no. (%)</i>	199,338 (38.7%)	11,723 (35.3%)	p<0.001
<i>Transfer from another hospital, no. (%)</i>	5,881 (1.1%)	418 (1.3%)	p<0.05
<i>Insurance type, no. (%)</i>			p<0.001
Medicare	472,437 (91.7%)	29,209 (88.2%)	
Medicaid	2,241 (0.4%)	687 (2.1%)	
Other	40,352 (7.8%)	3,235 (9.8%)	
<i>Neighborhood Socioeconomic Status, no. (%)</i>			p<.001
Low	45,463 (9.1%)	13,355 (41.1%)	
Average	238,633 (47.7%)	13,363 (41.2%)	
Above average	136,669 (27.3%)	3,995 (12.3%)	
High	79,642 (15.9%)	1,764 (5.4%)	
<i>Number of comorbidities, mean ($\pm$SD)</i>	2.1 ($\pm$ 1.5)	2.6 ($\pm$ 1.5)	p<0.001
Outcomes			
Any complication, no. (%)	214,946 (41.7%)	16,444 (49.6%)	p<.001
Failure-to-rescue (death after a complication), no. (%)	19,109 (8.8%)	1,415 (8.5%)	p=0.26
Deaths within 30 days of admission, no. (%)	19,109 (3.7%)	1,415 (4.3%)	p<.001

Note:*
p 0.05**
p 0.01***
p 0.001.

Average number of comorbidities as defined by Elixhauser (1998). Neighborhood SES measures created from U.S. Census ZIP code data using three dimensions: wealth/income, education, and occupation/employment (Birkmeyer et al., 2008). Percentages may not equal 100 due to rounding. Due to missing data, insurance status and SES do not equal 548,397.

Table 2**Study Hospital Characteristics by Race (n=548,397)**

Characteristic	White n=515,224	Black n=33,173	P value
Technology status (%)			<0.001
High	301,002 (58.4)	20,921 (63.1)	
Low	214,222 (41.6)	12,252 (36.9)	
Beds set up and staffed, no. (%)			<0.001
Large	316,188 (61.4)	23,680 (71.4)	
Medium	172,519 (33.5)	8,951 (27.0)	
Small	26,517 (5.2)	542 (1.6)	
Teaching status (%)			<0.001
Major	52,394 (10.2)	5,980 (18.0)	
Minor	206,111 (40.0)	15,093 (45.5)	
Non-teaching	256,719 (49.8)	12,100 (36.5)	
CBSA, no. (%)			<0.001
Division	184,786 (35.9)	20,242 (61.0)	
Metro	302,325 (58.7)	12,600 (38.0)	
Micro	25,856 (5.0)	320 (1.0)	
Rural	2,257 (0.4)	11 (0.03)	
<u>Staffing, patients per nurse</u>			
<5	<u>212,198 (41.2)</u>	<u>14,717 (44.4)</u>	<u><0.001</u>
5–6	<u>168,383 (32.7)</u>	<u>11,684 (35.2)</u>	
6–7	<u>78,502 (15.2)</u>	<u>4,303 (13.0)</u>	
>7	<u>56,141 (10.9)</u>	<u>2,469 (7.4)</u>	

Note:*
p 0.05**
p 0.01***
p 0.001.

Percentages may not add to 100 due to rounding. Due to missing data, total number for technology status does not equal 548,397. CBSA=Core Based Statistical Area

Table 3

Odds Ratios (95% CI) by Race for 30-Day Mortality and Failure-to-Rescue by Clusters of Individual, Hospital, and Nursing Characteristics

	Sex/Age	SES	Patient Characteristics	Hospital/Nursing Characteristics	Race*Staffing Interaction
<i>30-Day Mortality</i> <i>n=548,397</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Black	1.42 *** (1.32–1.52)	1.29 *** (1.20–1.39)	0.91 * (0.84–0.98)	0.94 (0.86–1.02)	0.95 (0.87–1.02)
Male	1.61 *** (1.56–1.66)	1.62 *** (1.57–1.67)	1.19 *** (1.15–1.24)	1.19 *** (1.15–1.23)	1.19 *** (1.15–1.23)
Age	1.09 *** (1.08–1.09)	1.09 *** (1.08–1.09)	1.08 *** (1.07–1.08)	1.08 *** (1.07–1.08)	1.08 *** (1.07–1.08)
SES		0.98 *** (0.97–0.98)	0.98 *** (0.98–0.99)	0.98 *** (0.98–0.99)	0.98 *** (0.98–0.99)
Nurse Staffing				1.03 ** (1.01–1.05)	1.03 * (1.01–1.05)
Black*Nurse Staffing					1.10 ** (1.03–1.18)
<i>Failure-to-Rescue</i> <i>n=231,390</i>	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>
Black	1.14 *** (1.07–1.23)	1.05 (0.97–1.13)	0.84 *** (0.78–0.91)	0.88 *** (0.81–0.95)	0.88 *** (0.82–0.96)
Male	1.46 *** (1.41–1.50)	1.46 *** (1.41–1.51)	1.18 *** (1.14–1.22)	1.17 *** (1.13–1.21)	1.17 *** (1.13–1.21)
Age	1.06 *** (1.06–1.07)	1.07 *** (1.06–1.07)	1.07 *** (1.06–1.07)	1.07 *** (1.06–1.07)	1.07 *** (1.06–1.07)
SES		0.98 *** (0.97–0.98)	0.98 *** (0.98–0.99)	0.98 *** (0.98–0.99)	0.98 *** (0.98–0.99)
Nurse Staffing				1.04 ** (1.01–1.06)	1.03 ** (1.01–1.06)
Black*Nurse Staffing					1.10 ** (1.03–1.17)

NOTE:

* p 0.05

p 0.01

p 0.001

Models are presented in step-wise fashion so that each subsequent model includes the variables in the prior model. Coefficients for patient and hospital characteristics were suppressed due to space. Model 1 includes adjustment for sex and age. Model 2 includes Neighborhood SES Index. Model 3 includes patient characteristics: surgical DRG, 27 Elixhauser comorbidity dummies, insurance type, and transfer status. Model 4 includes hospital characteristics: bed size, teaching status, technology status, CBSA, nurse staffing, as well as % of nurses working in medical-surgical and intensive care. Estimates for staffing represent the change in the odds associated with an increase of one patient in the average nurse's workload. Model 5 includes the significant interaction between race and nurse staffing. Surgical Patient Diagnosis Related Groups Included in the Analyses of Mortality and Failure to Rescue : General Surgery (146–155, 157–162, 164–167, 170,171,191–201,257–268,285–293,493, and 494); Orthopedic Surgery (209–211, 213, 216–219, 223–230, 232–234, 471, 491, 496–503, 519, 520, 537, 538, and 544–546); Vascular Surgery (110, 111, 113, 114, 119, and 120).