American Journal of Epidemiology
Vol. 166, No. 5
DOI: 10.1093/aje/kwm102
Advance Access publication June 21, 2007

Original Contribution

Explaining Racial Disparities in Incidence of and Survival from Out-of-Hospital Cardiac Arrest

S. Galea[1,2], S. Blaney[2], A. Nandi[3], R. Silverman[4], D. Vlahov[2,3], G. Foltin[5], M. Kusick[2], M. Tunik[5], and N. Richmond[6,7]

[1] Department of Epidemiology, School of Public Health, University of Michigan, Ann Arbor, MI.
[2] Center for Urban Epidemiologic Studies, New York Academy of Medicine, New York, NY.
[3] Department of Epidemiology, Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD.
[4] Department of Emergency Medicine, Long Island Jewish Medical Center, New Hyde Park, NY.
[5] Department of Pediatrics and Emergency Medicine, New York University School of Medicine, Bellevue Hospital Center, New York, NY.
[6] New York City Fire Department, New York, NY.
[7] Louisville Metro Emergency Medical Services, Louisville, KY.

Received for publication January 5, 2007; accepted for publication March 7, 2007.

A prospective observational study of 4,653 consecutive cases of out-of-hospital cardiac arrest (OOHCA) occurring in New York City from April 1, 2002, to March 31, 2003, was used to assess racial/ethnic differences in the incidence of OOHCA and 30-day survival after hospital discharge among OOHCA patients. The age-adjusted incidence of OOHCA per 10,000 adults was higher among Blacks than among persons in other racial/ethnic groups, and age-adjusted survival from OOHCA was higher among Whites compared with other groups. In analyses restricted to 3,891 patients for whom complete data on all variables were available, the age-adjusted relative odds of survival from OOHCA among Blacks were 0.4 (95% confidence interval: 0.2, 0.7) as compared with Whites. A full multivariable model accounting for demographic factors, prior functional status, initial cardiac rhythm, and characteristics of the OOHCA event explained approximately 41 percent of the lower age-adjusted survival among Blacks. The lower prevalence of ventricular fibrillation as the initial cardiac rhythm among Blacks relative to Whites was the primary contributor. A combination of factors probably accounts for racial/ethnic disparities in OOHCA survival. Previously hypothesized factors such as delays in emergency medical service response or differences in the likelihood of receipt of cardiopulmonary resuscitation did not appear to be substantial contributors to these racial/ethnic disparities.

African Americans; emergency medical services; ethnic groups; heart arrest; myocardial infarction; New York City; urban health

Abbreviations: CPR, cardiopulmonary resuscitation; EMS, Emergency Medical Services; FDNY, Fire Department of New York.

The proportion of sudden cardiac deaths occurring outside of hospital settings has increased from just over two thirds in 1989 to almost three quarters in 1998 (1). Of the 464,340 sudden cardiac deaths in the United States in 1999, 341,780 (73.6 percent) occurred out-of-hospital (2). Rates of survival from out-of-hospital cardiac arrest have been shown to range from 1.4 percent to 35 percent (3–5), and several studies have suggested that survival among urban populations is particularly poor (5–7).

Extant research has linked survival from out-of-hospital cardiac arrest to underlying cardiac pathology and morbidity (e.g., history of a heart condition) (8–11), event-related

Correspondence to Dr. Sandro Galea, Department of Epidemiology, University of Michigan School of Public Health, 1214 South University Avenue, Ann Arbor, MI 48104 (e-mail: sgalea@umich.edu).

circumstances (e.g., receipt of cardiopulmonary resuscitation (CPR), incident location, whether the cardiac arrest was witnessed) (12–16), event-related cardiac physiology (e.g., initial cardiac rhythm) (13, 14), and management of the out-of-hospital cardiac arrest by EMS and hospital care providers (e.g., paramedic response intervals) (4, 14, 17). A few studies have identified sociodemographic characteristics (e.g., patient socioeconomic position, patient race/ethnicity) that may be related to survival, although data about the relation between these characteristics and survival are equivocal, particularly regarding the role of race/ethnicity (18–22). In studies of out-of-hospital cardiac arrest in two US cities (Seattle, Washington, and Chicago, Illinois), White patients had more than 2.5 times the relative odds of surviving to hospital discharge as did Black patients, independently of risk factors related to the circumstances of cardiac arrest, the initial cardiac rhythm, and paramedic response times (18, 20). However, a multicenter study of out-of-hospital cardiac arrests from seven suburban cities in Michigan showed that race/ethnicity was not a statistically significant predictor of survival after adjustment for socioeconomic position (22).

We examined racial/ethnic disparities in incidence of and survival from out-of-hospital cardiac arrest in New York City and potential reasons for these disparities using data from a prospective observational study of consecutive out-of-hospital cardiac arrests occurring between April 1, 2002, and March 31, 2003.

MATERIALS AND METHODS

Participants and procedures

The Emergency Medical Services (EMS) Command of the Fire Department of New York (FDNY) is a multitiered system that uses about 900 8-hour ambulance tours per 24-hour period to provide prehospital care for approximately 8 million residents, 7 million commuters, and 3 million daily visitors in the 321-square-mile (514-km^2) New York City metropolitan area. The number of ambulance tours per 8-hour period may vary by time of day to accommodate the anticipated volume of emergency telephone calls. EMS units have responsibility only for emergency transportation, although occasionally they are involved in nonemergency transport as well. Each year, approximately 1.2 million calls are made to the New York City EMS for emergency medical assistance, with about two thirds of these calls resulting in transportation of a patient to one of 63 hospital emergency departments.

We used a prospective observational study design to collect data on all incident cases of out-of-hospital cardiac arrest occurring in New York City from April 1, 2002, to March 31, 2003, for which the FDNY EMS was dispatched and resuscitation was attempted. Patients who did not reside in New York City, who were less than 18 years of age, or for whom resuscitative efforts were not administered because of clinical signs of irreversible death, as well as those cases with an apparent nonprimary cardiac etiology (e.g., terminal illness, trauma, primary respiratory arrest, overdose, upper airway obstruction, or drowning), were excluded from these analyses.

Paramedic data collectors trained in the data collection requirements of the study obtained information from emergency medical care providers using a validated telephone interview process. Case finding was conducted by issuing systemwide operation orders and advisories requiring the highest-level on-scene provider to call in any out-of-hospital cardiac arrest incident for which resuscitation was attempted. Specifically, crews were instructed to call the paramedic data collectors following patient transport to the emergency department, after termination of resuscitation attempts for patients who were pronounced dead in the field, or by the end of their scheduled tour. To ensure compliance, continuous real-time computer-aided dispatch queries were performed by the on-duty paramedic data collector, who initiated contact with paramedics regarding any out-of-hospital cardiac arrest identified through the computer-aided dispatch review but not previously called in. A mean field responder compliance rate of 96 percent was attained over the 1-year study period. In situations where the paramedic data collectors were unable to establish contact with the EMS unit in question, definitive verification was made upon receipt of the ambulance call report, the retrieval of which ordinarily requires 3–4 months.

All information collected was scanned into data file format by means of an optical character recognition system (Teleforms Elite 7.1; Cardiff, Vista, California) and was reviewed daily for accuracy and completeness. All computer tracking, telephone interviews, manual completion of data collection instruments, and hospital outcome tracking was performed from designated stations at FDNY headquarters, and all information was collected under the quality assurance function of the FDNY Office of Medical Affairs. The institutional review boards of the New York Academy of Medicine, the Long Island Jewish Medical Center, and New York University Medical Center approved the study.

Measures

We collected data about patient demographic factors, including race/ethnicity, age, and gender, from the highest-level on-scene emergency medical care provider. We asked on-scene providers about the medical history of the patient. The patient was classified as having a history of a serious heart condition if the on-scene provider reported that he/she had a history of any of the following: myocardial infarction/angina/coronary artery bypass graft, congenital heart disease, congestive heart failure, pacemaker/arrhythmia, an unspecified heart disease, or use of heart medication. The patient's prior functional status was classified as active if the on-scene provider described the patient's functional state prior to the cardiac arrest as active; it was classified as nonactive if the patient was described as having limited mobility with a need for assistance, being bedridden, or requiring a home ventilator. We asked the on-scene provider about key features of the cardiac arrest, including: whether the arrest was witnessed by a bystander or by the EMS, whether bystander CPR was taking place when the first provider arrived, and whether the arrest occurred at a residence,

nursing home, or public location. The initial cardiac rhythm was classified as asystole, ventricular fibrillation/tachycardia, or other. Data on Utstein core measures (23) and critical time periods were collected from paramedic histories and other sources (e.g., FDNY records, emergency department charts) if available, and data were merged with FDNY EMS system times and FDNY Quality Assurance System survival data. We used year 2000 median household income for the census tract of the patient's residence as a proxy for socioeconomic position (24); this measure was categorized as less than $25,000, $25,000–$50,000, or greater than $50,000.

The primary outcome measure was 30-day patient survival following hospital discharge. Secondary measures included the percentage of patients admitted to a hospital, the percentage of patients who survived to discharge, and the percentage of patients who died in the hospital after being admitted. Outcome information on patients who expired at the scene of the cardiac arrest, during transport, or in the emergency department was often obtained from emergency medical care providers during the initial telephone interview. For outcomes not obtained from providers, information about final patient disposition and the discharge summary was obtained through mailings to any of the 63 individual hospitals where patients may have been transported. In both cases, all final patient dispositions were validated by searching several databases, including New York City vital statistics, the New York City Medical Examiner Records Match, the Social Security Death Index, and various Internet and electronic newsprint sources.

Statistical analysis

For the purposes of this analysis, cardiac arrests which took place in the presence of the EMS were excluded. We determined the patients' sociodemographic characteristics, prior health status, circumstances of arrest, initial cardiac rhythms, and response intervals and used two-tailed chi-squared tests and *t* tests as appropriate to test for differences between racial/ethnic groups. We used the same methods to test for associations between the aforementioned characteristics and survival. We calculated the crude incidence of out-of-hospital cardiac arrest per 10,000 adults for each racial/ethnic group as the number of incident cases occurring in New York City from April 1, 2002, to March 31, 2003, among city residents aged 18 years or more, using 2000 US Census population data (24). Ninety-five percent confidence intervals for crude incidence rates were calculated using the Poisson distribution.

For each racial/ethnic group, we calculated the following survival outcomes: the percentage of patients admitted to a hospital, the percentage of patients who survived to discharge, the percentage of patients who survived for at least 30 days postdischarge, and the percentage of patients who died in the hospital after having been admitted. To account for differences in the age structure of the racial/ethnic groups, we calculated age-adjusted survival outcomes using the age structure of the study population as the standard population. Age-adjusted incidence was calculated using the age distribution of the population of New York City (24) as the standard population. Ninety-five percent confidence intervals for age-adjusted incidence rates were calculated using the gamma distribution (25). Overall differences in both crude and adjusted incidence rates by race/ethnicity were tested with Pearson chi-squared tests.

We developed six multivariable models to assess the relation between race/ethnicity and survival to 30 days postdischarge. The first model included only age and race/ethnicity. In the subsequent four models, we individually adjusted the regression model results for the variables hypothesized to explain the relation between race/ethnicity and survival from out-of-hospital cardiac arrest (i.e., sociodemographic variables, prior health status, circumstances of arrest, and initial cardiac rhythm). Finally, in the sixth model, we adjusted the model results for all variables of interest and tested for potentially meaningful interactions between key covariates of interest. We calculated the percent change in the β coefficient between models to estimate the proportion of each association that was attenuated by the addition of explanatory variables. Rescaled R^2 values, likelihood ratio tests, and Hosmer-Lemeshow tests were used to assess the goodness of fit of the models. Secondarily, to further assess whether there were racial/ethnic differences in survival among persons whose cardiac arrests were witnessed by the EMS, we also calculated and compared racial/ethnic group differences among EMS-witnessed out-of-hospital cardiac arrests.

RESULTS

Overall, we collected data on 6,973 cardiac arrests among persons aged 18 years or more. Of the 4,159 adult cardiac arrests of primary cardiac etiology which were not witnessed by the EMS, 4,053 occurred among residents of New York City with complete information on racial/ethnic background. The crude and age-adjusted incidence of and survival from out-of-hospital cardiac arrest among these 4,053 New York City residents are shown in tables 1 and 2, respectively. The age-adjusted incidence of out-of-hospital cardiac arrest was highest among Blacks (10.1/10,000 adults) and lowest among Whites (5.8/10,000). Whites were more likely to be admitted to a hospital than Hispanics (11.2 percent vs. 8.6 percent), and Hispanics were more likely to be admitted than Blacks (8.6 percent vs. 6.0 percent). Age-adjusted survival at least 30 days past hospital discharge was 3.4 percent among White patients, as compared with 1.7 percent of Hispanic patients and 1.3 percent of Black patients. Once hospitalized, Blacks, Hispanics, and Whites had similar mortality rates.

Blacks comprised 1,257 (31.0 percent) of the 4,053 patients, while 636 (15.7 percent) patients were Hispanic, 1,908 (47.1 percent) were White, and 252 (6.2 percent) were of other racial/ethnic backgrounds. Table 3 presents information on sociodemographic characteristics, underlying pathology, circumstances of arrest, event-related physiology, and case management for the 3,891 cases of out-of-hospital cardiac arrest with complete data on key variables. Table 4 presents results from multivariable models assessing the adjusted relation between race/ethnicity and survival from out-of-hospital cardiac arrest among all patients. Model 1

TABLE 1. Crude incidence of out-of-hospital cardiac arrest and survival outcomes among New York City residents ($n = 4,053$), April 2002–March 2003

Race/ethnicity	New York City population*	No. of cardiac arrests	Incidence per 10,000 adults	95% confidence interval	Survival outcome							
					Admitted to hospital		Survived to discharge		Survived to discharge and lived for ≥30 days		Died in hospital, if admitted	
					No.	%	No.	%	No.	%	No.	%
Black	1,393,859	1,257	9.0	8.5, 9.5	76	6.0	18	1.4	18	1.4	55	72.4
Hispanic	1,499,208	636	4.2	3.9, 4.6	56	8.8	13	2.0	12	1.9	42	75.0
White	2,345,564	1,908	8.1	7.8, 8.5	207	10.8	57	3.0	56	2.9	146	70.5
Other	829,378	252	3.0	2.7, 3.4	26	10.3	3	1.2	3	1.2	21	80.8
Full sample	6,068,009	4,053	6.7	6.5, 6.9	365	9.0	91	2.2	89	2.2	254	69.6

* 2000 US Census data (24).

shows that both Blacks and Hispanics were significantly less likely than Whites to survive to 30 days postdischarge after adjustment for age (odds ratios were 0.4 (95 percent confidence interval: 0.2, 0.7) and 0.5 (95 percent confidence interval: 0.3, 1.0), respectively). Blacks were also significantly less likely than Whites to survive to 30 days postdischarge in models accounting separately for sociodemographic characteristics, underlying pathology and morbidity, the circumstances of the incident, and event-related physiology and initial cardiac rhythm. However, after adjustment for all of these variables in the fully adjusted model, there were no statistically significant racial/ethnic differences in 30-day survival (model 6). Altogether, after sociodemographic characteristics were accounted for, underlying pathology and morbidity, the circumstances of the incident, and event-related physiology explained approximately 41.0 percent (calculated as percent change in β values from the logistic regression models) of the lower age-adjusted survival among Blacks. There were no statistically significant interactions in the final models. Hosmer-Lemeshow goodness-of-fit tests conducted on the entire series of models produced nonsignificant results and hence did not indicate a lack of fit. According to the rescaled R^2 values, race/ethnicity and age alone explained 5.0 percent of the variation in survival; the full model explained 24.0 percent of the variation.

Among patients with out-of-hospital cardiac arrests that were witnessed by the EMS ($n = 294$), 87.1 percent died ($n = 256$) and 12.9 percent survived ($n = 38$). Survival by racial/ethnic group was 12.6 percent among Blacks, 18.3 percent among Latinos, 8.9 percent among Whites, and 25.0 percent among other racial/ethnic groups. These were not statistically significant differences ($p = 0.15$).

DISCUSSION

We found evidence of substantial racial/ethnic differences in out-of-hospital cardiac arrest incidence and survival in New York City. The age-adjusted incidence per 10,000 adults was 10.1 among Blacks, 6.5 among Hispanics, and 5.8 among Whites, and age-adjusted survival to 30 days postdischarge was more than twice as poor for Blacks as for Whites; age-adjusted survival among Hispanics was also significantly lower than that among Whites. In the fully

TABLE 2. Age-adjusted incidence of out-of-hospital cardiac arrest and survival outcomes among New York City residents ($n = 4,053$), April 2002–March 2003

	Race/ethnicity				*p* value
	Black	Hispanic	White	Other	
Incidence of cardiac arrest (per 10,000 adults)*	10.1	6.5	5.8	4.8	<0.01†
Survival outcome (%)					
Admitted to hospital‡	6.0	8.6	11.3	10.2	<0.01§
Survived to discharge‡	1.4	1.9	3.4	0.9	<0.01§
Survived to discharge and lived for ≥30 days*	1.4	1.7	3.4	0.9	<0.01§
Died in hospital after being admitted	72.5	76.9	67.2	82.1	0.26§

* Adjusted using the age structure of the New York City population (24) as the reference.
† Pearson chi-squared test.
‡ Adjusted using the age structure of the study population as the reference.
§ Two-tailed chi-squared test.

TABLE 3. Characteristics of New York City residents suffering out-of-hospital cardiac arrest ($n = 3,891$), April 2002–March 2003*

	Full sample		Blacks		Hispanics		Whites		Other racial/ethnic groups		*p* value†
	No.	%	No.	%	No.	%	No.	%	No.	%	
Age (years)											
18–34	86	2.2	33	2.7	27	4.5	20	1.1	6	2.5	<0.01
35–44	189	4.9	78	6.4	41	6.8	55	3.0	15	6.2	
45–54	369	9.5	150	12.3	82	13.6	109	6.0	28	11.6	
55–64	584	15.0	232	19.1	113	18.8	201	11.0	38	15.8	
65–74	812	20.9	254	20.9	132	21.9	374	20.4	52	21.6	
75–84	967	24.9	261	21.4	116	19.3	537	29.3	53	22.0	
≥85	884	22.7	209	17.2	91	15.1	535	29.2	49	20.3	
Gender											
Male	2,064	53.1	587	48.2	335	55.6	997	54.5	145	60.2	<0.01
Female	1,827	47.0	630	51.8	267	44.4	834	45.5	96	39.8	
Annual income proxy‡											
<$25,000	926	23.8	448	36.8	263	43.7	179	9.8	36	14.9	<0.01
$25,000–<$50,000	2,098	53.9	638	52.4	288	47.8	1,025	56.0	147	61.0	
≥$50,000	867	22.3	131	10.8	51	8.5	627	34.2	58	24.1	
History of heart condition											
No	2,045	52.6	677	55.6	325	54.0	899	49.1	144	59.8	<0.01
Yes	1,846	47.4	540	44.4	277	46.0	932	50.9	97	40.2	
Prior functional status											
Active	1,808	46.5	538	44.2	316	52.5	823	44.9	131	54.4	<0.01
Not active	1,841	47.3	615	50.5	246	40.9	893	48.8	87	36.1	
Unknown	242	6.2	64	5.3	40	6.6	115	6.3	23	9.5	
Cardiac arrest witnessed?											
Not witnessed	1,914	49.2	641	52.7	295	49.0	852	46.5	126	52.3	<0.01
Witnessed by bystander	1,562	40.1	438	36.0	258	42.9	771	42.1	95	39.4	
Unknown	415	10.7	138	11.3	49	8.1	208	11.4	20	8.3	
Cardiopulmonary resuscitation											
Yes	1,131	29.1	374	30.7	152	25.2	559	30.5	46	19.1	<0.01
No	2,506	64.4	764	62.8	404	67.1	1,165	63.6	173	71.8	
Unknown	254	6.5	79	6.5	46	7.6	107	5.8	22	9.1	
Incident location											
Residence	2,469	63.5	745	61.2	404	67.1	1,145	62.5	175	72.6	<0.01
Nursing home	1,098	28.2	380	31.2	151	25.1	523	28.6	44	18.3	
Public location	324	8.3	92	7.6	47	7.8	163	8.9	22	9.1	
Initial cardiac rhythm											
Asystole	2,534	65.1	829	68.1	400	66.4	1,150	62.8	155	64.3	0.06
Ventricular fibrillation/tachycardia	582	15.0	146	12.0	91	15.1	305	16.7	40	16.6	
Other	717	18.4	222	18.2	101	16.8	351	19.2	43	17.8	
Unknown	58	1.5	20	1.6	10	1.7	25	1.4	3	1.2	
Mean response time (minutes)§	4.7		4.7		5		4.5		4.7		<0.01

* Table is restricted to participants for whom complete information on all key covariates was available.
† Two-tailed chi-squared test for categorical variables and *t* test for continuous variables.
‡ Year 2000 median household income for the census tract of the patient's residence.
§ Refers to the time interval between activation of a call to New York City Emergency Medical Services (EMS) and the arrival of first responders at the scene of the cardiac arrest. Data on time to the patient's side are not available within the New York City EMS system.

adjusted model, racial/ethnic differences were no longer statistically significant after accounting for demographic factors, prior functional status, initial cardiac rhythm, and characteristics of the arrest event.

This study suggests that although it is probably a combination of factors that accounts for racial/ethnic disparities in out-of-hospital cardiac arrest survival, some of the previously hypothesized factors are less compatible with our data than others. Previous work has documented substantial racial/ethnic disparities in key components of the ''chain of survival'' of emergency cardiac care (26). For example, a number of studies have shown that the prevalence of bystander CPR is lower for Black patients than for White patients (18–20, 27). These studies suggest that racial/ethnic disparities in the circumstances of out-of-hospital cardiac arrest partially explain racial/ethnic disparities in survival. In our study, Black patients were slightly more likely than White patients to receive bystander CPR (30.7 percent vs. 30.5 percent), and Blacks were less likely than Whites to have their cardiac arrest witnessed by a bystander (36.0 percent vs. 42.1 percent). After controlling for the circumstances of arrest in a multivariable model, age-adjusted survival among Black patients was still lower than that among White patients, providing little evidence that differences in the circumstances of out-of-hospital cardiac arrest contributed substantially to racial/ethnic differences in survival.

It has been suggested that there are racial/ethnic differences in cardiac care in general (28) and in the management of out-of-hospital cardiac arrest by both EMS systems and hospitals. For example, Becker et al. (18) reported that survival among Black patients was 52 percent of that of White patients, even among those admitted to the hospital. In our study, there were no apparent racial/ethnic differences in the management of out-of-hospital cardiac arrest by EMS and hospital providers. First, although response intervals for the different racial/ethnic groups were significantly different, the disparity between Black and White patients was small. In addition, response time was not significantly associated with survival. A caveat to this observation is that in New York City, information on response time to the patient's side is not available, and the response time documented here was time to the scene of the cardiac arrest. It is therefore possible that the response times documented here were not capturing variability in full response time by race/ethnicity. Although these data may be reassuring with regard to EMS system performance in New York City, these findings clearly do not dismiss the importance of response times and other EMS care factors in determining intergroup heterogeneity in out-of-hospital cardiac arrest prognosis. Second, we found no racial/ethnic differences in survival among EMS-witnessed out-of-hospital cardiac arrests. Third, we found that mortality rates among patients admitted to a hospital were similar among Blacks, Hispanics, and Whites, suggesting that the management of out-of-hospital cardiac arrest by hospital care providers did not contribute substantially to racial/ethnic disparities in survival to 30 days postdischarge. Together, these findings suggest that racial/ethnic disparities in survival are not attributable to the management of out-of-hospital cardiac arrest by EMS and hospital providers in New York City.

Previous work has shown that socioeconomic position is associated with survival from out-of-hospital cardiac arrest independently of chronic morbidity and factors related to the circumstances of arrest (21). This has prompted the suggestion that racial/ethnic disparities in survival from out-of-hospital cardiac arrest (18, 20, 28) may be explained by socioeconomic position. Conditional on the occurrence of an event, there are several ways in which socioeconomic position may explain racial/ethnic disparities in survival from out-of-hospital cardiac arrest; for example, it may influence the number of concomitant pathologies, the severity of disease, or medical management of the disease (20, 29). Although our measurement of individual socioeconomic position was imperfect, our findings showed that racial/ethnic disparities in survival from out-of-hospital cardiac arrest persisted despite adjustment for socioeconomic position. Specifically, a multivariable model accounting for age, gender, and socioeconomic position showed that Black patients still had 58 percent lower odds of surviving from out-of-hospital cardiac arrest to 30 days postdischarge relative to White patients. Furthermore, we showed that differences in underlying cardiac pathology and morbidity, whether correlated with socioeconomic position or not, did not explain the racial/ethnic disparities in survival we observed. In our sample, Black and Hispanic patients were less likely to have a history of a heart condition than White patients and were as likely as or more likely than Whites to have an active prior functional status. A multivariable model accounting for underlying cardiac pathology and morbidity (i.e., history of a heart condition, prior functional status) explained only 7 percent of the lower age-adjusted survival among Blacks, which still remained significantly lower than that for Whites. Although we had no measure of disease severity, these findings suggest that pathways other than those mediated by differences in socioeconomic position or underlying pathology probably account for the observed racial/ethnic disparities in survival in our sample.

The lower prevalence of ventricular fibrillation as the initial cardiac rhythm appears to have been a strong contributor to the poorer observed survival among Black patients. After the results were controlled for initial cardiac rhythm, age-adjusted survival to 30 days postdischarge was no longer lower for Black patients than for White patients. Several factors may influence the likelihood that a patient is experiencing ventricular fibrillation when paramedics arrive. Younger age, the interval from collapse to EMS response, and early receipt of CPR have all been implicated as potential reasons for an increased likelihood of ventricular fibrillation as the initial cardiac rhythm (30, 31). In our sample, we found little evidence that differences in the receipt of CPR explained racial/ethnic differences in ventricular fibrillation. It has been hypothesized that Blacks may be more hesitant to request aid following a cardiac arrest, resulting in a longer period of time between collapse and receipt of assistance and thus a lower likelihood of survival (18). Although this was not the focus of our analysis, in our sample the prevalence of having an arrest witnessed by the EMS was higher among Blacks compared with Whites, suggesting this to be an unlikely explanation in our study. Blacks were younger than Whites in our study, which also suggests

TABLE 4. Multivariable regression models of the relation between race/ethnicity and survival from out-of-hospital cardiac arrest among New York City residents ($n = 3,891$), April 2002–March 2003*,†

Characteristic	Model 1		Model 2		Model 3		Model 4		Model 5		Model 6	
	OR‡	95% CI‡	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Race/ethnicity												
White	1.0		1.0		1.0		1.0		1.0		1.0	
Black	0.4	0.2, 0.7	0.4	0.2, 0.8	0.4	0.2, 0.7	0.4	0.2, 0.8	0.5	0.3, 0.9	0.6	0.3, 1.0
Hispanic	0.5	0.3, 1.0	0.6	0.3, 1.2	0.5	0.3, 1.0	0.6	0.3, 1.1	0.6	0.3, 1.2	0.7	0.4, 1.5
Other	0.4	0.1, 1.2	0.4	0.1, 1.2	0.4	0.1, 1.2	0.4	0.1, 1.5	0.4	0.1, 1.2	0.5	0.1, 1.7
Age (years)												
18–34	1.0		1.0		1.0		1.0		1.0		1.0	
35–44	0.4	0.1, 2.2	0.4	0.1, 2.3	0.4	0.1, 2.3	0.5	0.1, 2.6	0.5	0.1, 2.8	0.7	0.1, 3.7
45–54	0.7	0.2, 2.7	0.8	0.2, 2.8	0.7	0.2, 2.7	0.7	0.2, 2.8	0.7	0.2, 2.8	0.8	0.2, 3.2
55–64	0.8	0.2, 2.8	0.8	0.2, 2.9	0.8	0.2, 2.8	0.9	0.2, 3.1	0.9	0.2, 3.2	0.9	0.2, 3.6
65–74	0.7	0.2, 2.5	0.8	0.2, 2.6	0.8	0.2, 2.7	0.9	0.2, 3.0	0.8	0.2, 3.0	0.9	0.2, 3.3
75–84	0.4	0.1, 1.2	0.4	0.1, 1.3	0.4	0.1, 1.5	0.4	0.1, 1.6	0.5	0.1, 1.8	0.5	0.1, 2.0
≥85	0.1	0.0, 0.6	0.1	0.0, 0.6	0.2	0.0, 0.8	0.2	0.0, 0.9	0.2	0.1, 1.1	0.3	0.1, 1.3
Gender												
Female			1.0								1.0	
Male			0.9	0.6, 1.4							0.6	0.4, 1.0
Annual income proxy§												
<$25,000			1.0								1.0	
$25,000–<$50,000			1.3	0.7, 2.5							1.3	0.7, 2.6
≥$50,000			1.7	0.8, 3.5							1.6	0.7, 3.3
History of heart condition												
No					1.0						1.0	
Yes					1.7	1.0, 2.6					1.6	1.0, 2.6
Prior functional status												
Not active					1.0						1.0	
Active					2.5	1.5, 4.4					1.6	0.8, 2.9
Unknown					1.5	0.5, 4.4					1.2	0.4, 3.6
Cardiac arrest witnessed?												
Not witnessed							1.0				1.0	
Witnessed by bystander							3.8	2.1, 6.9			1.9	1.0, 3.5
Unknown							2.8	1.3, 6.1			1.8	0.8, 4.1
Cardiopulmonary resuscitation												
No							1.0				1.0	
Yes							1.4	0.8, 2.4			1.4	0.8, 2.5
Unknown							1.4	0.6, 3.1			1.4	0.6, 3.3
Incident location												
Residence							1.0				1.0	
Nursing home							1.3	0.7, 2.4			1.5	0.8, 2.8
Public location							2.8	1.6, 4.9			1.7	1.0, 3.2
Response time (minutes)¶							0.9	0.8, 1.0			0.9	0.9, 1.0

Initial cardiac rhythm								
Asystole					1.0		1.0	
Ventricular fibrillation/tachycardia					25.9	11.6, 58.0	18.5	8.0, 43.1
Other					12.0	5.1, 28.2	9.9	4.2, 23.4
Unknown					27.5	7.7, 97.9	23	6.2, 84.6
Goodness of fit of model								
Maximum rescaled R^2	0.05	0.05	0.07	0.12	0.21		0.24	
Likelihood ratio test								
χ^2 value (with df‡)	36.4 (9)	38.6 (12)	52.6 (12)	83.7 (16)	152.5 (12)		176.4 (25)	
p value for χ^2	<0.01	<0.01	<0.01	<0.01	<0.01		<0.01	
Hosmer-Lemeshow test								
χ^2 value (with df)	7.2 (8)	8.5 (8)	6.5 (8)	12.3 (8)	7.9 (9)		11.1 (8)	
p value for χ^2	0.52	0.39	0.59	0.14	0.54		0.19	

* Table is restricted to participants for whom complete information on all key covariates was available.

† The first model included only age and race/ethnicity. In the subsequent four models, results were individually adjusted for variables hypothesized to explain the relation between race/ethnicity and survival from out-of-hospital cardiac arrest—sociodemographic variables, prior health status, circumstances of the cardiac arrest, and initial cardiac rhythm. In the sixth model, results were adjusted for all variables of interest.

‡ OR, odds ratio; CI, confidence interval; df, degrees of freedom.

§ Year 2000 median household income for the census tract of the patient's residence.

¶ Refers to the time interval between activation of a call to New York City Emergency Medical Services (EMS) and the arrival of first responders at the scene of the cardiac arrest. Data on time to the patient's side are not available within the New York City EMS system.

that age was not a factor in the observed lower rates of ventricular fibrillation among Blacks. Differences in ventricular fibrillation may be related to underlying physiologic differences, including the severity of cardiac pathology, and genetic differences (32). Additionally, it has been observed that noncardiac causes of cardiac arrest are more common among persons with an initial cardiac rhythm of asystole, even after exclusion of obvious noncardiac causes (33). Therefore, it is possible that racial/ethnic differences in ventricular fibrillation may be related to differences in the underlying cause of cardiac arrest.

There were several limitations to this study. First, in the absence of individual income data, we used geocoding to assign the average income at the census tract level to individuals residing in that particular census tract. Variability within a census tract may have limited the validity of this measure as a proxy for individual income. In some respects, however, census tract-level income may well represent the potential role of socioeconomic position for this analysis. For example, unlike individual measures of income, which may underestimate the true effect of differences in socioeconomic position, income measured as an aggregate is probably correlated with the environmental conditions (e.g., food resources, transportation, medical care) that also may be important to cardiovascular health and out-of-hospital cardiac arrest (34). Second, because of the potential for racial/ethnic differences in access to clinical care and subsequent inequality in the detection and treatment of cardiac pathology, our measure of a history of a heart condition may have been more sensitive for Whites than for Blacks. For example, if Black patients were less likely to visit a clinician and be prescribed medication for a heart condition, differential misclassification of having a history of a heart condition by race/ethnicity may have resulted; in this case, our analysis would have underestimated the explanatory power of underlying cardiac pathology. Third, race/ethnicity was documented here by paramedics, relying on a variety of potential sources. It is possible that there was some misclassification of race/ethnicity in this sample, although it was probably nondifferential, hence suggesting that the racial/ethnic disparities documented here underestimated the actual disparities in out-of-hospital cardiac arrest incidence and survival.

With the above caveats considered, this study showed that racial/ethnic disparities in survival from out-of-hospital cardiac arrest exist. To consider this issue in comparison with other causes of death, while the cardiac arrest incidence rates documented here were lower than rates for other common conditions such as prostate cancer (35), the mortality rates documented here were substantially higher than the death rates from other conditions, such as human immunodeficiency virus/acquired immunodeficiency syndrome (36). The relative racial/ethnic differences in incidence of and mortality from out-of-hospital cardiac arrest that we documented in this study are well within the range of the relative Black-White differences in incidence and mortality for these two other causes of death (35, 36). These findings, then, both document substantial racial/ethnic differences and suggest reasons for these differences. We show that a combination of factors probably accounts for racial/ethnic

disparities in survival from out-of-hospital cardiac arrest, although the lower prevalence of ventricular fibrillation as the initial cardiac rhythm among Black patients relative to White patients was the primary contributor to the observed disparity, and previously hypothesized factors such as delays in EMS response or the likelihood of CPR receipt do not appear to have been substantial contributors. Rates of survival from out-of-hospital cardiac arrest in New York City are substantially lower than those reported in other cities (20). As the New York City EMS system aims to improve overall survival from out-of-hospital cardiac arrest, understanding the likely causes of poor survival is an important first step toward both mitigating racial/ethnic differences and increasing overall survival. In future research, investigators should examine the etiologic factors underlying the observed racial/ethnic differences in initial cardiac rhythm documented in this study.

ACKNOWLEDGMENTS

This study was funded by a grant from the American Heart Association.

The authors thank Dr. Demian Szyld for research assistance.

Conflict of interest: none declared.

REFERENCES

1. Zheng ZJ, Croft JB, Giles WH, et al. Sudden cardiac death in the United States, 1989 to 1998. Circulation 2001;104:2158–63.
2. State-specific mortality from sudden cardiac death—United States, 1999. MMWR Morb Mortal Wkly Rep 2002;51:123–6.
3. Engdahl J, Holmberg M, Karlson BW, et al. The epidemiology of out-of-hospital 'sudden' cardiac arrest. Resuscitation 2002; 52:235–45.
4. Holmberg M, Holmberg S, Herlitz J, et al. Survival after cardiac arrest outside hospital in Sweden. Swedish Cardiac Arrest Registry. Resuscitation 1998;36:29–36.
5. Lombardi G, Gallagher J, Gennis P. Outcome of out-of-hospital cardiac arrest in New York City. The Pre-Hospital Arrest Survival Evaluation (PHASE) Study. JAMA 1994;271: 678–83.
6. Becker LB, Ostrander MP, Barrett J, et al. Outcome of CPR in a large metropolitan area—where are the survivors? Ann Emerg Med 1991;20:355–61.
7. Westal RE, Reissman S, Doering G. Out-of-hospital cardiac arrests: an 8-year New York City experience. Am J Emerg Med 1996;14:364–8.
8. Dickey W, MacKenzie G, Adgey AA. Long-term survival after resuscitation from ventricular fibrillation occurring before hospital admission. Q J Med 1991;80:729–37.
9. Goldstein S, Landis JR, Leighton R, et al. Predictive survival models for resuscitated victims of out-of-hospital cardiac arrest with coronary heart disease. Circulation 1985;71:873–80.
10. Hallstrom AP, Cobb LA, Swain M, et al. Predictors of hospital mortality after out-of-hospital cardiopulmonary resuscitation. Crit Care Med 1985;13:927–9.
11. Hallstrom AP, Cobb LA, Yu BH. Influence of comorbidity on the outcome of patients treated for out-of-hospital ventricular fibrillation. Circulation 1996;93:2019–22.
12. Cummins RO, Eisenberg MS, Hallstrom AP, et al. Survival of out-of-hospital cardiac arrest with early initiation of cardiopulmonary resuscitation. Am J Emerg Med 1985;3:114–19.
13. Fischer M, Fischer NJ, Schuttler J. One-year survival after out-of-hospital cardiac arrest in Bonn city: outcome report according to the 'Utstein style'. Resuscitation 1997;33:233–43.
14. Herlitz J, Ekstrom L, Wennerblom B, et al. Survival in patients found to have ventricular fibrillation after cardiac arrest witnessed outside hospital. Eur Heart J 1994;15:1628–33.
15. Litwin PE, Eisenberg MS, Hallstrom AP, et al. The location of collapse and its effect on survival from cardiac arrest. Ann Emerg Med 1987;16:787–91.
16. Ritter G, Wolfe RA, Goldstein S, et al. The effect of bystander CPR on survival of out-of-hospital cardiac arrest victims. Am Heart J 1985;110:932–7.
17. Eisenberg MS, Bergner L. Paramedic programs and cardiac mortality: description of a controlled experiment. Public Health Rep 1979;94:80–4.
18. Becker LB, Han BH, Meyer PM, et al. Racial differences in the incidence of cardiac arrest and subsequent survival. The CPR Chicago Project. N Engl J Med 1993;329:600–6.
19. Chu K, Swor R, Jackson R, el al. Race and survival after out-of-hospital cardiac arrest in a suburban community. Ann Emerg Med 1998;31:478–82.
20. Cowie MR, Fahrenbruch CE, Cobb LA, et al. Out-of-hospital cardiac arrest: racial differences in outcome in Seattle. Am J Public Health 1993;83:955–9.
21. Hallstrom A, Boutin P, Cobb L, et al. Socioeconomic status and prediction of ventricular fibrillation survival. Am J Public Health 1993;83:245–8.
22. Sayegh AJ, Swor R, Chu KH, et al. Does race or socioeconomic status predict adverse outcome after out of hospital cardiac arrest: a multi-center study. Resuscitation 1999;40: 141–6.
23. Cummins RO, Chamberlain DA, Abramson NS, et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the Utstein Style. Task Force of the American Heart Association, the European Resuscitation Council, the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council. Ann Emerg Med 1991;20: 861–74.
24. Bureau of the Census, US Department of Commerce. 2000 Census of Population and Housing. Summary file 1. Technical documentation. Washington, DC: Bureau of the Census, 2005. (http://www.census.gov/prod/cen2000/doc/sf1.pdf).
25. Anderson RN, Rosenberg H. Age standardization of death rates: implementation of the year 2000 standard. Hyattsville, MD: National Center for Health Statistics, 1998:47.
26. Cummins RO, Ornato JP, Thies WH, et al. Improving survival from sudden cardiac arrest: the ''chain of survival'' concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. Circulation 1991;83:1832–47.
27. Brookoff D, Kellermann AL, Hackman BB, et al. Do blacks get bystander cardiopulmonary resuscitation as often as whites? Ann Emerg Med 1994;24:1147–50.
28. Henry J. Kaiser Family Foundation, American College of Cardiology Foundation. Racial/ethnic differences in cardiac care: the weight of the evidence. Menlo Park, CA: Henry J. Kaiser Family Foundation, 2006.
29. Alboni P, Amadei A, Scarfo S, et al. In industrialized nations, a low socioeconomic status represents an independent predictor of mortality in patients with acute myocardial infarction. Ital Heart J 2003;4:551–8.

30. Sekimoto M, Noguchi Y, Rahman M, et al. Estimating the effect of bystander-initiated cardiopulmonary resuscitation in Japan. Resuscitation 2001;50:153–60.
31. Weaver WD, Cobb LA, Dennis D, et al. Amplitude of ventricular fibrillation waveform and outcome after cardiac arrest. Ann Intern Med 1985;102:53–5.
32. Arking DE, Chugh SS, Chakravarti A, et al. Genomics in sudden cardiac death. Circ Res 2004;94:712–23.
33. Cobb LA, Fahrenbruch CE, Olsufka M, et al. Changing incidence of out-of-hospital ventricular fibrillation, 1980–2000. JAMA 2002;288:3008–13.
34. Lynch J, Kaplan G. Socioeconomic position. In: Berkman LF, Kawachi I, eds. Social epidemiology. 1st ed. New York, NY: Oxford University Press, 2000:13–35.
35. Ries LA, Harkins D, Krapcho M, eds. SEER cancer statistics review, 1975–2003. Tables I-5 and I-6. Bethesda, MD: National Cancer Institute, 2006. (http://seer.cancer.gov/csr/1975_2003/).
36. National Center for Health Statistics. Health, United States, 2006. With chartbook on trends in the health of Americans. Table 42. Hyattsville, MD: National Center for Health Statistics, 2006. (http://www.cdc.gov/nchs/data/hus/hus06.pdf).