RACIAL AND ETHNIC DIFFERENCES IN BYSTANDER CARDIOPULMONARY

RESUSCITATION FOR WITNESSED OUT-OF-HOSPITAL CARDIAC ARREST

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RACIAL AND ETHNIC DIFFERENCES IN BYSTANDER CARDIOPULMONARY RESUSCITATION FOR WITNESSED OUT-OF-HOSPITAL CARDIAC ARREST

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ABSTRACT

Differences in bystander cardiopulmonary resuscitation (CPR) contribute to survival disparities for witnessed out-of-hospital cardiac arrest (OHCA). Whether bystander CPR rates differ by race/ethnicity for witnessed OHCAs at home and in public settings is critical to understand for informing interventions.

Within a large U.S. registry, 110,054 witnessed OHCAs were identified during 2013-2019. Using hierarchical logistic regression, the rates of bystander CPR were compared in Blacks/Hispanics vs. Whites for witnessed OHCAs at home and in public locations, overall and by neighborhood race/ethnicity and income strata. Neighborhoods were classified as predominantly White (>80% of residents), majority Black/Hispanic (>50%), or integrated, and as high- (annual median household income >$80,000), middle- ($40,000-$80,000), or low-income (<$40,000).

Overall, 35,469 (32.2%) witnessed OHCAs occurred in Black/Hispanic individuals. Blacks/Hispanics were less likely to receive bystander CPR at home (38.5% vs. 47.4% for Whites; adjusted OR [aOR]=0.74 [95% CI: 0.71-0.76]) and in public (45.6% vs. 60.0%; aOR=0.59 [0.56-0.63]), and this difference was greater for OHCAs occurring in public (P for interaction <0.001). Rates of bystander CPR were lower in Blacks/Hispanics in majority

Black/Hispanic (home: aOR=0.81 [0.76-0.86]; public: aOR=0.60 [0.54-0.66]), integrated

(home: OR=0.79 [0.74-0.83]; public: OR=0.68 [0.62-0.74]), and predominantly White

neighborhoods (home: OR=0.78 [0.69-0.88]; public: OR=0.61 [0.51-0.72]), and this difference

was larger for OHCAs in public locations in each stratum (all *P*-values for interaction ≤0.02).

A similar pattern for lower bystander CPR rates for Blacks/Hispanics vs. White for home and

public OHCAs was found across neighborhood income strata.

Black and Hispanic victims of witnessed OHCA are less likely to receive potentially

life-saving bystander CPR, as compared with White patients, and this treatment difference was

pervasive for witnessed OHCAs at home and in public, regardless of the neighborhood.

APPROVAL PAGE

The faculty listed below, appointed by the Dean of the School of Medicine has examined this research proposal titled, "Racial and Ethnic Differences in Bystander Cardiopulmonary Resuscitation for Witnessed Out-of-Hospital Cardiac Arrest" presented by R. Angel Garcia, candidate for the Master's of Science Bioinformatics, and certify that in their opinion it is worthy of acceptance.

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CHAPTER 1

INTRODUCTION

A cardiac arrest is defined as the abrupt loss of heart function and the loss of blood flow, leading to a person becoming unresponsive, and if circulation is not successfully restored in time death can ensue.[1] Cardiac arrests are generally categorized as in-hospital cardiac arrests or out-of-hospital cardiac arrests (OHCA) as the causes for cardiac arrest and outcomes in each setting are significantly different.[2, 3] Particularly, survival after an OHCA are very low.[4, 5]

After any cardiac arrest, to improve the chance of survival, cardiopulmonary resuscitation (CPR) is performed in order to maintain the perfusion of blood and the distribution of oxygen to vital organs.[6] CPR is when external chest compressions are performed on OHCA victims – with or without rescue breaths – until more definitive treatment is available or, hopefully, until a person's own circulation is spontaneously restored.[6, 7] As such, CPR is a critical link to survival after an arrest. Additionally, since most arrests occur in the home setting, it is important to understand that CPR is most likely to be performed sooner from layperson bystanders, which has a significant impact on survival.[8-13]

Unfortunately, survival for Black or Hispanic OHCA victims is lower than that of White victims. Although previous reports could suggest why such a disparity exists, targeted analyses to explore how bystanders may respond differently to minorities after an OHCA can provide deeper insight towards such disparities. Furthermore, understanding which factors or environments may foster racial/ethnic differences in providing CPR can help guide next steps towards improving OHCA outcomes.

CHAPTER 2

REVIEW OF LITERATURE

Out-of-Hospital Cardiac Arrest and Cardiopulmonary Resuscitation

Over 350,000 OHCAs occur each year in the US and outcomes are poor as approximately

10% of OHCA victims survive to hospital discharge.[4, 5] However, CPR can significantly increase

the odds of survival up to 2-3 times after suffering an OHCA[9-13], and it is a critical link in the

Chain of Survival.[14] However, most victims of witnessed OHCAs do not receive bystander CPR,

despite its potential to improve survival and limit anoxic brain injury.[15]

Racial Disparities in Out-of-Hospital Cardiac Arrest

Racial and ethnic disparities in survival for OHCA have been previously reported[16-19]

among minorities. For example, one systematic review demonstrated that Blacks had a 41% lower

odds of surviving to hospital admission after an OHCA.[16] Such racial and ethnic survival

disparities have been thought to be due, in part, to lower rates of bystander CPR in Black and

Hispanic communities.[17, 20] However, prior reports on differences in bystander CPR by race and

ethnicity have not restricted analyses to witnessed OHCAs, where a layperson's performance of CPR

is most likely to occur. Understanding the differences in bystander CPR by race/ethnicity, for arrests

that are witnessed, can best confirm if minorities indeed do receive a life-saving treatment less

frequently. Moreover, it has been largely presumed that differences in bystander CPR between

neighborhoods are due to better CPR training and dispatcher-assisted CPR programs in White

communities. What has not been quantified is the difference in bystander CPR rates between

Blacks/Hispanics and Whites when examined by neighborhood race/ethnicity and income strata.

Additionally, whether differences exist only for OHCAs at home, where relatives and friends are

most likely to initiate CPR, or also in public, where there may be more potential bystanders, is unknown. Understanding the magnitude of racial/ethnic differences in bystander CPR by location of arrest would guide public health and policy interventions to improve rates of this potentially life-saving intervention.

Research Objectives

Through a large national registry, the first objective was to quantify (in absolute and relative terms) the racial/ethnic differences in receiving layperson bystander CPR for witnessed OHCAs occurring at home and in public locations. The next objective was to determine if these racial/ethnic differences in receiving bystander CPR would persist or change when comparing witnessed OHCAs across different neighborhoods – which will be examined by the racial/ethnic composition and the median annual income of the given neighborhood where OHCA occurred. As a result, such insight could inform community/public health interventions to reduce racial/ethnic differences in resuscitation response and disparities in OHCA survival.

Hypotheses

In the setting of a witnessed arrest at home, it was hypothesized that Black or Hispanic victims of an OHCA would be less likely to receive bystander CPR at home given lower rates of CPR training in these communities.[21] In the setting of a public witnessed arrest, the hypothesis was that the disparity of receiving bystander CPR (seen within the home setting) would become smaller for OHCAs occurring in public, where a larger number of potential bystanders are available to initiate CPR.

CHAPTER 3

METHODOLOGY

Data for this study are available from the corresponding author on request and approval by the Cardiac Arrest Registry to Enhance Survival (CARES).

Data Source

CARES is a prospective, multicenter registry of patients with OHCA in the U.S., with a current catchment area of approximately 167 million residents, representing 51% of the U.S. population. Established by the Centers for Disease Control and Emory University for public health surveillance and continuous quality improvement, the design of the registry has been previously described.[22, 23] Briefly, all patients with a non-traumatic OHCA, and without do-not-resuscitate orders, for whom resuscitation is attempted are identified and followed by emergency medical service (EMS) agencies. Data are collected from three sources: 9-1-1 dispatch centers, EMS agencies, and receiving hospitals. Among patients successfully resuscitated from their OHCA and who survive to hospital admission, hospitals submit data on survival outcomes, including survival to discharge and neurological status on survivors. Standardized international Utstein definitions for defining clinical variables and outcomes are used to ensure data uniformity.[24] Data are submitted using a secure Web database with restricted access for authorized users, and the platform has software to link data sources (EMS agencies, hospitals) to create a single HIPAA-compliant de-identified record for each OHCA event. A CARES analyst reviews records for completeness and accuracy, and data quality is assured through audit algorithms and data entry review by EMS and hospital users and CARES staff.[23] Once data entry is complete and accuracy is confirmed, patient

identifiers are removed. The study was approved by Saint Luke's Hospital's institutional review board, which waived the requirement for informed consent as the study involved deidentified data.

Study Population

In CARES, between January 1, 2013 and December 31, 2019, 460,827 non-traumatic OHCAs were identified. As the study group of interest were adults with a witnessed OHCA, 222,795 unwitnessed OHCAs and 12,739 OHCAs under 18 years of age were excluded (Figure 1). Also excluded were 56,272 cases witnessed by EMS personnel (i.e., no opportunity to provide layperson bystander CPR) and 22,899 OHCAs occurring at a nursing home or healthcare facility, as these have on-site healthcare professionals. Additionally, 30,559 patients were excluded for either unknown or missing information on race/ethnicity and 4590 OHCAs in Asians, Native Americans and Alaskan Natives, to focus the comparison between Black/Hispanic vs. White individuals with OHCA. An additional 47 OHCAs were excluded for missing information on bystander CPR and another 872 OHCAs were excluded as they were not linked to census tracts. The final study cohort was comprised of 110,054 witnessed OHCAs, among Black, Hispanic or White persons, from 1614 EMS agencies.
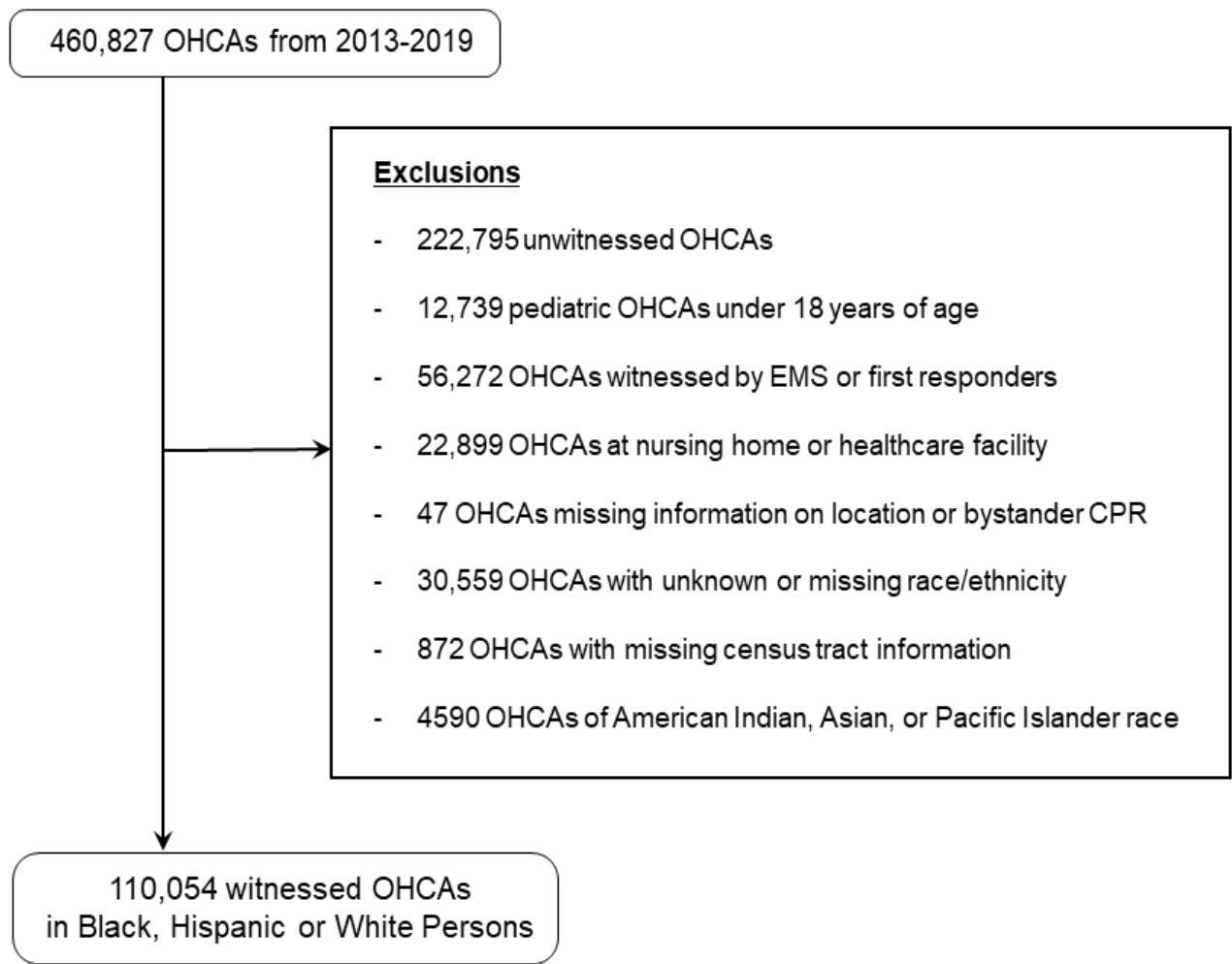
Figure 1: Derivation of Study Cohort

Race generally refers to the classification of a person or people based on their physical or biological characteristics. As per the United States Census Bureau, race is defined as a person's self-identification with one or more social groups.[25, 26] An individual can report as White, Black or African American, Asian, American Indian and Alaska Native, Native Hawaiian and Other Pacific Islander, or some other race.[25] Multiple races can be selected for an individual. CARES defines race similarly with the United States Census Bureau.

Ethnicity generally refers to the classification of a person or people based on their cultural or ancestral characteristics. As per the United States Census Bureau, ethnicity determines whether a person is of Hispanic origin or not.[26, 27] For this reason, ethnicity is broken out in two categories of Hispanic or Latino and Not Hispanic or Latino. Hispanics may report as any race. In CARES, race and ethnicity is self-reported by patients (if able), or it is reported by family members/close contacts (if present); or else, race and ethnicity is assigned by EMS personnel when the patient dies during the resuscitation and no family member or acquaintance is available. Within this study, Black individuals are defined as those who are non-Hispanic Black, White individuals are those who are non-Hispanic White, and Hispanics are those who have only been categorized as being Hispanic, regardless of racial designation.

Study Outcomes

The primary outcome was bystander CPR, defined as CPR initiated by any layperson (family member, medical provider, or other individual who is not a 9-1-1 responder [fire or police] or EMS personnel). The key independent variable was race/ethnicity (Black/Hispanic vs. non-Hispanic White). Within CARES, race and ethnicity is self-reported by patients or family members, whenever

possible, or is assigned by EMS personnel when the patient dies during the resuscitation and no family member or acquaintance is available.

The rates of bystander CPR were examined by patients' race/ethnicity for OHCAs occurring at home and in public locations. Analyses were further stratified by the racial/ethnic and income composition of the neighborhood in which the OHCA occurred. The address of each OHCA in CARES was geocoded to a U.S. census tract. Census tracts were used as proxies for neighborhoods as they typically represent economically and socially homogeneous groups of approximately 1200 to 8000 residents.[28] Neighborhood-level information on race/ethnicity and income were linked to each geocoded address with data from the 2019 U.S. Census Summary Files.[29] Based on prior work[30] and on the distribution of census tracts wherein 30% were compromised of >80% non-Hispanic White residents and 27% were comprised of >50% Black or Hispanic residents, neighborhoods were categorized as predominantly White (>80% White), majority Black/Hispanic (>50% Black or Hispanic), or integrated. Integrated neighborhoods were those that did not meet criteria for a predominantly White or majority Black/Hispanic neighborhood. Neighborhoods were also classified by income as high- (median annual household income >$80,000), middle- ($40,000 to $80,000), or low-income (<$40,000).[30]

Statistical Analysis

Given the large sample size, baseline characteristics of Black/Hispanic and White persons were compared using standardized differences, where a standardized difference of >10% indicated a clinically meaningful difference.[31]

To assess for racial/ethnic differences in rates of bystander CPR, multivariable hierarchical logistic regression models were constructed separately for those with an OHCA at home and in public locations. Besides race/ethnicity, these models adjusted for patient age, sex, etiology of OHCA (presumed cardiac, respiratory, and other) and urbanicity (U.S. Census tract classification: urbanized [$\geq$50,000 residents], urban cluster [non-urbanized areas with $\geq$2500 residents], or rural [<2500 residents])[29] as fixed effects, and EMS agency as a random effect to account for clustering of patient outcomes within site. Models tested for an interaction between race/ethnicity and location of OHCA in the entire cohort to determine if the magnitude of racial/ethnic differences in rates of bystander CPR differed for OHCAs at home vs. in public. Models did not adjust for witnessed status or arrest location (home vs. public) as only witnessed arrests were included, and also because bystander CPR rates would be reported by OHCA location. Moreover, models did not adjust for initial rhythm as this would not affect a layperson's likelihood of initiating bystander CPR.

To examine whether racial/ethnic differences in bystander CPR were explained by neighborhood factors, the above analyses were repeated within each neighborhood race/ethnicity strata and each neighborhood income strata, as outlined above. Within each neighborhood stratum, hierarchical logistic regression models were constructed to examine the differences in bystander CPR for Black/Hispanic vs. White persons with OHCAs at home and in public. The interaction between patient race/ethnicity and the location (home or public) of the arrest was also explored.

Final analyses examined whether racial/ethnic differences in bystander CPR were present in different public locations (workplace [commercial or industrial building], street/highway, recreational facility, public transportation location [e.g., airport, bus station], or other), as the number of potential bystanders and familiarity with the OHCA victim will vary across locations. A hierarchical model for OHCAs in a public location was constructed, adjusting for patient age, sex,

race/ethnicity, etiology of arrest, urbanicity, public location category, neighborhood race/ethnicity, neighborhood income, and an interaction between patient race/ethnicity and public location category.

Assumptions for binary logistic regression analysis were assessed. All observations were independent and unpaired, and the primary outcome of bystander CPR was binary (performed or not performed). Multicollinearity was assessed via a correlation matrix for which all values were <0.651. The assumption of linearity, between the only continuous variable of age and the log odds, was violated. However, this is to be expected given the effect of the large sample size of the study cohort on hypothesis testing.[32] All statistical tests and were two-tailed and an alpha level of 0.05 was considered statistically significant. All statistical analyses were performed with SAS 9.4 (SAS Institute, Cary, NC).

CHAPTER 4

RESULTS

Baseline Characteristics

Of 110,054 witnessed OHCAs, 35,469 (32.2%) occurred in Black (27,205 [24.7%]) or

Hispanic (8264 [7.5%]) patients. As compared to White patients, Black/Hispanic patients were

younger (mean age: 61.4 vs. 65.2 years), more frequently women, and more likely to reside in an

urbanized area (Table 1). There were no differences in rates of home vs. public OHCA or arrest

etiology between Black/Hispanic and White patients. Black/Hispanic patients were more likely to

have an OHCA in a low-income and Black/Hispanic neighborhood.

Table 1: Baseline characteristics of Black/Hispanic and White individuals with witnessed OHCA

	Total N = 110,054	Black or Hispanic n = 35,469	White n = 74,585	Standardized Difference (%)
Year of Arrest				
2013	7770 (7.1%)	2517 (7.1%)	5253 (7.0%)	
2014	10,507 (9.5%)	3378 (9.5%)	7129 (9.6%)	
2015	12,038 (10.9%)	3810 (10.7%)	8228 (11.0%)	2.9
2016	14,578 (13.2%)	4504 (12.7%)	10,074 (13.5%)	
2017	18,015 (16.4%)	5871 (16.6%)	12,144 (16.3%)	
2018	21,137 (19.2%)	6955 (19.6%)	14,182 (19.0%)	
2019	26,009 (23.6%)	8434 (23.8%)	17,575 (23.6%)	
Age				
Mean ± SD	64.0 ± 15.9	61.4 ± 16.3	65.2 ± 15.5	24.1
Median (IQR)	65.0 (54.0, 75.0)	62.0 (51.0, 73.0)	66.0 (56.0, 76.0)	
Sex				
Female	37,609 (34.2%)	14,163 (39.9%)	23,446 (31.4%)	17.8
Male	72,443 (65.8%)	21,305 (60.1%)	51,138 (68.6%)	
Race/Ethnicity				
Black, Non-Hispanic	27,205 (24.7%)	27,205 (76.7%)	0 (0.0%)	
Hispanic/Latino	8264 (7.5%)	8264 (23.3%)	0 (0.0%)	N/A
White, Non-Hispanic	74,585 (67.8%)	0 (0.0%)	74,585 (100.0%)	
Person Initiating CPR				
Layperson (all categories)	51,852 (47.1%)	14,231 (40.1%)	37,621 (50.4%)	

Unspecified layperson	19,059 (17.3%)	5048 (14.2%)	14,011 (18.8%)	22.8
Family member	28,280 (25.7%)	7941 (22.4%)	20,339 (27.3%)	
Medical provider	4513 (4.1%)	1242 (3.5%)	3271 (4.4%)	
Arrest Location				
Home/Residence	84,296 (76.6%)	27,573 (77.7%)	56,723 (76.1%)	4.0
Public	25,758 (23.4%)	7896 (22.3%)	17,862 (23.9%)	
Presumed Cardiac Arrest Etiology				
Presumed Cardiac	95,773 (87.0%)	31,151 (87.8%)	64,622 (86.6%)	
Respiratory/Asphyxia	9166 (8.3%)	2840 (8.0%)	6326 (8.5%)	
Drowning/Submersion	423 (0.4%)	117 (0.3%)	306 (0.4%)	
Drug Overdose	2377 (2.2%)	714 (2.0%)	1663 (2.2%)	4.2
Electrocution	158 (0.1%)	52 (0.1%)	106 (0.1%)	
Exsanguination/Hemorrhage	395 (0.4%)	111 (0.3%)	284 (0.4%)	
Other	1762 (1.6%)	484 (1.4%)	1278 (1.7%)	
Urbanicity Designation				
Urbanized Area	88,490 (80.4%)	32,635 (92.0%)	55,855 (74.9%)	
Urban Cluster	7474 (6.8%)	1209 (3.4%)	6265 (8.4%)	47.7
Rural	14,090 (12.8%)	1625 (4.6%)	12,465 (16.7%)	
Neighborhood Median Annual Household Income				65.3
> $80,000	26,504 (24.1%)	5311 (15.0%)	21,193 (28.4%)	
$40,000 - $80,000	61,075 (55.5%)	16,643 (46.9%)	44,432 (59.6%)	
< $40,000	22,475 (20.4%)	13,515 (38.1%)	8960 (12.0%)	
Neighborhood Race/Ethnicity				
Majority Black/Hispanic (>50%)	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%)	137.4
Predominantly White (>80%)	30,994 (28.2%)	1795 (5.1%)	29,199 (39.1%)	

Overall Bystander CPR Rates for Witnessed OHCAs: Home & Public

Overall, 84,296 (76.6%) witnessed OHCAs occurred at home and 25,758 (23.4%) in public. As compared with White patients, Black/Hispanic patients with OHCA were less likely to receive bystander CPR at home (38.5% vs. 47.4%; adjusted OR, 0.74 [95% CI: 0.71, 0.76]) and in public (45.6% vs. 60.0%; adjusted OR, 0.59 [0.56, 0.63]) (Table 2). The racial/ethnic difference in bystander CPR was larger for witnessed OHCAs occurring in public locations vs. at home (P for interaction <0.001).

Table 2: Overall Bystander CPR rates for Black/Hispanic and White individuals with a witnessed OHCA.* Rates are reported

for OHCAs occurring at home and in public locations, overall and when stratified by neighborhood race/ethnicity and income.

	Black or Hispanic	White	Adjusted OR	p-value	Interaction P-value
OVERALL					
Home	10,627 / 27,573 (38.5%)	26,899 / 56,723 (47.4%)	0.74 (0.71, 0.76)	<0.001	<0.001
Public	3604 / 7896 (45.6%)	10,722 / 17,862 (60.0%)	0.59 (0.56, 0.63)	<0.001	

* Models adjusted for age, sex, race/ethnicity, etiology of OHCA, and urbanicity

Neighborhood Bystander CPR Rates for Witnessed OHCAs: Home & Public

In analyses stratified by neighborhood composition, rates of bystander CPR were lower in

Black/Hispanic vs. White patients in majority Black/Hispanic neighborhoods (home: 37.3% vs.

43.4%; adjusted OR, 0.81 [0.76, 0.86]; public: 41.7% vs. 55.7%; adjusted OR, 0.60 [0.54, 0.66]),

integrated neighborhoods (home: 40.9% vs. 47.1%; adjusted OR, 0.79 [0.74, 0.83]; public: 50.4% vs.

60.3%; adjusted OR, 0.68 [0.62, 0.74]), and predominantly White neighborhoods (home: 43.8% vs.

49.1%; adjusted OR, 0.78 [0.69, 0.88]; public: 50.7% vs. 61.8%; adjusted OR, 0.61 [0.51, 0.72]). In

each neighborhood stratum, the magnitude of the racial/ethnic difference in bystander CPR was

greater for OHCAs in public, as compared with a home location (all interaction *P* values ≤0.02, Table

3). A similar pattern was found when analyses were stratified by neighborhood income, with lower

rates of bystander CPR for Black/Hispanic patients, both at home and in public. Again, the

racial/ethnic difference was greater for OHCAs in public locations (all interaction *P* values <0.001).

When all analyses were repeated with Black and Hispanic patients separately compared with White

patients, results were generally similar although some comparisons between Hispanic vs. White

patients were likely underpowered within neighborhood strata (Appendix Tables A-1 and A-2).

Table 3: Neighborhood Bystander CPR rates for Black/Hispanic and White individuals with a witnessed OHCA.* Rates are reported for OHCAs occurring at home and in public locations, overall and when stratified by neighborhood race/ethnicity and income.

BY NEIGHBORHOOD RACE					
Majority (>50%) Black/Hispanic					
Home	7148 / 19,143 (37.3%)	3306 / 7616 (43.4%)	0.81 (0.76, 0.86)	<0.001	<0.001
Public	1795 / 4309 (41.7%)	1636 / 2940 (55.7%)	0.60 (0.54, 0.66)	<0.001	
Integrated					
Home	2963 / 7253 (40.9%)	12,171 / 25,821 (47.1%)	0.79 (0.74, 0.83)	<0.001	0.004
Public	1496 / 2969 (50.4%)	5430 / 9009 (60.3%)	0.68 (0.62, 0.74)	<0.001	
Predominantly (>80%) White					
Home	516 / 1177 (43.8%)	11,422 / 23,286 (49.1%)	0.78 (0.69, 0.88)	<0.001	0.02
Public	313 / 618 (50.7%)	3656 / 5913 (61.8%)	0.61 (0.51, 0.72)	<0.001	
BY NEIGHBORHOOD MEDIAN HOUSEHOLD INCOME					
>$80,000					
Home	1637 / 3662 (44.7%)	8120 / 16,163 (50.2%)	0.81 (0.75, 0.87)	<0.001	<0.001
Public	854 / 1679 (51.8%)	3230 / 5030 (64.2%)	0.60 (0.53, 0.67)	<0.001	
$40,000 - $80,000					
Home	5311 / 13,026 (40.8%)	16146 / 34,313 (47.1%)	0.81 (0.77, 0.85)	<0.001	<0.001
Public	1712 / 3617 (47.3%)	5946 / 10,119 (58.8%)	0.66 (0.61, 0.71)	<0.001	

<$40,000					
Home	3679 / 10,885 (33.8%)	2615 / 6274 (41.9%)	0.72 (0.67, 0.78)	<0.001	<0.001
Public	1038 / 2630 (39.5%)	1546 / 2713 (57.0%)	0.53 (0.47, 0.60)	<0.001	

* Models adjusted for age, sex, race/ethnicity, etiology of OHCA, and urbanicity

Bystander CPR Rates for Witnessed OHCAs: Public Only

Finally, whether the racial/ethnic difference in bystander CPR rates was larger for certain public locations was examined, as the number of potential bystanders and familiarity with the OHCA victim may vary by location. Black/Hispanic patients were less likely to receive bystander CPR in every public location category, but this difference was smallest in workplace settings (53.2% vs. 61.8%; adjusted OR, 0.73 [0.67, 0.81]) and largest at recreational facilities (55.8% vs. 74.4%; adjusted OR, 0.50 [0.41, 0.60]) and public transportation centers (48.3% vs. 69.6%; adjusted OR, 0.43 [0.29, 0.66]; Table 4).

Table 4: Bystander CPR rates for Black/Hispanic and White individuals with a witnessed OHCA in a public location.*

	Black or Hispanic	White	Adjusted OR	Interaction p-value**
PUBLIC LOCATIONS				<0.001
Workplace	2206 / 4149 (53.2%)	6294 / 10,186 (61.8%)	0.73 (0.67, 0.81)	
Street or highway	891 / 2800 (31.8%)	2167 / 4555 (47.6%)	0.62 (0.55, 0.69)	
Recreational facility	371 / 665 (55.8%)	1816 / 2442 (74.4%)	0.50 (0.41, 0.60)	
Public Transportation Center	73 / 151 (48.3%)	249 / 358 (69.6%)	0.43 (0.29, 0.66)	
Other	63 / 131 (48.1%)	196 / 321 (61.1%)	0.69 (0.49, 1.10)	

* Model adjusted for age, sex, race/ethnicity, etiology of OHCA, public location, urbanicity, neighborhood race/ethnic category, and neighborhood income category.

** P value for interaction assessed whether the difference in bystander CPR rates between Black/Hispanic vs. White victims of OHCA differed by public location.

CHAPTER 5

DISCUSSION

Black and Hispanic patients have worse survival after OHCA than White patients, but reasons behind this have been elusive. Using a national U.S. registry, large racial/ethnic differences were found in bystander CPR rates for witnessed OHCAs—for which bystander CPR is most beneficial. Compared with White patients, Black and Hispanic patients had 26% lower odds of receiving bystander CPR for OHCAs occurring at home. However, contrary to original hypotheses, there was an even larger difference in bystander CPR rates by race/ethnicity for OHCA in a public location, with Black and Hispanic patients having 41% lower odds of receiving bystander CPR. In both instances, these differences were unattenuated across neighborhood race/ethnicity and income strata. These findings suggest multifaceted public health interventions are needed as racial/ethnic differences in bystander CPR—a potentially life-saving intervention for OHCA—are pervasive and more pronounced in the public setting where bystanders are less likely to know the victim.

Prior studies have reported that Black and Hispanic patients are less likely to receive bystander CPR after OHCA.[17, 18] These analyses extend earlier findings in several important ways. First, the analyses were restricted to witnessed OHCAs when bystander CPR is most likely to occur. Second, racial/ethnic differences in bystander CPR were examined by the neighborhood in which the arrest occurred. Although several studies have looked at the association between neighborhood factors and OHCA treatment,[17, 20, 33] this report quantifies, in absolute and relative terms, the magnitude of *individual-level* differences in bystander CPR treatment within neighborhoods that were stratified by both race/ethnicity and income. Third, it was hypothesized that racial/ethnic differences in bystander CPR would be smaller for OHCAs occurring in public locations. However, the opposite was found— although absolute bystander CPR rates for OHCAs were higher in public settings, racial/ethnic

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differences in treatment were larger. Finally, for OHCAs in public locations, it was discovered that racial/ethnic differences in bystander CPR were greatest in locations with potentially the largest number of layperson responders—recreational facilities and public transport centers.

Several factors could explain the lower rate of bystander CPR among Black/Hispanic patients at home. CPR training is less commonly conducted in counties with higher percentages of Black and Hispanic residents,[34] and dispatcher-assisted CPR may not be as available or effective in Black and Hispanic communities.[35] These differences *between neighborhoods* may be the consequence of factors like structural racism that have led to unequal investments in CPR training and community infrastructure. Additionally, barriers such as cost of CPR training, a different language from dispatchers, immigration status concerns, and/or untrustworthy institutions (e.g., police)[36] could further contribute to lower rates of bystander CPR at home in Black/Hispanic patients, regardless of the racial/ethnic composition or income of the neighborhood in which the arrest occurred.

A more disturbing finding was the larger disparity by race/ethnicity in bystander CPR in public locations. The *a priori* hypothesis was that any treatment disparities found for OHCAs at home would be smaller in public locations because typical barriers for initiating bystander CPR at home would be offset by the presence of bystanders without these barriers in public settings. The opposite was found to be true, however, with larger differences in bystander CPR rates between Black/Hispanic vs. White victims of a witnessed OHCA in public settings regardless of the racial/ethnic composition or income of the neighborhood in which the arrest occurred. The large and persistently lower rates of bystander CPR in Black/Hispanic patients in a public location raise concerns about implicit and explicit biases in layperson response. In contrast to a home location, bystanders may not know the victim in a public location. Implicit bias may deter bystander response for a Black or Hispanic vs. a White OHCA victim because of public safety concerns and/or a misperception of the severity of the medical emergency.

Although studies of implicit bias are scant for bystander CPR response, prior studies have shown that EMS personnel, the police and healthcare staff may demonstrate bias in their views and treatment of Black and Hispanic individuals[37-42] and that these biases may also be held by those of Black race.[43] Additionally, explicit bias may contribute to disparities in bystander CPR rates for public OHCAs if there is a differential bystander response to an OHCA based on the victim's perceived race and ethnicity.

Bias may also help explain why the racial/ethnic difference in bystander CPR rates for OHCAs in public locations was smallest when the location was a workplace, where the OHCA victim is more likely to be known to co-worker bystanders, and greatest at recreational facilities and public transportation centers such as airports and bus terminals. Although these latter public locations are expected to have many potential laypersons who could initiate bystander CPR, the OHCA victim is also least likely to be known to a bystander in these settings.

These findings highlight that efforts to reduce racial/ethnic disparities in bystander CPR rates for OHCA will require a multifaceted public health approach. First, there is a critical need to offer low- or no-cost CPR training in Black and Hispanic communities, particularly in settings most convenient to residents such as Black churches and barber shops and Hispanic community centers. Second, use of linguistically appropriate and culturally sensitive CPR training is necessary to effectively reach diverse communities. Third, prioritizing funding to ensure availability of dispatcher-assister CPR (including in Spanish and other African languages) in majority Black/Hispanic and low-income neighborhoods will provide additional opportunities to increase bystander CPR rates in these vulnerable communities. Fourth, there is a need to invest in community engagement to address delays in 9-1-1 activation and issues of trust for institutions of authority. Moreover, whether public service announcements (television, radio, social media) to promote the life-saving benefits of bystander CPR

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in public settings and revamping of CPR training materials (e.g., mannikins, videos) to portray OHCAs victims and bystanders as a diverse, multicultural population to normalize rescuing people of color are effective in addressing potential bias in layperson response is unknown but deserve study.

Limitations

This study should be interpreted with the following limitations. First, CARES does not collect information on the race of bystanders to better understand if bias contributed to differences in public settings. Moreover, detailed information on the number of potential responders for each OHCA case would have allowed for more robust adjustment. It is possible that White victims of OHCA had a higher number of potential responders in public settings than Black/Hispanic victims to account for the findings for witnessed OHCAs in public, although the use of hierarchical models with EMS agency as a random effect and analyses within neighborhood race/ethnicity and income strata would help account for differences across communities. Second, information on reasons for not providing bystander CPR is not collected in CARES. Since this study was conducted in patients with witnessed OHCAs in which there would be an opportunity for immediate bystander response, future efforts to collect this information would provide critical insights regarding which public health interventions may have the largest impact in reducing disparities in bystander CPR rates. Third, there is a potential for misclassification of a patient's race or ethnicity within CARES. Fourth, the findings of this report may not be generalizable to regions that do not participate in CARES. However, as CARES has a current catchment area of approximately half of the U.S. population, there is no reason to believe that the findings of this report are not representative of the U.S. experience, except perhaps in rural regions.

Conclusion

In conclusion, Black and Hispanic victims of a witnessed OHCA were less likely to receive potentially life-saving bystander CPR, as compared with Whites, and the magnitude of this disparity was greater for OHCAs occurring in public than at home. Given that the underlying factors contributing to differences varied by location, multifaceted public health interventions are needed to reduce disparities in bystander CPR and OHCA survival.

Table A-1. Bystander CPR rates for Black vs. White individuals with a witnessed OHCA.* Rates are reported for OHCAs occurring at home and in public locations, overall and when stratified by neighborhood race/ethnicity and income.

	Black	White	Adjusted OR	p-value	Interaction P value
OVERALL					
Home	7870/21375 (36.8%)	26,899/56,723 (47.4%)	0.71 (0.68, 0.74)	<0.001	<0.001
Public	2545/5830 (43.7%)	10,722/17,862 (60.0%)	0.57 (0.54, 0.61)	<0.001	
BY NEIGHBORHOOD RACE					
Predominantly (>80%) White					
Home	398/931 (42.8%)	11,422/23,286 (49.1%)	0.78 (0.68, 0.89)	<0.001	<0.001
Public	237/488 (38.6%)	3656/5913 (61.8%)	0.58 (0.48, 0.70)	<0.001	
Majority (>50%) Black/Hispanic					
Home	5305/14901 (35.6%)	3306/7616 (43.4%)	0.76 (0.71, 0.81)	<0.001	<0.001
Public	1243/3134 (39.7%)	1636/2940 (55.7%)	0.57 (0.52, 0.64)	<0.001	
Integrated					
Home	2167/5543 (39.1%)	12,171/25,821 (47.1%)	0.75 (0.71, 0.80)	<0.001	<0.001
Public	1065/2208 (48.2%)	5430/9009 (60.3%)	0.64 (0.58, 0.71)	<0.001	
BY NEIGHBORHOOD MEDIAN HOUSEHOLD INCOME					
>$80,000					

Home	1160/2671 (43.4%)	8120/16,163 (50.2%)	0.79 (0.72, 0.87)	<0.001	<0.001
Public	590/1183 (49.9%)	3230/5030 (64.2%)	0.57 (0.50, 0.66)	<0.001	
$40,000 TO $80,000					
Home	3719/9692 (39.1%)	16146/34,313 (47.1%)	0.78 (0.73, 0.82)	<0.001	<0.001
Public	1180/2579 (45.8%)	5946/10,119 (58.8%)	0.64 (0.58, 0.70)	<0.001	
<$40,000					
Home	2919/9012 (32.4%)	2615/6274 (41.9%)	0.70 (0.65, 0.76)	<0.001	<0.001
Public	775/2068 (37.5%)	1546/2713 (57.0%)	0.50 (0.44, 0.57)	<0.001	

* Models adjusted for age, sex, race, etiology of OHCA, and urbanicity

Table A-2. Bystander CPR rates for Hispanic vs. White individuals with a witnessed OHCA.* Rates are reported for OHCAs occurring at home and in public locations, overall and when stratified by neighborhood race/ethnicity and income.

	Hispanic	White	Adjusted OR	p-value	Interaction P value
OVERALL					
Home	2757/6198 (44.5%)	26,899/56,723 (47.4%)	0.86 (0.81, 0.92)	<0.001	<0.001
Public	1059/2066 (51.3%)	10,722/17,862 (60.0%)	0.65 (0.59, 0.72)	<0.001	
BY NEIGHBORHOOD RACE					
Majority (>50%) Black/Hispanic					
Home	1843/4242 (43.5%)	3306/7616 (43.4%)	0.93 (0.85, 1.01)	0.09	0.005
Public	552/1175 (47.0%)	1636/2940 (55.7%)	0.64 (0.55, 0.74)	<0.001	
Integrated					
Home	796/1710 (46.6%)	12,171/25,821 (47.1%)	0.90 (0.81, 0.99)	0.046	0.12
Public	431/761 (56.6%)	5430/9009 (60.3%)	0.78 (0.67, 0.91)	0.002	
Predominantly (>80%) White					
Home	118/246 (48.0%)	11,422/23,286 (49.1%)	0.86 (0.67, 1.13)	0.29	0.54
Public	76/130 (58.5%)	3656/5913 (61.8%)	0.76 (0.53, 1.09)	0.13	
BY NEIGHBORHOOD MEDIAN HOUSEHOLD INCOME					
>$80,000					
Home	477/991 (48.1%)	8120/16,163 (50.2%)	0.85 (0.74, 0.98)	0.02	0.04
Public	264/466 (56.7%)	3230/5030 (64.2%)	0.65 (0.53, 0.80)	<0.001	
$40,000 TO $80,000					

Home	1520/3334 (45.6%)	16146/34,313 (47.1%)	0.93 (0.86, 1.01)	0.11	<0.001
Public	532/1038 (51.3%)	5946/10,119 (58.8%)	0.70 (0.60, 0.80)	<0.001	
<$40,000					
Home	760/1873 (40.6%)	2615/6274 (41.9%)	0.90 (0.79, 1.03)	0.13	<0.001
Public	263/562 (46.8%)	1546/2713 (57.0%)	0.62 (0.51, 0.76)	<0.001	

* Models adjusted for age, sex, ethnicity, etiology of OHCA, and urbanicity.

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