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ORIGINAL RESEARCH ARTICLE

Racial Differences in Long-Term Outcomes Among Older Survivors of In-Hospital Cardiac Arrest

Lena M. Chen, MD, MS
Brahmajee K. Nallamothu, MD, MPH
John A. Spertus, MD, MPH
Yuanyuan Tang, PhD
Paul S. Chan, MD, MSc
And the GWTG-R Investigators

BACKGROUND: Black patients have worse in-hospital survival than white patients after in-hospital cardiac arrest (IHCA), but less is known about long-term outcomes. We sought to assess among IHCA survivors whether there are additional racial differences in survival after hospital discharge and to explore potential reasons for differences.

METHODS: This was a longitudinal study of patients ≥65 years of age who had an IHCA and survived until hospital discharge between 2000 and 2011 from the national Get With The Guidelines–Resuscitation registry whose data could be linked to Medicare claims data. Sequential hierarchical modified Poisson regression models evaluated the proportion of racial differences explained by patient, hospital, and unmeasured factors. Our exposure was black or white race. Our outcome was survival at 1, 3, and 5 years.

RESULTS: Among 8764 patients who survived to discharge, 7652 (87.3%) were white and 1112 (12.7%) were black. Black patients with IHCA were younger, more frequently female, sicker with more comorbidities, less likely to have a shockable initial cardiac arrest rhythm, and less likely to be evaluated with coronary angiography after initial resuscitation. At discharge, black patients were also more likely to have at least moderate neurological disability and less likely to be discharged home. Compared with white patients and after adjustment only for hospital site, black patients had lower 1-year (43.6% versus 60.2%; relative risk [RR], 0.72), 3-year (31.6% versus 45.3%; RR, 0.71), and 5-year (23.5% versus 35.4%; RR, 0.67; all $P<0.001$) survival. Adjustment for patient factors explained 29% of racial differences in 1-year survival (RR, 0.80; 95% confidence interval, 0.75–0.86), and further adjustment for hospital treatment factors explained an additional 17% of racial differences (RR, 0.85; 95% confidence interval, 0.80–0.92). Approximately half of the racial difference in 1-year survival remained unexplained, and the degree to which patient and hospital factors explained racial differences in 3-year and 5-year survival was similar.

CONCLUSIONS: Black survivors of IHCA have lower long-term survival compared with white patients, and about half of this difference is not explained by patient factors or treatments after IHCA. Further investigation is warranted to better understand to what degree unmeasured but modifiable factors such as postdischarge care account for unexplained disparities.

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Clinical Perspective

What Is New?

- Compared with white survivors of in-hospital cardiac arrest, black survivors had a >10% lower absolute rate of long-term survival after hospital discharge.
- This translated to a 28% lower relative likelihood of living to 1 year and a 33% lower relative likelihood of living to 5 years after hospital discharge for black versus white survivors.
- Nearly one third of the racial difference in 1-year survival was dependent on measured patient factors; only a small proportion was explained by racial differences in hospital care; and approximately one half was the result of differences in care after discharge or unmeasured confounding.

What Are the Clinical Implications?

- These findings suggest a need to examine whether there are racial differences in postdischarge care that would explain racial disparities in long-term survival for patients after in-hospital cardiac arrest.

Substantial racial differences in in-hospital survival exist among the estimated 200 000 patients who have an in-hospital cardiac arrest each year.[1,2] Compared with white patients, black patients with an in-hospital cardiac arrest have a 27% lower likelihood of surviving to hospital discharge, and this difference is explained, in part, by the hospital at which patients receive care.[1] For those patients fortunate enough to survive a hospitalization complicated by in-hospital cardiac arrest, long-term survival is comparable to that of other common chronic illnesses such as heart failure.[3] However, it remains unclear whether there are additional racial differences in long-term survival among cardiac arrest survivors beyond those observed during the index hospitalization and, if so, the reasons for such differences.

Understanding the source of racial differences in survival could guide efforts to narrow disparities in care and to improve outcomes. If racial differences in long-term survival stem primarily from patient factors such as demographics and pre-existing comorbidities, altering treatment differences may have little impact. In contrast, if racial differences in long-term survival are explained by differences in treatments during postresuscitation care (eg, coronary angiography, therapeutic hypothermia, implantable cardioverter-defibrillator implantation), neurological status at discharge (which may result from differential acute resuscitation and postresuscitation care), discharge destination, or postdischarge care, these may represent targets for reducing racial disparities in treatment and long-term survival among patients with in-hospital cardiac arrest.

To better understand long-term outcomes after surviving an in-hospital cardiac arrest, we used the national Get With The Guidelines (GWTG)–Resuscitation registry to examine long-term survival among white and black survivors of an in-hospital cardiac arrest at 1, 3, and 5 years. We examined the extent to which any racial differences in long-term survival were explained by patient demographics and pre-existing conditions, invasive interventions during the index hospitalization, neurological status at discharge, and discharge destination, with residual unexplained differences in outcomes presumed to be attributable to postdischarge care and other unmeasured factors.

METHODS

The data, analytical methods, and study materials can be made available to other researchers who apply to GWTG-Resuscitation for data access for the purpose of reproducing the results or replicating the procedure.

Data Sources

We used data from GWTG-Resuscitation, a national registry of in-hospital cardiac arrest from >700 US hospitals. At participating hospitals, patients are included in the registry if they have a pulseless in-hospital cardiac arrest, which is defined as apnea, pulselessness, and unresponsiveness in patients without do-not-resuscitate orders. Using standard variable definitions (Table I in the online-only Data Supplement) and Utstein-style definitions,[4,5] trained personnel collect data from medical records for all patients with an in-hospital cardiac arrest. As has been described by others,[6] case-finding protocols include review of resuscitation documentation, hospital paging logs, checks of code carts, and review of pharmacy and billing records for resuscitation drugs. Abstractors undergo training and testing for accuracy of data submission before their site can submit cases to GWTG-Resuscitation. In addition, data are collected by the abstractors who are unaware of subsequent research questions within GWTG-Resuscitation. The variables encompass a number of factors, including baseline demographics and clinical variables, cardiac arrest characteristics, and in-hospital outcomes.

To capture survival outcomes after hospital discharge, we linked patient-level GWTG-Resuscitation data to Medicare Provider and Analysis Review and Denominator files from 2000 through 2012. With the use of an approach described in prior work,[7] records between GWTG-Resuscitation and Medicare files were linked using a deterministic matching algorithm on the basis of patients' hospital admission and discharge dates, age, sex, admitting hospital, and diagnosis and procedure codes.

Study Population

Because the linkage between GWTG-Resuscitation and Medicare files was available only for data through 2012 and because we wanted to assess survival for up to 5 years, we identified 31 012 patients who survived to discharge after an index in-hospital cardiac arrest within GWTG-Resuscitation between January 1, 2000, and December 31, 2012 (Figure I in

the online-only Data Supplement). We excluded patients <65 years of age (n=14 844) because they would not be linked to Medicare claims data. We also excluded 5591 patients who could not be linked to Medicare files. This scenario occurred when a patient was admitted to a non-Medicare hospital (eg, Veterans Administration hospital), had insurance other than fee-for-service Medicare, was admitted to a hospital with few registry patients (thus precluding a unique match), or lacked a qualifying diagnosis or procedure code for cardiac arrest in the Medicare files. Patients who could and those who could not be linked to Medicare files were similar in baseline characteristics except for location of cardiac arrest (Table II in the online-only Data Supplement). We also excluded patients who were missing data on race or were neither white nor black. We additionally excluded patients whose in-hospital cardiac arrest occurred after December 31, 2011 (n=962), to allow at least 1 year of follow-up. The final study sample included 8764 patients treated at 469 hospitals.

Study Exposure and Outcomes

The primary independent variable was patient-reported race, categorized as black or white. The primary study outcome was 1-year survival after discharge from the index hospitalization for cardiac arrest, with secondary outcomes of 3-year and 5-year survival.

Statistical Analyses

We used descriptive statistics to compare patient and hospital characteristics of survivors of in-hospital cardiac arrest by race (white versus black) with the Student *t* test for continuous variables and χ^2 tests (Fisher exact test) for categorical variables. Similarly, we compared unadjusted 1-, 3-, and 5-year survival rates by race using χ^2 tests. We also created 5-year survival curves after discharge from in-hospital cardiac arrest by race using Kaplan-Meier estimates.

To examine the degree to which observed racial differences in long-term survival after in-hospital cardiac arrest were explained by patient or hospital factors, we constructed sequential hierarchical modified Poisson regression models for each survival time point (1, 3, and 5 years). Use of sequential models provides insights as to what types of factors accounted for observed racial differences in survival. The base model was unadjusted, except for hospital site, which was modeled as a random effect in the hierarchical model to account for patient clustering within hospitals. We next adjusted for patient factors in 3 steps, with each sequential model comprising all covariates from the prior models: (1) age and sex, (2) clinical comorbidities and interventions in place at the time of cardiac arrest, and (3) initial cardiac arrest rhythm and cardiac arrest location. The aforementioned comorbidities included diagnoses of heart failure (during index admission, history), acute myocardial infarction (during index admission, history), diabetes mellitus, renal insufficiency, hepatic insufficiency, respiratory insufficiency, stroke, pneumonia, hypotension, septicemia, metastatic or hematologic malignancy, baseline depression in central nervous system function, and metabolic or electrolyte abnormalities. Interventions present at the time of cardiac arrest included hemodialysis, continuous infusion of vasopressor therapy, and mechanical ventilation.

Next, we additionally adjusted for hospital interventions during postresuscitation care, which included therapeutic hypothermia (as identified in the GWTG-Resuscitation data set), coronary angiography (as documented in Medicare files with *International Classification of Diseases, Ninth Revision, Clinical Modification* procedure codes 0066, 3603, 3606, 3607, 3609, 3722, 3723, 8853, 8854, 8855, 8856, and 8857), and de novo implantation of an implantable cardioverter-defibrillator (codes 0051 and 3794). Lastly, a final model further adjusted for discharge neurological status (as measured by Cerebral Performance Category scores) and discharge destination (home without home health care, home with home health care, inpatient care, skilled nursing facility, nursing home, hospice, and other). These adjustments were included to account for known differences in discharge neurological status and discharge destination by race after an in-hospital cardiac arrest because they represent, in part, racial differences in acute resuscitation and postresuscitation care and could explain racial differences in survival after discharge.

For each step in the sequential hierarchical models, modified Poisson regression was used to estimate relative rates.[8–10] For the primary outcome of 1-year long-term survival, we included all patients in the analyses. For the outcomes of 3- and 5-year survival, only patients with at least 3 and 5 years of follow-up, respectively (ie, with an in-hospital cardiac arrest before January 1, 2010 [7205 patients], and January 1, 2008 [5383 patients]), were included.

For each analysis, we evaluated the null hypothesis at a 2-sided significance level of 0.05 and calculated 95% confidence intervals (CIs) using robust standard errors. All analyses were performed with SAS version 9.4 (SAS Institute, Cary, NC) and R version 3.3.1 (R Foundation for Statistical Computing, Vienna, Austria).[11] The Institutional Review Board at the Mid-America Heart Institute waived the requirement for informed consent because the study used deidentified data.

RESULTS

Of 8764 patients with an in-hospital cardiac arrest who survived to hospital discharge, 7652 (87.3%) patients were white and 1112 (12.7%) were black (Table 1). Black patients were younger, more frequently female, and sicker, with higher rates of renal insufficiency, respiratory insufficiency, septicemia, pneumonia, and requirement for hemodialysis before cardiac arrest. Notably, black patients were less likely to have an acute myocardial infarction during the admission or a history of acute myocardial infarction. As a result, they were more likely to have a nonshockable initial cardiac arrest rhythm of asystole or pulseless electric activity and to have their cardiac arrest in a nonmonitored hospital unit. During the index hospitalization for cardiac arrest, black patients were less likely to undergo coronary angiography after achieving return of spontaneous circulation compared with whites, but they were as likely to be treated with therapeutic hypothermia and an implantable cardioverter-defibrillator before discharge (if their initial rhythm was ventricular fibrillation or pulseless ventricular tachycardia; Table 2). Lastly, black

Table 1. Patient Characteristics by Race

	White (n=7652)	Black (n=1112)	*P* Value
Demographics			
Age at admission, y			<0.001
Mean±SD	76.1±7.0	75.0±7.2	
Median (25th, 75th percentile)	76.0 (70.0, 81.0)	74.0 (69.0, 80.0)	
Age category, n (%)			<0.001
≥65–74 y	3369 (44.0)	583 (52.4)	
≥75–84 y	3287 (43.0)	409 (36.8)	
≥85 y	996 (13.0)	120 (10.8)	
Male, n (%)	4378 (57.2)	478 (43.0)	<0.001
Pre-existing conditions before arrest, n (%)			
CHF this admission	1682 (22.0)	245 (22.0)	0.97
History of CHF	1912 (25.0)	321 (28.9)	0.005
AMI this admission	1950 (25.5)	186 (16.7)	<0.001
History of AMI	1875 (24.5)	191 (17.2)	<0.001
Diabetes mellitus	2373 (31.0)	488 (43.9)	<0.001
Renal insufficiency	1880 (24.6)	439 (39.5)	<0.001
Hepatic insufficiency	165 (2.2)	25 (2.2)	0.84
Respiratory insufficiency	2595 (33.9)	435 (39.1)	<0.001
Baseline depression in CNS function	716 (9.4)	192 (17.3)	<0.001
Acute stroke	269 (3.5)	62 (5.6)	<0.001
Acute CNS nonstroke event	437 (5.7)	71 (6.4)	0.37
Pneumonia	804 (10.5)	154 (13.8)	<0.001
Hypotension	1437 (18.8)	179 (16.1)	0.03
Septicemia	538 (7.0)	116 (10.4)	<0.001
Major trauma	152 (2.0)	17 (1.5)	0.30
Metabolic electrolyte abnormality	771 (10.1)	144 (12.9)	0.003
Pre-existing ICD	101 (1.3)	19 (1.7)	0.30
Metastatic or hematologic malignancy	573 (7.5)	73 (6.6)	0.27
Interventions in place at time of arrest, n (%)			
Continuous intravenous vasopressor	1234 (16.1)	146 (13.1)	0.01
Dialysis	111 (1.5)	36 (3.2)	<0.001
Mechanical ventilation	1409 (18.4)	207 (18.6)	0.87
Cardiac arrest factors, n (%)			
Initial cardiac rhythm*			<0.001
Asystole	1890 (24.7)	283 (25.4)	
Pulseless electric activity	2303 (30.1)	501 (45.1)	
Ventricular fibrillation	2227 (29.1)	199 (17.9)	
Pulseless ventricular tachycardia	1232 (16.1)	129 (11.6)	
Location of cardiac arrest			<0.001
Intensive care unit	3112 (40.7)	406 (36.5)	
Monitored	1895 (24.8)	266 (23.9)	
Nonmonitored	896 (11.7)	179 (16.1)	
Emergency room	730 (9.5)	139 (12.5)	
Procedural	876 (11.4)	102 (9.2)	
Other	142 (1.9)	20 (1.8)	

AMI indicates acute myocardial infarction; CHF, congestive heart failure; CNS, central nervous system; and ICD, implantable cardioverter-defibrillator.

*Initial cardiac rhythm is the cardiac rhythm when the need for chest compression or defibrillation was first identified.

Table 2. Hospital Treatments and Factors by Race

	White (n=7652)	Black (n=1112)	*P* Value
Interventions, n (%)			
Induced hypothermia initiated	179 (2.6)	27 (2.7)	0.82
Coronary angiography	2531 (33.1)	200 (18.0)	<0.001
Defibrillator implanted	900 (11.8)	79 (7.1)	<0.001
Nonshockable rhythms	170 (4.1)	13 (1.7)	0.001
Shockable rhythms	730 (21.1)	66 (20.1)	0.72
Disability on discharge, n (%)			
CPC score			<0.001
Little to no disability	3486 (45.6)	352 (31.7)	
Moderate disability	2052 (26.8)	328 (29.5)	
Severe disability	859 (11.2)	215 (19.3)	
Coma or vegetative state	190 (2.5)	56 (5.0)	
Brain dead	1 (0.0)	0 (0.0)	
Unknown (missing CPC score)	1063 (13.9)	161 (14.5)	
Discharge destination, n (%)			<0.001
Home	1846 (24.1)	184 (16.5)	
Home with home health care	1108 (14.5)	153 (13.8)	
Inpatient care	1466 (19.2)	196 (17.6)	
Skilled nursing	2080 (27.2)	315 (28.3)	
Long-term care	662 (8.7)	194 (17.4)	
Hospice	459 (6.0)	68 (6.1)	
Other	31 (0.4)	2 (0.2)	

CPC indicates Cerebral Performance Category.

patients were more likely to leave the hospital with moderate or severe neurological disability and were less likely to be discharged home without home health care.

Racial Differences in Survival

Compared with white patients, black patients had substantially lower unadjusted rates of 1-year (43.6% versus 60.2%), 3-year (31.6% versus 45.3%), and 5-year (23.5% versus 35.4%, all *P*<0.001) survival (Table 3 and Figure). For the primary end point of 1-year survival, black survivors of in-hospital cardiac arrest were 28% (relative risk, 0.72; 95% CI, 0.67–0.78; *P*<0.001) less likely to survive to 1 year compared with white patients after adjustment only for hospital site. After sequential adjustment for other demographic factors of age and sex, clinical comorbidities, interventions present at the time of cardiac arrest, and initial cardiac arrest rhythm and location of cardiac arrest, racial differences in 1-year survival narrowed (relative risk, 0.80; 95% CI, 0.75–0.86), with 29% [calculated as 100×(0.80–0.72)/(1–0.72)] of the racial difference in survival explained by these relatively nonmodifiable patient factors (Table 4).

Additional adjustment for hospital postresuscitation treatments (coronary angiography, therapeutic hypothermia, and implantable cardioverter-defibrillator implantation) had a modest impact on racial differences in 1-year survival (relative risk, 0.82; 95% CI, 0.76–0.88), with 7% of the racial difference in 1-year survival explained by differences in rates of these interventions. Further adjustment for discharge neurological status and discharge destination resulted in additional attenuation of racial differences in survival (relative risk, 0.85; 95% CI, 0.80–0.92), with an additional 10% of racial differences in 1-year survival explained by these hospital discharge factors. Results were generally similar for the outcomes of 3-year and 5-year survival (Table 4).

Table 3. Unadjusted Rates of Long-Term Survival by Race

	White (n=7652)	Black (n=1112)	*P* Value
1-y Survival			<0.001
Survived 1 y, n	4610	485	
Survived to discharge, n	7652	1112	
Percentage	60.2	43.6	
3-y Survival			<0.001
Survived 3 y, n	2855	283	
Survived to discharge, n	6309	896	
Percentage	45.3	31.6	
5-y Survival			<0.001
Survived 5 y, n	1683	149	
Survived to discharge, n	4748	635	
Percentage	35.4	23.5	

DISCUSSION

In this national multisite registry, we found that black survivors of in-hospital cardiac arrest, compared with white survivors, had a >10% lower absolute rate of long-term survival after hospital discharge. This was the case at each time point for black survivors, which, given

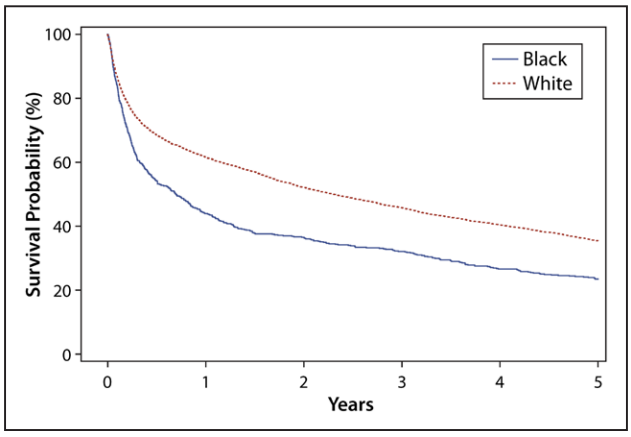

Figure. Long-term survival among survivors of in-hospital cardiac arrest by race.
The Kaplan-Meier curves are based on Medicare claims data linked to death data, so no patients were lost to follow-up.

Table 4. Association Between Black Race and Likelihood of 1-Year, 3-Year, and 5-Year Survival in Patients With In-Hospital Cardiac Arrest

	RR	95% CI	*P* Value	Survival Difference Explained, %
1-y Survival				
Unadjusted	0.72	0.67–0.78	<0.001	NA
Adjusted for patient factors				
Age and sex	0.71	0.66–0.76	<0.001	–4
Plus clinical/cardiac arrest	0.79	0.74–0.85	<0.001	25
Plus rhythm/arrest location	0.80	0.75–0.86	<0.001	29
Adjusted for hospital factors				
Plus hospital interventions	0.82	0.76–0.88	<0.001	36
Plus CPC score, discharge destination	0.85	0.80–0.92	<0.001	46
3-y Survival				
Unadjusted	0.71	0.63–0.79	<0.001	NA
Adjusted for patient factors				
Age and sex	0.68	0.61–0.76	<0.001	–10
Plus clinical/cardiac arrest	0.81	0.73–0.89	<0.001	34
Plus rhythm/arrest location	0.83	0.75–0.91	<0.001	41
Adjusted for hospital factors				
Plus hospital interventions	0.85	0.77–0.94	0.002	48
Plus CPC score, discharge destination	0.89	0.80–0.98	0.021	62
5-y Survival				
Unadjusted	0.67	0.57–0.78	<0.001	NA
Adjusted for patient factors				
Age and sex	0.64	0.54–0.75	<0.001	–9
Plus clinical/cardiac arrest	0.79	0.68–0.92	0.002	36
Plus rhythm/arrest location	0.81	0.70–0.93	0.004	42
Adjusted for hospital factors				
Plus hospital interventions	0.82	0.71–0.95	0.009	45
Plus CPC score, discharge destination	0.87	0.75–1.01	0.06	61

CI indicates confidence interval; CPC, Cerebral Performance Category; NA, not applicable; and RR, relative risk.

absolute rates of long-term survival, translated to a 28% lower relative likelihood of living to 1 year and a 33% lower relative likelihood of living to 5 years after hospital discharge. At the 1-year follow-up, about 29% of the racial difference in long-term survival was attributable to patients' demographics and clinical factors present at the time of cardiac arrest, whereas only a modest (7%) proportion was attributed to hospital treatment differences after resuscitation during the index hospitalization such as coronary angiography and revascularization and defibrillator placement. Moreover, patients' neurological and functional (ie, discharge destination) status at discharge, which partly reflects the quality of acute resuscitation and postresuscitation care after cardiac arrest, accounted for a modest 10% of the difference in 1-year survival between black and white patients. Notably, about half of the racial difference in 1-year survival remained unexplained. Collectively, our findings suggest that substantial racial differences in long-term survival exist among survivors of in-hospital cardiac arrest, with patient factors and hospital treatments accounting for approximately half of these differences. Further investigation is warranted to better understand whether modifiable aspects of postdischarge care account for the remaining differences and whether interventions can be developed to eliminate racial disparities in care and survival for cardiac arrest survivors.

Although studies on racial differences in survival after in-hospital cardiac arrest exist, they focus largely on in-hospital survival. Chan and colleagues[1] previously reported that, for patients with a shockable in-hospital cardiac arrest caused by ventricular fibrillation or pulseless ventricular tachycardia, unadjusted survival rates to hospital discharge were substantially lower for black versus white patients (25.2% versus 37.4%), with a significant proportion of the explained difference attributable to the hospital at which patients received care. Similarly, among patients with a nonshockable in-hospital cardiac arrest resulting from asystole or pulseless electric activity, black patients had lower rates of in-hospital survival.[2] Although these studies found that hospital treatments and systems of care accounted for

a significant proportion of the explained racial differences, it remained unclear whether there would be additional racial differences in survival among those surviving to hospital discharge. By leveraging the linkage of data between GWTG-Resuscitation and Medicare inpatient files, our study extends the literature on racial disparities in survival for in-hospital cardiac arrest by examining postdischarge survival, which were in addition to the existing disparities found for in-hospital survival.

Our finding that black patients had lower long-term survival after surviving in-hospital cardiac arrest contrasts with data on long-term survival after heart failure. For that condition, prior studies have found that older black patients have higher 6-month and 1-year survival compared with white patients.[12,13] It may be that for cardiac arrest, a condition associated with high levels of postdischarge disability, the quality and availability of postacute care matter more than they do for other conditions. Indeed, others have reported that, compared with whites, black patients are less likely to be admitted to high-quality skilled nursing facilities[14] and nursing homes.[15] It is also possible that other differences in care after hospital discharge account for the remaining unexplained racial differences in long-term survival. For example, prior research on general medical and surgical care suggests that black patients are more likely to receive care at low-quality hospitals[16] and to have outpatient providers who are more isolated[17] and have fewer resources.[18] Unmeasured socioeconomic factors such as financial security, medical literacy, and social support at home[19] may also contribute to the unexplained racial difference in long-term survival. It may also be that a higher baseline severity of comorbid conditions for black compared with white patients increases the downstream risk of complications and comorbidities after an in-hospital cardiac arrest. For instance, although we adjusted for renal insufficiency, we did not have precise information on creatinine clearance, and the extent of renal insufficiency in black patients may have been more severe and contributed to unmeasured confounding. Future studies that link GWTG-Resuscitation to Medicare outpatient and pharmacy data, which are not available in the currently linked data, and to laboratory data could provide further insights into how much of the unexplained racial differences in long-term survival may be the result of differences in patterns of medical care after hospital discharge as opposed to unmeasured confounding and social determinants of health.

Although this study found that providers performed coronary angiography much less frequently in black survivors, to date, no randomized trials have assessed the efficacy of this treatment in patients successfully resuscitated from an in-hospital cardiac arrest. We found that racial differences in the rates of this and other interventions explained only a small amount of the 1-year survival gap between black and white patients. This suggests a need for ongoing randomized trials or well-conducted observational studies to identify which postresuscitation treatments may actually improve survival outcomes for survivors of in-hospital cardiac arrest.

Our findings should be interpreted in the context of the following potential limitations. First, the study population was limited to older adults enrolled in fee-for-service Medicare, so results cannot necessarily be generalized to younger adults. Second, this study included only hospitals participating in a quality improvement registry for in-hospital cardiac arrest; therefore, the extent of racial differences in long-term survival may differ among survivors of in-hospital cardiac arrest from nonparticipating hospitals. Third, although we were able to account for a number of demographic and patient characteristics, as well as some interventions during postresuscitation care, we did not have information on patients' socioeconomic status, income, and social support, nor did we have information on postdischarge outpatient use of medical care or zip code information for patients. As a result, we were unable to identify what proportion of the unexplained racial difference in long-term survival was the result of social determinants of health versus differences in postdischarge outpatient care and follow-up.

CONCLUSIONS

This study found that black survivors of in-hospital cardiac arrest, compared with white survivors, had a >10% lower absolute rate of 1-year, 3-year, and 5-year survival after hospital discharge. Nearly one third of the racial difference in 1-year survival was not modifiable; only a small proportion was explained by racial differences in hospital treatments and care; and approximately one half was the result of differences in care after discharge or unmeasured confounding. This finding suggests a need to examine whether racial differences in postdischarge care explain a substantial proportion of racial differences in long-term survival after in-hospital cardiac arrest. Such work would help inform efforts to reduce racial disparities in long-term survival for patients with in-hospital cardiac arrest.

ARTICLE INFORMATION

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Correspondence

Lena M. Chen, MD, MS, University of Michigan Division of General Medicine, North Campus Research Complex, 2800 Plymouth Rd, Bldg 16, Room 407E, Ann Arbor, MI 48109-2800. E-mail lenac@umich.edu

Affiliations

Division of General Medicine (L.M.C.), Center for Healthcare Outcomes & Policy and Institute for Healthcare Policy and Innovation (L.M.C., B.K.N.), Department of Internal Medicine (L.M.C., B.K.N.), and Division of Cardiovascular Medicine (B.K.N.), University of Michigan, Ann Arbor. Veterans Affairs Health Services Research and Development Center for Clinical Management Research, Veterans Affairs Ann Arbor Healthcare System, MI (B.K.N.). Saint Luke's Mid-America Heart Institute, Kansas City, MO (J.A.S., Y.T., P.S.C.). University of Missouri, Kansas City (J.A.S., P.S.C.).

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Disclosures

Dr Chen has served as a senior advisor to the Deputy Assistant Secretary for Health Policy, US Department of Health and Human Services. Dr Chan has served as a consultant for the American Heart Association. The other authors report no conflicts. GWTG-Resuscitation is sponsored by the American Heart Association, which had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication. The manuscript was reviewed and approved by the GWTG-Resuscitation research and publications committee before journal submission.

APPENDIX

American Heart Association's GWTG-Resuscitation Adult Research Task Force Members: Anne Grossestreuer, Ari Moskowitz, Dana Edelson, Joseph Ornato, Mary Ann Peberdy, Matthew Churpek, Michael Kurz, Monique Anderson Starks, Patricia Howard, Paul Chan, Saket Girotra, Sarah Perman, and Zachary Goldberger.

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Racial Differences in Long-Term Outcomes Among Older Survivors of In-Hospital Cardiac Arrest

Lena M Chen, Brahmajee K. Nallamothu, John A Spertus, Yuanyuan Tang and Paul S. Chan
the GWTG-R Investigators

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SUPPLEMENTAL MATERIAL

Racial Differences in Long-term Outcomes among Older Survivors of In-Hospital Cardiac Arrest

Chen LM, Nallamothu BK, Spertus JA, Tang Y, Chan PS, and the GWTG-R Investigators

Contents

Supplemental Table 1. Definitions of Select Pre-Existing Conditions

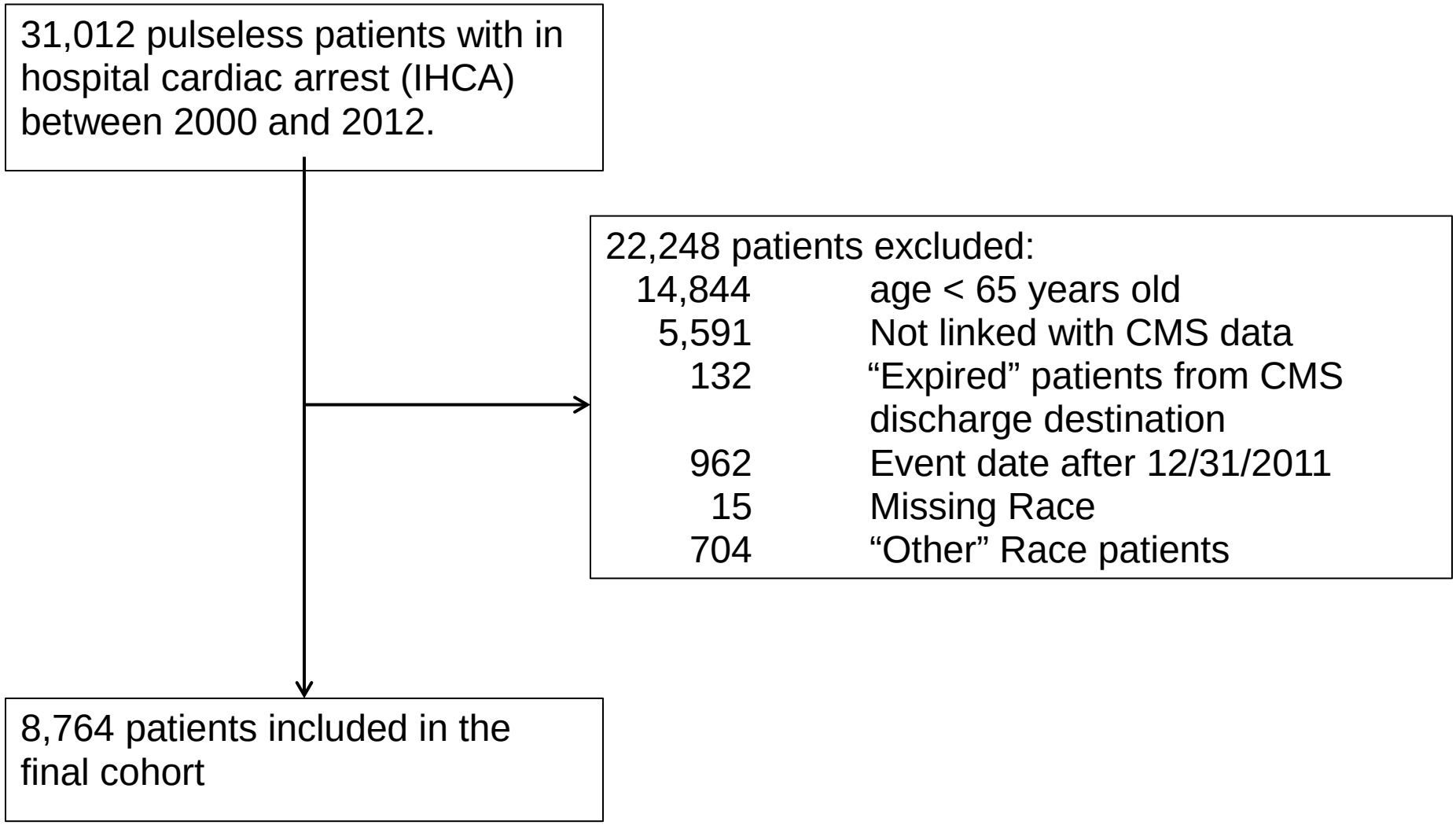
Pre-existing Conditions Prior to Arrest	Instructions to Data Abstractors
Acute CNS non-stroke event	Select if there was evidence of decreased mental status, delirium, or coma not due to acute stroke within 4 hours up to time of the event.
Baseline depression in CNS function	Select if there was evidence of a motor, cognitive, or functional baseline deficit (at time of system entry).
Hypotension/hypoperfusion	Select if there was evidence of hypotension within 4 hours up to the time of the event, defined by ANY of the following: • SBP < 90 or MAP < 60 mmHg. • Vasopressor/inotropic requirement after volume expansion (except for dopamine 3 mcg/kg/min). • Intra-aortic balloon pump
Hepatic insufficiency	Select if there was evidence of hepatic insufficiency within 24 hours up to the time of the event, defined by ANY of the following: • Total bilirubin > 2 mg/dL and AST > 2x normal • Cirrhosis
Major trauma	Select if there was evidence of multi-system injury or single system injury associated with shock or altered mental status (during this hospitalization).
Metabolic/electrolyte abnormality	Select if there was evidence of metabolic/electrolyte abnormality within 4 hours up to the time of the event, defined by ANY of the following: • Sodium < 125 or > 150 mEq/L • Potassium < 2.5 or > 6 mEq/L • pH < 7.3 or > 7.5, arterial • Lactate > 2.5 mmol/L, Blood glucose < 60 mg/dL

Supplemental Table 1. Definitions of Select Pre-Existing Conditions (cont'd)

Renal insufficiency	Select if there was evidence of renal insufficiency prior to the event, defined by ANY of the following: • Requiring ongoing dialysis or extracorporeal filtration therapies. • Creatinine > 2 mg/dL within 24 hours up to the time of the event.
Respiratory insufficiency	Select if there was evidence of acute or chronic respiratory insufficiency within 4 hours up to the time of the event, defined by ANY of the following: • PaO2/FiO2 ratio < 300 (in the absence of pre-existing documented cyanotic heart disease). • PaO2 < 60 mm Hg (in the absence of pre-existing documented cyanotic heart disease). • SaO2 < 90 %, (in the absence of pre-existing documented cyanotic heart disease); • PaCO2, EtCO2 or TcCO2 > 50 mm Hg. • Ages 18+ years – spontaneous respiratory rate > 40/min or < 5/min. • Requiring non-invasive ventilation (e.g., Bag-Valve-Mask, Mask CPAP/BiPAP, Nasal CPAP/BiPAP, negative pressure ventilation). • Requiring ventilation via invasive airway (e.g., T-piece, assist control, IMV, pressure support, high frequency).
Septicemia	Select if there is a documented bloodstream infection where antibiotics have not yet been started or the infection is still being treated with antibiotics.

Source: American Heart Association National Registry of CPR (2007). Operational Definitions: CPA Event v6.00

Supplemental Figure 1. Study Cohort



Supplemental Table 2. Characteristics of Patients Linked vs. Not Linked to Medicare Data

	Not Linked to Medicare (n = 4,896)	Linked to Medicare (n = 8,764)	Total (n = 13,660)	Standardized Difference, %*
Race, No. (%)				6.85
White	4,159 (84.9%)	7,652 (87.3%)	11,811 (86.5%)	
Black	737 (15.1%	1,112 (12.7%)	1,849 (13.5%)	
Age at Admission (years)				9.62
Mean ± Standard Deviation	75.3 ± 7.1	76.0 ± 7.1	75.7 ± 7.1	
Median (25th percentile, 75th percentile)	75.0 (69.0, 80.0)	76.0 (70.0, 81.0)	75.0 (70.0, 81.0)	
Age Category (years), No. (%)				8.32
65-75	2,437 (49.8%)	3,952 (45.1%)	6,389 (46.8%)	
75-85	1,886 (38.5%)	3,696 (42.2%)	5,582 (40.9%)	
≥85	573 (11.7%)	1,116 (12.7%)	1,689 (12.4%)	
Sex				6.41
Male	2,868 (58.6%)	4,856 (55.4%)	7,724 (56.5%)	
Female	2,028 (41.4%)	3,908 (44.6%)	5,936 (43.5%)	

Supplemental Table 2. Characteristics of Patients Linked vs. Not Linked to Medicare Data (cont'd)

	Not Linked to Medicare (n = 4,896)	Linked to Medicare (n = 8,764)	Total (n = 13,660)	Standardized Difference, %*
Pre-existing Condition Prior to Arrest, No. (%)				
CHF this Admission	962 (19.6%)	1,927 (22.0%)	2,889 (21.1%)	5.76
Prior History of CHF	1,149 (23.5%)	2,233 (25.5%)	3,382 (24.8%)	4.68
AMI this Admission	1,137 (23.2%)	2,136 (24.4%)	3,273 (24.0%)	2.70
Prior History of AMI	1,064 (21.7%)	2,066 (23.6%)	3,130 (22.9%)	4.40
Diabetes Mellitus	1,685 (34.4%)	2,861 (32.6%)	4,546 (33.3%)	3.75
Renal Insufficiency	1,208 (24.7%)	2,319 (26.5%)	3,527 (25.8%)	4.10
Hepatic Insufficiency	108 (2.2%)	190 (2.2%)	298 (2.2%)	0.26
Respiratory Insufficiency	1,689 (34.5%)	3,030 (34.6%)	4,719 (34.5%)	0.16
Baseline Depression in CNS Function	432 (8.8%)	908 (10.4%)	1,340 (9.8%)	5.22
Acute Stroke	184 (3.8%)	331 (3.8%)	515 (3.8%)	0.10
Acute CNS Non-Stroke Event	265 (5.4%)	508 (5.8%)	773 (5.7%)	1.67
Pneumonia	478 (9.8%)	958 (10.9%)	1,436 (10.5%)	3.84
Hypotension	839 (17.1%)	1,616 (18.4%)	2,455 (18.0%)	3.41
Septicemia	375 (7.7%)	654 (7.5%)	1,029 (7.5%)	0.75
Major Trauma	122 (2.5%)	169 (1.9%)	291 (2.1%)	3.83
Metabolic or Electrolyte Abnormalities	491 (10.0%)	915 (10.4%)	1,406 (10.3%)	1.36
Metastatic or Hematologic Malignancy	381 (7.8%)	646 (7.4%)	1,027 (7.5%)	1.55

* Given large sample size, a standardized difference of >10% would be considered significantly different.

Supplemental Table 2. Characteristics of Patients Linked vs. Not Linked to Medicare Data (cont'd)

	Not Linked to Medicare (n = 4,896)	Linked to Medicare (n = 8,764)	Total (n = 13,660)	Standardized Difference, %*
Interventions in Place at Time of Arrest, No. (%)				
Mechanical Ventilation	893 (18.2%)	1,616 (18.4%)	2,509 (18.4%)	0.52
Continuous Intravenous Vasopressor	681 (13.9%)	1,380 (15.7%)	2,061 (15.1%)	5.17
Implantable Cardiac Defibrillator	75 (1.5%)	120 (1.4%)	195 (1.4%)	1.36
Hemodialysis	82 (1.7%)	147 (1.7%)	229 (1.7%)	0.02
Therapeutic Hypothermia, No. (%)				1.43
Yes	138 (3.0%)	206 (2.6%)	344 (2.8%)	
No	4,379 (96.7%)	7,759 (97.4%)	12,138 (97.2%)	
N/A	10 (0.2%)	0 (0.0%)	10 (0.1%)	
Missing	369	799	1,168	
Neurological Status at Discharge, No. (%)				4.90
Little to No Disability	2,134 (43.6%)	3,838 (43.8%)	5,972 (43.7%)	
Moderate Disability	1,217 (24.9%)	2,381 (27.2%)	3,598 (26.3%)	
Severe Disability	598 (12.2%)	1,074 (12.3%)	1,672 (12.2%)	
Coma or Vegetative State	185 (3.8%)	246 (2.8%)	431 (3.2%)	
Brain Dead	0 (0.0%)	1 (0.0%)	1 (0.0%)	
Unknown	762 (15.6%)	1,224 (14.0%)	1.986 (14.5%)	

* Given large sample size, a standardized difference of >10% would be considered significantly different.

Supplemental Table 2. Characteristics of Patients Linked vs. Not Linked to Medicare Data (cont'd)

	Not Linked to Medicare (n = 4,896)	Linked to Medicare (n = 8,764)	Total (n = 13,660)	Standardized Difference, %*
Discharge Destination, No. (%)†				N/A
Home	Unknown	2,030 (23.2%)		
Home with home health	Unknown	1,261 (14.4%)		
Inpatient care	Unknown	1,662 (19.0%)		
Skilled nursing	Unknown	2,395 (27.3%)		
Long term care	Unknown	856 (9.8%)		
Hospice	Unknown	527 (6.0%)		
Other	Unknown	33 (0.4%)		
Initial Cardiac Arrest Rhythm, No. (%)				7.73
Asystole	1,319 (26.9%)	2,173 (24.8%)	3,492 (25.6%)	
Pulseless Electrical Activity	1,664 (34.0%)	2,804 (32.0%)	4,468 (32.7%)	
Ventricular Fibrillation	1,177 (24.0%)	2,426 (27.7%)	3,603 (26.4%)	
Pulseless Ventricular Tachycardia	736 (15.0%)	1,361 (15.5%)	2,097 (15.4%)	
Location of Cardiac Arrest, No. (%)				15.24
Intensive Care Unit	1,757 (35.9%)	3,518 (40.1%)	5,275 (38.6%)	
Monitored Unit	1,093 (22.3%)	2,161 (24.7%)	3,254 (23.8%)	
Non-Monitored Unit	622 (12.7%)	1,075 (12.3%)	1,697 (12.4%)	
Emergency Room	621 (12.7%)	869 (9.9%)	1,490 (10.9%)	
Procedural	582 (11.9%)	978 (11.2%)	1,560 (11.4%)	
Other	221 (4.5%)	162 (1.8%)	383 (2.8%)	
Missing	0	1	1	

* Given large sample size, a standardized difference of >10% would be considered significantly different.
† Discharge status comes from Medicare claims and is therefore unknown among patients that were not linked to Medicare data.

American Heart Association's Get With the Guidelines-Resuscitation Adult Research Task Force Members

Anne Grossestreuer PhD, Beth Israel Deaconess Medical Center
Ari Moskowitz MD, Harvard Medical School
Dana Edelson MD MS, University of Chicago Medicine
Joseph Ornato MD, Virginia Commonwealth University Health System
Mary Ann Peberdy MD, Virginia Commonwealth University Medical Center
Matthew Churpek MD MPH PhD, University of Chicago Medicine
Michael Kurz MD MS-HES, University of Alabama school of Medicine
Monique Anderson Starks MD MHS, Duke Clinical Research Institute
Patricia Howard PhD RN, University of Kentucky HealthCare
Paul Chan MD MSc, Saint Luke's Mid America Heart Institute
Saket Girotra MBBS SM, University of Iowa Carver College of Medicine
Sarah Perman MD MSCE, University of Colorado School of Medicine
Zachary Goldberger MD MS, University of Washington School of Medicine