

## ORIGINAL ARTICLE

# Racial and Ethnic Differences in Bystander CPR for Witnessed Cardiac Arrest

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## ABSTRACT

**BACKGROUND**

Differences in the incidence of cardiopulmonary resuscitation (CPR) provided by bystanders contribute to survival disparities among persons with out-of-hospital cardiac arrest. It is critical to understand whether the incidence of bystander CPR in witnessed out-of-hospital cardiac arrests at home and in public settings differs according to the race or ethnic group of the person with cardiac arrest in order to inform interventions.

**METHODS**

Within a large U.S. registry, we identified 110,054 witnessed out-of-hospital cardiac arrests during the period from 2013 through 2019. We used a hierarchical logistic regression model to analyze the incidence of bystander CPR in Black or Hispanic persons as compared with White persons with witnessed cardiac arrests at home and in public locations. We analyzed the overall incidence as well as the incidence according to neighborhood racial or ethnic makeup and income strata. Neighborhoods were classified as predominantly White (>80% of residents), majority Black or Hispanic (>50% of residents), or integrated, and as high income (an annual median household income of >\$80,000), middle income (\$40,000–\$80,000), or low income (<\$40,000).

**RESULTS**

Overall, 35,469 of the witnessed out-of-hospital cardiac arrests (32.2%) occurred in Black or Hispanic persons. Black and Hispanic persons were less likely to receive bystander CPR at home (38.5%) than White persons (47.4%) (adjusted odds ratio, 0.74; 95% confidence interval [CI], 0.72 to 0.76) and less likely to receive bystander CPR in public locations than White persons (45.6% vs. 60.0%) (adjusted odds ratio, 0.63; 95% CI, 0.60 to 0.66). The incidence of bystander CPR among Black and Hispanic persons was less than that among White persons not only in predominantly White neighborhoods at home (adjusted odds ratio, 0.82; 95% CI, 0.74 to 0.90) and in public locations (adjusted odds ratio, 0.68; 95% CI, 0.60 to 0.75) but also in majority Black or Hispanic neighborhoods at home (adjusted odds ratio, 0.79; 95% CI, 0.75 to 0.83) and in public locations (adjusted odds ratio, 0.63; 95% CI, 0.59 to 0.68) and in integrated neighborhoods at home (adjusted odds ratio, 0.78; 95% CI, 0.74 to 0.81) and in public locations (adjusted odds ratio, 0.73; 95% CI, 0.68 to 0.77). Similarly, across all neighborhood income strata, the frequency of bystander CPR at home and in public locations was lower among Black and Hispanic persons with out-of-hospital cardiac arrest than among White persons.

**CONCLUSIONS**

In witnessed out-of-hospital cardiac arrest, Black and Hispanic persons were less likely than White persons to receive potentially lifesaving bystander CPR at home and in public locations, regardless of the racial or ethnic makeup or income level of the neighborhood where the cardiac arrest occurred. (Funded by the National Heart, Lung, and Blood Institute.)

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**C**ARDIOPULMONARY RESUSCITATION (CPR) performed by bystanders increases the odds of survival for persons with out-of-hospital cardiac arrest<sup>1-5</sup> and is a critical link in the chain of survival.<sup>6</sup> However, most persons with cardiac arrest do not receive bystander CPR despite the potential that it may improve survival and limit anoxic brain injury.<sup>7</sup>

Racial and ethnic disparities in survival for out-of-hospital cardiac arrest have been reported<sup>8-11</sup> and are due, in part, to lower incidence of bystander CPR in communities with populations that are mostly Black or Hispanic.<sup>9,12</sup> However, previous reports on the differences in bystander CPR according to race and ethnic group have not restricted analyses to witnessed arrests, in which layperson responses are the most effective. In addition, these studies have largely focused on differences between neighborhoods in the incidence of bystander CPR, under the presumption that CPR training and dispatcher-assisted CPR programs are better in White communities. What has not been quantified is the difference between Black or Hispanic and White populations when the incidence of bystander CPR is examined according to the racial or ethnic makeup and income composition of the neighborhood in which the cardiac arrest occurred. Moreover, it is unknown whether differences exist only with regard to cardiac arrests that occur at home, where relatives and friends are most likely to initiate CPR, or also in cardiac arrests that occur in public locations, where there may be more potential bystanders. Understanding the magnitude of racial and ethnic differences in bystander CPR according to the location of the arrest could guide policies to improve the incidence of this potentially life-saving intervention.

We hypothesized that Black and Hispanic persons with out-of-hospital cardiac arrest would be less likely to receive bystander CPR at home, given the lower incidence of CPR training in their communities,<sup>13</sup> and that this treatment difference would be smaller for cardiac arrests that occurred in public locations, where there probably would be more bystanders who could initiate CPR. To address these knowledge gaps, we leveraged data from a large national registry to quantify racial and ethnic differences in layperson-initiated bystander CPR for witnessed out-of-hospital cardiac arrests at home and in public loca-

tions, stratified according to the racial or ethnic and income composition of the neighborhood where the arrest occurred. Collectively, study insights could inform efforts to reduce racial and ethnic differences in resuscitation response and survival from out-of-hospital cardiac arrest.

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## METHODS

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### DATA SOURCE

The Cardiac Arrest Registry to Enhance Survival (CARES) is a prospective, multicenter registry of persons who have had an out-of-hospital cardiac arrest in the United States, with a current catchment area that includes approximately 167 million residents, which represents 51% of the U.S. population. The registry was established by the Centers for Disease Control and Prevention and Emory University, and has been previously described<sup>14,15</sup> (details are provided in the Supplementary Appendix, available with the full text of this article at NEJM.org). The registry includes all persons with a nontraumatic (i.e., not caused by a trauma) out-of-hospital cardiac arrest for whom resuscitation was attempted and who were identified by emergency medical service (EMS) agencies. Standardized international Utstein definitions for reporting clinical variables and outcomes associated with cardiac arrest were used to ensure the uniformity of the data included in the registry.<sup>16</sup> The study was approved by the institutional review board of Saint Luke's Hospital, which waived the requirement for informed consent because the study involved deidentified data. The fifth, sixth, and last authors vouch for the accuracy and completeness of the data in this report; author contributions are listed in the Supplementary Appendix.

### STUDY POPULATION

Between January 1, 2013, and December 31, 2019, we identified 460,827 persons with a nontraumatic out-of-hospital cardiac arrest. We were interested in adults with witnessed out-of-hospital cardiac arrest, so we excluded 222,795 unwitnessed arrests and 12,739 pediatric arrests (Fig. S1 in the Supplementary Appendix). Also excluded were 56,272 persons whose arrests were witnessed by EMS personnel (i.e., there was no opportunity for a layperson bystander to provide CPR) and 22,899 persons with arrests that occurred at a

nursing home or health care facility (since these locations had on-site health care professionals). In addition, we excluded 30,559 cardiac arrests in persons with unknown or missing information on race or ethnic group and 4590 arrests that occurred in persons of other races (4018 Asians and 572 Native Americans or Alaska Natives) in order to focus the comparison on the differences in out-of-hospital cardiac arrest between Black or Hispanic persons and White persons. We further excluded 47 arrests in which there was missing information on bystander CPR and 872 arrests that were not linked to census-tract data. Our final study cohort consisted of 110,054 witnessed out-of-hospital cardiac arrests that were reported by 1614 EMS agencies.

### STUDY OUTCOMES

The primary outcome was the initiation of bystander CPR, defined as CPR initiated by any layperson (family member, medical provider, or other person) who was not a 911 responder (fire, police, or EMS employee). The independent variable was race or ethnic group (Black or Hispanic vs. non-Hispanic White). For cases included in CARES, race and ethnic group are reported by persons who had a cardiac arrest or their family members, whenever possible, or are reported by EMS personnel when the person dies during resuscitation and no family member or acquaintance is available to provide race or ethnic-group information.

We analyzed the incidence of bystander CPR according to the race or ethnic group of persons who had out-of-hospital cardiac arrests that occurred at home and in public locations. Analyses were further stratified according to the racial or ethnic makeup and the income composition of the neighborhood in which the arrest occurred. The address of each out-of-hospital cardiac arrest that was included in CARES was geocoded to a U.S. census tract. Census tracts were used as proxies for neighborhoods because they typically represent economically and socially homogeneous groups of approximately 1200 to 8000 residents.<sup>17</sup> Neighborhood-level information on racial and ethnic makeup and income were linked to each geocoded address with data from the 2019 American Community Survey.<sup>18</sup> Using previously gathered data regarding the distribution of the racial composition of census tracts included in CARES,<sup>19</sup> we categorized neighborhoods as predominantly

White (>80% White), majority Black or Hispanic (>50% Black or Hispanic), or integrated. Integrated neighborhoods were those that did not meet the criteria for a predominantly White or majority Black or Hispanic neighborhood. Neighborhoods were also classified as high-income (median annual household income, >\$80,000), middle-income (\$40,000 to \$80,000), or low-income (<\$40,000).

### STATISTICAL ANALYSIS

Owing to the large sample size, characteristics of Black or Hispanic persons and White persons at baseline were compared with the use of standardized differences, in which a standardized absolute difference of more than 10 percentage points was considered clinically meaningful.<sup>20</sup>

To assess for racial and ethnic differences in the incidence of bystander CPR, multivariable hierarchical logistic regression models were constructed separately for out-of-hospital cardiac arrests that occurred at home and those that occurred in public locations. Besides race and ethnic group, these models adjusted for the age and sex of the person who had a cardiac arrest, the calendar year of arrest, the cause of the arrest (presumed cardiac, respiratory, or other), and urbanicity (according to U.S. census urban–rural tract classification: urbanized [ $\geq 50,000$  residents], urban cluster [non-urbanized areas,  $\geq 2500$  residents]; or rural [ $< 2500$  residents])<sup>21</sup> as fixed effects. Because an EMS agency might have worked in more than one census tract, each combination of EMS agency and census tract was modeled as a unique random effect to account for clustering of patient outcomes within the site. In all models, the effect of race was categorized according to between-cluster and within-cluster effects, with the latter representing the association between the race or ethnic group of a person who had an arrest and the likelihood of bystander CPR within an individual neighborhood.

To examine whether racial and ethnic differences in bystander CPR were explained by neighborhood factors, we repeated the above analyses of out-of-hospital cardiac arrests that occurred at home and in public locations for each neighborhood racial or ethnic-group designation and each income strata. In addition, we examined the number of Black or Hispanic persons as compared with the number of White persons for survival to hospital discharge and for favorable neurologic

survival (survival with a discharge Cerebral Performance Category score of 1 or 2 out of 5, in which 1 denotes no-to-mild neurological disability and 2 denotes moderate disability) after an out-of-hospital cardiac arrest. The analyses for survival to hospital discharge and favorable neurologic survival initially were adjusted for the same variables that were used for the outcome of bystander CPR. The analyses were further adjusted for the presence or absence of bystander CPR and the cardiac-arrest rhythm that was initially detected (since this variable may be influenced by receipt of bystander CPR). To account for potential bias owing to missing data regarding race or ethnic group, we used inverse probability weighting to generate all model estimates.

Finally, we evaluated whether racial or ethnic differences in bystander CPR were present in different public locations (i.e., workplace settings [commercial or industrial building], street or highway, recreational facility, public transportation center [e.g., airport or bus terminal], or other), since the number of potential bystanders and their familiarity with the person having an out-of-hospital cardiac arrest would differ according to the location. We constructed a hierarchical model for arrests in a public location and adjusted for the age and sex of the person who had the arrest, calendar year, the race or ethnic group of the person, the cause of the arrest (i.e., cardiac, respiratory, other), urbanicity, public location category, neighborhood racial and ethnic makeup, and neighborhood income.

Because we did not prespecify that there would be correction for multiplicity when conducting tests, results are reported as point estimates and 95% confidence intervals. The widths of the confidence intervals have not been adjusted for multiplicity, so the intervals should not be used to infer definitive associations. All analyses were performed with SAS software, version 9.4 (SAS Institute).

## RESULTS

### PERSONS WITH CARDIAC ARREST

Of 110,054 witnessed out-of-hospital cardiac arrests, 35,469 (32.2%) occurred in Black (27,205 [24.7%]) or Hispanic (8264 [7.5%]) persons, percentages that were representative of the U.S. population (Table S1). Among persons who were excluded, a total of 3961 Asians and 30,244 per-

sons whose race and ethnic group were unknown would have otherwise met study criteria. Black and Hispanic persons with cardiac arrest were younger (mean age, 61.4 years) than White persons (mean age, 65.2 years), were more frequently women, were more likely to reside in an urbanized area, and were more likely to have an arrest in a low-income and Black or Hispanic neighborhood (Table 1). The incidence of at-home versus public out-of-hospital cardiac arrest and the causes of the arrests were similar among Black or Hispanic persons and White persons (Table S2).

### OUTCOMES

Overall, 84,296 (76.6%) of the total cardiac arrests occurred at home and 25,758 (23.4%) occurred in public locations. Black and Hispanic persons were less likely than White persons to receive bystander CPR at home (38.5% vs. 47.4%; adjusted odds ratio, 0.74; 95% confidence interval [CI], 0.72 to 0.76) and in public locations (45.6% vs. 60.0%; adjusted odds ratio, 0.63; 95% CI, 0.60 to 0.66) (Table 2, Fig. 1, and Table S3). After stratification according to neighborhood racial and ethnic makeup, the incidence of bystander CPR was lower for Black and Hispanic persons in predominantly White neighborhoods when the cardiac arrest occurred at home (43.8% vs. 49.1%; adjusted odds ratio, 0.82; 95% CI, 0.74 to 0.90) or in public locations (50.7% vs. 61.8%; adjusted odds ratio, 0.68; 95% CI, 0.60 to 0.75); in neighborhoods with majority Black or Hispanic populations when the cardiac arrest occurred at home (37.3% vs. 43.4%; adjusted odds ratio, 0.79; 95% CI, 0.75 to 0.83) or in public locations (41.7% vs. 55.7%; adjusted odds ratio, 0.63; 95% CI, 0.59 to 0.68); and in integrated neighborhoods when the cardiac arrest occurred at home (40.9% vs. 47.1%; adjusted odds ratio, 0.78; 95% CI, 0.74 to 0.81) or in public locations (50.4% vs. 60.3%; adjusted odds ratio, 0.73; 95% CI, 0.68 to 0.77).

A similar pattern was found when out-of-hospital cardiac arrests that occurred at home and those that occurred in public locations were analyzed according to neighborhood income. Results were similar when separate analyses were conducted for Black and Hispanic persons as compared with White persons (Tables S4 and S5); when Black and Hispanic neighborhoods were redefined as those composed of more than 80% Black or Hispanic residents (Table S6); and when the analyses were performed in a population of

**Table 1. Characteristics of Persons with Witnessed Out-of-Hospital Cardiac Arrest at Baseline.\***

Characteristic	All Persons with Cardiac Arrest (N=110,054)	Black or Hispanic Persons (N=35,469)	White Persons (N=74,585)	Standardized Difference† percentage points
Year of cardiac arrest — no. (%)				2.9
2013	7,770 (7.1)	2,517 (7.1)	5,253 (7.0)	
2014	10,507 (9.5)	3,378 (9.5)	7,129 (9.6)	
2015	12,038 (10.9)	3,810 (10.7)	8,228 (11.0)	
2016	14,578 (13.2)	4,504 (12.7)	10,074 (13.5)	
2017	18,015 (16.4)	5,871 (16.6)	12,144 (16.3)	
2018	21,137 (19.2)	6,955 (19.6)	14,182 (19.0)	
2019	26,009 (23.6)	8,434 (23.8)	17,575 (23.6)	
Age — yr				24.1
Mean	64.0±15.9	61.4±16.3	65.2±15.5	
Median (IQR)	65.0 (54.0–75.0)	62.0 (51.0–73.0)	66.0 (56.0–76.0)	
Sex — no. (%)				17.8
Female	37,609 (34.2)	14,163 (39.9)	23,446 (31.4)	
Male	72,443 (65.8)	21,305 (60.1)	51,138 (68.6)	
Race or ethnic group — no. (%)‡				NA
Black, non-Hispanic	27,205 (24.7)	27,205 (76.7)	0	
Hispanic or Latino	8,264 (7.5)	8,264 (23.3)	0	
White, non-Hispanic	74,585 (67.8)	0	74,585 (100.0)	
Person initiating CPR — no. (%)				22.8
Layperson of any category	51,852 (47.1)	14,231 (40.1)	37,621 (50.4)	
Unspecified layperson	19,059 (17.3)	5,048 (14.2)	14,011 (18.8)	
Family member	28,280 (25.7)	7,941 (22.4)	20,339 (27.3)	
Medical provider	4,513 (4.1)	1,242 (3.5)	3,271 (4.4)	
First responder	32,294 (29.3)	10,972 (30.9)	21,322 (28.6)	
EMS	25,908 (23.5)	10,266 (28.9)	15,642 (21.0)	
Location of cardiac arrest — no. (%)				4.0
Home or residence	84,296 (76.6)	27,573 (77.7)	56,723 (76.1)	
Public location	25,758 (23.4)	7,896 (22.3)	17,862 (23.9)	
Urbanicity designation — no. (%)§				47.7
Urbanized area	88,490 (80.4)	32,635 (92.0)	55,855 (74.9)	
Urban cluster	7,474 (6.8)	1,209 (3.4)	6,265 (8.4)	
Rural	14,090 (12.8)	1,625 (4.6)	12,465 (16.7)	
Neighborhood median annual household income — no. (%)				65.3
>\$80,000	26,504 (24.1)	5,311 (15.0)	21,193 (28.4)	
\$40,000 to \$80,000	61,075 (55.5)	16,643 (46.9)	44,432 (59.6)	
<\$40,000	22,475 (20.4)	13,515 (38.1)	8,960 (12.0)	
Race or ethnic makeup of neighborhood — no. (%)				137.4
More than 50% Black or Hispanic	34,008 (30.9)	23,452 (66.1)	10,556 (14.2)	
Integrated	45,052 (40.9)	10,222 (28.8)	34,830 (46.7)	
More than 80% White	30,994 (28.2)	1,795 (5.1)	29,199 (39.1)	

\* Plus–minus values are means ±SD. EMS denotes emergency medical services, IQR interquartile range, and NA not applicable.

† The standardized difference is a measure of effect size and is calculated as the difference in the mean or proportion between two groups divided by the standard deviation of that difference. A standardized difference of greater than 10 percentage points indicates a clinically meaningful difference.

‡ Race or ethnic group was reported by the person who had the cardiac arrest, family members, or acquaintances when available; otherwise, race or ethnic group was assigned by EMS personnel.

§ Urbanicity designation is according to U.S. census tract classification (urbanized, ≥50,000 residents; urban cluster, nonurbanized areas with ≥2500 residents; or rural, <2500 residents).

**Table 2. Bystander CPR in Persons with a Witnessed Out-of-Hospital Cardiac Arrest.\***

Event	Black or Hispanic Persons	White Persons	Adjusted Odds Ratio (95% CI)†
	no./total no. (%)		
Overall‡			
At home	10,627/27,573 (38.5)	26,899/56,723 (47.4)	0.74 (0.72–0.76)
In a public location	3604/7896 (45.6)	10,722/17,862 (60.0)	0.63 (0.60–0.66)
Racial or ethnic makeup of neighborhood			
>80% White			
At home	516/1177 (43.8)	11,422/23,286 (49.1)	0.82 (0.74–0.90)
In a public location	313/618 (50.6)	3656/5913 (61.8)	0.68 (0.60–0.75)
>50% Black or Hispanic			
At home	7148/19,143 (37.3)	3306/7616 (43.4)	0.79 (0.75–0.83)
In a public location	1795/4309 (41.7)	1636/2940 (55.6)	0.63 (0.59–0.68)
Integrated			
At home	2963/7253 (40.9)	12,171/25,821 (47.1)	0.78 (0.74–0.81)
In a public location	1496/2969 (50.4)	5430/9009 (60.3)	0.73 (0.68–0.77)
Median household income of neighborhood			
>\$80,000			
At home	1637/3662 (44.7)	8120/16,163 (50.2)	0.80 (0.76–0.85)
In a public location	854/1679 (50.9)	3230/5030 (64.2)	0.66 (0.61–0.72)
\$40,000–\$80,000			
At home	5311/13,026 (40.8)	16,146/34,313 (47.1)	0.82 (0.79–0.85)
In a public location	1712/3617 (47.3)	5946/10,119 (58.8)	0.68 (0.64–0.73)
<\$40,000			
At home	3679/10,885 (33.8)	2615/6274 (41.7)	0.74 (0.70–0.78)
In a public location	1038/2630 (39.5)	1546/2713 (57.0)	0.57 (0.54–0.62)

\* U.S. census tract data were used to define the racial and ethnic makeup of neighborhoods (White, 6936 census tracts [30.2%]; Black or Hispanic, 6182 [26.9%]; and integrated, 9850 [42.9%]) and median household income of neighborhoods (>\$80,000, 6763 census tracts [29.5%]; \$40,000–\$80,000, 12,123 [52.8%]; and <\$40,000, 4082 [17.8%]).

† The estimates of effect reflect marginal within-cluster estimates from a hierarchical model adjusted for the age, sex, and race or ethnic group of the person who had a cardiac arrest, the calendar year of arrest, the cause of cardiac arrest, and urbanicity as fixed effects and EMS agency–census tract as a random effect. The width of the confidence intervals (CIs) should not be used to infer definitive associations.

‡ The median odds ratio for site-level variation in layperson bystander CPR was 1.91 (95% CI, 1.88 to 1.95) for cardiac arrests at home and 2.10 (95% CI, 2.02 to 2.18) for arrests in a public location, a ratio that suggests that among EMS agency–census tract clusters there were sizeable variations in the likelihood of receiving bystander CPR.

persons with unwitnessed arrests, who were excluded from the study cohort (Table S7). The incidence of bystander CPR performed among Asian persons who were excluded from the study as compared with White persons is reported in Table S8.

Black and Hispanic persons had lower incidence of survival to discharge and favorable neurologic discharge than White persons, both for

cardiac arrests at home and in public locations (Table 3 and Tables S9 and S10). Differences according to race and ethnic group in survival outcomes were attenuated with further adjustment for receipt of bystander CPR and initial cardiac-arrest rhythm (categorized as shockable or non-shockable).

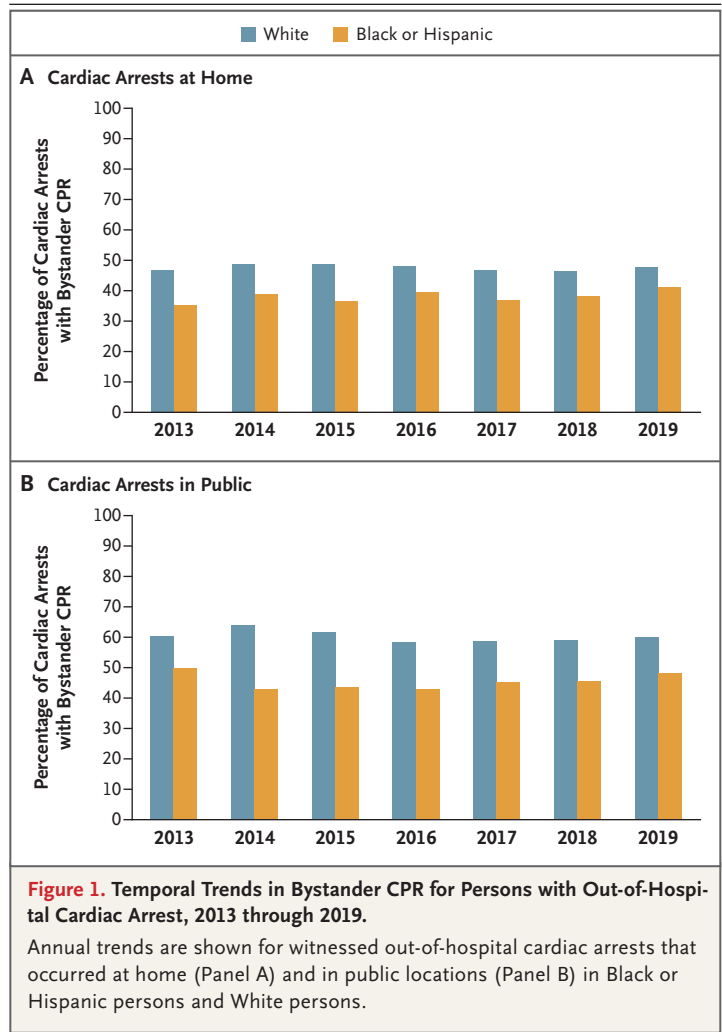
Finally, we examined the incidence of bystander CPR according to public location type. Black

and Hispanic persons were less likely than White persons to receive bystander CPR in every public location category, including in workplace settings (53.2% vs. 61.8%; adjusted odds ratio, 0.73; 95% CI, 0.70 to 0.77), recreational facilities (55.8% vs. 74.4%; adjusted odds ratio, 0.50; 95% CI, 0.43 to 0.56), and public transportation centers (48.3% vs. 69.6%; adjusted odds ratio, 0.46; 95% CI, 0.37 to 0.57) (Table 4).

## DISCUSSION

Black and Hispanic persons typically have worse survival after out-of-hospital cardiac arrest than White persons, but the reasons for this finding are not clear. Using a national U.S. registry, we found large racial and ethnic differences in the incidence of bystander CPR for witnessed out-of-hospital cardiac arrest. The relative likelihood of receiving bystander CPR at home was 26% lower for Black and Hispanic persons than for White persons, and the likelihood of bystander CPR for arrests in public locations was 37% lower for Black and Hispanic persons than for White persons. These differences were present across neighborhoods; accounting for differences in the incidence of bystander CPR attenuated the racial and ethnic differences in cardiac arrest survival. Our findings suggest that multifaceted public health interventions that go beyond CPR training may be needed to reduce racial and ethnic differences in bystander CPR.

Previous studies have shown that Black and Hispanic persons are less likely than White persons to receive bystander CPR after out-of-hospital cardiac arrest.<sup>9,10</sup> Our analyses expand on earlier findings in several ways. First, we restricted analyses to witnessed arrests, when bystander CPR is most likely to occur and be beneficial. Second, we examined racial and ethnic differences in bystander CPR according to the neighborhood in which the arrests occurred. Although several studies have evaluated the association between neighborhood factors and treatment for out-of-hospital cardiac arrest,<sup>9,12,22</sup> we quantified individual-level differences in bystander CPR treatment according to racial and ethnic strata and income strata in the neighborhood. Third, we analyzed for racial and ethnic differences in bystander CPR in public locations to better understand whether differences were confined to arrests that occurred at home. Finally, for out-of-hospital cardiac arrests



that occurred in public locations, we found that racial and ethnic differences in bystander CPR were present even at locations with potentially the largest number of layperson responders — recreational facilities and public transportation centers.

Several factors could explain the lower incidence of bystander CPR among Black and Hispanic persons as compared with White persons in arrests that occurred at home. CPR training is less commonly conducted in Black and Hispanic communities,<sup>13</sup> and dispatcher-assisted bystander CPR may not be as readily available.<sup>23</sup> These differences between neighborhoods may be the consequence of structural racism that has led to unequal investments in CPR training and community infrastructure. Additional barriers, such as the cost of CPR training, difference in lan-

**Table 3. Survival Outcomes for Persons with a Witnessed Out-of-Hospital Cardiac Arrest.\***

Outcome	Black or Hispanic Persons	White Persons	Adjusted Odds Ratio (95% CI)†	
			Model 1	Model 2
<i>no./total no. (%)</i>				
Survival to hospital discharge				
At home	3033/27,573 (11.0)	7089/56,723 (12.5)	0.77 (0.73–0.81)	0.88 (0.84–0.92)
In a public location	1786/7896 (22.6)	5628/17,862 (31.5)	0.60 (0.58–0.63)	0.72 (0.69–0.75)
Favorable neurologic outcome‡				
At home	1957/27,573 (7.1)	5866/56,723 (10.3)	0.59 (0.57–0.62)	0.68 (0.64–0.71)
In a public location	1385/7896 (17.5)	5156/17,862 (28.9)	0.51 (0.48–0.54)	0.60 (0.57–0.63)

\* Sequential adjustment showed that bystander CPR attenuated differences in survival outcomes by race and ethnic group. Results by neighborhood race and ethnic group and by income strata are reported in Tables S9 and S10 in the Supplementary Appendix.

† Model 1 was adjusted for the age, sex, and race or ethnic group of the person who had a cardiac arrest, the calendar year of arrest, the cause of the out-of-hospital cardiac arrest, and urbanicity as fixed effects and EMS agency–census tract as a random effect. Model 2 was additionally adjusted for bystander CPR and initial cardiac-arrest rhythm (shockable vs. nonshockable). The width of the confidence intervals should not be used to infer definitive associations.

‡ Favorable neurologic survival was defined as survival with a Cerebral Performance Category score of 1 or 2 (scores range from 1 to 5, with 1 denoting no neurologic disability or mild disability and 2 denoting moderate disability) at the time of hospital discharge.

languages spoken by dispatchers and persons in the communities, concerns about immigration status, and lack of trust in institutions (e.g., police),<sup>24</sup> could contribute to the lower within-neighborhood incidence of bystander CPR in out-of-hospital cardiac arrests at home among Black and Hispanic persons than among White persons.

Racial and ethnic differences in bystander CPR in public locations raise additional concerns about implicit and explicit biases in layperson response to out-of-hospital cardiac arrests. In contrast to a home location, bystanders may not know the person who has a cardiac arrest in a public location. Implicit bias stemming from public safety concerns may deter bystander response for a Black or Hispanic person having a cardiac arrest as compared with a White person. If present, this bias was not confined to predominantly White communities; we found racial and ethnic differences in the incidence of bystander CPR in Black and Hispanic communities and in low-income communities. Police and health care staff have been shown to harbor bias in their views and treatment of Black and Hispanic persons,<sup>25–30</sup> and these biases may also be held by Black persons.<sup>31</sup> In addition, explicit bias may contribute to differences in bystander CPR for cardiac arrests that occur in public locations,

especially those that occur at recreational facilities and public transportation centers (e.g., airports and bus terminals), where bystanders were probably strangers.

Our findings suggest that efforts to reduce racial and ethnic differences in the incidence of bystander CPR for out-of-hospital cardiac arrest will require a multifaceted approach. First, there is a critical need to offer low-cost or no-cost CPR training in Black and Hispanic communities, particularly in convenient settings such as Black churches and Hispanic community centers. Second, the use of linguistically appropriate and culturally sensitive CPR training is necessary to effectively reach diverse communities. Third, prioritizing funding for dispatcher-assisted CPR (including in Spanish and African languages) in majority Black and Hispanic neighborhoods and low-income neighborhoods can increase the incidence of bystander CPR in those vulnerable communities. Fourth, engaging community leaders is critical to address delays in the activation of 911 calls and issues of residents' trust in institutions of authority. In addition, it is unknown whether revamping of CPR training materials (e.g., mannikins and videos) to portray persons with cardiac arrest and bystanders as a diverse, multicultural population would be effective in



**Table 4. Bystander CPR Among Persons with Witnessed Out-of-Hospital Cardiac Arrest in a Public Location.**

Location	Black or Hispanic Persons	White Persons	Adjusted Odds Ratio (95% CI)*
	no./total no. (%)		
Workplace	2206/4149 (53.2)	6294/10,186 (61.8)	0.73 (0.70–0.77)
Street or highway	891/2800 (31.8)	2167/4555 (47.6)	0.61 (0.57–0.64)
Recreational facility	371/665 (55.8)	1816/2442 (74.4)	0.50 (0.43–0.56)
Public transportation center	73/151 (48.3)	249/358 (69.6)	0.46 (0.37–0.57)
Other	63/131 (48.1)	196/321 (61.1)	0.66 (0.44–0.90)

\* Model was adjusted for the age, sex, and race or ethnic group of the person who had a cardiac arrest, the calendar year of the cardiac arrest, the cause of the cardiac arrest, public location, urbanicity, neighborhood race or ethnic category, and neighborhood income category as fixed effects and EMS agency–census tract as a random effect. The width of the confidence intervals should not be used to infer definitive associations.

addressing potential bias in layperson response, but the issue merits study.

Our study has some limitations. First, we did not have information on the race of bystanders, information that could help show whether bias contributed to differences in bystander CPR in public settings. In addition, detailed information on the number of potential laypersons who witnessed each arrest case would have allowed for more robust adjustment in the event that White persons who had cardiac arrest had a higher number of potential responders than Black or Hispanic persons who had cardiac arrest. Second, information on bystanders' reasons for not providing CPR was not available. Since this study was conducted with data from persons with witnessed arrests, future efforts to collect bystander information would provide critical insights with regard to which public health interventions may have the largest effect in reducing differences in the incidence of bystander CPR. Third, there may be misclassification of race and ethnic groups in some cases reported in CARES, but any misclassification is expected to be nondifferential and yield results toward the null. Fourth, our findings may not be

generalizable to regions — especially rural regions — that do not participate in CARES.

We showed that Black and Hispanic persons with witnessed out-of-hospital cardiac arrest were less likely to receive potentially lifesaving bystander CPR than White persons, and this difference was seen in arrests both at home and in public locations. This finding suggests that multifaceted public health interventions may be needed to reduce racial and ethnic differences in bystander CPR.

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Disclosure forms provided by the authors are available with the full text of this article at NEJM.org.

Study data are available from the corresponding author on request and with approval by CARES.

#### APPENDIX

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