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Association of Neighborhood Demographics With Out-of-Hospital Cardiac Arrest Treatment and Outcomes
Where You Live May Matter

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IMPORTANCE We examined whether resuscitation care and outcomes vary by the racial composition of the neighborhood where out-of-hospital cardiac arrests (OHCAs) occur.

OBJECTIVE To evaluate the association between bystander treatments (cardiopulmonary resuscitation and automatic external defibrillation) and timing of emergency medical services personnel on OHCA outcomes according to the racial composition of the neighborhood where the OHCA event occurred.

DESIGN, SETTING, AND PARTICIPANTS This retrospective observational cohort study examined patients with OHCA from January 1, 2008, to December 31, 2011, using data from the Resuscitation Outcomes Consortium. Neighborhoods where OHCA occurred were classified by census tract, based on percentage of black residents: less than 25%, 25% to 50%, 51% to 75%, or more than 75%. Multilevel mixed-effects logistic regression modeling examined the association between racial composition of neighborhoods and OHCA survival, adjusting for patient, neighborhood, and treatment characteristics.

MAIN OUTCOMES AND MEASURES Survival to discharge, return of spontaneous circulation on emergency department arrival, and favorable neurologic status at discharge.

RESULTS We examined 22 816 adult patients with nontraumatic OHCA at Resuscitation Outcomes Consortium sites in the United States. The median age of patients with OHCA was 64 years (interquartile range [IQR], 51-78). Compared with patients who experienced OHCA in neighborhoods with a lower proportion of black residents, those in neighborhoods with more than 75% black residents were slightly younger, were more frequently women, had lower rates of initial shockable rhythm, and less frequently experienced OHCA in a public location. The percentage of patients with OHCA receiving bystander cardiopulmonary resuscitation or a lay automatic external defibrillation was inversely associated with the percentage of black residents in neighborhoods. Compared with OHCA in predominantly white neighborhoods (<25% black), those with OHCA in mixed to majority black neighborhoods had lower adjusted survival rates to hospital discharge (25%-50% black: odds ratio, 0.76; 95% CI, 0.61-0.93; 51%-75% black: odds ratio, 0.67; 95% CI, 0.49-0.90; >75% black: odds ratio, 0.63; 95% CI, 0.50-0.79; $P < .001$). There was similar mortality risk for black and white patients with OHCA in each neighborhood racial quantile. When the primary model included geographic site, there was an attenuated nonsignificant association between racial composition in a neighborhood and survival.

CONCLUSIONS AND RELEVANCE Those with OHCA in predominantly black neighborhoods had the lowest rates of bystander cardiopulmonary resuscitation and automatic external defibrillation use and significantly lower likelihood for survival compared with predominantly white neighborhoods. Improving bystander treatments in these neighborhoods may improve cardiac arrest survival.

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Invited Commentary

Author Video Interview

Supplemental content

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Approximately 350 000 patients experience out-of-hospital cardiac arrest (OHCA) each year in the United States.[1] Out-of-hospital cardiac arrest survival rate is 8.3% to 10% annually[1,2]; however, there is regional variation in the incidence of and survival from OHCA.[3,4] The incidence of OHCA has been consistently higher in black individuals compared with white individuals in the United States.[5-9] Notable disparities exist in cardiopulmonary resuscitation (CPR) training and the use of bystander CPR in predominantly black vs white communities.[2,5,10] Studies examining differences in survival among black and white individuals who experience OHCA have produced conflicting results.[8,9,11-15] Although there has been robust research that black neighborhoods have lower bystander CPR,[10] there has been limited comprehensive examination of whether the racial composition of black residents in a neighborhood is associated with other bystander treatments, emergency medical services (EMS) processes of care, and OHCA outcomes, to our knowledge. Elucidating such an association could help to allocate finite national and local resources to areas in most need of improved training, care, and outcomes. The Resuscitation Outcomes Consortium (ROC) registry[16] is a large OHCA registry with consecutive case capture. Using ROC data, we sought to determine whether differences in care and outcomes exist in predominantly black neighborhoods vs neighborhoods with a lower proportion of black residents.

Key Points

Question Is the racial composition of neighborhoods associated with bystander treatments, emergency medical services processes of care, and survival to hospital discharge after out-of-hospital cardiac arrest?

Findings In this cohort study of 22 816 patients with out-of-hospital cardiac arrests across 2543 census tracts between 2008 and 2011, we found that out-of-hospital cardiac arrests occurring in mixed to majority black neighborhoods had lower survival to discharge compared with neighborhoods composed of less than 25% black residents.

Meaning Directing attention toward improving education and treatment of cardiac arrest in predominantly black neighborhoods may save lives.

Methods

Study Design and Setting

From January 1, 2008, to December 31, 2011, we conducted a retrospective observational cohort study using data from the ROC Cardiac Arrest Epidemiologic Registry, which is a prospective, multicenter, observational registry of consecutive patients with nontraumatic OHCA from 7 US sites (Birmingham, Alabama; Dallas-Fort Worth, Texas; Pittsburgh, Pennsylvania; Portland, Oregon; San Diego, California; Seattle and King County, Washington; and Milwaukee, Wisconsin) and 3 Canadian sites (British Columbia, Ottawa, Toronto).[16] In the United States and Canada, ROC Cardiac Arrest Epidemiologic Registry covers a service area population of 23.7 million people and involves 264 EMS agencies and 287 receiving hospitals.[17]

Information on each patient was collected from EMS and hospital records using standardized definitions, which included Utstein data elements. Data were collected by trained personnel who followed uniform procedures to ensure validity and reproducibility. Site-specific quality assurance included initial and continuing education of EMS personnel data collection. The data coordinating center ensured data quality by using range and logic checks in web-based data entry forms and the batch upload process, systematically reviewing data to uncover inconsistencies, reviewing randomly selected records to confirm accuracy of data entry, and conducting annual site visits.[3]

Participating sites obtained institutional review board approval to conduct this research with a waiver of written consent under the Common Rule minimal risk criteria. The registry was approved by a central institutional review board at the University of Washington with concurrent approval at 100 US institutional review board sites.

Study Population

We characterized EMS-treated adult patients with OHCA (aged ≥18 years) as those who received an attempt at external defibrillation by lay responders or emergency personnel or received chest compressions by EMS personnel.[16] We excluded patients with OHCA who were assessed by EMS personnel but not treated, including cases where there was (1) clear evidence confirming death (eg, rigor mortis); (2) a "do not attempt resuscitation" directive; or (3) a compelling reason that included extensive history of terminal or intractable disease or a request from the patient's family not to treat. Patients were also excluded if they were participating in an active ROC clinical trial (n = 7) during the study period. Canadian ROC sites were excluded from this analysis because of differences in racial and ethnic make-up, as well as different census tract distributions from the United States.[18]

Geospatial Information

The addresses where an OHCA occurred were standardized and geocoded, then assigned to the appropriate US census tract; these are traditionally used as proxies for neighborhoods because they typically represent socially and economically homogeneous groups of approximately 1200 to 8000 individuals.[19] We geocoded approximately 99% of the ROC cohort population. Neighborhood-level demographic information (race), socioeconomic status (median household income and percentage of individuals with college education), and geographic information (percentage of rural populations) were assigned to each census tract using the 2000 Decennial Census information. Choropleth maps of census tracts from the 7 ROC sites were created using neighborhood race and OHCA survival to hospital discharge.

Primary Variable

The primary independent variable was the percentage of black residents living in each neighborhood (ie, census tract), as defined by demographic data collected from the census. For the

primary analysis, the cohort was divided into the following quantiles according to proportion of black residents in a neighborhood: less than 25%, 25% to 50%, 51% to 75%, or more than 75%. We also modeled neighborhood black race continuously (per 5-percentage point change).

Key Variables

Covariates of interest included the age, sex, witnessed OHCA status, initial cardiac rhythm, bystander CPR status, location of arrest (public or private), and lay use of automatic external defibrillation (AED) before EMS arrival. Neighborhood census tract covariates included median household income, percentage of residents with a college degree, and rural populations.

Emergency medical services processes of care included time from call to first EMS professional at the scene (defined by arrival to the OHCA location), time from call to first advanced life support professional on the scene, EMS arrival to rhythm check, EMS arrival to first shock, EMS arrival to first return of spontaneous circulation (ROSC), EMS arrival to ceased efforts (ie, termination of resuscitation), and EMS arrival to hospital transport. Initial rhythm was determined with either a manual defibrillator or an AED with a built-in computer algorithm capable of classifying the patient's initial rhythm as resembling ventricular fibrillation or ventricular tachycardia (ie, shockable) or not (ie, nonshockable). For this analysis, ventricular tachycardia, ventricular fibrillation, and shockable rhythms were grouped together into a "ventricular tachycardia/ventricular fibrillation" category. Pulseless electrical activity; asystole; and no-shock, no-strip were grouped together into the nonshockable category. Cardiopulmonary resuscitation processes included compression depth and rate. These process data were measured by commercially available monitor defibrillators during attempted resuscitation.[20] Study-site coordinators and internal study monitoring committees audited these data for accuracy.

Outcomes Measures

The primary outcome of interest was survival to hospital discharge among all patients within each census tract. Secondary outcomes included ROSC at emergency department (ED) arrival and favorable neurologic status at discharge. The latter was defined as discharged alive with a modified Rankin Scale score of 3 or less.[21,22] Patients who died before discharge were assigned a modified Rankin Scale score of 6. The modified Rankin Scale score was assessed by trained individuals who reviewed the hospital clinical record.[20]

Statistical Analysis

We examined variability in census tract and individual-level patient and cardiac arrest characteristics, EMS process of care time intervals, and outcomes for patients with OHCA. For the primary analysis, we defined quantiles by ordering census tracts from lowest to highest by the proportion of black residents in each tract. We compared patient and neighborhood factors with EMS processes of care across quantiles using Kruskal-Wallis tests for continuous variables and χ^2 tests for categorical variables. Trends across unadjusted outcomes were compared across quantiles using the Cochran-Armitage trend test.

Multilevel mixed-effects logistic models with a hierarchical approach were used to assess the association between neighborhood race and OHCA outcomes. This model was chosen given the hierarchical nature of the data with clustering of patients within census tracts. We adjusted for patient, neighborhood socioeconomic status, and bystander factors, as well as EMS response intervals. Variables included in the models were neighborhood race quantiles, patient age (<40, 40-65, >65 years) and sex, bystander CPR and/or AED use, advanced life support response time (<6 vs ≥6 minutes), EMS response time (<5 vs ≥5 minutes), witness status (none, EMS, bystander, unknown), location of OHCA (public vs private), initial rhythm (shockable vs nonshockable), median household income (per $10 0000 change), rural population (per 5-percentage point change), and percentage with a college degree (per 5-percentage point change). There was multiple collinearity with bystander CPR and bystander AED use, so these treatments were added to models as a combined categorical variable.

Furthermore, we explored whether associations between neighborhood racial composition on outcomes persisted after adjusting for ROC geographic site. Finally, we examined a prior designated subgroup analysis by the presence or absence of a shockable rhythm.

In a sensitivity analysis, we sought to determine whether black vs white patients with OHCA had different survival in each neighborhood race quantile. This was performed through interaction testing (neighborhood black race × individual OHCA race [black vs white]). Because of the high missing rate for OHCA race (48.5%), we restricted the cohort population only to patients with OHCA who had race and ethnicity identified. We ran the model without race to ensure that neighborhood effect remained after excluding patients with missing information. We then added individual race as an independent variable in the model, along with neighborhood race (as the primary dependent variable), as well as other confounders. Finally, the interaction term was added to the primary model to assess the differential impact of individual race on the association between neighborhood race and survival.

All statistical tests were 2-sided, with $P < .05$ indicating statistical significance. No adjustments were made for multiple comparisons. Analyses were performed using Stata Release 11 (StataCorp).

Results

We analyzed 22 816 patients with OHCA from 2543 census tracts. The median age of patients was 64 years (interquartile range [IQR], 51-78), 13 982 were men (61.3%), 4915 had a shockable initial rhythm (21.5%), 3069 had a cardiac arrest that occurred in a public location (13.5%), and 8316 had a bystander-witnessed event (36.4%) (**Table 1**). Bystander CPR was performed in 9012 patients (39.5%), and bystander AED use before EMS arrival was performed in 938 (4.1%). The median percentage of black residents in US ROC neighborhoods was 4.5%, and the median household income was $40 598 (Table 1).

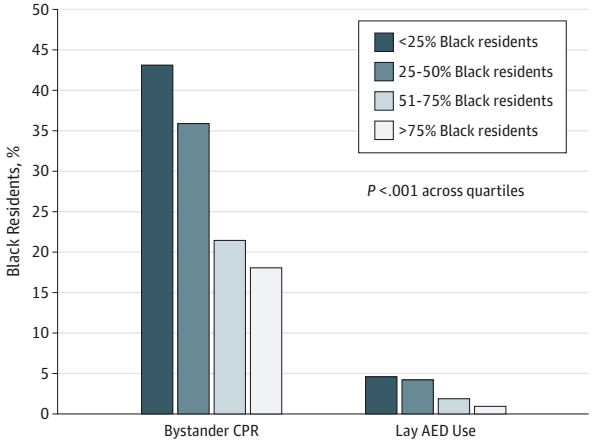
Table 1. Baseline Characteristics, Bystander Treatment, and EMS Processes of Care for Study Population by Percentage of Black Residents[a]

Characteristic	Overall (N = 22 816)	<25% Black (n = 18 198)	25%-50% Black (n = 1823)	51%-75% Black (n = 893)	>75% Black (n = 1902)	*P* Value
Age, median (IQR), y	64 (51-78)	64 (51-78)	64 (51.5-78)	63 (52-79)	63 (51-79)	<.001
Male, No. (%)	13982 (61.3)	11374 (62.5)	1060 (58.1)	523 (58.6)	1025 (53.9)	<.001
Initial EMS rhythm, No. (%)						
VT/VF	4915 (21.5)	4131 (22.7)	339 (18.6)	156 (17.5)	289 (15.2)	<.001
PEA	5272 (23.1)	4134 (22.7)	439 (24.1)	203 (22.7)	496 (26.1)	
Asystole	10858 (47.6)	8584 (47.2)	896 (49.1)	455 (51.0)	923 (48.5)	
AED: no-shock, no-strip	1017 (4.5)	765 (4.2)	84 (4.6)	48 (5.4)	120 (6.3)	
Cannot determine	681 (3.0)	525 (2.9)	59 (3.2)	28 (3.1)	69 (3.6)	
Public location, No. (%)	3069 (13.5)	2537 (13.9)	245 (13.4)	107 (12.0)	180 (9.5)	<.001
Witness status, No. (%)						
EMS	2598 (11.4)	1965 (10.8)	227 (12.5)	111 (12.4)	295 (15.5)	<.001
Bystander	8316 (36.4)	6824 (37.5)	592 (32.5)	304 (34.0)	596 (31.3)	
None	10507 (46.1)	8481 (46.6)	828 (45.4)	394 (44.1)	804 (42.3)	
Bystander CPR, No. (%)						
Yes	9012 (39.5)	7828 (43.0)	652 (35.8)	190 (21.3)	342 (18.0)	<.001
No	11989 (52.5)	9083 (49.9)	1012 (55.5)	589 (66.0)	1305 (68.6)	
Unknown	1805 (7.9)	1279 (7.0)	159 (8.7)	114 (12.8)	253 (13.3)	
Lay AED use before EMS, No. (%)	938 (4.1)	827 (4.5)	77 (4.2)	17 (1.9)	17 (0.9)	<.001
Census characteristics, median (IQR)						
Black residents in neighborhood, %	4.5 (1.5-16.6)	2.9 (1.2-7.4)	34.8 (29.1-40.9)	61.9 (55.8-70.1)	91.3 (85.5-95.7)	<.001
Hispanic residents in neighborhood, %	6 (2.9-14.8)	6.3 (3.2-14.7)	12.1(4.2-28.4)	4.7 (2.6-24.2)	1.9 (0.9-4.9)	<.001
White residents in neighborhood, %	76.6 (50.6-88)	81.4 (69.1-90.4)	44.2 (35.1-54.1)	25.6 (20.3-32)	4.4 (1.8-9.4)	<.001
Median household income, $	40 598 (31 034-52 231)	43 324 (35 245-56 780)	35 507 (29 063-42 536)	28 185 (22 231-36 366)	21 563 (17 875-27 817)	<.001
College education attained, %	21.1 (11.6-36.9)	24.3 (15-40.7)	20.4 (10.5-27.4)	10.9 (6.8-16.1)	7.3 (5.1-10.5)	<.001
EMS process characteristics, mean (SD)						
Time from dispatch call to EMS arrival, min	5.3 (2.5)	5.4 (2.5)	4.8 (2.7)	4.5 (1.9)	4.4 (2)	<.001
Time from dispatch call to AED arrival, min	5.4 (5.6)	5.5 (6.1)	4.8 (2.9)	4.5 (2.1)	4.5 (2.4)	<.001
Time from dispatch call to ALS arrival, min	7.1 (4.2)	7.3 (4.3)	6.3 (3.9)	6 (3)	6.1 (3.3)	<.001
Time from EMS arrival to rhythm analysis, min	4.1 (5.4)	4.1 (5.7)	4.5 (3.6)	4.3 (3.5)	4.4 (3.5)	<.001
Time from EMS arrival to first shock, min	5.2 (4.2)	5.1 (4.1)	6 (4.7)	6.2 (4.7)	5.7 (4.3)	<.001
EMS preshock pause duration, s	15.1 (16.3)	15 (17.1)	14.5 (11.9)	16.7 (13.5)	15.8 (10.1)	.76
Compression rate, per min	113.6 (16.6)	112 (15.6)	118.2 (18)	120 (18.3)	120.1 (19.1)	.07
Compression depth, mm	41.4 (10.5)	41.2 (10.4)	41.8 (10.6)	41.6 (10.8)	42.5 (10.4)	<.001
Time from EMS arrival to first ROSC, min	18.7 (10.3)	18.4 (10.3)	19.2 (10.1)	20.6 (10.4)	20.9 (10)	<.001
Time from EMS arrival to ceased efforts, min	22.3 (13.9)	21.8 (14.2)	23.6 (12.2)	25.5 (9.5)	25.7 (12.5)	.04
Time from EMS arrival to left scene, min	22.1 (13.6)	23.1 (13.9)	19.9 (11.7)	18.6 (11.3)	17 (11.4)	<.001

Abbreviations: AED, automatic external defibrillator; ALS, advanced life support; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; IQR, interquartile range; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; VT/VF, ventricular tachycardia/ventricular fibrillation.

[a] Missing data rates for covariates included in the model: age, 0; sex, 11; initial EMS rhythm, 73; location of cardiac arrest, 27; witness status, 1395; bystander CPR, 1815; first EMS arrival time, 733; ALS arrival time, 277; median household income, 0; percentage of college education attained, 6; and neighborhood race data, 0.

Figure. Bystander Treatments of Patients With Out-of-Hospital Cardiac Arrest Before Emergency Medical Services Arrival Among Neighborhoods by Percentage of Black Residents



AED indicates automatic external defibrillator; CPR, cardiopulmonary resuscitation.

The median percentage of black residents in the United States is 3.0%,[2] and the median household income was $42 148 in 2000.[23]

In neighborhoods with a higher percentage of black residents, patients with OHCA were more likely to be young and were less likely to be men, have an initial shockable rhythm, experience OHCA in a public location, or have a bystander-witnessed event (Table 1). With a higher percentage of black residents in the neighborhood, the percentage of patients with OHCA who received bystander CPR and lay AED use decreased (**Figure**). Similarly, median household incomes and college education decreased with a higher percentage of black residents in the neighborhood (Table 1).

Emergency medical services process of care times varied among neighborhood race quantiles (Table 1). The interval from dispatch call to EMS arrival was shorter for neighborhoods with a higher percentage of black residents. Time from EMS arrival to hospital transport was also shorter for neighborhoods with a higher percentage of black residents. Compared with other neighborhoods, time from EMS arrival to first ROSC was longest in neighborhoods with more than 75% black residents, and EMS personnel spent more time in black neighborhoods with more than 75% black residents before ceasing resuscitation efforts (Table 1). Compared with other neighborhoods, time to first defibrillation was longer for patients in neighborhoods with more than 75% black residents, but for patients with shockable rhythms, time to ceased efforts was shortest in neighborhoods with more than 75% black residents (Table 1 and eTable 1 in the Supplement).

Overall, 6343 of 22 816 patients had ROSC at ED arrival (27.8%). The percentage of patients with OHCA who had ROSC at ED arrival decreased for neighborhoods with a higher percentage of black residents (**Table 2**). Survival to discharge was 11.1% (2528 of 22 816) for the overall cohort. Unadjusted survival to discharge rates decreased for neighborhoods with a higher percentage of black residents (Table 2 and eFigure in the Supplement). Favorable neurologic status at discharge followed similar patterns to ROSC at ED arrival and survival to discharge (Table 2).

After adjustment, patients with OHCA in neighborhoods with a higher percentage of black residents experienced lower survival to hospital discharge (>75% black residents: odds ratio [OR], 0.65; 95% CI, 0.51-0.82; 51%-75% black residents: OR, 0.68; 95% CI, 0.51-0.93; and 25%-50% black residents: OR, 0.76; 95% CI, 0.61-0.93; $P = .001$) compared with neighborhoods with less than 25% black residents (**Table 3** and eTable 2 and eTable 3 in the Supplement for full model). A similar inverse association was demonstrated for favorable neurologic status at discharge (>75% black residents: OR, 0.56; 95% CI, 0.38-0.82; 51%-75% black residents: OR, 0.77; 95% CI, 0.50-1.20; and 25%-50% black residents: OR, 0.69; 95% CI, 0.50-0.94; $P < .001$) for predominantly black neighborhoods compared with neighborhoods with less than 25% black residents, as well as ROSC at ED arrival (>75% black residents: OR, 0.47; 95% CI, 0.39-0.55; 51%-75% black residents: OR, 0.58; 95% CI, 0.47-0.73; and 25%-50% black residents: OR, 0.66; 95% CI, 0.56-0.78; $P < .001$) (Table 3 and eTable 2 in the Supplement). When neighborhood race was modeled continuously, every 5-percentage point increase in neighborhood black residents was associated with 0.97 adjusted odds (95% CI, 0.96-0.98) for survival to discharge.

There were significant differences in the proportion of black residents living in census tracts among geographic sites in ROC (eFigure and eTable 4 in the Supplement). In a sensitivity analysis in which ROC geographic site was included as a covariate, survival to hospital discharge was not significantly different between neighborhoods with a higher percentage of black residents compared with neighborhoods with less than 25% black residents (Table 3).

There remained an association between neighborhood race and survival to discharge after accounting for individual race (Table 3). Within each neighborhood race quantile, black and white patients with OHCA had similar mortality risk (interaction $P = .80$; Table 3). Patients with OHCA who had shockable rhythms had significantly higher unadjusted and adjusted rates of ROSC at ED arrival, survival to discharge, and favorable neurologic status at discharge across all quantiles compared with patients with nonshockable rhythms (Table 2 and Table 3 and eTable 2 in the Supplement). The association between proportion of black residents in a neighborhood and survival differed by initial rhythm. There was a greater magnitude of disparity in outcomes among neighborhoods with more than 75% black residents compared with neighborhoods with less than 25% black residents among patients with a shockable rhythm compared with those with a nonshockable rhythm (interaction $P < .001$).

Discussion

Patients with OHCA with any initial rhythm in neighborhoods with higher percentages of black residents had lower rates of bystander CPR and AED use and were significantly less

Table 2. Unadjusted Outcomes of OHCA by Percentage of Black Residents in Neighborhoods: Overall and by Initial Rhythm

Outcomes	No. (%) Overall (N = 22 816)	<25% Black (n = 18 198)	25%-50% Black (n = 1823)	51%-75% Black (n = 893)	>75% Black (n = 1902)	*P* Value
ROSC at ED Arrival						
EMS treated	6343 (27.8)	5452 (30.0)	404 (22.2)	179 (20.0)	308 (16.2)	<.001
Initial rhythm VT/VF	2249 (45.8)	1996 (48.3)	126 (37.2)	45 (28.8)	82 (28.4)	
Initial rhythm PEA/asystole	3586 (22.2)	3025 (23.8)	252 (18.9)	113 (17.2)	196 (13.8)	
Survival to Hospital Discharge						
EMS treated	2528 (11.1)	2174 (11.9)	165 (9.1)	67 (7.5)	122 (6.4)	<.001
Initial rhythm VT/VF	1491 (30.3)	1319 (31.9)	92 (27.1)	29 (18.6)	51 (17.6)	
Initial rhythm PEA/asystole	801 (5.0)	659 (5.2)	61 (4.6)	28 (4.3)	53 (3.7)	
Favorable Neurologic Status at Discharge						
EMS treated	1010 (4.7)	885 (5.1)	60 (3.4)	28 (3.2)	37 (2.0)	<.001
Initial rhythm VT/VF	706 (16.4)	629 (17.5)	45 (14.8)	13 (9.2)	19 (7.3)	
Initial rhythm PEA/asystole	218 (1.4)	181 (1.5)	13 (1.0)	11 (1.7)	13 (0.9)	

Abbreviations: ED, emergency department; EMS, emergency medical services; OHCA, out-of-hospital cardiac arrests; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; VT/VF, ventricular tachycardia/ventricular fibrillation.

likely to achieve ROSC at ED arrival, survive to hospital discharge, or have favorable neurologic status at discharge compared with patients who experienced OHCA in predominantly white neighborhoods. Despite lower survival in predominantly black neighborhoods, survival was no different for black and white patients having a cardiac arrest in any neighborhoods. Greater differences were observed among those with an initial shockable rhythm than an initial nonshockable rhythm. Because patients with shockable rhythms can immediately be treated with an AED and are associated with higher survival, these differences may be modifiable. The association between neighborhood race and survival was not significant after adjusting for geographic site.

To our knowledge, prior investigations examining treatments and outcomes for OHCA have focused on the race of the individual. Nonetheless, such analyses are difficult to interpret because patient race is typically missing on a large number of patient records in cardiac arrest registries.[24] Prior historical investigations of racial disparities have produced conflicting results,[8,9,12,15,25] but most demonstrate large disparities in outcomes for black vs white patients.[8,9,11,25] We specifically focused our investigation on the demographic characteristics of the neighborhoods in which the OHCA events occurred to understand whether neighborhood racial composition was associated with bystander treatments, EMS processes of care, and OHCA outcomes.

We found that in neighborhoods with a higher proportion of black residents, the use of bystander treatments decreased. Bystander CPR is consistently lower among black individuals and in black communities.[15,24-26] Sasson et al[24] found that bystander CPR was lowest in low-income neighborhoods composed of more than 80% black residents with an adjusted odds of bystander CPR less than half that of high-income neighborhoods composed of more than 80% white residents. We also found that bystander CPR rates decreased in a stepwise fashion with a higher proportion of black residents living in a community. A prior qualitative study[27] in 3 primarily black high-risk neighborhoods (high OCHA incidence, low bystander CPR) identified the following barriers to performing CPR: not recognizing a cardiac arrest and lack of knowledge with performing CPR, fear of litigation, personal health risks, and feeling disconnected from community members. Barriers to CPR training in these communities included cost of CPR training, lack of knowledge about cardiac arrest and CPR, competing priorities, and health concerns associated with performing CPR.[27]

Bystander AED use has rarely been examined in studies seeking to understand health disparities in OHCA, to our knowledge. We found that rates of bystander AED use were low overall, but there was wide disparity in AED use according to the community's racial composition. Bystanders in communities with more than 75% black residents were 5 times less likely to use an AED prior to EMS arrival compared with communities with less than 25% black residents. Partly contributing to this disparity is that as the percentage of black residents in a neighborhood increased, OHCAs were less likely to occur in a public location where an AED could be available. However, even in public locations, predominantly black neighborhoods had less AED use (11.3% in neighborhoods with <25% black residents, 5.6% in neighborhoods with >75% black residents) compared with other communities. Other reasons for this disparity may be general lack of AED availability in black communities, or lack of general education about cardiac arrest and possible treatments in primarily black neighborhoods compared with other neighborhoods.

Multiple previous studies have shown that EMS response times are either similar or shorter for black vs white individuals with cardiac arrest.[8,9,25] We found that OHCA occurring in predominantly black neighborhoods had the shortest time from call to dispatch to EMS arrival, as well as transport times to hospital. Overall, EMS responders also spent more time at the scene before ceasing resuscitation attempts in predominantly black communities; however, we did identify gaps that warrant further study. Emergency medical services arrival-to-first defibrillation was significantly longer, and total time spent on resuscitation efforts was shorter for OHCA with shockable

rhythms in neighborhoods with more than 75% black residents compared with neighborhoods with less than 25% black residents. It remains unclear why it takes longer to provide an initial shock in predominantly black communities, especially with better EMS arrival times. Some reasons may be related to OHCAs occurring in apartment complexes or high-rise buildings where it may take longer to get to the patient.[28] What also remains unclear is why there are shorter resuscitation times in patients with OHCA with shockable rhythms for predominantly black communities, particularly when time to ROSC was longer for patients in black communities. Evidence-based criteria for advanced life support termination of resuscitation rules exist,[29,30] but we did not evaluate whether such criteria were applied consistently across communities.

We found that OHCAs occurring in black neighborhoods have lower rates of ROSC at ED arrival, survival to hospital discharge, and lower favorable neurologic status at discharge. After adjustment for known common correlates of outcome, a higher proportion of black residents in a neighborhood was independently associated with worse outcomes. Socioeconomic status did not attenuate the association between black communities and outcomes of OHCA, as previously observed in other studies.[15,31-33] In a sensitivity analysis, black patients and white patients with OHCA had similar survival in each neighborhood. These findings suggest that urgent attention should be directed toward improving education and treatment of patients with cardiac arrest in predominantly black neighborhoods.

Limitations

Our study has several limitations. First, our observational data demonstrate an association between neighborhood race and survival, but this association does not prove causation. Second, unmeasured confounders may have played a role in our observed adjusted association between neighborhood race and outcomes. Third, our sensitivity analysis examining individual race should be interpreted with caution. As with other large data sets of OHCA, information about race was missing in approximately half (49.5%) of patients. Although individual race was not the focus of our analysis, we believe it was important to shed light on whether black patients and white patients with OHCA had the same survival rates in predominantly black neighborhoods. Fourth, we did not evaluate the individual components of EMS care, such as endotracheal intubation and drug use. Fifth, it is well established that there are geographic variations in survival after OHCA across the United States. We assessed the racial composition of neighborhoods because it was a significant and important contributor to survival. When we adjusted for geographic site in addition to accounting for census tract, this association was attenuated and nonsignificant. Experts may disagree whether it is preferable to adjust only for small areas (ie, census tract) or both small and large areas (ie, geographic site). We defined a priori adjustment for small areas as our primary analysis given concern for overadjustment with census tract and geographic site in the models. Importantly, most of the black neighborhoods clustered in 4 sites. Because 3 of the sites with higher survival had no census tracts with more than 75% black residents (and few with 51%-75% black residents), we are further limited in our ability to evaluate the association between racial composition and survival after OHCA. Finally, 2000 census data were used for this analysis because ROC sites did not uniformly adopt 2010 census data until 2012. Although census variables may slightly differ between reporting periods, using the 2000 census data ensured that all patients had consistent and uniform reporting.

Table 3. Association Between Outcomes of OHCA in ROC Neighborhoods With More Than 75% Black Residents Compared With Less Than 25% Black Residents

Outcomes	Patients, No. (%) (N = 22 816)	Adjusted OR (95% CI)[a]
ROSC at ED arrival		
EMS treated	21 510 (94.3)	0.47 (0.39-0.55)
Initial rhythm VT/VF[b]	4673 (95.1)	0.50 (0.36-0.69)
Initial rhythm PEA/asystole[b]	15 367 (95.3)	0.45 (0.37-0.55)
Survival to hospital discharge		
EMS treated	21 703 (95.1)	0.65 (0.51-0.82)
Initial rhythm VT/VF[b]	4665 (94.9)	0.61 (0.43-0.88)
Initial rhythm PEA/asystole[b]	15 547 (96.4)	0.60 (0.43-0.83)
Sensitivity analysis (individual race)		
EMS treated with available individual race	10 313 (45.2)	0.66 (0.48-0.95)
EMS treated adjusted for individual race[c]	10 313 (45.2)	0.68 (0.48-0.95)
Sensitivity analysis (ROC site to adjustment model)		
EMS treated including ROC site	21 703 (95.1)	1.00 (0.79-1.03)
Favorable neurologic status at discharge		
EMS treated	20 772 (91.0)	0.56 (0.38-0.82)
Initial rhythm VT/VF[b]	4146 (84.4)	0.49 (0.29-0.83)
Initial rhythm PEA/asystole[b]	15 210 (94.3)	0.65 (0.36-1.20)

Abbreviations: ED, emergency department; EMS, emergency medical services; OHCA, out-of-hospital cardiac arrests; OR, odds ratio; PEA, pulseless electrical activity; ROC, Resuscitation Outcomes Consortium; ROSC, return of spontaneous circulation; VT/VF, ventricular tachycardia/ventricular fibrillation.

[a] All models are adjusted for the following variables: age, sex, EMS response time, advanced life support response time, bystander witness status, bystander cardiopulmonary resuscitation and/or bystander automatic external defibrillator use, initial cardiac arrest rhythm, median household income, rural population, and college degree.

[b] Percentages are calculated from the proportion of all patients within each subgroup, not by the entire cohort.

[c] Interaction $P = .80$ for individual race × neighborhood race; the interaction term was therefore omitted.

Conclusions

Bystander treatments and survival after OHCA are significantly lower in neighborhoods with a higher percentage of black residents. Black and white patients with OHCA had similar survival in each neighborhood quantile. Novel education and implementation efforts are needed to improve resuscitation outcomes in these neighborhoods.

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