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Better Nurse Staffing Is Associated With Survival for Black Patients and Diminishes Racial Disparities in Survival After In-Hospital Cardiac Arrests

Margo Brooks Carthon, PhD, APRN, FAAN,* Heather Brom, PhD, APRN,*
Matthew McHugh, PhD, JD, MPH, RN, FAAN,* Douglas M. Sloane, PhD,* Robert Berg, MD,†
Raina Merchant, MD, MHSP, FAHA,‡ Saket Girotra, MD, SM,§
and Linda H. Aiken, PhD, FAAN, FRCN*

Background: Racial disparities in survival among patients who had an in-hospital cardiac arrest (IHCA) have been linked to hospital-level factors.

Objectives: To determine whether nurse staffing is associated with survival disparities after IHCA.

Research Design: Cross-sectional data from (1) the American Heart Association's Get With the Guidelines-Resuscitation database; (2) the University of Pennsylvania Multi-State Nursing Care and Patient Safety Survey; and (3) The American Hospital Association annual survey. Risk-adjusted logistic regression models, which took account of the hospital and patient characteristics, were used to determine the association of nurse staffing and survival to discharge for black and white patients.

Subjects: A total of 14,132 adult patients aged 18 and older between 2004 and 2010 in 75 hospitals in 4 states.

Results: In models that accounted for hospital and patient characteristics, the odds of survival to discharge was lower for black patients than white patients [odds ratio (OR) = 0.70; 95% confidence interval (CI), 0.61–0.82]. A significant interaction was found between race and medical-surgical nurse staffing for survival to discharge, such that each additional patient per nurse lowered the odds of survival for black patients (OR = 0.92; 95% CI, 0.87–0.97) more than white patients (OR = 0.97; 95% CI, 0.93–1.00).

Conclusions: Our findings suggest that disparities in IHCA survival between black and white patients may be linked to the level of medical-surgical nurse staffing in the hospitals in which they receive care and that the benefit of being admitted to hospitals with better staffing may be especially pronounced for black patients.

Key Words: nursing, staffing, in-hospital cardiac arrest, disparities, cardiopulmonary resuscitation

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In-hospital cardiac arrests (IHCA) represent catastrophic and often terminal events. Despite investments to improve the quality of resuscitation efforts, fewer than 25% of all patients that experience cardiac arrests in hospitals survive to discharge, and survival varies significantly across hospitals and by race.[1,2] Black patients, for example, experience up to 12% lower odds of IHCA survival than white patients.[3] Racial disparities in survival have been linked to patient characteristics such as differences in clinical presentation. Hospital-level factors, such as racial clustering in hospitals with worse outcomes, have also been linked to poorer arrest outcomes, with up to 42%–65% of the variance in postresuscitation outcomes being explained by the hospitals where black patients receive care.[4,5]

Of the studies attributing survival disparities to hospital-level factors, few have been able to specify reasons for the between-hospital differences.[6] One possible explanation for in-hospital survival disparities may be attributed to differences in nursing to patient ratios of nursing care in hospitals where blacks and whites receive care. Nurses represent a constant presence in the management of cardiac arrests, either as members of the arrest team or as providers of post arrest care.[7] They are the primary clinical surveillance system in hospital settings and play an integral role in the detection of

clinical deterioration, identification of an arrest, and initiation of emergency responses.[8–10] At least 2 studies have demonstrated a link between nursing staffing ratios and arrest outcomes. In their study of 358 hospitals, Chen et al[11] found that the one modifiable hospital factor that most attenuated the incidence of IHCAs and survival to discharge was a hospital's nurse-to-bed ratio. In our prior work, we found, using the same data used in this report, that IHCA survival was significantly *higher* when nurses cared for *fewer* patients.[12]

These studies build on a robust body of evidence, both within the United States and globally demonstrating a significant relationship between nurse staffing levels and a large number of patient outcomes,[13–15] including readmissions and postsurgical mortality.[16–18] Better nurse staffing is believed to afford nurses more time to spend with patients to monitor changes in patient status and initiate appropriate interventions as warranted.[19,20] Low staffing compromises these activities, and to the extent that black patients are hospitalized in settings with insufficient staffing, this may heighten their risk of poor IHCA survival outcomes.[21,22]

The aim of our study is to examine the association between nurse staffing and IHCA survival outcomes among black and white patients. To complete the study, we merged hospital administrative data with data from the American Heart Association Get With the Guidelines-Resuscitation (GWTG-R) database and with survey data from nurses in 75 hospitals across 4 states. We hypothesized that differences between black and white patients in the likelihood of survival to discharge after an IHCA would be attributable, at least in part, to black patients being disproportionately cared for in hospitals with poorer nurse staffing.

METHODS

This cross-sectional study linked data from 3 sources: (1) the American Heart Association's GWTG-R database, (2) The University of Pennsylvania Multi-State Nursing Care and Patient Safety Survey, and (3) the American Hospital Association's (AHA) annual survey of hospitals. Hospitals included were those that participated in GWTG-R between 2004 and 2010, were in the 4 states studied in the nurse survey (California, Florida, New Jersey, and Pennsylvania), and responded to the 2006 AHA survey.

Data Sources

Get with the Guidelines Resuscitation

Data regarding patient characteristics and outcomes are from GWTG-R, a large, national prospective quality-improvement registry of IHCA sponsored by the AHA. Participating hospitals voluntarily submit clinical information regarding the medical history, patient care, and outcomes of patients hospitalized for cardiac arrest using an online report form and Patient Management Tool.[23] Standardized Utstein-style definitions are utilized to facilitate uniform reporting across hospitals.[24,25] IQVIA is the data collection coordination center for the American Heart Association/American Stroke Association Get with the Guidelines programs.[26] The University of Pennsylvania is the analytic center and has an agreement to prepare the data for research purposes.

Multi-State Nursing Care and Patient Safety Survey

The nurse staffing measure was derived from a previously collected survey of nurses working in Pennsylvania, California, and New Jersey between September 2005 and August 2006 and Florida between 2007 and April 2008. The survey was mailed to the homes of a random sample of 272,783 nurses in the 4 states holding an active RN license and over 100,000 responded, achieving a response rate of 39%. Nurses were asked to provide detailed information about their employing hospital (including hospital name), allowing responses across nurses to be aggregated to the hospital level. On average there were 57.4 (range, 7–169) nurse respondents per study hospital. By mailing the survey to the homes of nurses, we attempted to reduce concerns about the respondent bias that might have arisen had the survey been sent to the site of nurses' employment.[27] A resurvey of 1300 original nonresponders with a 91% response rate demonstrated no significant differences in responders and nonresponders in reports of hospital-level nursing workloads.[27] Additional details about the survey methodology are available elsewhere.[28]

AHA Annual Survey

The annual survey was used to describe additional hospital characteristics, including organizational, structural, and financial measures that may be associated with nursing measures and patient outcomes.

Study Population

Our sample included patients who experienced an IHCA and where we also had survey responses from nurses. For patients who experienced multiple IHCAs within the same admission, we included only the first, or index arrest in our analysis. Patients were excluded if they were (1) under the age of 18 years; (2) on selected unit types (pediatrics, emergency department, surgical, and procedural areas); (3) patients with implantable cardioverter-defibrillators; (4) patients who were not black or white; (5) or if they were staff or visitors (and not patients) at the time of the arrest. Hospitals with <10 cardiac arrests reported between 2004 and 2010 were excluded, as were hospitals with extreme and outlying medical-surgical nurse staffing (> 20 patients/nurse) and with missing medical-surgical or intensive care unit (ICU) nurse staffing. Our analytic sample consisted of 14,132 patients in 75 hospitals (Fig. 1).

Measures

Nurse Staffing

Each nurse surveyed reported the numbers of nurses and patients on the unit on the last shift worked. We created staffing measures for medical-surgical and adult ICU nurses by dividing the average number of patients reported by nurses by the average number of nurses on the unit for that same shift. We then aggregated these reports of staff nurses across all shifts worked in a given hospital to estimate the average workload for nurses on medical-surgical units and on ICUs.[16,28] Our measure of staffing has been repeated studies with patient outcomes including mortality and has good predictive validity.[12,13,16]

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┌─────────────────────────────┐
│ 85 hospitals in Pennsylvania,│      ┌──────────────────────────────┐
│ Florida, New Jersey and      │─────▶│ 3,667 recurrent arrests      │
│ California that match with   │      │ excluded                     │
│ GWTG-R data (25,249 events;  │      └──────────────────────────────┘
│ 21,583 patients)             │
└─────────────────────────────┘
┌─────────────────────────────┐      ┌──────────────────────────────┐
│ 21,582 patients in 85        │─────▶│ 1 hospital excluded for      │
│ hospitals                    │      │ having <10 IHCA events       │
└─────────────────────────────┘      └──────────────────────────────┘
┌─────────────────────────────┐      ┌──────────────────────────────┐
│ 21,577 patients in 84        │─────▶│ 1 hospital excluded for      │
│ hospitals                    │      │ extreme medical/surgical     │
│                              │      │ staffing, 3 hospitals        │
│                              │      │ excluded for missing         │
│                              │      │ medical/surgical staffing,   │
│                              │      │ and 6 hospitals excluded for │
│                              │      │ missing ICU staffing         │
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│ 21,096 patients in 75        │─────▶│ 3,754 events excluded for    │
│ hospitals                    │      │ events not occurring in      │
│                              │      │ cardiac, intensive care,     │
│                              │      │ medical-surgical, or         │
│                              │      │ telemetry units, or events   │
│                              │      │ experienced by staff/visitors│
└─────────────────────────────┘      └──────────────────────────────┘
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│ 17,342 patients in 75        │─────▶│ 304 patients excluded with   │
│ hospitals                    │      │ implantable cardioverter-    │
│                              │      │ defibrillators               │
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│ 17,038 patients in 75        │─────▶│ 2,431 patients excluded who  │
│ hospitals                    │      │ were not black or white      │
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│ 14,607 patients in 75        │─────▶│ 440 events excluded due to   │
│ hospitals                    │      │ missing or inconsistent data │
│                              │      │ (negative time to            │
│                              │      │ compression);                │
│                              │      │ 35 events excluded due to    │
│                              │      │ missing data on survival to  │
│                              │      │ discharge (34) or whether    │
│                              │      │ the event was witnessed (1)  │
└─────────────────────────────┘      └──────────────────────────────┘
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│ 14,132 patients in 75        │
│ hospitals                    │
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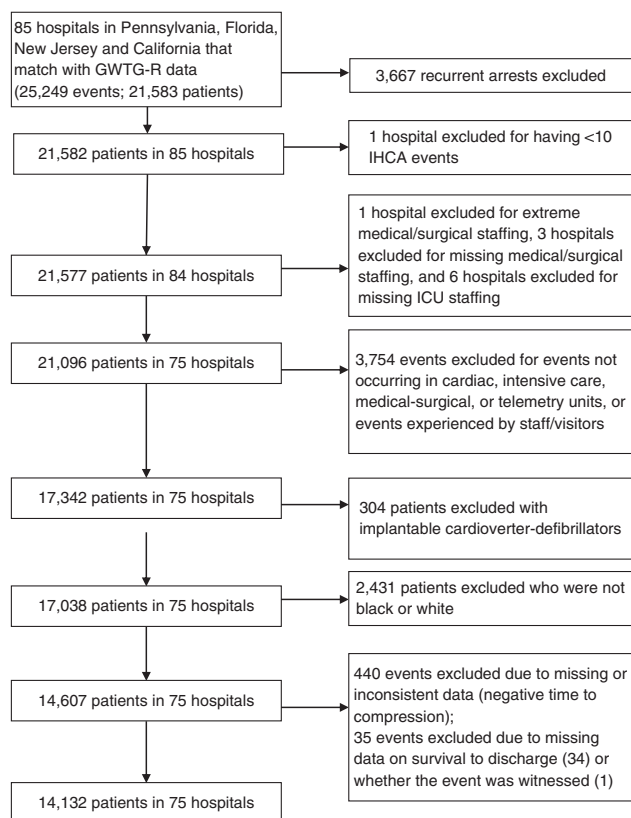
FIGURE 1. Study cohort inclusion/exclusion criteria. GWTG-R indicates Get With The Guidelines-Resuscitation; ICU, intensive care unit; IHCA, in-hospital cardiac arrest.

Hospital Characteristics

We included control variables for other potentially confounding hospital factors (eg, teaching status, size, technology status, and proportion of minority patients) that have been shown to be associated with patient outcomes in prior work.[5,16,29] These variables were derived from the AHA Annual Survey. Hospital size was categorized by the number of beds (<250, 251–500, and >500 beds). Teaching status was categorized as major teaching (hospitals with a residency and fellowship program), minor teaching (hospitals with a residency program, but no fellowship program), and nonteaching (hospitals without a residency or fellowship program). High-technology hospitals were defined as those that performed open-heart surgery, major organ transplant, or both. High minority serving hospitals were defined as those representing the top 25th percentile in their admissions for black patients. We additionally included indicators for the state in which the hospital was located and rural/urban status.[12]

Survival to Discharge

Our primary outcome of interest was a binary variable indicating whether or not a patient survived until discharge. Patients who survived the event were then considered to have survived to discharge if they had been discharged alive, regardless of neurological status, outcome, or discharge destination, from inpatient hospital care.[24]

Risk Adjustment

Based on the work by Chan et al,[4] we controlled for 26 predictor variables. Patient characteristics included age, sex, whether the admission was for a cardiac illness, and characteristics before cardiac arrest [acute stroke, baseline central nervous system depression, congestive heart failure (CHF) this admission, CHF prior admission, diabetes mellitus, hemodialysis, hepatic insufficiency, hypotension, major trauma, metastatic cancer and hematologic malignancy, myocardial infarction (MI) this admission, MI prior admission, pneumonia, respiratory insufficiency, renal insufficiency, and septicemia]. Event characteristics included arrest occurring in the ICU, shockable rhythm, interventions in place before arrest (mechanic ventilation and vasopressors), whether the event was witnessed or monitored and if a hospital-wide alert was called.

Statistical Analysis

The hospital-level measures of nurse staffing derived from the nurse survey were merged with other hospital-level measures from the AHA survey and ultimately patient-level data from GWTG-R, using common hospital identifiers. All patient data and hospital names were de-identified by GWTG-R. Thus, the merged analytic file was a multilevel dataset that included individual patient and event characteristics and characteristics of the hospitals where they received care. Our measure of nurse staffing was treated as a continuous variable and was constrained to have a linear effect on the outcome survival to discharge based on prior work by our team.[16] First patient, event, hospital, and nursing characteristics were compared between black and white patients using the χ^2 tests for categorical variables and t tests for continuous variables. Next, a series of multilevel sequential logistic regression models were used to estimate the likelihood of surviving to discharge before and after controlling for confounding factors. All logistic regression models were estimated by using Huber-White (robust) procedures to account for the clustering of patients within hospitals and to adjust for the SEs of the parameter estimates appropriately.[30] As we cannot link patients and nurses and because our staffing measures are hospital-level measures, differences in staffing cannot predict or account for differences between black and white patients within hospitals, though we do take account of patient and event characteristics that can. Thus, when we investigate the effects of nurse staffing, we are estimating whether being in well-staffed hospitals rather than poorly staffed hospitals affects the likelihood of patients surviving to discharge, and whether this effect differs for black and white patients.

Five sequential models were constructed: (1) an unadjusted model examining the bivariate association between survival and race, and adjusted models that re-estimate the race/survival association after adjusting for (2) patient characteristics (3) patient characteristics, and event characteristics (4), patient characteristics, event characteristics, hospital characteristics including nurse staffing and year of the event, and (5) all of the main effects of the characteristics in the

fourth model plus interaction between race and medical-surgical nurse staffing. All analyses were conducted using STATA V.15. This study protocol met the eligibility criteria for institutional review board review exemption by the University of Pennsylvania Intuitional Review Board, protocol number 828379.

RESULTS

Our analysis included 14,132 patients who experienced IHCA in 75 hospitals. Table 1 displays characteristics of black and white patients. Of these patients, 11,620 (82.2%)

TABLE 1. Patient and Event Characteristics

	White (82.2%, N = 11,620)	Black (17.8%, N = 2512)	P
Age in years by decile, n (%)			<0.001
18–<50	1169 (10.1)	578 (23.0)	
50–59	1387 (11.9)	515 (20.5)	
60–69	2094 (18.0)	538 (21.4)	
70–79	3231 (27.8)	483 (19.2)	
80 to 89	3113 (26.8)	326 (13.0)	
≥90	626 (5.4)	72 (2.9)	
Male, n (%)	6808 (58.6)	1321 (52.6)	<0.001
Cardiac admitting diagnosis	4697 (40.4)	786 (31.3)	<0.001
characteristics before arrest, n (%)			
Acute stroke	459 (3.9)	168 (6.7)	<0.001
Baseline CNS depression	1622 (14.0)	345 (13.7)	0.772
CHF this admission	2329 (20.0)	461 (18.4)	0.054
CHF prior admission	2378 (20.5)	473 (18.8)	0.065
Diabetes mellitus	3306 (28.4)	836 (33.3)	<0.001
Hemodialysis	384 (3.3)	116 (4.6)	0.001
Hepatic insufficiency	1018 (8.8)	231 (9.2)	0.486
Hypotension	3341 (28.7)	695 (27.7)	0.275
Major trauma	355 (3.1)	90 (3.6)	0.169
Metastatic/hematologic malignancy	1631 (14.0)	341 (13.6)	0.545
MI this admission	1854 (16.0)	231 (9.2)	<0.001
MI prior admission	1884 (16.2)	240 (9.6)	<0.001
Pneumonia	1788 (15.4)	426 (17.0)	0.049
Renal insufficiency	4075 (35.1)	1102 (43.9)	<0.001
Respiratory insufficiency	5170 (44.5)	1169 (46.6)	0.060
Septicemia	2228 (19.2)	579 (23.0)	<0.001
Interventions in place before arrest, n (%)			
Mechanical ventilation	3769 (32.4)	1044 (41.6)	<0.001
Vasoactive medications	3196 (27.5)	803 (32.0)	<0.001
Event characteristics, n (%)			
Shockable rhythm	1784 (15.3)	270 (10.7)	<0.001
Arrest in ICU	6654 (57.3)	1516 (60.3)	0.004
Time to defibRilation (for shockable rhythm) in minutes, mean (SD)	3.9 (37.4)	3.2 (6.0)	0.414
Weekend arrest	3669 (31.6)	770 (30.6)	0.367
Night arrest	4084 (35.1)	865 (34.4)	0.498
Witnessed	9527 (82.0)	2035 (81.0)	0.250
Monitored	9713 (83.6)	2090 (83.2)	0.635
Hospital-wide arrest response activated	10941 (94.2)	2276 (90.6)	<0.001
Event duration in minutes, mean (SD)	19.7 (16.9)	19.9 (16.0)	0.507
Time to compressions in minutes, mean (SD)	1.8 (96.3)	1.4 (28.8)	0.853
Survival to discharge, N (%)	1836 (15.8)	292 (11.6)	<0.001

CHF indicates congestive heart failure; CNS, central nervous system; ICU, intensive care unit; MI, myocardial infarction.

were white and 2512 (17.8%) were black. A smaller percentage of black patients than white patients survived to discharge (11.6% vs. 15.8%, P <0.001). Black patients were younger and less likely to be male individuals. Black patients were significantly more likely than white patients to be septic before their arrest (23.0% vs.19.2%, $P < 0.001$), to already be supported by mechanical ventilation (41.6% vs. 32.4%, $P < 0.001$), and to be receiving vasoactive medications (32.0% vs. 27.5%, $P < 0.001$). Black patients were less likely than white patients to have a shockable rhythm at the time of IHCA (10.7% vs. 15.3%, $P < 0.001$), more likely to arrest in the ICU (60.3% vs. 57.3%, $P = 0.004$), and less likely to have a hospital-wide alert called (90.6% vs. 94.2%, $P < 0.001$). Black and white patients were equally likely to have an arrest at night or on the weekend, and an arrest that was witnessed or monitored. There were no differences between black and white patients in event duration or time to compressions.

Table 2 shows hospital and nursing characteristics and their differences for black and white patients. Black patients were more likely than white patients to be cared for in hospitals with lower medical-surgical staffing ratios (mean medical-surgical patient-to-nurse ratios for hospitals to which black and white patients were admitted were 7.3 and 7.1, respectively, $P = 0.037$). Black patients were also more likely than white patients to be cared for in large and urban hospitals, in hospitals with high technology and that were teaching institutions, and hospitals with higher percentages of Medicaid beds.

Table 3 displays the results of the multilevel logistic regression models, which estimate the differences between black and white patients who had an IHCA and the effects of nurse staffing on the likelihood of survival until discharge, before and after adjusting for patient characteristics, event characteristics, and other hospital characteristics. In the unadjusted model (1), the odds of survival are lower for black patients who had an IHCA than for white patients by a factor of 0.70 [95% confidence interval (CI), 0.62–0.80, $P<0.001$]. When we add controls for patient characteristics in model (2), event characteristics in model (3), and hospital characteristics, including nursing staffing in model (4)—the odds ratios (ORs) reflecting the black-white difference in survival in those 3 models are 0.66, 0.71, and 0.74, respectively. Model (5), however, reveals an interaction between race and medical-surgical staffing that is both statistically significant and substantively important. The main effect of race in model (5) remains pronounced (OR = 0.74), whereas the main effect of the medical-surgical staffing measure is small (OR = 0.97). The interaction term in the model (0.95), however, implies that the black-white difference is more pronounced when medical-surgical patient-to-nurse ratios are higher (ie, when staffing is poorer) and that the medical-surgical staffing effect is decidedly smaller for white patients (OR = 0.97) than for black patients (OR = 0.97×0.95 = 0.92). Although this difference in the estimated staffing effect (0.97 vs. 0.92) may not seem pronounced, these are multiplicative estimates that reflect the difference in survival for white and black patients in hospitals that differ in staffing by a single unit or by 1 patient per nurse. White and

TABLE 2. Hospital Characteristics

	Hospital (N = 75)	White (82.2%, N = 11,620)	Black (17.8%, N = 2512)	*P*
Medical-surgical staffing, mean (SD)	7.2 (2.8)	7.1 (2.8)	7.3 (2.7)	0.037
Medical-surgical staffing, n (%)				<0.001
<5 patients/nurse	13 (17.3)	2182 (18.8)	301 (12.0)	
5–7 patients/nurse	35 (46.7)	5351 (46.0)	1403 (55.8)	
>7 patients/nurse	27 (36.0)	4087 (35.2)	808 (32.2)	
ICU staffing, mean (SD)	2.3 (0.6)	2.3 (0.5)	2.3 (0.7)	0.002
ICU staffing, n (%)				<0.001
<2 patients/nurse	22 (29.3)	3089 (26.6)	501 (19.9)	
2-2.5 patients/nurse	36 (48.0)	5002 (43.0)	1405 (55.9)	
>2.5 patients/nurse	17 (22.7)	3529 (30.4)	606 (24.1)	
Beds, n (%)				<0.001
≤250	30 (40.0)	2643 (22.3)	341 (13.6)	
251-500	35 (46.7)	7090 (61.0)	1419 (56.5)	
>500	10 (13.3)	1887 (16.2)	752 (29.9)	
High technology, n (%)	41 (54.7)	7371 (63.4)	1678 (66.8)	0.001
Teaching status, n (%)				<0.001
None	30 (40.0)	4865 (41.9)	833 (33.2)	
Minor	36 (48.0)	4894 (42.1)	862 (34.3)	
Major	9 (12.0)	1861 (16.0)	817 (32.5)	
State, n (%)				<0.001
California	22 (29.3)	3297 (28.4)	467 (18.6)	
Florida	23 (30.7)	3899 (33.6)	984 (39.2)	
New Jersey	10 (13.3)	1827 (15.7)	273 (10.9)	
Pennsylvania	20 (26.7)	2597 (22.3)	788 (31.4)	
Urban, n (%)	71 (94.7)	11,241 (96.7)	2500 (99.5)	<0.001
High minority serving hospital, n (%)	18 (24.0)	1855 (16.0)	1582 (63.0)	<0.001

    High minority serving hospitals are those representing the top 25th percentile in their admissions for black patients.
    ICU indicates intensive care unit.

black patients in hospitals that differ by 4 patients per nurse (eg, 8 patients per nurse vs. 4 patients per nurse) would have odds of survival that are lower by factors of $0.97^4 = 0.84$ and $0.92^4 = 0.72$, respectively, or by 16% and 28%.

    Figure 2 illustrates how survival to discharge varies for black and white patients across hospitals with varying medical-surgical staffing levels and, alternatively, how the effect of varying staffing levels is more pronounced for black than white patients. Notably, in hospitals in which nurses care for the average amount of patients (7 per nurse), the odds of

survival are 0.13 for black patients (95% CI = 0.12–0.15) and 0.19 for white patients (95% CI = 0.18–0.20). This racial disparity narrows when the nurse cares for fewer patients. When nurses care for an average of 4 patients, the odds of survival are 0.17 for black patients (95% CI = 0.13–0.20) and 0.21 for white patients (95% CI = 0.18–0.23). Conversely, this disparity widens when nurses care for more patients. In hospitals where nurses care for 10 patients, the odds of survival are 0.11 for black patients (95% CI = 0.09–0.12) and 0.17 for white patients (95% CI = 0.15–0.19). This interaction

TABLE 3. Sequential Modeling Indicating the Effects of Racial Disparities and Nurse Staffing on Survival to Discharge

Predictors	Unadjusted OR (95% CI)	Adjusted for Patient Characteristics OR (95% CI)	Adjusted for Event Characteristics OR (95% CI)	Adjusted for Hospital Characteristics OR (95% CI)	Fully Adjusted with Interaction of Centered Staffing and Race OR (95% CI)
Black	0.70*** (0.62–0.80)	0.66*** (0.57–0.77)	0.71*** (0.61–0.83)	0.74** (0.62–0.89)	0.74** (0.62–0.89)
MS staffing	—	—		0.96* (0.92–0.99)	0.97 (0.93–1.00)
Interaction	—	—		—	0.95* (0.91–0.99)
ICU staffing	—	—		1.07 (0.92–1.24)	1.06 (0.91–1.24)

    All models utilize multivariable logistic regression that accounts for clustering within hospitals. Patient characteristics include age (categorical), sex, whether the admission was for a cardiac illness, and characteristics before cardiac arrest (acute stroke, baseline CNS depression, CHF this admission, CHF prior admission, diabetes mellitus, hemodialysis, hepatic insufficiency, hypotension, major trauma, metastatic cancer & hematologic malignancy, MI this admission, MI prior admission, pneumonia, respiratory insufficiency, renal insufficiency, and septicemia). Event characteristics include arrest occurring in the ICU, shockable rhythm, interventions in place before arrest (mechanic ventilation and vasopressors), whether the event was witnessed or monitored, and if a hospital-wide alert was called. Hospital characteristics include medical-surgical and ICU nurse staffing, teaching status, whether the hospital was high technology, bed size, high minority serving hospitals, urban/rural location, state, and year. In the interaction model, medical-surgical staffing is centered at the mean.
    CHF indicates congestive heart failure; CI, confidence interval; CNS, central nervous system; ICU, intensive care unit; MI, myocardial infarction.
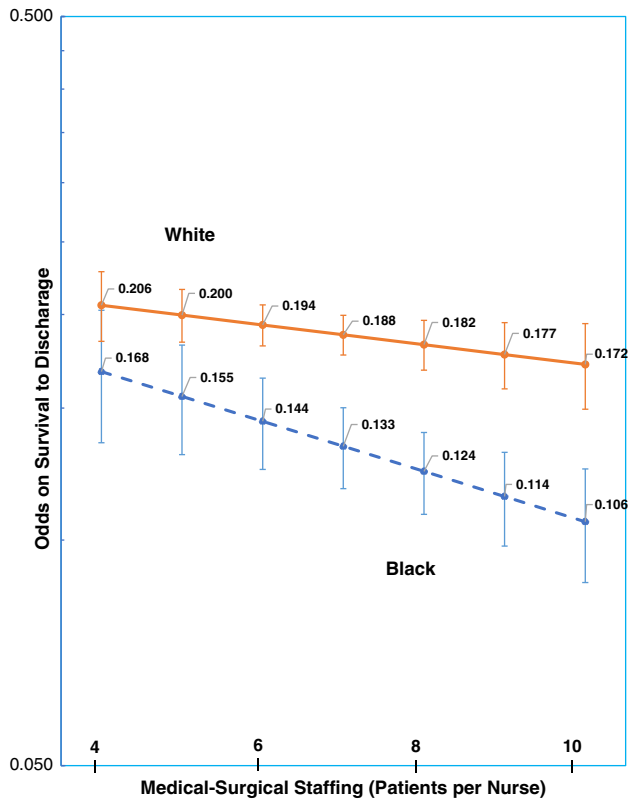   *P < 0.05.
    **P < 0.01.
    ***P < 0.001.

FIGURE 2. Odds on survival to discharge for blacks and whites, in hospitals with different staffing levels.

also indicates that the effect of nurse staffing, or the effect of each one patient increase in average nurse workloads, diminishes the odds of survival more for blacks (by a factor of 0.92) than for whites (by a factor of 0.97). This interaction implies that the odds of survival for white patients are somewhat lower in hospitals where the average workload is 10 patients per nurse than in hospitals where the average workload is 4 patients per nurse (by a factor of 0.171/ 0.206 = 0.83, or by roughly 17%), whereas the difference in survival for black patients across those 2 groups of hospitals are decidedly lower (by a factor of 0.106/0.168 = 0.63, or by roughly 37%).

DISCUSSION

This study is the first to describe the relationship between nurse staffing and its association with racial disparities in survival after IHCAs. Our findings suggest that the likelihood of survival to discharge is lower for black patients than for white patients in both poorly staffed and well-staffed hospitals. However, the effect of being cared for in hospitals with better medical-surgical staffing has a greater effect on black patients than white patients, and differences in survival to discharge between black and white patients are more pronounced in poorly staffed hospitals than in well-staffed hospitals.

Our findings are consistent with a small but growing number of studies that suggest that hospital-based disparities may be related to variation in nursing care quality in the settings where black patients receive care. A 2011 study of 528 hospitals found that ratings of patient satisfaction were lower in hospitals serving higher proportions of black patients. Lower ratings of satisfaction were explained, in part, by nurse staffing levels.[22] A separate study by Lasater and McHugh,[31] noted increased odds of 30-day readmissions after hip and knee surgery when older blacks were cared for in settings with lower staffing levels. The association between staffing and disparities in prior studies suggest that variation in nurse staffing across hospitals may contribute, at least in part, to previously noted hospital-level variation in survival outcomes between black and white patients.[3,6]

A notable finding of our study was the significant interaction between nurse staffing levels and black-white survival. This suggests that when patients in hospitals with better staffing (or lower patient-to-nurse ratios) are compared with patients in hospitals with poorer nurse staffing (or higher patient-to-nurse ratios), the survival difference produced by better staffing is more pronounced for black patients than for white patients. We suspect that black patients are more clinically complex during the inpatient admission due a range of pre-existing medical and social factors, some of which we are able to account for (eg, comorbidity) some of which we are not (eg, community and individual-level socioeconomic status and severity of comorbid illnesses). This vulnerability likely requires more vigilant clinical surveillance and when not provided, it heightens the risk for poor arrest outcomes. Conversely, when cared for in better-staffed hospitals, black patients likely experience less missed or delayed nursing care and receive more frequent assessments, thereby allowing nurses to detect complications and initiate appropriate interventions as warranted.[19,20] Low staffing compromises these activities, and to the extent that black patients are hospitalized in settings with insufficient staffing, this may heighten their risk of poor IHCA survival outcomes.

We acknowledge that encouraging health care systems to markedly increase nurse staffing may not be an immediately viable solution. As it stands, nurses currently account for up to 40% of a hospital's cost, and organizations with narrow operating margins may be hard pressed to add additional nursing FTEs.[32] Recent safe staffing initiatives enacted at the state and federal levels suggest that improving staffing ratios is increasingly viewed as a key determinant to maintaining patient safety. Notably, some states, including California—one of the states in our sample, legislated minimum staffing ratios in 2004, which resulted in nurses caring for fewer patients.[33] Another 14 states and the District of Columbia have adopted regulations or legislation to address nurse staffing.[34] Although approaches to improving nurse staffing vary, our findings of diminished disparities in the presence of lower patient-to-nurse ratios offer a valuable addition to current efforts to improve resuscitation outcomes.

Our findings should be interpreted with the following limitations in mind. We acknowledge, for example, that nurse staffing by its nature is likely only partially and indirectly

linked to survival outcomes and that the relationship between structural variables may be mediated through other process variables. Indeed, there are many interventions that occur during an arrest (eg, time to compressions). Although the databases used in this study do not provide information on the quality of cardiopulmonary resuscitation, we noted no differences in survival outcomes between black and white patients when these other interventions were evaluated across varying levels of staffing. The 2006 AHA Hospital Survey used in this study did not provide staffing details about other providers, hence we were unable to account for their potential role in our analyses. We also acknowledge that other important resuscitation quality-improvement strategies were likely implemented over the course of our study, which we had limited information on.[35,36] Finally, we note that there is no within-hospital variation in staffing included in our models, hence we are only able to evaluate variations in staffing across hospitals.

CONCLUSIONS

Our findings suggest that disparities in IHCA survival may be linked to the level of nurse staffing in the hospitals in which they receive care and that the benefit of being admitted to hospitals with better staffing may be especially pronounced for black patients.

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